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"LET KNOWLEDGE GROW FROM MORE TO MORE
AND THUS BE HUMAN LIFE ENRICHED."

A New Survey of Universal Knowledge

ENCYCLOPÆDIA BRITANNICA

Volume 17

P TO PLANT QUARANTINE

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P *TO* PLANT QUARANTINE

P This letter throughout its known history has represented the unvoiced labial stop. It corresponds to Semitic 𐤐 *(pe)*, perhaps deriving from an earlier sign for "mouth," Greek Γ, Γ, Π (pi). The rounded form occurs in the early Greek inscriptions from the island of Thera. In the Italic alphabets the form varied strangely. Etruscan had Π and Ꝑ. The standard form in the Latin alphabet mas evidently borrowed from the Etruscan P, but the colonial Latin alphabet of the 3rd century B.C. also shows a form Π resembling the Chalcidic. The Umbrian alphabet had 1, a form resembling the ancient Semitic. Faliscan had the rounded form Ϙ, Ρ. Oscan lengthened the second small vertical stroke and developed the form Π.

The minuscule letter resembles the majuscule, the chief difference being that the loop is brought down to the level of the line of writing and the vertical stroke extended below the line. Thus a cursive form of the 6th century was ꝑ, the uncial form was ꝓ, the Carolingian ꝑ.

The English initial *p* is slightly aspirated, that is, it is accompanied by a slight puff of breath, in contrast to the unaspirated *p* of French for example. In English, as in French and German, the letter is used in combination with h in words of Greek origin to denote the unvoiced labiodental spirant expressed in other words by the letter f; *e.g.*, "philosophy," "phonetics" and "graphic." Initial p is silent in the combinations *ps* and *pt* in such Greek-derived words as "psychology" and "pterodactyl."

For the history of sound changes affecting the letter *p*, see GERMANIC LANGUAGES. See also ALPHABET.

(B. F.C.A.; J. W.P.)

NAME OF FORM	APPROX-IMATE DATE	FORM OF LETTER
PHOENICIAN	B.C. 1,200	7
CRETAN	1.100-900	3
THERAEAN	700-600	3
ARCHAIC LATIN	700-500	P
ATTIC	600	7
CORINTHIAN	*600*	1
CHALCIDIAN	600	P
IONIC	403	7
ROMAN COLONIAL	PRE-CLASSICAL AND TIMES	ᴩ Γ P
URBAN ROMAN		ᴩ P
FALISCAN		9
OSCAN		Π Π
UMBRIAN		1
CLASSICAL LATIN AND ONWARDS		P

DEVELOPMENT OF LETTER "P" FROM EARLIEST TIMES TO THE PRESENT

PAARL, a town 36 mi. by rail E.N.E. of Cape Town, U. of S. Af., situated about 400 ft. above sea level on the banks of the Berg river, along which it straggles for about 7 mi. To the west are the Paarl mountains; to the east the Drakenstein range. In and around Paarl are gardens, orange groves and vineyards. It is a busy agricultural and industrial centre. Fruit and tobacco cultivation is increasing. Wine, brandy, wagons and harness are made. There are several high schools. a training college and an industrial institute. In 1951 the population was *30,036* and con-

sisted of 15,295 mixed, 2,507 natives, 38 Asians and 12,196 Europeans. Paarl mas founded in 1687.

PABJANICE, a town of Poland, in the province of Lodz. 10 mi. S.S.W. from Lodz. Pop. (1950) 48,800. It lies amid extensive forests around the headwaters of the Nér, which were the hunting grounds of the Polish kings. It has woolen, cloth and paper mills, and manufactures agricultural implements. German troops took the town in 1939. It was returned to Poland in 1945.

PABNA or PUBNA, a municipal town and district in the Rajshahi division of East Pakistan. Pabna (pop., 1951, 32,240) is situated on the Ichhmati river, a dying tributary of the Padma whose erosion of the town was nevertheless a serious problem by the 1950s. It is noted for its Hindu temple of Bengla, built about the middle of the 18th century.

PABNA DISTRICT (area 1,826 sq.mi.) had a population in 1951 of 1,587,247. It lies in the angle between the Brahmaputra. or Jamuna, river in the east and the Ganges, or Padma, in the southwest. It is intersected by countless water channels so that during the rainy season most of the villages are accessible by boat, and many by boat only. The district is a wide alluvial plain, the southwestern portion being higher in level. Fields of rice and jute, the two staple crops, are almost encircled by clumps of trees and bamboos which conceal the village sites.

PACA, a large, heavily built, short-tailed rodent recognized by its spotted fur. This rodent (*Cuniculus paca*), together with one or two other tropical American species, represents a genus akin to the agoutis and included in the family Dasyproctidae. Pacas may be distinguished by their heavier and more compact build, the longitudinal rows of light spots on the fur, the five-toed hind feet and the peculiar structure of the skull. Their habits are similar to those of agoutis.' Males differ from females in the rough outer surface of their cheekbones.

The paca-rana (*Dinomys* branickii), from the highlands of Peru, differs by its well-developed tail and the arrangement of the spots. See RODENTIA.

PACARAIMA, SERRA (Sp. SIERRA PACARAIMA; Eng. PAKARAIMA MTS.), is the tabular upland that surmounts the Guiana highlands along the border between Brazil and Venezuela, and between Brazil and British Guiana. It reaches its highest elevation in Mt. Roraima (9,432 ft.), located where the boundaries of the three countries come together. The Serra Pacaraima extends for about 500 mi. in an east-west direction. None of these surface features, including Mt. Roraima, is properly called a mountain, for the summits are flat or gently rolling; but the steeply cliffed sides make these tabular forms look like mountains as one approaches them on the ground. They are developed on the very thick, flat-lying sandstones of Cretaceous Age that lie over the top of the ancient crystalline rocks of the Guiana highlands. The rivers that rise on the plateau tops pour over the cliffed edges in spectacular waterfalls: such as Kaieteur falls in British Guiana. It was these massive tablelike features: their tops often obscured by clouds, that inspired A. Conan Doyle to write The Lost *World,* an imaginative account of an exploring expedition that found the almost inaccessible heights populated by dinosaurs and other extinct animals. Although the Serra Pacaraima has not been carefully explored, its essential character is known and the border between Venezuela and Brazil has been surveyed. The region is almost uninhabited except by a few tribes of Indians. Although the crystalline rocks of the Guiana highlands contain gold and diamonds, iron ore and other industrial minerals, the cover of sandstones contains no minerals of value. (P. E. J.)

PACATUS DREPANIUS, LATINIUS (LATINUS) (fl. c. A.D. 390), Gallo-Roman orator and poet, was the author of an extant panegyric addressed to Theodosius I at Rome in A.D. 389 after the defeat of the usurper Maximus. He was a friend of Symmachus, the chainpion of paganism, and of the Christian poet Ausonius. It is uncertain whether Pacatus was pagan or Christian; in his speech he denounced Maximus' persecution of the Priscillianist heretics.

In A.D. 390 Pacatus received the proconsulship of Africa and later held other high office.

For text see W. Baehrens (ed.), *XII Panegyrici* Latini (1911). See also E. Galletier, *Panégyriques latins,* vol. iii (1955). (W. S. Ms.)

PACHECO, FRANCISCO (1564–1654), Spanish painter and author, whose pictures and writings are equally representative of the Spanish baroque, mas born at Sanlhcar de Barmeda, where he was baptized on Nov. 3, 1564. He went early to Seville, where he lived with his cousin, F. Pacheco, a canon whose house was a meeting place of the learned and artistic world of the town. Pacheco studied art under Luis Fernandez. It is not known whether he went abroad, but he greatly admired Italian art and formed a collection of Italian Renaissance drawings. Later he opened an academy, which was largely attended. Of his pupils the most distinguished were Alonzo Cano and Velázquez, who became his son-in-law. His early work is hard and cut out. After a visit in 1611 to Madrid and Toledo, where he met El Greco, he became interested in chiaroscuro. Specimens of his work are in the gallery. the university and the cathedral at Seville. The church of St. Sebastian at Alcala de Guadaira, near Seville! contains one of his most important works. He was a successful portraitist and is said to have executed 150 portraits. Pacheco visited Madrid again in 1623 with Velázquez and stayed until 1625. In his later life he devoted himself to writing. His treatise on the art of painting (Arte de la *pintura* [1649]) is of considerable value for the study of Spanish art.

PACHER, MICHAEL (fl. 1465–1498), German painter and wood carver, executed his chief work, the great altarpiece in the parish church of St. Wolfgang, in Upper Austria, between 1478 and 1481. It is one of the greatest monuments of the late German Gothic period. The centrepiece is an elaborate wood carving representing Christ and Mary with St. Wolfgang and St. Benedict. The wings, two on each side, are painted with scenes from the life of Christ and St. Wolfgang. While the carving is of the Late Gothic style prevalent in Germany at the time, the paintings are influenced by the Italian Renaissance, which penetrated into the Tirol from Verona; they especially show the influence of Mantegna. The figures are plastic, the composition clear and monumental. Other works by Pacher are: the altarpiece (wood carving) in the church of Gries, near Bozen (mod. Bolzano, Italy) (1471); the high altar for the church of St. Francis, in Salzburg, begun in 1484 and left uncompleted; and the altarpiece of the cathedral at Brixen (mod. Bressanone, Italy), representing the fathers of the church, panels of which are in the Munich and Augsburg galleries.

PACHMANN, VLADIMIR VON (1848–1933), Russian pianist known for his performances of Chopin was born at Odessa on July 27, 1848. In 1866 he went to Vienna where he studied under Joseph Dachs. He first appeared as a pianist at Odessa in 1869 and later played in Germany, Austria and France. Though his early concerts were successful he was severely self-critical and withdrew for long periods of study. He first appeared in London in 1882, married his Australian pupil Marguerite Oakey in 1884, and made his first visit to the United States in 1891. Until about 1925 he toured Europe and America as a performer almost exclusively of the works of Chopin which he played in an intimate, miniature style. The informal commentaries he provided on the music in the course of performance were a peculiarity of his concerts. He died in Rome on Jan. 7, 1933.

PACHOMIUS, SAINT (292?–346?), Egyptian monk, founder of Christian cenobitical life, was born, probably in 292, at Esna in Upper Egypt, of heathen parents. He served as a conscript in one of Constantine's campaigns, and on his return became a Christian (314); he at once went to live an eremitical life near Dendera by the Nile, putting himself under the guidance of an aged hermit. After three or four years he was called (by an angel, says the legend) to establish a monastery of cenobites, or monks living in common. (See MONASTICISM, § 4.) Pachomius spent his life in organizing and directing the great order he had created, which at his death included nine monasteries with some 3,000 monks and a nunnery. The order was called Tabennesiot, from Tabennisi, near Dendera, the site of the first monastery. Athanasius was his firm friend and visited his monastery c. 330 and later.

The date of his death was probably in 346.

The best modern work on Pachomius is by P. Ladeuze, Le *Céno-*

bitisme pakhomien (1898). There have been differences of opinion in regard to the dates; those given above are Ladeuze's, now commonly accepted. The priority of the Greek *Life* of Pachomius over the Coptic may be said to be established; the historical character and value of this life are now fully recognized. A good analysis of all the literature is supplied in Herzog's *Realencyklopädie* (ed. 3). *See* also W. E. Crum, *Theological* Texts *from Coptic papyri* (1913).

PACHUCA, a city of Mexico and capital of the state of Hidalgo, 55 mi. direct and 68 mi. by rail north-northeast of the city of Mexico. Pop. (1950) 58,650. Pachuca's railway connections are provided by the Mexican and the Mexican National.

It stands in a valley of an inland range of the Sierra Madre Oriental, at an elevation over 8,000 ft. above the sea. and in the midst of several very rich mineral districts — Atatonilco el Chico, Capula, Potosi, Real del Monte, Santa Rosa and Tepenené. It is said that some of these silver mines were known to the Indians before the discovery of America. It was there that Bartolomé de Medina discovered the "patio" process of reducing silver ores with quicksilver in 1557, and his old *hacienda* de *beneficio* is still to be seen. Pachuca was founded in 1534, some time after the mines were discovered. The city has some fine modern edifices, among which are the palace of justice, a scientific and literary institute (now a university), a school of mines and metallurgy, founded in 1877, a meteorological observatory and a public library. Mining is the chief occupation. Electric power is derived from the Regla falls, in the vicinity. The city's industrial establishments include smelting works and a large number of reduction works, including some of the most important metallurgical works in the republic.

PACHYDERMATA, a term often applied to thick-skinned animals, such as the rhinoceros, elephant and hippopotamus. The animals included by it have no close affinities.

PACHYSANDRA, a small genus of the Buxaceae family, comprising four species of herbs or subshrubs of value as ground cover in shade because of their more or less evergreen leaves. P. *procumbens*, native to eastern North America from the mountains of Kentucky to western Florida and Louisiana, is of little value as an ornamental because of the dingy colour and deciduous character of its leaves. P. *terminalis*, from Japan, is a true evergreen with thick glossy foliage, which makes it a very desirable low-growing cover plant, succeeding admirably in full sun or partial shade. The variety *variegata* is a choice cover plant for ornamental effects. (J. M. BL.)

PACIFIC, COMMAND OF THE. The history of modern naval strategy in the Pacific ocean may be said to have begun in 1894, when a victorious Japan eliminated the Chinese navy as a serious factor in the balance of sea power. Three European sovereignties then proceeded to establish bases in the far east; Russia at Port Arthur. Germany at Tsingtao, the naval fortress of Kiaochow on Shantung. and Great Britain at Wei-hai-wei. During this period, the most serious rivalry lay between Russia and Japan, each intent upon the control of Korea, and in 1904–05 the issue was resolved by a war in which Japan eliminated the Russian navy in the far east as completely as it had eliminated the Chinese navy ten years before. Japan was left in undisputed mastery of Asiatic waters from Kamchatka in the north to the Philippine archipelago in the south.

To safeguard its interests in the far east. Great Britain in 1902 concluded an alliance with Japan. The British force on the China station was then reduced to a mere cruiser squadron. While Germany continued to fortify Tsingtao as a refuge for its small Asiatic fleet, it was clear that its forces, whether on land or sea, did not materially affect Japan's supremacy in armaments. The United States kept a few secondary ships of war at Manila in the Philippines, but took no steps to develop the naval resources of this fine harbour. Lying 1,500 mi. to the east of the Philippines in the Marianas group was the island of Guam, like the Philippines a U.S. inheritance from the Spanish-American War of 1898, but despite its position, which invested it with unique strategic value, it was used only as a fuel station.

This situation continued, substantially unchanged, from the year 1905, when the treaty of Portsmouth was signed between Russia and Japan, to the outbreak of World War I in 1914. The far eastern seas, which had long been the arena of conflicting claims to supremacy. had passed definitely under Japanese dominance. The conquest of Tsingtao early in World War I eliminated the only German stronghold in the Pacific. Domestic convulsions in Russia, by apparently reducing the naval forces of that state to impotence. rendered still more remote the prospect of Vladivostok again becoming the headquarters of a formidable fleet.

Cnder the treaty of Versailles. the former German islands north of the equator passed as mandates into the custody of Japan. while those south of the equator were assigned to members of the British Commonwealth. Japan now exercised mandatory powers over several island groups situated far out in the Pacific. Strategically. its most important acquisitions were the Peleliu Islands (500 mi. east of the Philippines): the Carolines; the Mariana Islands, except Guam; and the Marshall group. lying about 1,joo mi. to the southwest of Hawaii. It was believed that light naval vessels, aircraft and submarines, judiciously distributed among these islands, would represent a serious menace to a hostile force advancing toward Japan from the east. Fortification of these islands and their use for warlike purposes was, however, forbidden under the League of Nations mandate.

Under the Washington Treaty of 1922 the British empire. the U.S., and Japan agreed to limit naval building under the terms of the five-five-three ratio, and to maintain the *status quo* regarding fortifications and naval bases in a number of highly important strategic positions. The U.S. pledged itself not to improve the shore defenses or naval works in the Philippines, Guam or the Aleutian Islands; Japan accepted the like obligation in regard to the Bonin Islands. Formosa and other insular possessions; while the British empire was debarred from adding to the naval resources of Hong Kong.

The Hawaiian Islands were exempted. and Oahu became the pivoting centre of a fleet charged with the task of defending not only the western seaboard of the U.S. but also the outlying territories of Alaska, the Philippines and Samoa.

Singapore, likewise, was exempted from the agreement, and became the southern base of the British China squadron. During the 1930s it was developed into a Pacific naval base second only to Pearl Harbor in Oahu. The bulk of the British fleet was. however, kept in Atlantic waters, and it was never assumed that this fleet would be able during a general European war to exercise in the far east an influence at all commensurate with that of either the U.S. or Japan.

Between World Wars I and II the major determinants of the strategic situation in the Pacific were the Japanese and U.S. fleets. The Panama canal enabled the C.S. to operate its fleet in two oceans, the Atlantic and Pacific. and it was to the Pacific that it devoted its main naval developments. But since at that time any fleet was presumed to be limited to a narrow radius of action, determined by the relatively meagre fuel capacity of its larger ships, it could not be said that any one power, or group of powers, had achieved control of the vast Pacific. It remained for World War II to show whether Japan could challenge the undisputed control of the U.S. in the eastern Pacific, and the more dubious control of the British empire in the southwest Pacific waters, or whether the U.S. could invade the waters surrounding Japan.

As long as Great Britain and the U.S. chose not to interfere actively in the Japanese conquest of Manchuria and China. which began in 1931, Japanese sea power remained unchallenged. The opening of World War II saw the major portion of the British navy committed to keeping open the sea lanes of the Atlantic and Mediterranean. Ever-increasing losses to submarines and aeroplanes and finally the grave threat of a German invasion of the British homeland left no margin for anything but a skeletal naval force in the far east.

By 1941 substantial U.S. naval forces were being transferred to the Atlantic to support the endangered British position there. It was at this time that Japan chose to extend its conquests to southeast Asia. Since the U.S. battle fleet was the only concentrated and readily available force which could oppose such conquest, it was this battle fleet at which Japan struck first.

PACIFIC, COMMAND OF THE

The attack on Pearl Harbor on Dec. 7, 1941, temporarily destroyed the offensive striking power of the U.S. in the Pacific. Three days later the British capital ships "Repulse" and "Prince of Wales," which had arrived at Singapore only the preceding week, were sunk at sea.

There then followed the most gigantic demonstration of seaborne invasion that the world had ever seen. By the time Japan had conquered Singapore and the smaller bases in the Philippines, the East Indies and Melanesia, its control of the western Pacific was complete, and it was even threatening communications with Australia and India.

The pattern of Japanese conquest was a centrifugal one, a moving outward from a centre toward a periphery. This gave Japan the advantage of interior lines, with Japanese forces always disposed between the major concentrations of the forces opposing it and thereby able, so long as it held the initiative, to threaten two or more widely removed points simultaneously while concentrating mainly against one. But this advantage contained in itself the seeds of its own dissolution. However far the surge of Nipponese conquest might reach, always beyond its periphery were uncominanded seas over which Japan's enemies were bound ultimately to bring the full pressure of their vastly superior strength. Japan was isolated from its allies and surrounded by a hostile world.

The strategic problems of the Pacific war were in many respects without precedent in naval history. Never before had a war been fought by two great naval powers whose main sources of strength were on opposite sides of a wide ocean, in this case the widest ocean of all. Domination of the Atlantic, at least as far as surface ships were concerned, could be exercised from British bases against a European enemy by control of the exits to the North sea, the Mediterranean, and the waters off the coast of France. But in the Pacific no one area would if dominated automatically give command of the whole. And for the first year of the war neither side had the resources to assert supremacy in all the areas which might at any moment become critical.

Before World War II, it had become axiomatic that the first step in acquiring command in a disputed maritime area was to maintain there a force capable of dealing with the largest single force which the enemy could bring to bear. This usually meant concentration of one's major ships into a unified battle fleet. This idea, which was basic to the whole principle of command of the sea. was rejected as outmoded by both sides in the first year of the Pacific war. Both sides divided their fleets into separate formations or "task forces," each of which was considered an independent tactical unit. The task force system provided a means of covering widely separated areas simultaneously and of rotating units of strength in those areas which were especially important at the time but where it was impossible to maintain a fleet continuously. And at a time when enemy land-based air attack was a threat of profoundly disturbing proportions, the task force system offered a means of accomplishing one's ends without exposing to such attack any more ships than were absolutely necessary for the execution of the mission.

The task force principle was not wholly new, for in all great naval wars squadrons had been detached from fleets for independent missions. What was new was a dissolution of the fleet so complete as to enable a senior naval officer testifying before a U.S. congressional committee as late as the summer of 1943 to declare: "The fleet as such has ceased to exist!"

The Guadalcanal campaign illustrated both the operation of the task force principle and its limitations. The convoy which made the initial U.S. landing on Aug. 7, 1942, was covered by a sizeable force, including three aircraft carriers, one modern battleship and several heavy cruisers. But the carrier group and the battleship were shortly withdrawn because of fear of Japanese land-based air attack. On the night of Aug. 7–8, a Japanese surface force inflicted heavy damages on the remaining cruisers and destroyers in the battle of Savo Island, a blow that was second only to Pearl Harbor in its severity.

In the naval engagements which followed both sides suffered losses, but the U.S. surface forces were able, because of aid from the land-based aircraft operating from Henderson field, to exercise a continuity of influence out of all proportion to the time they actually spent in the disputed waters. Nevertheless, real naval command was never established by either side. Both sides continued to send more men and supplies into Guadalcanal, and the U.S. eventually won the campaign at sea, thereby making possible victory ashore, only by superior fighting and staying power in a simple contest of attrition. Considering their own limited replacement facilities, the Japanese could not continue expending major ships for the defense of one remote island. But the cost to the U.S. was not light, and had it begun the campaign with all the forces dispatched to the area before it ended, it should have won the victory more speedily and with less cost.

The only conclusion to the chain of matching big by bigger, which was a consequence of the task force strategy, was a showdown match of maximum strength. But after the Guadalcanal campaign the Japanese showed increasing unwillingness to offer their surface ships for action. By the end of 1943, they withdrew the bulk of their fleet to home waters, where it was obviously being held in reserve for some decisive issue. Their disinclination to fight was due simply to the fact that they had become grossly inferior. The vast ship construction and armament production programs in the U.S. were making available ships, planes and weapons in unprecedented volume. And the Japanese had to be content to impede U.S. advances in the Solomons and the Aleutians as best they could with aircraft, submarines and occasional light surface forces—besides their land garrisons, which being isolated were considered expendable.

The descent of U.S. naval forces upon the Gilbert Islands in Nov. 1943 marked a revolution in U.S. naval strategy. For the first time in the Pacific war, the U.S. began an operation with a task force which was really an entire battle fleet, one capable of engaging and defeating the whole Japanese fleet. Moreover, the fleet remained off the shores of Tarawa and Makin, day and night, until the conquest of these islands was accomplished—which, in contrast to the six-months' fight for Guadalcanal, required only a few days. Such was to be the pattern of all future U.S. invasions—from the Marshalls to Okinawa. The establishment of the "fleet train," a tremendous auxiliary force of tankers and other supply ships, permitted the battle fleet to remain at sea for prolonged periods, and enormously extended its radius of operations. And with each new operation the fleet grew steadily larger. The principle of achieving and retaining decided command round any land area chosen for invasion replaced the attrition tactics which had won so costly and tardy a victory at Guadalcanal.

The revolution in United States strategy resulted from three factors: first, the great accretion in its ship and plane strength; second, a return in naval thinking to the classic principles of Alfred T. Mahan; and third, a tactical revolution in U.S. aerial offense and defense. The last factor consisted in the use of aircraft carriers for the first time in large concentrations, and the building up on the decks and superstructures of the ships a stupendous anti-aircraft shield comprising guns and directors of marvelous accuracy and novel projectiles of almost miraculous performance.

By using carriers in large groups, the U.S. navy incorporated within itself the only truly mobile air force of any size in the world. This force enjoyed all the peculiar advantages of mobility, such as ability to concentrate and to achieve surprise. Japanese ability, on the other hand, to combine or co-ordinate separate groups of land based aircraft depended on forewarning and on the distance between the stationary airfields.

The most striking single result of the great growth in the aerial offensive and defensive strength of the U.S. navy was the restoration to this navy of all its old freedom of movement. By the end of 1943 it enjoyed a decisive surface superiority over the Japanese fleet, and it roved in Japanese waters with all the insouciance which superior fleets had been wont to display in days long past. It exhibited a freedom of action among Japanese-held archipelagoes which many had predicted would never again characterize the movements of ships.

Following U.S. occupation of the Gilbert Islands, the Marshalls,

the Carolines, the Marianas and the Palaus were assaulted, and many key islands captured. with almost total absence of loss or even damage to U.S. surface units. The taking of Guam and Saipan in the Marianas in June 1944 provoked the Japanese to the first major fleet action after Guadalcanal, and their fleet carrier strength was there severely crippled.

When the U.S. fleet moved into the Ryukyu-Formosa-Philippine area. it was for the first time in the war assaulting what was in effect a large land mass which, because of its position, was the key to the whole Japanese strategic system. Because of the qualitative superiority of U.S. carrier planes over Japanese land-based planes. and because of the capacity of U.S. planes to make themselves numerically superior at the point of attack, most of the Japanese land-based planes in this area were neutralized before U.S. landings in the Philippines.

Capture of the Philippines by the U.S. could mean only that that country would have a great staging base for future operations against Japan itself, and also the means of severing Japanese communications with all the lands between the Bay of Bengal and the Solomon sea. A more critical strategic situation for Japan could not arise unless the Japanese home islands themselves were being invaded. The Japanese fleet. therefore. moved in for the decisive fight, the battle for Leyte gulf. There its fighting strength was approximately halved. and the half which escaped did so in a very bad state of repair. U.S. losses were slight. The career of Japan as a major sea power was definitely ended, and the whole of the Pacific. with the exception of part of the home waters of Japan itself, could be regarded as a United Nations sea. The struggle ior command had been decided.

The last great challenge of the Japanese to the U.S. fleet was the *Kamikaze* assault at Okinawa. In capturing this island the U.S. lost to the Japanese suicide squadrons 30 U.S. warships. and saw damage to an additional 223. The casualties in men comprised about one-seventh of the navy's total for the entire war. But heavy as was this damage, it did not begin to compensate for the estimated 2,500 Japanese planes lost during the assault. No major U.S. ship was sunk, and there was no question of which side could better absorb the blows inflicted upon it. Japanese recognition of the failure of the Kamikaze no doubt helped to assure their surrender within a very few months.

The close of World War II left the U.S. indisputably the master of the entire Pacific. Its navy, by this time far the greatest in the world. could see in that wide ocean no rival to oppose it. New air and ship bases had been won in the formerly Japanese-held islands, and the U.S. was plainly determined to keep them for its security, whether under United Nations organization trusteeship or otherwise.

However, this unparalleled dominance in the Pacific was no sooner won by the United States than it seemed to belong to an era that had vanished. The atomic bomb, which had helped bring World War II to a close, cast into considerable doubt the real meaning for the future of old-style naval command. The emergence of the Soviet power as the centre of an empire hostile to the United States and the latter's weakened allies in western Europe coincided with the beginning of a race in nuclear weapons which was soon to produce vast capabilities for destruction on either side. It began to appear increasingly that in an unrestricted war between the two major power blocs in the future. the affairs of the Pacific would be governed, and very quickly determined, by events taking place elsewhere.

In that context even the loss of China to the Communist camp, which was effectively completed in the summer of 1949, and the somewhat artificial alliance between the United States and its erstwhile enemy. Japan. had—in marked contrast to what such political shifts would have meant a decade or more earlier—relatively little strategic meaning. On the other hand, the Korean war of 1950–53 proved that so long as the major powers on both sides remained anxious to keep their military contests limited in scope and in location, the unchallenged naval power of the United States gave it complete access to any littoral area in the Pacific in which it might choose to intervene.

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(B. BE.)

PACIFIC, WAR OF THE (1879–1884), a conflict that grew out of a dispute between Chile and Bolivia over control of a part of the Atacama desert lying between the 23rd and 26th parallels on the Pacific coast of South America, a territory that contained valuable mineral resources, particularly sodium nitrate. Peru became embroiled in the war when, after an offer to mediate was rejected by Chile, a secret Bolivian-Peruvian treaty of alliance was revealed. In the opening phases of the war the Peruvian navy was destroyed by Chile, vhich then invaded Peru and captured several of its provinces and the capital city of Lima

An effort by the United States at mediation failed in 1880, and although the last engagement took place in 1882 it was not until 1883 that Chile and Peru negotiated a treaty by which Peru made numerous concessions The following year a truce was concluded betueen Chile and Bolivia by which the latter country lost its entire coastline.

PACIFIC ISLANDS. The Pacific islands are scattered largely in the southwest and west of an ocean twice as big as the Atlantic and more than 20 times as large as the United States. The word "Oceania" is popularly used to define loosely the ocean area and the islands of the southwest Pacific. Some of the innumerable islands are large land masses, separated in an earlier geologic age from the nearby continents. Borneo, Sumatra and Java were once part of Asia. New Guinea was cut off more recently from Australia. Elsewhere are isolated islands or island groups erupted from the ocean bottom by volcanoes; some of them are in chains 1,000 mi. or more in length: many islands owe their existence in part to the tiny animals that build coral reefs. From New Guinea north to the mainland of Asia, the floor of the Pacific reveals contours more varied and rugged than any on the land. It is pocked with mountains the tops of many of which are islands; other peaks are still below the surface; the bottom is incised by deep trenches. The two deepest abysses are the Philippine trench (Mindanao deep), 34,583 ft., and the Marianas trench, 35.800 ft. (by descent) or 35,958 ft. (by sounding). Other deeps include the Japan trench, the Bonin trench and the Ryukyu trench.

PHYSICAL STRUCTURE AND CHARACTERISTICS

Structurally, the Pacific may be divided into a large eastern and a smaller western part. The eastern part, the area that lies east of a line running north from New Zealand through the Tonga Islands, is an ancient undisturbed basin. All the islands in this basin. from Samoa to Hawaii and eastward across the ocean to the Galápagos and Juan Fernandez, are composed of volcanic materials that have been forced up through fissures or cracks in the earth's crust. The tops of some of them have emerged from the ocean relatively recently.

The islands of the western basin have a much more complicated structure and history. representing the exposed crests of upfolds of the earth's crust lying in a series of long arcs. One of these folds saeeps southeastward from New Guinea to the Solomon, Fiji and Tonga Islands, New Caledonia, and, perhaps. New Zealand. Another set of at least two parallel folds begins in Burma and can be traced through Sumatra and Java to the Moluccas, and possibly to the Philippines and the Palaus. The successive upfolds are separated from one another by the deep trenches or doanfolds. Their origin, with the exception of New Zealand, seems to be relatively recent. geologically apeaking. They represent part of mountain-building earth movements dating back not more than a fen tens of millions of years.

Scientists have made many suggestions about the origin of the Pacific arcs and trenches. but so far no one theory has been fully acceptable. However, there is no longer any doubt that the earth's crust just beneath the main Pacific basin is different from the uppermost crust of the rest of the globe. The boundary

roughly marking off this difference is the so-called "andesite line" or "Marshall line," the latter named after Patrick Marshall of New Zealand. Granite, an "acid" type of rock, is not known in the Pacific floor, yet everywhere else that man or his instruments get a deep look at the crustal rocks of the earth, there is evidence of granite in the topmost several miles of crust, whether dealing with continents or other ocean basins. In terms of rock composition, the material on the continental side of the line, that is in the continents and islands surrounding the Pacific basin, is more andesitic than the rocks in the region enclosed by the "andesite line." Basalt, a basic type of rock, is common in the Pacific basin.

Because ocean deeps in the Pacific follow fairly closely the andesite line where it is known, many earth scientists have come to think of these trenches as setting off the continental blocks from the oceanic block. Seismologists have evidence that the so-called "Mohorovicic" discontinuity (a zone beneath which longitudinal seismic waves are able to travel more swiftly) is zo to 30 mi. down beneath continental blocks, but only a few miles beneath the Pacific floor. This is not an unexpected phenomenon where the granite layers appear to be missing. Between the ocean bottom and the Mohorovicic discontinuity in the Pacific lie sediments and basaltic rocks.

When we approach the island arcs from the Pacific side, in most cases we encounter first an ocean deep or trench. According to seismic soundings by the expedition of the Scripps Institution of Oceanography, La Jolla, Calif, in 1953, the deeps contain a large accumulation of a sedimentary type of rock which seems to extend 10–20 km. (6–12 mi.) deeper than in the surrounding area, on both sides. Consequently gravity is much lower over the trenches than on both sides:—a "negative gravity anomaly."

In the western part of the Pacific ocean, a belt of volcanic activity begins in New Zealand, at the south, and continues through the New Hebrides, the Solomons, the Bismarck archipelago and the islands north of New Guinea. A second line of active volcanoes starts at Sumatra in the west and runs through Java, and the Lesser Sunda Islands, turns northward in the northern Moluccas and extends through the Philippines, finally reaching the Japanese islands, the Aleutian arc in the North Pacific. and Alaska.

The belts of volcanic activity, following the upfolds, are sharply defined. They coincide also to a large extent with one of the heavier earthquake zones in the world. The earthquake zone, however, is more extensive than that of the volcanoes. and includes New Guinea and other areas of recent active mountain building.

Most of these earthquake belts. which account for about 80% of all earthquakes in the world, are not more than 100 km. (60 mi.) wide. The negative gravity anomaly decreases from the deeps toward the continent, and near the continent gravity is too high relative to the average. In the zones of high gravity are situated most of the recently active volcanoes and also belts of earthquake shocks at a depth of about roo km. Inland from recent and presently active volcanoes there is a considerable number of older, extinct volcanoes, where the earthquake focuses descend to a depth of about 200 km. (120 mi.). The seismic activity indicates that relatively strong tectonic processes are continuing in these belts. In some Pacific arcs, as one goes inland, seismic activity descends to greater depths. Only one shock (in Spain) below 300 km. (zoo mi.) has been observed anywhere on earth except inland of these belts. The maximum depth at which a shock has been observed is about 720 km. (450 mi.).

At the meeting of the American Geophysical union in 1953, the whole problem of the structure of the Pacific was discussed, but there was no agreement on details. Conclusions drawn from several theories regarding the arcs and deeps were not confirmed by observations. However, all such observations were in an early stage in the 1950s and were far too few to warrant any definite conclusions.

Under a geological classification, Pacific islands comprise two types—continental and oceanic. Continental islands are those that rise from the continental shelves and actually form parts of the continents, separated from them only by shallow water. Most of them are mountainous. Oceanic islands are those that rise from the bed of the ocean and are separated from the continents by great depths of water; some are only a few score miles from continental lands, others several thousand miles away. Some oceanic islands are high and rugged; many are coral atolls. Coral atolls conform to a well defined type, namely a roughly circular or horseshoe-shaped fringe of low islets about a central lagoon. Some lagoons are accessible by passages from the sea; others are completely enclosed by reefs. Lagoons are from about 3 fathoms to 30 fathoms deep, studded with coral patches, some of which rise nearly to the surface; their floors are normally growing coral or coral sand. In contrast to the quiet wavelets of lagoon beaches, a heavy surf breaks on the ocean side of the atoll. Fragments of dead coral, forced above sea level by the action of tide, wind and wave, form land surfaces, many of which are only a few feet high.

(B. GG.; J. W. CR.)

Corals.—Among the more characteristic features of the Pacific islands are the coral reefs which form the bases of the low islands and which more or less completely girdle each of the high islands. Although a constant menace to navigation, they are the raison *d'être* of the low islands and the defenses of the high islands against wave attack. The reefs are solid masses of organic limestone—flattopped, and steep to seaward, extending from low tide level to considerable depths. There are many controversial problems connected with their development, especially that of the ring-shaped atolls. They represent accumulations of the calcareous skeletons secreted bv the life processes of shallow-water marine organisms. principally reef-building corals, calcareous algae, and subordinate animals such as Foraminifera, mollusks, echinoderms, etc. Not all the organic limestone developed by reef organisms, however, goes into the construction of reefs. Loose material is carried by waves across the more or less even surface of reef flats and either heaped up on the flat here and there to form low islands and banks, especially during storms, or carried on beyond the flat and dumped into the lagoon behind the reef.

Most of the Pacific island reefs are covered on their seaward, windward margins by luxuriant growths of red calcareous algae, which can gro and maintain themselves in the very teeth of the breakers where corals are less able to survive. But down the seaward slope and behind the algal ridge, reef corals abound and contribute largely to the growth of the reefs. The thickets and heads of corals and the sandy bottom or rocky pavement between them give shelter to a vast variety of brilliantly coloured animals particularly adapted to the reef environment: fish; mollusks. including giant clams, oysters, gastropods, octopods; echinoderms, as starfish, sea urchins and crinoids; crabs, crayfish and other arthropods; bryozoans, sponges and other forms. The reefs of each island constitute a self-contained and slowly-expanding marine community whose ultimate nourishment comes from the plankton of the surrounding sea.

Corals are essentially sea anemones with the power of forming limy skeletons of great size and strength. They form one division of the Coelenterata, which also includes hydroids, jellyfish, sea fans, and soft corals, and are known to most persons in the form of bleached masses of a wide variety of shapes. Living corals are richly coloured in shades of brown, yellow, green, violet and gray, but the skeletons of most of them are white. The vast majority of corals on coral reefs are colonial in habit; that is, each mass of coral consists of a number, often running into hundreds of thousands, of individual coral polyps secreting a common skeleton and multiplying by incomplete division. Colonies are established as the result of the settling to the bottom of free-swimming, skeletonless, larvae, produced by sexual means. Soon after settling, the skeleton begins to develop and continues to he secreted as long as the founder polyp and its asexual offspring live. Some colonies are hundreds of years old. The rate of growth of colonies naturally varies from one species to another, but it averages about an inch per year. However, the accumulation of limestone from corals and other reef-building organisms on a reef site is probably less than one-half inch per year, and reefs grow very slowly, but steadily.

The conditions under which reef corals live are unique to the shallower parts of the tropical seas where the average annual water temperature is not less than 70° F. In the Pacific islands, the sur-

face water temperature is about 80° F, and reef corals flourish wherever other conditions are suitable. They shun muddy water and water diluted by influxes of fresh water, as around the mouths of rivers. They can live down to a maximum depth of about 150 ft., but actually most are found in the well-lighted waters less than 25 ft. deep. The reef coral polyps themselves are insensitive to light, but their endodermal tissues contain myriads of microscopic one-celled algae (zooxanthellae). The corals and these symbiotic algae, the latter living only in the presence of strong light, have become mutually interdependent, and the corals rely on the algae to absorb their waste products. Without this self-contained disposal system, the number of polyps that could live on a reef tract mould be very much smaller, and great colonies, the mainstay of the reefs, would be impossible. (J. W. W.)

Climate. — The great majority of the Pacific islands lie within the tropics, but, because of their various altitudes, all kinds of climate from tropical heat at sea level to polar cold in high altitudes are found.

There are the steaming jungles of Guadalcanal, the snowy windswept reaches of high New Guinea, and the balmy climate of Haaaii and other mid-ocean islands. At and near the equator, at sea level. the temperature remains about the same throughout the year, but everywhere else there are definite seasons of heat and less heat. On both sides of the equator, for a distance of about 20° varying with the position of the sun, is an equatorward flow of air, known as the trade winds. Those north of the equator always blow from the northeast and those south of the equator from the southeast. In the western part of the Pacific the heat and cold of the huge land mass of Asia causes the trade winds to be replaced by alternating seasonal winds knoun as monsoons. A belt of very light winds, or, in some islands, an upward current of air (convectional current), lies between the northeast and southeast trade-wind belts. Known as the doldrums, its position also shifts with that of the sun during the course of the year.

Rainfall is the most variable factor in the climate; there is great variation from year to year, from month to month, and from day to day. On high islands the windward sides receive a heavy rainfall from 60 to 100 in., whereas the leeward sides are comparatively dry. Atolls receive much less rain than high islands, for rain-bearing winds blow over them without losing much. if any, of their moisture; in a year of drought the precipitation is sometimes as low as 5 or 6 in.

An important exception to the genial climate must be noted: the even weather is occasionally interrupted by tropical cyclones which are also known as hurricanes or typhoons according to their place of origin. These terrific wind- and rainstorms. generally occurring at the season of greatest heat, leave ruin in their wake. Tropical cyclones in the Pacific ocean are restricted to three fairly well defined areas. One is in the eastern Pacific, north of the equator, off the Central American and Mexican coasts. A second area is in the western North Pacific, in and near the China sea. In the western South Pacific, where most of the islands lie, the tropical cyclone belt is extensive, stretching from Australia eastward nearly half the width of the ocean, between latitudes 10° and 30° south.

The Pacific, like the other oceans, has its own system of currents. There is a movement of surface water toward the equator on the American side, and a movement largely away from the equator on the Asiatic side. One result of this is that tropical waters are squeezed into a narrow belt near the Americas, but are spread out widely in the western Pacific.

A number of complicated forces, acting together, cause a variety of tidal patterns among Pacific islands. But on all of them, the range between high and low water is usually very small compared nith tidal ranges along continental shores.

The stars have been important factors in the lives of people of Pacific islands from time immemorial. Sailing south, after leaving the equator, the Southern Triangle and the Mngellanic clouds lift higher and higher every night, as the North Star vanishes wholly from sight. and the Dipper sinks closer to the northern horizon. The Southern Cross comes into view—that constellation which throughout all history for the people who live "down under," has been the guiding symbol. In the darkness of the open ocean, the ancestors of modern Pacific islanders made thousands of voyages in open canoes without compass or sextant, steering by the stars over widespread distances from one island to another.

Flora and Fauna. — To explain the presence and the distribution of plants and animals in the islands of the Pacific ocean, the islands may be thought of both in relation to their geological history and also in relation to their geographical positions. Continental islands were connected with their respective continents during the last ice age, which ended about 30.000 years ago. In those times such an immense volume of water from the oceans was frozen in the polar icecaps that the ocean level is estimated to have been some 300 ft. lower than it is today. The direct effects of this reduction of sea level were to reunite many of the continental islands to their parent continents and to make some of the oceanic islands appreciably larger.

Perhaps the most remarkable characteristic of the flora and fauna of the islands is the great difference of so many of the plants and animals, including birds. from those living on the continents. Islands have acted as places of refuge for many species threatened with extinction and later wiped out by nature on the mainland. As one proceeds eastward from the western borders of the Pacific, plant and animal life become more and more restricted both in genera and species. (J. W. CR.)

Land Flora. — The plant cover of the Pacific islands varies from rain forest to grassland and desert, depending on geographic and topographic situations, and also on the history of human occupation. The parts of the area that are within the trade-wind zones have a characteristic pattern of rain forest on the windward sides of the islands and sclerophyllous forest. grassland, scrub, or even desert in the rainshadow on the lee slopes; on some islands there are areas of luxuriant vegetation on dry slopes resulting from convection rainfall. The upper belts and crests of islands of moderately high altitude in this zone are usually covered with a cloud forest or mossy forest of small trees and dense undergrowth, conspicuously clothed with epiphytic mosses, hepatics, ferns and orchids. Rarely, on these summits. there are bogs and moorlike areas of dwarfed vegetation, underlain by peat. The higher mountains, as in Hawaii, protrude above the belt of effective orographic precipitation and have their upper slopes covered by xerophytic scrub and very sparse dwarfed alpine vegetation. Typical halophytic strand vegetation lines the coasts, with mangrove swamps common in the western islands, becoming rarer eastward, and altogether absent east of Samoa except where they have resulted from man's activity, for example, in the Hawaiian Islands. The low coral islands and atolls are clothed with strand vegetation except in the interiors of the larger and wetter ones where there are broad-leafed, mesophytic forest types. Very dry islands in the doldrums and other areas of calms have sparse herbaceous vegetation or open grasslands. In the western Pacific, where the influence of the monsoons is felt, the clear pattern of a wet windward side and a dry leeward side on each island becomes obscure, and the islands are generally covered by moderately luxuriant forests, most of which are not wet enough to be classified as true rain forests. Extensive savannas are found on some of these western islands, characterized by coarse grasses and scattered shrubs and trees. The origin of these is not clear, but may be in large part due to a long history of clearing and repeated burning by the native inhabitants.

Man's activities, beginning with the aborigines, but greatly accelerated since the coming of Europeans, have profoundly changed the vegetation of almost all the islands. Great areas have been cleared and converted to plantations, principally coconuts, breadfruit, sugar cane and pineapples. Clearing and burning resulted in the creation and extension of savannas arid in the replacement of large areas of primary forest, rain forest and moist to dry forest, by secondary forest of various sorts including *Prosopis*, guava thicket, and, probably. the *Aleurites* in the Hawaiian Islands, *Hibiscus* forest in many islands, and mixed secondary forest of many widespread weedy trees in the western Pacific islands. *Lantana*, *Acacia*, *Leucaena*, and other weedy shrubs, as well as cacti. introduced into many islands, have become so abundant, especially

after disturbance by hoofed animals and fire, as to change, completely, the landscape.

The flora of the islands in general is essentially an attenuated Indo-Malayan one, possibly with New Guinea as the main centre of distribution. Outstanding centres of local development occur in New Caledonia, the Hawaiian Islands, and in New Zealand. The majority of the genera represented are those with a large number of species in the Malaysian region. Their number rapidly decreases eastward except where there have been centres of secondary development of local species on some of the higher island groups. Strong representations of Australian and New Zealand genera are also found, with a few American and boreal ones, and a number that are endemic in the islands, some of whose geographic affinities are not at all clear. The number of native species is generally not large, and it decreases from west to east and from higher islands to lower ones. (F. R. F.)

Marine Flora.—The marine flora of the Pacific islands is almost entirely an algal flora. Very small amounts of Thalassia and Halophila, the only flowering marine plants seen in the islands, play an insignificant role in their economy. In the Gilbert Islands Thalasia is a food of the turtles. Fungi in marine environments of the tropical Pacific are almost unknown. There are no truly marine ferns. No marine bryophytes are known. All the algal phylla are reported from the Pacific with the exception of the Chloromonadophyta.

The algae of the Pacific islands may be grouped into two categories according to their roles—physical and physiological. Red algae (Rhodophyta), mostly of the genus Porolithon, are apparently largely responsible for the development of, or for controlling the development of, atolls and reefs through their contributions—largely limestones, and through binding detrital solid materials from other sources. The lagoons of atolls gradually become filled. mostly with branch segments of Halimeda (Chlorophyta), but also with fragments of other calcareous algae and animals such as those found on the reef. Fragmentary reef materials accumulate on the flat reef surface as sand behind boulders and as sand bars. These topographic features are ephemeral unless bound together, for example, by the filaments and gelatinous masses of blue-green algae. By binding sand they cause the growth of islands on reef surfaces. They apparently contribute both to the formation and also to the removal of conglomerate rocks of an island above low water mark through effecting changes in the solubility of carbonates and promotion of rasping by snails.

When an island remains above high tide long enough, there are two major limitations to the development of a terrestial biota. These are a fresh-water supply and a source of available nitrogen. The first of these limiting factors is removed by an increase in the size of the island and the lowered permeability of the shore area where island conglomerates form. Under these circumstances, when it rains, the formation of a "Ghybent-Herzberg" fresh-water lens results.

The blue-green algae play several physiological roles, one of the major of which is that of providing a source of available nitrogen. The soil of many atolls consists of a layer of coral fragments about a foot deep, coated above largely with blue-green algae. The roots of plants appear in and among the white to buff sandy material forming deeper layers of the island mass. In view of the absence of ordinary humus, and the fact that there is a high degree of aeration, the blue-green algae may well provide the essentials of humus as exocrine or decayed material.

In addition to the above roles, algae provide the food on which both the oceanic and reef fishes depend. It has been estimated that it takes at least 10,000 lb. of algal plankton to produce 1 lb. of tuna. Some fish (Scaridae) eat even the stonelike calcareous algae directly from the reef where they grow; others habitually feed on noncalcareous algae. (M. S. Dy.)

Mollusks.—The mollusks of the Pacific islands are particularly interesting in that they are represented by a wider assortment of species and have many unusual patterns of distribution. Each of the three major ecological groups—land. fresh-water and marine—has its distinctive families with their special modes of dispersal, unique habits and peculiar modes of living.

The shell-strewn beaches of the tropical Pacific islands are indicative of the comparative richness of the marine fauna. The great Indo-Pacific region, stretching from the eastern shores of Africa, through the Indian ocean and on eastward to Polynesia, is the largest and most diversified marine faunal region in the world. The southwestern Pacific islands constitute a particularly rich subregion of the Indo-Pacific. While many shells, such as the money cowrie, (Cypraea moneta), are found from the Red sea to Easter Island, and northward to the Hawaiian chain and Japan, a number of species are either endemic to or flourish especially in Oceania. It is estimated that there are about 4,000 species of marine mollusks in the Pacific islands. A number of subspecies and a few species are endemic to the Hawaiian (volcanic) chain of islands and others to nonvolcanic atolls of Polynesia and Micronesia.

Among the larger and more attractive gastropod or snail-like shells that are well represented in the subregion of Oceania are the cone shells (*Conus*), the cowries (Cypraea), the marlinspikes (Terebra) and the spider conchs (Lambis). There are more than 100 kinds of cone shells in the Pacific islands, some of which live in sand, others in muddy bays, a few on rocky, coral shelves and others in deep, offshore water. Five species of cones, very venomous, are known to have inflicted fatal stings on human beings. Most other snails are not only harmless but edible and highly nutritious.

The golden cowrie, a bright-orange shell four inches long of glossy, enamel finish is highly prized as an adornment by the natives of the Fijian and the Solomon Islands. This species occurs as far west as the Philippines. The green turban (Turbo marmoratus) is fished in the southwestern sections of Melanesia and Australia for the manufacture of pearl buttons. Of the sea clams the Tridacna and bear's-paw (Hippopus) are best known among the reef dwellers, although they do not reach as great a size as do specimens in northern Australia and the East Indies. The heart clams (Trachycardium), the sunset clams (Tellina and *Asaphis*) and the tiger lucinas (Codakia) are probably the commonest bivalves.

The land-snail fauna of the Pacific islands is very extensive and, for the most part, specialized into many isolated and endemic species. Most kinds are small, insignificant-looking; some of them live under fallen leaves, others in humus in the forests. Partula, Achatinella, and a few other highly coloured groups are arboreal in habit. The land-snails may be divided into two groups: those living on low islands and on the shores of high islands, and those inhabiting the forests of high, volcanic islands. Many of the first group have a wide distribution suggesting dispersal by human or other adventitious agencies. Hurricanes are often very destructive, especially to those near the sea; their occurrence may be among the more important reasons for the usual absence of endemic species on the lower islands. It is possible, however, that hurricanes assist in their dispersal.

The mid-Pacific islands are unique in lacking the groups that constitute the bulk of all known continental land-snail fauna since the Eocene—the Helicidae, slugs, carnivorous snails and operculate Cyclophorid snails. Those of the Melanesian islands from Fiji westward show strong affinities with the Papuan, Australian and southeast Asian fauna. The Polynesian varieties. closely related to those of Melanesia, do not show any affinities with the groups of the Americas.

Most notable among land snails introduced into the Pacific islands is the giant East African snail (*Achatina fulica*) which reached the Marianna. Caroline and Hawaiian Islands in the 1930s and 1940s. Some of their shells attain a length of five inches. This animal, which feeds upon vegetable detritus and succulent plants, is a horticultural nuisance, but is not an agricultural menace.

The fresh-water mollusks, few in species. are represented by widely distributed pond-snails (*Lymnaea, Planorbis* and Physa). One operculate snail (*Thiara granifera*) is found in the larger streams of Tahiti, the Hawaiian and the Marianna Islands. Fresh-water mollusks increase in kinds and numbers in the southwestern Pacific islands with the *Neritina,* Thiara and *Bulinus* becoming

the dominant groups. Their affinities are with the fauna of the Philippines and southeast Asia. (R. T. A.)

GENERAL GROUPS

The Pacific islands owe their populations to a series of extraordinary migrations from south and southeastern Asia. The full story of the origin of the various native peoples will probably never be known. They comprise three main ethnic groups, distinguished from each other by their physical characteristics, their speech and the regions of the Pacific in which they live. These regions are called respectively Polynesia (Gr. *poly*, many; nesos, island). Melanesia (Gr. *melanos*, black; nesos, island), and Micronesia (Gr. micros, small; nesos, island).

Polynesia. — The principal Polynesian islands and island groups include Samoa, the Phoenix, Tonga, the Society. the Tuamotu and the Marquesas Islands. Easter Island and Hawaii. New Zealand is properly a part of Polynesia because its indigenous inhabitants are Polynesians. The islands of Polynesia, large and small, are innumerable, yet their aggregate area, excluding New Zealand, is only about 10,000 sq.mi. At one time the natives of this area were estimated at more than 1,000,000. By 1900, however, four-fifths of the original population of Polynesia had disappeared. These people who had developed an ideal culture in their own environment, were decimated by European diseases to which they had no immunity, and were injured in various ways by the treatment they received from foreigners. (See POLYNESIA.)

Melanesia. — Until World War II the islands of Melanesia were of comparatively little importance in world affairs. Certainly the names of many of them were unknown to most of the world. But Guadalcanal, Bougainville, Rabaul and Munda then took an unforgettable place in history.

New Guinea, the largest island, accounts for the bulk of the land area of Melanesia. Other important islands are the Bismarck~.the Solomons, the New Hebrides. New Caledonia. the Loyalties, and the Fijis. The last-named form the eastern outpost of Melanesia and the connecting link to vast Polynesia.

This region of the Pacific, named after the dark skins of its native inhabitants, extends from Fiji, a little west of the international date line in latitudes 15°–20° S. to about 130° E. longitude and northward to the equator. The total indigenous population in the 1950s was estimated at about 1,270,000, though figures were still far from accurate.

Beyond the fact that the people of Melanesia are distinguished from those of Polynesia and Micronesia by darker skins and more tightly curling hair, it is hard to name a physical characteristic common to all of them. Formerly the term "Melanesian" was used of one of two supposed main elements, the relatively light-skinned ones predominating toward the east and in coastal areas of larger islands. The darker, presumably aboriginal inhabitants of inland mountains (plus some lowlands) were called Papuans. As facts accumulate this simple dichotomy no longer fits. Later analyses distinguished three types: an atypical Negrito in the mountainous interiors of New Guinea and probably of the Solomons and New Hebrides: an Australoid type in marginal areas of the northern Bismarck archipelago and northern New Caledonia; and a short, long-headed people of Negroid cranial type on the south shore and the plains of New Guinea. Elsewhere, so far as now known, the people represent various mixtures of these elements, blended locally with Polynesian, Micronesian and Indonesian strains.

Staple vegetables are raised in Melanesia with the digging stick, the main or only tool. Taro, yams and sweet potatoes are supplemented by bananas, coconuts and a variety of wild vegetables. In some places, as in the river deltas of New Guinea, starch from the pith of the sago palm is a staple. The sea furnishes the main supply of animal food, even inland peoples trading their produce for it when they can. Pigeons. cassowaries and other wild birds are hunted but domestic fowl are not common. Except for parts of New Guinea where wallaby are found, wild pigs are the only land game of considerable size. Pork from domestic pigs is the favourite meat for festivals.

Thatched roofs supported by timbers are perhaps the only common architectural characteristic. Outstanding in the profusion of building styles are the men's clubhouses of parts of New Guinea. Men in many localities are organized into elaborately graded societies, embellished with initiation ceremonies, unique equipment and secret lore.

Social organization is characterized by a variety of clans and other kinship groups, some of them marked by multiple totems. Local units, by contrast, are simple. Even where chieftainship is important, chiefs nowhere rule over large areas. The important local unit is the village of 100 to 500 population, whose members co-operate in such undertakings as fishing and trading expeditions.

Underlying the maze of kinship ties, the simple family is everywhere fundamental in fitting individuals for participation in local life; though in some areas the role of the mother's brother approaches that of the parents in importance.

Christian missions have been active in all but the most remote parts of Melanesia, and it seemed likely at mid-20th century that the whole population was on the way to becoming at least nominally Christian. European governments — Australian, British, French and Dutch — are governing the area through territories, colonies, protectorates and trusteeships. (See also MELANESIA.)

Micronesia. — Micronesia is so-called because of the small size of the islands. However, the importance of some of these islands in world affairs is far out of proportion to their size. Yap and Guam were once vital links in the U.S. Pacific cable system. Earlier, Guam was a regular stopping place for the westbound Spanish galleons from Acapulco to Manila. Truk in the Carolines prior to World War II was the Japanese naval centre and key to the South Pacific. These islands will probably always serve as important naval bases, airports and weather stations.

Micronesia lies west of Polynesia and north of Melanesia, in latitudes from 3° S. to 20° N., and longitudes from the international date line to 130° E. The region includes four main groups of islands: on the east the Gilberts, adjoining Polynesia; north and a little west of them the Marshalls; then the Carolines, extending westward for nearly 1,750 miles; and the Marianas, running northward from the western Carolines. The westernmost group, the Palaus, is generally included in the Carolines.

The total area of Micronesia is about 3,000,000 sq.mi., approximately that of the United States; but the islands are so small and so widely scattered that, though there are more than 2,000 of them, the total land area is less than 1,000 sq.mi. Most of the islands are atolls, small rings of coral; but most of the land area is in the few high islands, notably Guam, Babelthuap in the Palaus, and Ponape in the eastern Carolines. Islands of a third, "raised coral" type, few in number, are economically important because of their phosphate deposits; for example Nauru west of the Gilberts and Angaur in the Palaus.

The origin of the inhabitants of Micronesia is not well known. Only after World War II was considerable study made of them. There was an obvious trend at mid-20th century from the nearly pure Polynesian stock in the Gilbert Islands to Malayan and Melanesian in the westernmost islands. The total population was approximately 108,000 most of it still native. Politically. except for the Gilberts, Nauru and Guam in the Marianas, the area comprises the U.S. trust territory of the Pacific islands.

All the native languages belong to the Malayo-Polynesian stock, but within that broad category vary widely. The native cultures represent local variations on a common base.

The high islands, whose larger populations have encouraged local development, are peaks not only geographically, but culturally, each with its own specialties. In general, native technology, dependent on rather meager resources, is extremely simple.

An outstanding exception is the outrigger sailing canoe, which in the "flying proa" (more accurately prao) of the Marianas and western Carolines is an admirable craft for speed and, considering its size, seaworthiness. Everywhere, but especially on the atolls, the people depend on the coconut, putting every part of this plant to a variety of uses.

Common features in the intangibles of the culture include small size of villages and of political units, strength of kinship obligations, ancestor worship, importance of hereditary rank developed

locally into complex hierarchies and reinforcement of the authority of chiefs by a belief that they are descendants of gods. Other emphases in native religions are tabus and magic, possession of certain living individuals by supernatural beings, concern with weather because of its importance to food supply, and with sickness and death. The basic kinship groups are matrilineal except where foreign influence has changed them, as among the Chamorros.

Some of the local developments in the extreme west — Palau, Yap and apparently ancient Guam — emphasize a prestige economy based on exchange of various kinds of valuables made of stone, shell, even fragments of ancient pottery. These treasures resemble money in their high symbolic value; but are more like jewellery in that the value of individual pieces is enhanced by their history.

Foreign influence changed native cultures in many ways. Except in the Yap, west Truk and Palau districts, all the people profess Christianity, though fragments of native belief persist among them. Protestants predominate toward the east, Catholics toward the west. The degree of change seems greatest among the Chamorros of Guam, long exposed to Spanish influence. *(See* also MICRONESIA.) *(E. G.* B.)

Languages.——The languages of Polynesia, Melanesia and Micronesia constitute three branches of the Austronesian language family, of which the Indonesian constitutes the fourth. A few languages in Melanesia are not Austronesian. These are restricted to the northern and western Solomon Islands. The Melanesian languages represent a fairly old stage of development, the Polynesian the youngest stage, while the position of the Micronesian language is not yet determined. The Melanesian languages are subdivided into the following groups: (1) New Guinea; (2) the Solomon Islands; (3) Santa Cruz Islands; (4) Torres Islands, Banks Islands and northern New Hebrides; (5) southern New Hebrides; (6) Fiji Islands; (7) New Caledonia and Loyalty Islands. These all have a certain part of the vocabulary in common, derived from the Austronesian mother tongue, and shared also with the other three groups.

In structure, the pronoun is the most complicated part of a Melanesian language. There are generally three numbers: singular, dual and plural, and in some cases a fourth — the trial. There is a distinction in the first person between "we" including "you," and "we" excluding "you." The pronoun roots are part of the common heritage. There is no gender, and in nouns usually no separate plural form. Suffixed pronouns are used to indicate possession. In Indonesian languages these are added to all nouns, in the Polynesian to none. In Micronesian and Melanesian, nouns are divided into two classes. one taking suffixed pronouns and one not. The former consist of parts of the body and of any whole, and most kinship terms. The latter may be subdivided into various groups. Thus in Fiji, *luve-nggu,* "my child"; *yava-nggu,* "my leg"; but *no-nggu vale,* "my house," *nggau kakana,* "my food," and *me-nggu mbu,* "my coconut to drink." In Micronesian there may be a dozen or more such subdivisions of possessive forms, according to the nature of the object possessed. In Polynesia the forms are, for example, in the Maori language *t-o-ku tamana,* "my father"; *t-a-ku tama,* "my child," on the basis of "passive" and "active" possession. Verbs do not change for person, and only in Polynesia for number. Tense and mood are shown by particles placed before the verb: Fijian, *au na lako," I* shall go"; *au sa lako,* "I go, I went"; *au a lako,* "I went." The system is similar in Micronesian, but Polynesian has developed some different types of forms. Suffixes are used to indicate whether the verb is transitive or not, and in Polynesia these suffixes have developed a passive meaning. Thus in Florida in the central Solomons, *ke tangi,* "he weeps," but *ke tangi-hi-u,* "he weeps for me," and Maori *kua zwhaka-he-ngia,* "he has been judged."

Among the natives of the Pacific islands counting is in some instances decimal, as the original Austronesian counting was, and where this holds good, the numerals are common vocabulary. It is so in Polynesia and Micronesia, but in Melanesia this is not always the case; for among some tribes counting is done by fives, as in the southern New Hebrides; or by fives with a special word for "ten," and in other parts it is done by twenties. In Micronesia there is elaborate classification of numerals, and on Truk Island some 60 different ways of counting are found, suffixes being added to the roots of numerals 1 to 9 to indicate the nature, size, shape, etc., of the objects being counted.

Polynesian, representing the latest stage in development of the languages of the natives of Pacific islands, has the largest degree of phonetic simplification. The general theory is that the Indonesians first moved out from the Asiatic homeland, then the Melanesians and Micronesians (in which order is not clear), and finally the Polynesians. The relationship between the Polynesian languages is much closer than that between the Melanesian group and that between the various Micronesian languages. A Maori from New Zealand, a Hawaiian and native of the Cook Islands do not have much difficulty in learning to understand each other, but two Melanesians from different islands, and, in some cases, from the same island, would have to learn each other's language as something foreign. Melanesians and Micronesians seem to have found earlier peoples in possession of their islands. for the common mother tongue has been modified differently by different aboriginal peoples in the different islands. **(A.** CL.)

HISTORY

In 1519 Charles V of Spain sent Ferdinand Magellan, a Portuguese in Spanish service, westward across the Atlantic in search of a route to the fabulous spice islands. now known as the Moluccas. Magellan reached the coast of South America and sailed along it southward until he found the strait on the southern end of South America which bears his name. Working his way through the strait, he came up the west coast of that continent. Then turning westward again into the Pacific, he was carried by ocean currents and the trade winds to Guam and the Philippines. For zoo years Spanish ships — the Manila galleons — plied regularly back and forth between America and the outpost of the Spanish empire in the far east. The Marianas, the Caroline and the Marshall Islands, which lay along this route, were all claimed by Spain toward the end of the 17th century.

Though a Spanish ocean highway was thus in use across the heart of the Pacific from the late 16th century onward, it was not until toward the end of the 18th century that the continental coast lines and all the principal islands of the ocean were finally discovered and charted. Among the great figures of the early navigators who passed across this stage were Sir Francis Drake, Alvaro de Mendaña, Pedro Femandez de Quirós, Luis Vaez de Torres and Abel Janszoon Tasman. Toward the middle of the 18th century, a new era in the exploration of the Pacific dawned, in which the advancement of knowledge became a dominant motive. The Englishman James Cook was the greatest trained navigator to explore the Pacific. He made three voyages, in 1768–69, 1772–75, and 1776–79. The first of these voyages took him to Tahiti and the Society group, to New Zealand and to the eastern coast of Australia. The second included visits to New Zealand, the Tuamotu archipelago, the Society Islands, Tonga, Easter Island, the Marquesas and the New Hebrides, The third included Tonga, the Cook Islands and Hawaii. Hawaii may have been known to the Spaniards earlier.

With the completion of Cook's voyages, the period of discovery in the Pacific came to an end. Subsequent voyages, made by navigators, served merely to fill in details on the map. Jean-François La Pérouse, a Frenchman, was the first navigator who was equipped with and made regular use of chronometers of considerable accuracy and was, therefore, able to establish longitudes with precision.

Although many discoverers laid claim to islands in behalf of their own countries, the home governments were in many instances in no hurry to confirm these claims by annexation. Great Britain, France and the United States were at first reluctant to assume the responsibility and expense of administering and defending remote and undeveloped places. However, by 1900 France was dominant in the east-central Pacific and also held the large island of New Caledonia, with its rich mineral deposits. The British and the Germans dominated the central and western Pacific. From

Spain the Germans had bought the Caroline, Mariana (except Guam) and Marshall Islands, after the Spanish-American War. In the 1880s they had acquired northeastern New Guinea, the Bismarck archipelago, the northern Solomons, and Nauru, where, in 1897, rich deposits of phosphates were found. In 1900 they had divided the Samoan group with the United States, taking the western part. The British ruled the central and southwestern islands, except for French New Caledonia, American Samoa, and the New Hebrides, the last of which they governed jointly with the French. The United States controlled the northeast Pacific, holding Hawaii and the Aleutians. The United States had also acquired the Philippines and Guam from Spain in 1898.

The principal change between 1900 and the Japanese invasion of 1941–42 was the establishment of mandates by the League of Nations under Australian, New Zealand and Japanese governments. The Japanese seized the Mariana, Caroline and Marshall Islands in 1914, immediately after the beginning of World War I; they were given a mandate for them in 1920. The Australian mandate covered northeastern New Guinea, the Bismarck archipelago and the northern Solomons; that of New Zealand covered western Samoa. Nauru became a mandated territory of the British empire — Great Britain, Australia and New Zealand jointly deciding from time to time which of the three should administer it.

After the discovery of the major islands of the Pacific, it was not long before white men followed to trade or otherwise to exploit the islands' resources. These were bad days for the natives. Traders and planters came, and with them adventurers of all types — beachcombers, deserters from whaling vessels, and escaped convicts from penal settlements. With no well-established government control, these men brought the worst of "civilization" with them. There were of course, better elements among the Europeans. The last century was also the time of missionaries — French Catholics and British and American Protestants. When western governments finally stepped into Pacific islands, their primary motive was power and wealth in the form of colonies.

DESCRIPTION OF INDIVIDUAL ISLANDS AND GROUPS

Government. — Various forms of government in the Pacific islands have arisen in large part from the diversity of circumstances under which they were acquired by European nations and by the United States. The position of the traditional native authorities under existing regimes differs considerably in different archipelagoes. Many islands are still governed by so-called "indirect rule." Under it the chiefs govern the natives according to their traditional laws and customs — the "native code." The chiefs are responsible to the governments concerned for law and order and other aspects of good government of the people. District commissioners, who are of the same racial extraction as the administrative authorities, exercise general supervision of their areas.

Fiji. — The Fiji Islands centred on the 180th meridian of longitude, exactly opposite Greenwich, Eng., are a crown colony of Great Britain. They form the eastern outpost of the chain of islands of continental origin that extends eastward from New Guinea through the Solomon Islands and the New Hebrides.

The colony is administered by a governor responsible to the British colonial office. He is assisted by an executive council, and a legislative council which meet regularly, in the style of a parliament. The duties of the two councils, however, are only advisory. The immediate problem of government in Fiji is that of preserving a balance of power among the three dominant races who live there: Europeans, Fijians and East Indians. Out of a total population of 293,764 in 1950, Europeans numbered 6,501; persons of mixed European and native descent 6,902; Fijians 129,896; Indians 138,425. (See also FIJI.)

Tonga. — Tonga's 160 islands are distributed in two distinct chains that trend roughly north and south, following a great submarine ridge that connects New Zealand with Samoa, through the Kermadec Islands. Tonga is a kingdom, the only one in the Pacific to survive the period of expansion of the great powers. The kingdom became a protectorate of Great Britain by a "treaty of friendship and protection" signed in 1900. A British agent and consul there is responsible to the governor of Fiji. Immigration of foreigners to Tonga is discouraged by a law that prohibits them from owning land. (See TONGA.)

The governor of Fiji, with headquarters at Suva, has also jurisdiction over Pitcairn, Ducie, Oeno and Henderson islands and Rotuma. Pitcairn Island, an area of 2 sq.mi., is situated at 25° 3′ S. lat. and 130° 8′ E. long. It was discovered by Philip Carteret in 1767, but remained uninhabited until 1790, when it was occupied by the mutineers of the H.M.S. "Bounty," with some women from Tahiti. Ducie, Oeno and Henderson. uninhabited, are included in the district of Pitcairn. Rotuma is the principal island of a small group which lies about 220 miles N.N.W. of Fiji.

The Western Pacific High Commission. — The post of high commissioner for the Western Pacific was established in 1877, and thenceforward it was held by the governors of Fiji. The commissionership was made a separate office in 1952 and the headquarters were transferred from Suva to Honiara in the Solomon Islands protectorate. The territories of the Western Pacific high commission comprise the Gilbert and Ellice archipelagoes, a British crown colony; the British Solomon Islands protectorate; and the condominium of the New Hebrides, administered jointly by Great Britain and France. The 25 islands of the Gilbert and Ellice groups form a chain of coral atolls roughly between lat. 4° N. and 11° S., long. 170° E. and 180° E. Ocean Island, where the headquarters of the colony are located, lies some 250 mi. west of the Gilbert Islands; it is of great commercial value as a source of phosphate. The immediate representative of the high commissioner for the Western Pacific is the resident commissioner on Ocean Island. (See GILBERT AND ELLICE ISLANDS.)

Fanning, Washington and Christmas Islands, some 1,800 mi. east of the Gilberts, and the Phoenix group, some 600 mi. east of the Gilberts (except Canton and Enderbury Islands) also form part of the Gilbert and Ellice Islands colony. Fanning, Washington and Christmas have large plantations of coconut palms from which their populations produce copra.

British Solomon Islands Protectorate. — The Solomon Islands lie to the east of New Guinea and to the north of the New Hebrides. The main group comprises a double chain of islands, stretching roughly from northwest to southeast. It includes seven major islands: Bougainville, Choiseul, Ysabel, New Georgia, Malaita, Guadalcanal and San Cristobal; between 20 and 30 smaller islands, and numerous islets. Volcanic activity, which has been the main agent in forming the group, has been intermittent from Cretaceous or early Tertiary times to modern times. The core of the main islands is composed of ancient lavas.

Several smaller groups of islands, also isolated, are considered as part of the Solomons archipelago. They include: to the south, the large island of Rennell and its smaller neighbour, Bellona; to the southeast, the Santa Cruz group of Ndeni, Vanikoro and Utupua; the Reef and Taumako groups, and the small isolated islands of Tikopia, Anuta and Fatutaka; and, to the east and north, a number of atolls of which the most important are Ontong Java and Sikiana.

For administrative purposes only the major part of the group forms the British Solomon Islands protectorate. Bougainville, Buka, and several atolls to the north fall within the limits of the Trusteeship Territory of New Guinea which is administered by the Commonwealth of Australia.

The economic resources of the Solomons, only slightly exploited, are imperfectly known. The total population of the protectorate is about 100,000 of which a little over 100 are Europeans. The capital is at Honiara on Guadalcanal.

Condominium of the New Hebrides. — The New Hebrides, midway between the Solomons and the Fijis and north of New Caledonia, include upraised coral reefs, active volcanoes, and perhaps remnants of granite mountains in the larger islands at the north. The group includes 12 principal islands, arranged like a "Y" between 13° and 21° S. lat. In this archipelago 1,000 French and English planters living on four or five of the larger islands earn a living for the most part by raising coconuts to make copra; some of them also raise cacao beans for chocolate and cocoa. Settlers and speculating companies appropriated large areas of land, the ownership of which were still in dispute

in the 1950s. Along the coasts and in the interiors of the islands some 45,000 natives live largely in the ways of their ancestors. All three groups are subject to a joint administration called in international parlance a "condominium" but which in operation is really a tripartite government. In general, the national administrations have jurisdiction over their respective nationals, and the condominium has jurisdiction over natives and where the interests of British and French clash. *(See* NEW HEBRIDES.)

New Guinea. — New Guinea, after Greenland, the largest island in the world, lies to the north of Australia, separated from it by only about 100 mi. at Torres strait, the water of which is very shallow. The people of New Guinea — a handful of Australians, a few Chinese and a host of aborigines — gain a livelihood in mays which reflect their origins. The Australians, managers of plantations and mines, maintain in considerable part the habits and customs of their homeland; the Chinese, middlemen and small merchants, still practise the culture of Asia. A small proportion of the aborigines are labourers on plantations and in mines, working under indenture. The great majority of them are tribesmen, hostile to neighbours, carrying on native ways of living.

The inhabitants of New Guinea live under various forms of government. The Territory of Papua in the southeast, formerly a British protectorate is administered by Australia under a governor. The Trusteeship of New Guinea in the northeast including many islands off the coast is administered by Australia for the United Nations. The northern Solomon Islands and the Bismarck archipelago are included in the administration of the Trusteeship of New Guinea. Dutch New Guinea, lying between 10° S. and the equator, comprises approximately half of the entire island. *(See* NEW GUINEA.)

The island of Nauru and Norfolk Island are also under the administration of Australia. Nauru, in lat. 0" 30' S., long. 166° 55′ E., was discovered by Capt. Fearn in the "Hunter" in 1798; it mas formerly often called Pleasant Island. It is the most important source of Australia's great supply of phosphate. World War I brought international attention to Nauru. In 1914 Australians occupied the island and evacuated all Germans to stake a claim which, after the war, the League of Nations honoured in mandating Nauru to the British empire; Australia was assigned administrative responsibility. A World War II sequel in Nauruan history had to do with its new status as a trust territory when, on Nov. 1, 1947, the United Nations general assembly approved a trusteeship agreement for the island, with Australia continuing as administering authority.

Norfolk Island. — Norfolk Island, in lat. 29° 04′ S., long. 167° 56' E., is roughly 5 mi. long and 3 mi. wide, with a total area of 13.3 sq.mi.; it is about 920 mi. east of Sydney. It is a dependency of the Commonwealth of Australia, known officially as the Territory of Norfolk Island.

New Zealand Dependencies. — The more important islands in the Pacific administered by New Zealand are the Western Samoan Islands and the Cook Islands. Western Samoa, a trusteeship of the United Nations, consists primarily of the two large islands of Savai'i and Cpolu which comprise 99% of the total area of 1,130 sq.mi. Physiographically the islands are volcanic or "high" islands with an axial range of peaks which extend in an east-west direction and which lie close to the southern coast. The rugge'd, mountainous core rises more than 3,500 ft. on Upolu and more than 6,000 ft. on Savai'i. Three tree Crops, cacao, coconuts and bananas, constitute some 90% of the exports and form the chief source of revenue. The population of Western Samoa is dominantly Polynesian. Under the trusteeship administration, with New Zealand as the administering authority, the natives have made considerable progress in self-government *(see* SAMOA).

The Tokelau (or Union) archipelago, administered from Apia, in Western Samoa is not included in the trusteeship. The chief settlement is on Fakaofo Island where there is a wireless station communicating with Apia.

Cook Islands. — The Cook Islands, located in the southwest Pacific, are some 1,500 mi. northeast of New Zealand, 1,200 mi. east of Fiji, and 600 mi. west of Tahiti. Totalling 84 sq.mi. of land, the 15 islands of the group are widely scattered over 850,000 sq.mi. of ocean. Annexed to the colony of New Zealand in 1901, they were incorporated within the dominion on its proclamation in 1907. Physically the islands comprise two contrasting groups. The seven islands of the northern group — Penrhyn, Manihiki, Rakahanga, Pukapuka, Suwarrow, Nassau and Palmerston — are all coral atolls. The members of the southern group, primarily volcanic. include the major islands from the points of view of agricultural production, population and land area. They are Rarotonga. the administrative centre for the whole group and the most important agricultural island; Mangaia, Aitutaki. Atiu Mitiaro, Mauke and Manuae. The remaining island of the southern group, Takutea, is a coral atoll and is not permanently inhabited. Agricultural changes in the Cook Islands after mid-19th century fundamentally disrupted the traditional, native subsistence economy. European intervention resulted in a great demand for commercial crops, and a wide variety was grown at various times by both native and European planters. The export production of the northern atolls continued to depend upon copra and pearl shell Copra from all the islands, with oranges and tomatoes from the southern group provide a threefold agricultural base for the islands' economy.

Niue (or Savage Island) is a New Zealand dependency administered by the department of external affairs of the New Zealand government as a separate administration, through a resident commissioner at Alofi.

The Kermadec Islands, a rocky group lying 600 mi. northnard of Auckland, are also a dependency of New Zealand. Sunday Island, thickly wooded, is the only island regarded as habitable. However, several attempts at colonization have been defeated by the factor which originally prompted them. namely isolation.

The other islands administered by New Zealand are the Chatham Islands, Auckland Islands, Campbell Island, Antipodes Islands and Bounty Islands.

The French Union in the Pacific. — The overseas territories of France in the Pacific are New Caledonia and the French Settlements in Oceania. The island of New Caledonia ends the southern swing of the Melanesian arc. It extends 220 mi. from southeast to northwest, about 700 mi. east of the Queensland coast of Australia; its average width is 30 mi. It lies at the southern border of the tropical zone, about 20° to 22° S. lat. The mountains include ancient rocks like those of New Zealand, rich in minerals, especially nickel. Politically. New Caledonia and its dependencies are a French colony, administered by a governor, nho acts as high commissioner in charge of French interests elsewhere in the Western Pacific. The government of New Caledonia also administers the Isle of Pines, the Wallis archipelago, the Loyalty Islands, the Huon Islands, Futuna and Afofu. Though New Caledonia lies along the line of volcanic disturbances in the Western Pacific and is near the New Hebrides. where considerable volcanic activity has taken place, there is no active volcano on the island and no volcanic lava or ash has been found. Both metamorphic and sedimentary formations occur in great quantity. The metamorphic rocks fall into two major groups: gneiss and schists; and serpentine. The principal outcrop of gneiss constitutes the Ignambi chain about 40 mi. long in the northeast part of the island, with several main summits. Chief of these is Mount Panie, 5,413 ft., one of the higher points in New Caledonia. The second group of metamorphic rocks, composed largely of serpentine, attains its chief development in the south of the island. Among the principal summits are Mount Humboldt, 5,380 ft.

The mineral wealth of the island is great and varied. though some of the resources have been only partially developed owing to competition from other areas with lower production costs. The metamorphic rocks of the north yield a certain amount of copper, gold and argentiferous lead and zinc. The serpentine of the northwest and southeast yields nickel, chrome, cobalt and iron, and the sedimentary earths give some manganese, antimony and coal The amount of nickel ore is large. and the island is the producer of third rank in the world. Honever, it does not supply a high proportion of the world's output, the major share being contributed by Canada. The climate of New Caledonia, though tropical, is not excessively hot or damp; it is sunny and, for the most

part. tempered by frequent light breezes. The prevailing winds are the trades, from the southeast and east. The vegetation is remarkable from several points of view. Endemic species form about 77% of all the native plants. A second remarkable feature of the vegetation is that, unlike that of most of the large Pacific islands, it consists very largely of drought-resistant plants.

Native agriculture still relies to a considerable extent upon the cultivation of the coconut palm, various kinds of yam and taro, and the banana. Advantage has been taken of introduced manioc to provide a drought-resistant crop. European agriculture has had only a restricted success in New Caledonia. Cultivation of many types of crops has been attempted, but few have been effectively estahlished commercially. Commercial agriculture depends primarily upon coffee, copra and cotton, all produced for export; and cattle-raising, to a large extent for the domestic market. The pastoral industry. taking advantage of the large savanna areas with their native grasses, has occupied an important position since the early days of the colony. Among the industrial plants established in the colony are blast furnaces for smelting nickel ore, a meat-preserving works, timber mills, a barking mill for coffee, a grain storage and cleaning depot, distilleries for the manufacture of *niaouli* essence, and several printing establishments.

France took possession of New Caledonia in 1853, stimulated particularly by the development of Australia and by the desire to have an alternative convict settlement to Guiana. In 1864 the first batch of convicts arrived. and from then until 1894, when transportation began to be reduced, the majority of the European population was composed of them. Europeans were attracted to the island by various colonization schemes, most of which had indifferent success. A scarcity of labour led to the importation of orientals.

In 1956 the population totalled 68,480, of whom 25,160 were Europeans and Asians, 43,320 indigenous.

French Polynesia (*Établissements français* de la *Polynésie*, abbreviated E.F.P.)—comprises five archipelagoes: the Society Islands: the Tuamotus; the Gambier Islands; the Marquesas; the Tubuai or Austral Islands; and one island. Clipperton, off the coast of Central America. These island groups. administered as a colony of France, comprise the whole of the eastern portion of the Pacific islands. They are administered from one centre, the town of Papeete, situated on a beautiful bay on the northwest coast of Tahiti.

The Society Islands in the heart of Polynesia, first attracted the attention of Europeans in mid-18th century. It was in these islands that the first efforts were made by Protestant missionaries to convert the natives. In April. 1769, a year after Bougainville, Cook, charged by the Royal society of London with the mission of observing the passage of Venus before the sun and of pursuing geographic researches. arrived in his turn at Tahiti. The ships which visited French Oceania from this epoch on cannot be enumerated.

A great many adventurers began to roam the south seas; sailors who deserted their ships established themselves in the islands, where they often gave the natives a poor idea of western civilization.

From the point of view of geographic characteristics, the archipelagoes are very different from one another. Tahiti. the Leeward Islands of the Society group, the Marquesas, the Gambier Islands, and the Austral Islands are made up of high basaltic lavas surrounded by a fringe or barrier of coral reefs, the others—the Tuamotus and Clipperton are low, coral islands.

Society Islands.—This archipelago comprises two groups: the Windward Islands and the Leeward Islands. The principal island of the Windward group is Tahiti; then comes its neighbour Moorea. then Tetiaroa. Maiao and Mehetia. Tahiti has an interesting feature in its tides. They come every day at approximately the same time—midday and midnight for the high tides, six o'clock morning and evening for the low tides, with the exception of local variations due to ocean currents. The island. high and rugged, has about 100 rivers, but most of them are torrents which flow only after heavy rains. Tahiti, 33 mi. long and 388 sq.mi. in area. is one of the more widely known small islands in the world. It has often figured in the tales of adventurers and writers of romantic fiction. There Paul Gauguin settled after leaving his home in Paris and it was there and in the Marquesas that he painted the pictures that later made him famous.

Of the Leeward Society Islands, which are west of the Windward group, Raiatea is the most important; its chief village is Uturoa.

The Tuamotu (or *Paumotu)* Archipelago, east of Tahiti, extends for many miles. Its 80 islands are low atolls with a total area of 345 sq mi. In the warm, limpid waters of the lagoons where pearl oysters are found native divers sometimes reach 19 fathoms. The natural vegetation is poor because of insufficient moisture. Coconut palms, however, do very well. Makatea, a raised coral atoll, is noted for its great deposits of phosphate rock. Many thousands of tons have been exported and the work still goes on. The Gambier Islands, stretching out to the south of the Tuamotus, have an area of 47 sq.mi. The four principal islands are volcanic, inclosed in a common lagoon. The largest, Mangareva, has the little port of Hikiha, the chief village of the group

The *Marquesas Archipelago*, constituting a group of 11 islands. is the most equatorial of French Polynesia. Knife-edged ridges separate most of the valleys on the larger Marquesas, a fact that isolated the original Polynesian inhabitants into a number of hostile communities. The valleys are the only habitable and cultivable areas. There are only a few European planters and traders scattered through the group owing to the isolation of the archipelago.

The Tubuai or Austral Islands are the most southerly of French Polynesia. They form a chain extending from the southwest to the northwest over a distance of about 800 mi. Of the four principal islands the most important is Tubuai which has an area of 19 sq mi.

Clipperton Island, at 10° 30′ N. lat. and 106° 20′ W. long., the remaining French island, is an uninhabited atoll.

French Polynesia comprised, according to the census of 1956, a total population of 73,201, among whom there were 2,298 French born outside the islands. 489 other Europeans, and 6,748 Chinese.

U.S. Territories in the Pacific.—Of the territories in the Pacific for which the United States is governmentally responsible, Hawaii (a state since 1959), American Samoa, Guam and the U.S. Trust Territory of Pacific Islands are by far the more important. All of them have strategic value in the defense of the mainland; in addition Hawaii is an important source of sugar and pineapples. For a description of this island group, see HAWAII.

American Samoa.—American Samoa, an unincorporated territory of the United States, comprises the island of Tutuila and the other Samoan islands east of long. 171° west of Greenwich; they extend from 14° 10′ S. to 14° 32' S. Administered by the C.S. navy for 51 years. the territory was placed under the administrative jurisdiction of the department of the interior on July 1, 1951, by executive order of the president of the United States. The islands are mountainous and only about one-third of the land is arable even in terms of the rudest types of hand cultivation. On Tutuila, the main island, the interest of Samoans is centred mainly in wage-earning activities. Considerable employment is available at the U.S. naval station at Pango Pango, on the best harbour in the whole Samoan archipelago.

The government of American Samoa comprises three branches: the executive, headed by a governor, the legislative (of Fono) and the judiciary. The enactments of the Fono are resolutions addressed to the governor in the form of advice and recommendation.

The sovereignty of the United States was extended to Swains Island. which was made part of American Samoa by a joint resolution of congress, approved March 4, 1925. Swains Island is in lat. 11° 04′ S. and long. 171° 06′ W.

Guam.—Guam, the largest and southernmost island of the Marianas. has an area of 209 sq.mi. The population in 1960 nas 66.910. including about 35.000 military; about half of the population were service personnel; the other half mere workers recruited in the U.S. (including Hawaii). the Philippines and other

Pacific islands. Agana is the capital.

Guam is an unincorporated territory of the United States and an organized sovereignty, governed under the Organic Act of Guam. passed by the U.S. congress and approved by the president on Aug. 1, 1950. Under this legislation, Guamanians became citizens of the U.S.

United States *Trust* Territory of the Pacific Islands.—The United States Trust Territory of the Pacific Islands comprises the Marshall, Caroline and Mariana islands with the exception of Guam. Located in the western Pacific, north of the equator, the islands are scattered over an area roughly as large as the United States. The total land mass of about 687 sq.mi., distributed among 96 island units, contains 65,039 inhabitants (1956 est.). There is no ethnic unity, and nine different languages are spoken.

The islands of the trust territory were governed by Japan from World War I until World War II under mandate from the League of Nations. Japan invested heavily in the area in an effort to promote agriculture and fishing, and sent thousands of colonists. Following World War II, all Japanese nationals were repatriated, and the islands were placed under the United Nations trusteeships system. The area was designated as a strategic trusteeship, and the United States was authorized to administer it under terms of the trusteeship agreement of 1947.

The navy of the United States was assigned administrative responsibility on an interim basis in 1947. July 1, 1951, marked the formal end of the naval administration of the trust territory and the assumption of responsibility by the department of the interior. The territory is divided into six administrative districts: Majuro (Marshall Islands), Ponape, Truk, Yap, Palau and Saipan. Headquarters of the territory is at Fort Ruger, Honolulu.

Marshall Islands.—The Marshall Islands comprise a large group of low coral atolls, with a total area of 61 sq.mi., scattered in two irregular, roughly parallel chains extending in a north-south direction from about 14° 43' to 4° 34'. They lie between 160° 48′ and 172° 10′ E. The easternmost row, called the Ratak Chain, comprises 14 atolls and two single islands. The westernmost row, called the Ralik Chain, comprises 15 atolls and three single islands.

The northern Marshalls lie in the westward flowing north-equatorial current; the equatorial countercurrent flows eastward through the southern islands. The northern Marshalls, well within the trade-wind belt, are appreciably drier than the southern Marshalls. The climate is tropical oceanic, without any orographic rainfall. December to March is the dry season, May to August the wet season. The precipitation on any one atoll varies tremendously from year to year, even in corresponding months.

The material of the islets is so porous that rainfall filters downward readily and quickly. There is no running surface water, except during typhoons or tsunamis, when great waves occasionally sweep across the islets. There is normally no standing surface water except where depressions or taro pits extend down below the water table. Most of the original vegetation of the atolls has been replaced by coconut plantations, especially on the larger islets. The northern Marshalls are much less densely populated than the southern, more fertile islands.

The Caroline *Islands*.—The Caroline Islands, west of the Marshall~form a broad belt extending from 131° E. long. to 163° E. long. They lie between 1° and 10° N. lat. The 148th meridian east longitude separates the archipelago into two divisions, the eastern and the western Carolines. The total land surface of the eastern Carolines is about 245 sq.mi. The climate. like that of all the islands in Micronesia, is tropical oceanic. Precipitation is especially heavy in the high islands. Kusaie, in the southeast, has the heaviest rainfall. Two of the atolls in the eastern Carolines, namely Kapingamarangi and Nukuoro, are inhabited, not by Micronesians but by true Polynesians.

The total land surface of the western Carolines amounts to approximately 200 sq.mi. Most of this area is made up of two principal islands—Yap with 39 sq.mi. and Babelthuap in Palau with 158 sq.mi. The western Carolines lie in the belt of alternating northeast trade winds and southwest monsoons. which divide the year into two seasons. Although there is considerable variation from year to year, the northeast trades ordinarily begin in October and prevail until May and often until June. The Asiatic (southwest) monsoon usually sets in fairly early in June on Yap, but not until July or even later in Palau. The monsoon lasts until October, or sometimes a little later, when the trade winds return.

The Mariana Islands.—The Marianas form a chain extending from 14° to 20° 33' N. lat., and lie between 144° 54' and 146° 05' E. long. They consist of 13 single islands and one group—Maug—of three small islands. They are all high and volcanic.

The total land surface of the Marianas amounts to approximately 184 sq.mi. About two-thirds of this area is made up by the three principal islands of the group: Saipan with 47 sq.mi., Tinian with 39 sq.mi. and Rota with 33 sq.mi.

Extending 385 mi. from Pajaros in the north to Rota in the south, these islands are the southernmost volcanic peaks of a gigantic mountain range rising almost six miles from the ocean bed of one of the deeper parts of the Pacific. The island peaks of this range form a series of steppingstones from Guam to Japan.

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PACIFICO, DON or DAVID PACIFICO (1784–1854), a Portuguese Jew, born a British subject in Gibraltar, who brought an action against the Hellenic government claiming £26,000 compensation for his house in Athens, burned down in 1847 in an anti-Semitic riot Pacifico finally received compensation.

PACIFIC OCEAN, the largest division of the hydrosphere, lying between Asia and Australia and North and South America. It is nearly landlocked to the north, communicating with the Polar sea only by Bering strait, the open passage of which is 40 mi. wide and less than 180 ft. deep. The southern boundary was sometimes regarded as the parallel of 66½° S., but this limit is artificial, and it is now considered that the Pacific extends to the borders of the Antarctic Continent, exactly as the Atlantic and Indian oceans do. As east and west boundaries in the higher southern latitudes one may take the meridians passing through South cape in Tasmania and Cape Horn. The north to south distance from Bering strait to Antarctica, near Cape Colbeck, is 9,900 mi., and the Pacific attains its greatest breadth between Panamá and Mindanao (Philippine Islands), where it measures 10,700 mi. The distance between Yokohama. Jap., and San Francisco, Calif., is about half as great again as that from New York city to Southampton, Eng.; similarly, the distance between Sydney, Austr., and Cape Horn is greater than that from Buenos Aires, Arg., to Cape Town. U. of S. Af., by fully a half. The coasts of the Pacific are of varied contour. The American coasts are for the most part mountainous and unbroken, the chief indentation being the Gulf of California; but the general type is departed from in the extreme north and south, the southern coast of South America consisting of bays and fiords with scattered islands, while the coast of Alaska is similarly broken in the south and becomes low and swampy toward the north. The coast of Australia is high and unbroken; there are no inlets of considerable size, although the small openings include some of the finest harbours in the world, as Moreton bay and Port Jackson.

The Asiatic coasts are for the most part low and irregular and a number of seas are more or less completely enclosed and cut off from communication with the open ocean. Bering sea is bounded by the Alaskan peninsula and the chain of the Aleutian Islands; the Sea of Okhotsk is enclosed by the peninsula of Kamchatka and the Kuril islands; the Sea of Japan is shut off by Sakhalin Island, the Japanese islands and the peninsula of Korea; the Yellow sea is an opening between the coast of China and Korea; the China sea lies between the Asiatic continent and the island of Formosa, the Philippine group, Palawan and Borneo. Among the islands of the Malay archipelago are a number of enclosed areas—the Sulu, Celebes, Java, Banda and Arafura seas.

The Pacific was first scientifically explored by the great English deep-sea expedition of H.M.S. "Challenger" (1827–76), by the German expedition of S.M.S. "Gazelle" (1874–76) and then by the two United States ships "Tuscarora" (1874–79) and "Albatross" (1888–1905), by the Russian warship "Vitiaz" (1887), by

S.M.S. "Planet" (1906–14) and others. Many important soundings in the southwest Pacific were made by H.M.S. "Penguin" and a number of British cable ships; in high southern latitudes the "Discovery" (1901–04) carried out many observations. Extensive investigations were made by the Danish vessel "Dana II" (1928–29) in the South Pacific and by the Netherlands H.M.S. "Willebrord Snellius" in the East Indies (1929–30). The nonmagnetic vessel "Carnegie" had only partially completed a program of oceanographic exploration when it was destroyed by explosion and fire at Apia, Samoa, in 1929. U.S. naval vessels have accumulated data from Bering strait to Antarctica. Intensive studies have been conducted off the west coast of the United States and Canada by oceanographic, naval and fisheries groups and in the waters surrounding Japan by Japanese naval and fisheries organizations. Under the direction of the British Discovery committee, "Discovery II" investigated the high southern latitudes and "William Scoresby" the waters off the west coast of South America.

Extent. — The area of the Pacific ocean, excluding adjacent seas, is about 64,000,000 sq.mi. and its volume 170,000,000 cu.mi. The Pacific ocean has double the area of the Atlantic — the next largest division of the hydrosphere — and has more than double its volume of water. Its area is greater by as much as the area of Africa than the whole land surface of the globe, Antarctica included. The total land area draining to the Pacific was estimated by Sir John Murray at 7,500,000 sq.mi., or little more than one-fourth of the area draining to the Atlantic. The few large American rivers draining to the Pacific include the Yukon, Columbia, Fraser and Colorado. The chief Asiatic rivers are the Amur, Yellow river and Yangtze, none of which enters the open Pacific directly. Hence the proportion of purely oceanic area to the total area is greater in the Pacific than in the Atlantic.

Relief of the Ocean Floor. — The more or less symmetrical basin and ridge topography characteristic of the Atlantic is not found in the Pacific. The central Pacific trough, extending from the Aleutian Islands in the north to latitude 60° S. and from Japan to the North American coast, has free communication at depths exceeding 13,000 ft., although numerous elevations and ridges are present. Particularly west of 150° W. many of these elevations extend above the surface as single islands, groups or chains of islands. The West Pacific ridge, which actually consists of several shorter ridges, extends from Japan to Antarctica and is continuous at 13,000 ft. except for small breaks at 11° N. and 10° S. That portion of the andesite line which separates the igneous rock province of the continental blocks of Asia and Australia from that of the central Pacific basin follows this ridge system rather closely.

A broad elevation extends from Central America to the south and west, joining Antarctica in the longitude of New Zealand. This elevation is actually branched so that a series of deep basins are isolated along the Central and South American coasts. These branches also form the northern and western boundaries of the Pacific antarctic basin. The Tuamotu archipelago rises from a western extension of the ridge.

Depths in the great basins are commonly greater than 16,000 ft. but, even in their deepest parts. rarely exceed 23,000 ft. On the other hand, depths in many of the smaller elongated trenches and troughs located near and parallel to continental coasts, island arcs and submarine ridges often exceed 26,000 ft. Some examples of such structure are found along the Central and South American coasts, of which the deepest is Atacama trench (25,050 ft.). Island arcs with deep trenches on their convex sides in the central Pacific trough are the Aleutians, Kurils, Japan, Bonins, Marianas and Tonga-Kermadec. In the western trough are the deep trenches associated with the Ryukyus, Philippines and Bougainville-New Britain.

Most of these trenches have depths exceeding 26,000 ft., and in at least four of them soundings greater than 33,000 ft. have been obtained. These have been found in the Japan trench by the U.S.S. "Ramapo," in the Philippine trench by the German vessel "Emden," in the Marianas trench by the H.M.S. "Challenger" (the greatest accepted depth of the Pacific is at a point midway between Guam and Yap called Challenger Depth, which has been descended to 35,800 ft.) and in the Tonga-Kermadec trench by the C.S. ship "Horizon." In 1957 the Russian ship "Vityaz" reported a sounding of 35,958 ft. in the Marianas trench and 35,567 in the Tonga depression. The trenches are associated with vulcanism, large gravity anomalies and high seismic activity.

Emphasis on depths exceeding 13,000 ft. excludes many features of interest and importance. Isolated basins cut off from the open ocean but with depths exceeding 13,000 ft. are found in the Sea of Japan, South China sea, Sulu sea, Celebes sea, Banda sea, Coral sea and Fiji basin. Partially isolated basins occur in the Bering sea, Caroline basin, New Hebrides basin and east Australia basin.

Islands are numerous to the west of 150° W., and most of these have volcanic cores, although in low latitudes they are surrounded with coral reefs or surmounted with coral islands or atolls. Detailed soundings made after 1940 revealed hundreds of guyots, flat-topped sea mounts rising from the ocean bed to minimum depths mostly between 3.000, and 7.000 ft. The flat top is attributed to wave erosion at a lower relative stand of sea level. Fossils collected from sea mounts and from bore holes in the Marshall Islands indicate extensive subsidence relative to the sea surface has occurred within the last 100,000,000 years. Despite the numerous oceanic islands the depths between them are great; and the average depth of the Pacific (including adjacent seas) is 13,21j ft., exceeding that of the Atlantic by about 2,300 ft. The mean depth of the Pacific ocean (excluding adjacent seas) is 14,050 ft.

Bottom Deposits. — The characteristics of sea-bottom sediments are described in OCEAN AND OCEANOGRAPHY: Marine Sediments because they are common to all oceans.

Red clay rather than calcareous globigerina ooze is the most abundant deep-sea sediment, primarily because of the virtual absence of calcareous deposits in the North Pacific. In the southern hemisphere the sediments are similar to those in the Atlantic and Indian oceans, with globigerina ooze giving place to red clay in the deeper basins, with small patches of radiolarian ooze. The diatom ooze characteristic of high southern latitudes extends across the Pacific except for a break south of Cape Horn. On the other hand, in the North Pacific there are virtually no calcareous open-ocean sediments; diatom ooze is present in the northern portion (unlike the Atlantic), and radiolarian ooze is abundant in a band between about 5° N. and 15° N. in the eastern Pacific. The absence of calcareous sediments in the North Pacific is believed to be related to the relatively slow circulation of the deep water.

Pelagic sediments cover 86.7% (55,000,000 sq.mi.) of the open Pacific (excluding adjacent seas), red clay covering 42.6%, globigerina ooze 31.4%, diatom ooze 8.7% and radiolarian ooze 4.0%. The remaining 13.3% and all adjacent seas (5,560,000 sq.mi.) are covered with terrigenous sediments containing coarse-grained debris of land origin or calcareous sediments produced by shallow-water bottom-living plants and animals.

The red clay of the Pacific differs from that of the Atlantic in having a higher content of manganese dioxide which colours the sediments a dark chocolate brown. Manganese concretions, often containing sharks' teeth and earbones of whales, are rather common.

Meteorology. — Partly because of its great extent, and partly because there is no wide opening to the arctic regions, the normal wind circulation is on the whole less modified in the North Pacific than in the Atlantic, except in the west where the southwest monsoon of southern Asia controls the prevailing winds, its influence extending eastward to 145° E., near the Marianas, and southward to the equator. In the South Pacific, during the winter months of the northern hemisphere, the northwest monsoon of Australia affects a belt running east of New Guinea to the Solomon Islands. In the east the northeast trade belt extends between 5° and 25" N., the southeast trade crosses the equator, and its mean southern limit is 25° S.

The trade winds are generally weaker and less persistent in the Pacific than in the Atlantic, and the intervening belt of equatorial calms is broader. Except in the east of the Pacific, the southeast

trade is only fully developed during the southern winter; at other seasons the regular trade belt is cut across from northwest to southeast by a band 20°–30° wide. in which the trades alternate with winds from the northeast and north, and with calms, the calms prevailing chiefly at the boundary of the monsoon region (5° N.–15° S., 160° E.–185° E.). This area, in which the southeast trade is interrupted, includes the Fiji, Samoa and Society groups and the Tuamotus. In the Marquesas group the trade wind is fairly constant.

The great warming and abundant rainfall of the island regions of the western South Pacific and the low temperature of the surface water in the east cause a displacement of the southern tropical maximum of pressure to the east; hence we have a permanent South Pacific anticyclone close to the coast of South America. The characteristic feature of the southwestern Pacific is therefore the relatively low pressure and the existence of a true monsoon region in the middle of the trade-wind belt. It is to be noted that the climate of the islands of the Pacific becomes more and more healthful the farther the islands are from the monsoon region. The island regions of the Pacific are everywhere characterized by uniform high air temperatures; the mean annual range varies from 1° to 9° F., and the diurnal range from 9° to 16° F. In the monsoon region relative humidity is high, viz., 80% to 90%. The rainfall is abundant; in the western island groups there is no well-marked rainy season, but over the whole region the greater part of the rainfall takes place during the southern summer, even as far north as Hawaii.

The whole North Pacific from the tropic to the Bering sea has on its Asiatic side a monsoonal reversal of its prevailing winds, winter and summer. In winter exceedingly dry and cold northwesterly winds, dependent on an air-pressure maximum over Siberia and an air-pressure minimum near the Aleutians, blow over the whole area. Flowing over the ocean, this air is heated and its moisture content is greatly increased by evaporation from the sea surface. In summer, with low pressure over the Asiatic continent. warm and rainy south and southeasterly winds (in connection with the southtvest monsoon of the China sea) prevail over the whole area of the Yellow sea, Japan sea, Okhotsk sea and Bering sea. On the American side of the Pacific from southern Alaska to northern California marine air moves toward land or follows the mountainous coast throughout the year except for temporary changes associated with passing atmospheric depressions or with an especially well-developed continental high-pressure cell. In winter, winds are predominantly southerly, varying locally from southwest to southeast, but in summer shift ciockwise to give northerly winds increasing in persistence going southward from Vancouver Island. These circumstances explain the great differences shown in the following table between the average air

Air Temperature (° F.) and ***Rainfall*** *(in.) in the* ***Pacific***

Place	Lat.	Feb.	May	Aug.	Nov.	Year	Amplitude	Rain
Ajan, Sea of Okhotsk	56° N.	0.0	35.4	55.0	14.4	27.0	57.2	44
Sitka, Alsk.		32.5	44.1	54.9	36.7	42.5	22.4	81
Yokohama, Jap.	36° N.	40.8	62.2	78.1	51.3	57.7	38.2	58
San Francisco, Calif.		52.5	54.1	58.6	56.1	55.2	10.8	23
Sydney, Austr.			58.5	54.5	66.4	62.8	19.1	50
Valparaíso, Chile		70.5	55.6	52.5	59.0	57.7	10.6	14
		63.1						

temperatures on the Australo-Asiatic side of the Pacific and on the American.

Surface currents. — In the North Pacific, approximately between latitudes 10° N. and 25° N., the trade winds maintain a permanent current from east to west. As this current reaches the Philippine Islands one part turns south along the coast of Mindanao and bends back toward the east as the beginning of the equatorial countercurrent. The greater part bends north, flows past the northern Philippines and along the eastern coast of Formosa, continues on the western side of the Ryukyu Islands and then follows the eastern side of the main islands of Japan as far as latitude 3j° N. North of Formosa the current is known as the Kuroshio or the Japan current. During summer one branch of the Kuroshio enters the Sea of Japan through Tsushima strait and flows north along the western coasts of the Japanese Islands.

The Kuroshio is a counterpart of the Gulf stream, and according to theory advanced since 1950, the intensity of each is associated with the oceanic wind systems, the presence of a western oceanic boundary, and the variation with latitude of the deflecting force of the earth's rotation. When departing from the coast of Japan, the current continues toward the east as the Kuroshio extension, but branches are sent to the south and to the north. The greater bulk of the warm water turns south before reaching the Hawaiian Islands and forms part of a large clockwise eddy in the western Pacific. A minor part passes to the north of the Hawaiian Islands and approaches the American mainland to within 500–600 mi., where it turns south and contributes to a smaller, clockwise eddy between the Hawaiian Islands and the mainland.

The branches of the Kuroshio which turn northeast off Japan mix with the waters of the Oyashio, the cold current which flows toward the southeast along the Kuril Islands. The Oyashio represents an outflow of surface water from the Bering sea and is a counterpart of the Labrador current. The mixing of the warm Kuroshio water with the Oyashio water, chilling in winter, and dilution by rain lead to the formation of the cold water of low salinity which flows east to the south of the Aleutian Islands. On nearing the American coast part of this water turns north and forms an eddy in the Gulf of Alaska, whereas part turns south as the cold California current. which can be traced to about lat. 2j° N., where it is deflected to the west. In spring and summer, upwelling *(see* OCEAN AND OCEANOGRAPHY: *Movement of Sea Water: Vertical Water Movements)* takes place along the coast of California and lowers the temperature near shore.

In the Bering sea the circulation is counterclockwise, with a sluggish inflow between the westernmost of the Aleutian Islands and a surface outflow along Kamchatka. In the Sea of Japan the circulation is also counterclockwise, with warm water flowing north along the west coasts of the islands of Japan and very cold water flowing south along the Siberian coast (the Liman current). In the Yellow sea and the East China and the South China seas, the currents change with the monsoon and are directed to the south in winter and to the north in summer.

The equatorial countercurrent sets eastward primarily between the latitudes of 5° N. and 10° N. In the region between Mindanao and the Marshalls it is broken up into eddies, but farther east it is better developed and velocities frequently exceed two knots. Observations since 1950 show that the countercurrent may double in velocity within a five-week period, and that it fluctuates greatly within shorter periods. At times it apparently breaks down into two or more branches. The countercurrent shifts its location with season, and in August is found farther north than in February. An equatorial undercurrent beneath the westward flowing water of the south equatorial current has been observed to set eastward to the vicinity of the Galapagos. For an explanation of the countercurrent *see* OCEAN AND OCEANOGRAPHY: *Movement of Sea Water: Permanent Currents.*

In the South Pacific trade winds maintain a steady flow to the west from the South American coast to about long. 180°. This current, the south equatorial current, flows approximately between lat. 5° N. and lat. 15° S.–20° S. To the south of 40° S. the antarctic circumpolar current, which is maintained by the permanent west winds, flows from west to east. The greater part of this current continues to the South Atlantic ocean through Drake passage, between South America and Graham Land, but part turns north along the west coast of South America as the Peru (Humboldt) current. Within the Peru current low temperatures are found along the coast to within 5° of the equator because of the intense upwelling. The Peru current is one of the most productive areas of the oceans, as is evident from the enormous schools of fish upon which the guano birds feed.

A warm current flows southwest from the Gulf of Panamá and converges with the Peru current. Occasionally this warm current continues much farther to the south past the latitude of Callao (12° S.) and is then known as El Niño ("The Child"). The development of El Niño has disastrous consequences to the life in the sea and to the guano birds which live off the fish. It is also

associated with excessive rainfall which leads to catastrophic floods and tremendous erosion. It is probable that the extreme developments of El Niño are caused by a slight change in the atmospheric circulation and that the disastrous rainfalls are related to such change and are not an effect of the southward extension of the warm current.

Deep-Sea Circulation and Character of Deep Water.—NO deep and bottom water forms anywhere in the Pacific by sinking of surface water. The great basins of that ocean are filled by water which enters the Pacific from the west between Australia and the antarctic continent. This deep water has been formed mainly by sinking near the shelf of the antarctic continent in the Weddell sea region and contains admixture of deep water from the North Atlantic and the Mediterranean.

The deep and bottom water of the Pacific is characterized by a very uniform salinity and temperature. To the north of 55° S. the salinity at a depth of 6,600 ft. is $34.6^0/_{00}$ (per mille) and increases toward the bottom, reaching values of about $34.68^0/_{00}$ in the North Pacific and about $34.72^0/_{00}$ in the South Pacific. In the North Pacific the temperature decreases from about 2° C. (36" F.) at 6,600 ft. to about 1.5° C. (35° F.) at 13,000 ft., and in the South Pacific from about 2° C. (36" F.) to about 1° C. (34° F.) at 16,000 ft. At greater depths the temperature increases about as would be expected from heating associated with compression (adiabatic heating) and reaches 2.45" C. at 31,200 ft. depth in the Philippine trench and 1.74° C. at 30,500 ft. in the Tonga trench.

In the South Pacific there is evidence of a northward flow of the coldest water along the bottom and of a northward flow of low-salinity antarctic intermediate water (see ATLANTIC OCEAN) at a depth of about 3,000 ft. Between depths of 6,000 ft and 13,000 ft. the deep water probably moves to the south and rises toward the surface near the antarctic continent. In the North Pacific there is no evidence of such a circulation except that intermediate water of low salinity is encountered at depths of 1,300–2,600 ft. and participates in the large-scale clockwise circulation of the surface layers. A slight clock ise movement appears also to be present at very great depths with an occasional renewal of the deep water in the western part of the ocean. In agreement with the sluggish deepwater circulation it is found that the oxygen content of the deep water is low, particularly in the North Pacific, where the values range from 2 to 33 cc. per litre.

Temperature.—The distribution of the sea-surface temperature is closely related to the character of the currents. In the tropics only a narrow belt of high temperatures is found on the eastern side of the ocean, but on the western side where the equatorial currents branch north and south, warm tropical waters are found over a wide range in latitude.

The effect of the currents, including the effects of upwelling off the coasts of North and South America, is particularly evident in the great contrast between temperatures in the western and the eastern parts of the ocean in latitudes 20°–35° N. and S. Thus, in lat. 35° N. the average temperature in August is about 25° C. (77° F.) on the coast of Japan and about 15° C. (50° F.) in the same latitude on the coast of California. In February the temperature in 20° S. is 27° C. (81° F.) on the coast of Australia and 19° C. (66° F.) off the coast of Peru. In high southerly latitudes the sea-surface isotherms run nearly east-west, but in the northern part of the North Pacific the highest temperatures are found in the east, and the lowest in the nest where the cold Oyashio flows south.

In the tropics a belt of low temperatures stretches across the ocean at depths between 500 ft. and about 2,000 ft. The presence of this cold water at shallow depths does not show that deep water rises to the surface, but the temperature distribution is directly related to the existence of the equatorial currents which flow toward the west and within which the warm water must be to the right in the northern hemisphere and to the left in the southern. For the distribution of temperature at great depths, see the section Deep-Sea Circzrlation *and* Character of Deep Water, above. For annual and diurnal variation in temperature, see OCEAN AND OCEANOGRAPHY: *Physical* Properties of Sea Water: Temperature, Freezing Point and Heat Capacity.

Salinity.—The salinity of the surface water of the South Pacific is nearly the same as that of the South Atlantic and the Indian oceans, but the surface salinities of the North Pacific are lower than those of any other ocean. The maximum values are about $35.5^0/_{00}$ (per mille) as contrasted with values exceeding $37^0/_{00}$ in the North Atlantic.

The general distribution of salinity follows the same pattern as in the other oceans. It is related to the currents and is greatly influenced by precipitation and evaporation. In 5°–10° N. where precipitation dominates, the surface salinities are less than $34.5^0/_{00}$, whereas in about 25° N. and 20° S. where evaporation exceeds precipitation. maximum values of $35.5^0/_{00}$ and $36.5^0/_{00}$ are encountered. To the north of 40° N. and along the American west coast to the equator the salinity is less than $34^0/_{00}$, except in the Gulf of California. To the south of 55° S. the salinity is also less than $34^0/_{00}$. Large seasonal variations in salinity are found along the coasts, particularly along the Asiatic coast where large rivers empty into the sea. For the salinity of the deep water, see the section Deep-Sea Circulation and Character of Deep Water.

Ice.—The Polar sea is considered part of the Atlantic ocean, and ice conditions in that sea are described in ATLANTIC OCEAN. The Bering sea is free from ice during the greater part of July and August; but, from September on, ice is carried south through Bering strait and also freezes in the bays. Some of this ice breaks and drifts away from the coasts. In February drift ice is generally found as far south as the Pribiloff Islands and may come within sight of the Aleutian Islands. In winter and early spring ice is carried south along the east coast of Asia and past the Kurils, where it may be encountered as far south as lat. 40°–42° N. Part of this ice comes from the Sea of Okhotsk. Ice also freezes in the northern part of the Sea of Japan. In the North Pacific icebergs are found only in some of the sounds on the coast of Alaska between latitudes 55°–60° N. No icebergs are encountered in the Bering sea.

In the South Pacific the pack ice around the antarctic continent reaches its greatest extension in October, when the northern limit is found in about lat. 62° S. In March the entrance to and the western coast of Ross sea are generally ice free, but all other parts of the antarctic continent are blocked by ice. The northern limit of icebergs from the antarctic follows approximately the parallel of 50° S., except near South America, where no icebergs have been reported to the north of 56° S.

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PACIFISM is a word that is first found at the beginning of the 20th century in connection with the movements which attempted to establish peace between nations and advocated the settlement of disputes by means of arbitration, the setting up of international courts and the reduction of armaments. The pacifists of this period did not necessarily claim that no war under any conceivable circumstances could be justifiable, but they maintained that there were practicable methods of avoiding war and tried to arouse the opinion of the peoples of the world in favour of adopting these methods. Their critics, on the whole, attacked them for an undue optimism, which might lead a country to depend on unreliable methods to the extent of weakening the nation's defenses and sacrificing its essential interests.

During World War I the word pacifism became especially associated with the conscientious objectors who refused military service when conscription was introduced. And it gradually came to bear the more specific and now accepted meaning of a belief that the waging of war by a state and the participation in war by an individual are absolutely wrong, under any circumstances.

HISTORY

Ideas of the Ancient World. — In the ancient world, on the whole, war was taken for granted as a necessary evil by some people, while in some parts of the world it was not even regarded as an evil. Military service, therefore, was regarded as a natural obligation, either for a special military caste or for the whole body of citizens or tribesmen or subjects. Individual voices in various lands cried out against the evils of war, but the first genuinely pacifist movement known came from Buddhism, whose founder demanded from his followers absolute abstention from any act of violence against their fellow creatures. It may have seemed at one time as if this might become a practical policy when in India the great king Asoka, in the 3rd century B.C., definitely renounced war. It must, however, be remembered that he was thinking primarily of wars of conquest. He ruled over a secure and well-established empire, and what he would have done if he had been faced, as his successors were, with attacks from barbarians beyond his frontiers, we do not know. At any rate, in succeeding ages Buddhism does not seem to have been very successful in restraining the rulers of the countries in which it was adopted from making war. This may to some degree have been due to the fact that the Buddhist rule of life, as generally understood, was by way of being a counsel of perfection which comparatively few could be expected to follow in its completeness.

In the western world there is little trace of any pacifist teaching until the rise of Christianity. The only notable exception is to be found in the sect of the Essenes, a small religious fraternity which arose among the Jewish population of Palestine. Knowledge of them is extremely scanty, but it seems certain that they were established some time before the beginning of the Christian era and that throughout the greater part of their history they renounced war and indeed any use of violence.

Early and Medieval Church. — It was, however, with the rise of the Christian church that the question of participation in war really became a significant problem. It seems that from an early date there were differences of opinion on the point within the Christian body. The exact meaning of the teaching contained in the Gospels will be considered later. But it is clear that for the earliest Christian community the question hardly arose as a practical problem at all. No doubt few of its members were either liable or eligible for service in the Roman armies. Quite apart from that. however, they thought of themselves as a small body of the elect, living in constant expectation of the Second Coming, walking the path of separation and taking no responsibility for the affairs of the world, either in civil administration or military service. It is evident from St. Paul's writings that they expected the civil powers, who "bear not the sword in vain for the punishment of evil doers," to use force when necessary, and it is natural to suppose, with St. Augustine, that this would have applied to defense against attack from outside as much as to the suppression of lawbreaking within. The Christian did not necessarily disapprove of this, but it was clear to him that it was not his function. Christian writers were particularly concerned to stress, both at this time and later, that Christianity in itself was a religion of peace that used only spiritual weapons, that there could be no question of its adherents attempting to advance their views by force and, above all, that there was no thought of a rising against the Roman government.

As Christianity spread and drew in people from every class and every part of the Roman world, the problem became more urgent. Christians might be faced with the possibility of joining the army and soldiers already in the army might be converted to Christianity. What was their position? In the 2nd and 3rd centuries there were definite statements by some Christian writers, Justin, Tatian. Tertullian in his latest writings, and others, to the effect that Christianity was incompatible with the soldier's profession. But that was certainly not a unanimous view, and it is doubtful whether it was even a majority one.

Clement of Alexandria maintained that a convert to Christianity should remain in the profession in which he already was, and mentions the soldier's profession among others in that connection. There is good evidence that by the end of the 2nd century there were considerable numbers of Christians in the army. Tertullian in his Apology says that they fill the camps and puts forward as part of their claim to consideration that they go to war alongside the other Romans. The situation was complicated, particularly in the 3rd century, by the fact that the soldier might be called upon to take part in pagan religious ceremonies and that he might be called upon to help in the enforcement of the penal decrees against his fellow Christians. It is probable that these things provided a stumbling block to the Christian soldier much more serious than the duty of fighting.

When the empire became officially Christian and Christian rulers had to take the responsibility for keeping law and order within and dealing with barbarian attacks from without, the pacifist view seems to have disappeared. St. Augustine held that a war to resist aggression or to enforce justice might be a Christian duty and that there was nothing incompatible with Christianity in the profession of a soldier. He must only fight in obedience to lawful authority and he must always remember that wars are fought for the sake of the peace that will follow them. Of course, a life devoted to the service of religion was the highest and those who had the vocation for this would eschew military service. But the majority of men did not have this vocation, and for them service in the army was as proper as any other secular calling. This became the accepted doctrine throughout the middle ages, and is restated and developed by St. Thomas Aquinas, who bases his view largely on the teaching of Augustine. This doctrine, which distinguishes "just" from "unjust" war, is still the doctrine of the Roman Catholic Church; it has some resemblance to the doctrine of the United Nations which forbids the use of force in international relations except in individual or collective self-defense. and then only under authority of the United Nations or on invitation of the state in whose territory force is used.

A thin stream of pacifist doctrine can be detected during the middle ages in connection with certain heresies that arose from time to time. The Waldenses, for instance, in the original form of their doctrine, maintained that not only war but any kind of taking of human life was contrary to true Christianity. Eventually they did take up arms to resist violent persecution, and it is likely that if they had not put up such a vigorous resistance in their Alpine valleys their sect would not have survived at all. In any case, their pacifism was only a small element in their whole doctrine and it was probably other elements that particularly aroused the hostility of the church.

The Reformation and After. — It is not surprising that pacifist ideas made their reappearance during the religious ferment at the time of the Reformation. In the 16th century their most prominent advocates were the Anabaptists, a sect which for a time, until it was checked by the most savage and bloodthirsty persecution from both Catholics and Protestants, seemed to be making considerable headway in Europe. The pacifist beliefs of the Anabaptists were again, of course, only one part of a much wider creed. There was, indeed, an extreme wing which advocated the use of

force for the spread of the true religion and eventually went down fighting in its theocratic republic at Münster. But the great majority remained true to their pacifist beliefs throughout. This did not, however, save them from persecution as cruel as any that befell their more militant brethren.

A somewhat kindred movement, that of the Mennonites, also abjured all participation in war. So did the early Socinians, though the view seems to have been soon abandoned by their successors. Though persecution of all of these movements was largely directed against their other theological and social doctrines, their refusal to bear arms is sometimes specifically mentioned in the indictments against them. The persecutions wkre so effective that only scattered remnants managed to survive. Some of the Anabaptists went to England: but by the 17th century they had dropped the pacifist element in their beliefs and there were numerous Anabaptists in Oliver Cromwell's army.

In the 17th century, on the whole, especially in England, religious enthusiasm tended to take more militant forms. But there was one striking exception to this. For that century saw the origin of the sect which has been most consistently associated with pacifist doctrine. the Quakers or Society of Friends. At different periods there have been Quakers who, in one cause or another. have taken up arms. As a general rule, however, the witness against war and the refusal to bear arms have been among the outstanding characteristics of the society. The society, which never spread to any extent outside the English-speaking countries, met with some persecution at first, though nothing remotely comparable to the systematic campaigns of extermination waged against the Anabaptists. It does not appear that the repudiation of war was ever one of the major counts in the indictments against its members, and, after they had abandoned the extravagances of behaviour which marked some of the earlier enthusiasts, their manifest virtues secured them a considerable degree of tolerance. Their greatest triumph came when William Penn founded the colony of Pennsylvania as a predominantly Quaker settlement. There they showed that an unarmed society, practising strict justice and benevolence to the native population, could live in safety among the Indian tribes which were a constant threat to the other colonies.

As hitherto surveyed, pacifism appears as a part of the creed of some dissident Christian bodies and is invariably combined with a complex of other beliefs, some of which have a fairly close logical connection with it. Thus, a frequent source of inspiration is found in the idea of a return to the way of life of the primitive church, and the refusal to bear arms is sometimes associated with a call to apostolic poverty or a communion of goods or a renunciation of all earthly power over others. There is a general denial of the right of the secular power to enforce religious conformity, and there is frequently a reliance on individual religious inspiration, such as the "inner light" of the Quakers. Alongside of this we can observe a tendency for these bodies to abandon their hopes of a general acceptance as the one true form of Christianity and to think of themselves rather as a small body of the faithful in a world which, as a whole, can never be expected to receive their message. In modern times some of these bodies have expressly renounced all idea of proselptization. Their position, in fact, begins to approach that of the religious orders in Catholic Christianity. which are only open to those with a special vocation for that way of life.

These characteristics also mark some of the other religious bodies adopting pacifist views which sprang up in the 19th century. The Plymouth Brethren and the Christadelphians, with occasional individual exceptions, not only refuse to bear arms but also refuse to take any part in public affairs, to enter the service of the government or even to join trade unions. Their pacifism is, therefore, incidental to a much wider renunciation of privileges and responsibilities for a world that, as a whole. has rejected Christ. Fundamentally the same attitude, though modified in different degrees, is characteristic of many smaller religious bodies and communities. 'The Quakers, of course: have never cut themselves off from public service. They remain, nevertheless. to some degree a dedicated community with a may of life which would be unlikely ever to appeal to more than a small minority.

The 20th Century. — A phenomenon of more recent times, beginning roughly from the time of World War I, is the rise of a pacifist movement nithin existing Christian bodies which, as a whole, are not pacifist. There have been for a number of years strong pacifist movements in the Anglican and Methodist churches, though in neither do they represent more than a small minority of the whole. The movement has penetrated into almost all religious bodies including, to a slight extent, the Roman Catholic Church. There is also a small number of persons who, without any particular religious background. base their pacifism on a moral revulsion from the horrors of war. Also, and not always to be distinguished from these, there was, particularly at the time of World War I, a group whose members could most accurately be described as rationalist pacifists. Their attitude might be fairly described as the view that war is such an irrational folly that the intelligent man will have nothing to do with it. This group contained some distinguished names. but was on the whole restricted to a small number of intellectuals. Some of these, such as Bertrand Russell and C. E. M. Joad, abandoned their pacifism during World War II, but following the development of atomic weapons, many became convinced of the mutually suicidal character of war, and this type of pacifism increased.

The upshot of these developments was that, for the first time to any serious extent, pacifism became in itself a proselytizing creed, aiming at winning adherents from all religious bodies and indeed from every section of the community. A typical expression of this was the foundation of the Peace Pledge union in 1936 by an Anglican clergyman, H. R. L. Sheppard. It aimed at getting as many persons as possible to sign a solemn pledge to refuse to take part in any war; it was argued that if a sufficient number of persons would subscribe to this pledge war would become impossible. It would be wrong to say that the beliefs of the leaders of this movement depended entirely on this hope being fulfilled, but it was undoubtedly the prospect of that result that appealed to a large number of its adherents.

It is probably correct to say that the pacifist movement became strongest in Great Britain and the U.S., less strong in the British dominions and weaker still on the continent of Europe. In none of those parts of the world, however, did it attain a level at which it could seriously affect the policies of governments. In India, on the other hand, the figure of Mohandas Gandhi, with his creed of nonviolence, was in the centre of the scene for many years up to the time of his death. Though it is difficult to say how deep and permanent his influence has been in his own country, he nevertheless remains an object of universal reverence and an inspiration to pacifist movements all over the world.

PRINCIPLES

It will be apparent from this survey that there is no one set of principles at the back of all pacifist movements. It is possible to distinguish two general lines of approach, which are different and, in some of the forms they take, really incompatible, though in other forms they can be combined and are not infrequently confused. The one rests on the advocacy of pacifism and the complete renunciation of any form of war as a possible policy to be adopted by a nation. The other depends rather on the conviction of an individual that his personal conscience forbids him to participate in any act of war and perhaps in any act of violence of any kind. Such an individual may, no doubt, also advocate pacifism as a policy for the nation. But it is by no means necessary that he should and some of the religious sects mentioned would expressly renounce any responsibility for suggesting a policy for the nation at all.

Conversely, the advocate of pacifism as a policy may also feel it a personal duty to refuse any participation in warlike activities if war does break out. On the other hand, he might logically hold that, though a decision to go to war at all was a disastrous mistake, once the decision has been taken a war ending in the defeat of his country would be even more disastrous than a war ending in its victory. In such a case he would regard it as a duty to work for his country's victory in every way possible.

Pacifism as National Policy. — The arguments for pacifism as

a possible national policy run on familiar lines. The obvious and admitted evils of war are stressed, the human suffering and loss of life, the economic damage and, perhaps above all, the moral and spiritual degradation that it brings. In recent years particular emphasis has been laid on the increasing power of destruction of the latest weapons. This argument sharply distinguishes the use of force in war, to promote conflicting policies of independent groups, from its use in police operations, to enforce the law of an organized community against dissident members. Its advocates often assume that the abandonment of war as an instrument of national policy will not be possible until the community of nations has become so organized that it can enforce justice among its members.

The nonpacifist of the present day would, in general, accept what the pacifist says about the evils of war and the need for international organization. But he would claim that the pacifist had not fairly faced the possible evils that would result from the alternative policy of nonresistance, the possible mass deportations and even mass extermination, or the subjection of conquered peoples to totalitarian regimes which claim to control their whole lives and, in particular, suppress just those values for which the pacifist stands.

The reply of thoughtful pacifists to this is to admit the seriousness of these evils but to claim that there are ways of meeting them which have already proved successful in some cases. They fix their faith on the process of collective security and pacific settlement or on the methods of nonviolence and nonviolent resistance. The two latter methods are often confused, but they put the emphasis in very different places and should be distinguished. The idea of nonviolence lays stress on the general attitude of benevolence and friendliness which, it is claimed, may often disarm the most savage aggressors. Nonviolent resistance, on the other hand, relies on the difficulties and inconvenience that can be caused to the conqueror or oppressor by a general refusal to co-operate. One of the classic instances of nonviolence is the success of the Quakers in Pennsylvania. There are numerous instances in which nonviolent resistance has been attempted with varying degrees of success. In many of these, it was merely a matter of tactics and did not proceed from any pacifist principles.

There are a striking number of occasions on which nonviolence and nonviolent resistance alike entirely failed to disarm the enemy or even to preserve the communities practising them. Pacifist sects were often the objects of the most ruthless persecution from the middle ages to the days of Adolf Hitler and were, in some cases, practically exterminated. The story of the persecution of the Jews over many centuries is only too familiar, though for generations they practised nonviolence toward their persecutors. As for nonviolent resistance, in the U.S.S.R. tribes or communities suspected of imperfect co-operation disappeared in whole or in part into the depths of Siberia.

It seems that these methods can only be effective against a power which has no very strong motives for going to extremes of suppression. It therefore seems clear to most or all nonpacifists that complete nonresistance would inevitably open the door to the domination of the most fanatical and ruthless elements. And it may well be asked what chance there would be for the eventual survival of pacifist creeds under such a domination.

A great part, if not the whole, of the argument in this connection turns on the probability or improbability of certain future results following a certain course of action. Difference of opinion about that is always possible but is hardly, in itself, a moral difference. If the authorities responsible for the policy of the state arrive at a different estimate of future probabilities from our own, we may disagree with them but we cannot say that they are morally in the wrong, and there is no warrant for our refusing to accept their decision, any more than there would be for our refusing to obey every law with which we disagreed.

Personal Pacifism.—The situation, however, is quite different when we come to the more fundamental pacifism of those who hold that their conscience tells them that it would be absolutely wrong to participate in warlike activities, whatever the consequences. As has already been seen, some of those who hold such a view may expressly renounce all responsibility for the decisions of the national community. But others may equally well regard it as a duty to try to persuade others of the truth of their views, with the eventual hope that pacifism may be adopted as the policy of the whole nation. Their conviction of their own personal duty, however, would not be affected by their success or failure in this.

It has been a frequent subject of dispute among moral philosophers whether any action can be regarded as absolutely good or evil in itself regardless of any consequences that may follow from it. The ordinary man, it must be confessed, generally seems to want to have it both ways and to believe at the same time that we ought to do right regardless of the consequences and that we are morally responsible for the natural consequences of our action. Yet these two propositions taken strictly might easily lead to contradictory conclusions. Obviously, further analysis is needed, but that can hardly be attempted here. What can be done is to consider briefly the kind of arguments that have led people to believe in the absolute and unconditional wrongness of war and warlike activities and then, if necessary, consider the question of the possible relevance of the consequences as it arises.

A few pacifists would base their views on the claim to an immediate moral intuition which admits of no argument. But, though no doubt some kind of direct experience is an ingredient in every moral conviction, most pacifists would find the chief validation of their belief in the teaching of Christ in the Gospels, as they understand it and as they believe that His immediate followers understood it. There are, however, the widest differences of opinion among professed Christians about the true interpretation of this teaching and about its application.

It is common ground that Christ rejected war as a means of spreading His message. It is also clear that in individual relations He taught the greatest degree of forbearance and nonviolence in the face of personal injuries. But it is not at all clear what the bearing of this is on the problem of war and the position of the soldier. It is to be noted that on several occasions soldiers appear in the New Testament narrative—when the soldiers came to John the Baptist, when Christ healed the centurion's servant and when Peter baptized Cornelius—and on none of these occasions is there even a hint that their profession was necessarily incompatible aith the reception of the new message. As for the renunciation of war it is part of the essential nature of Christ's message that it was an appeal to the hearts of men which could not be imposed on them by force. It must be remembered that, if He renounced war, He renounced even more definitely any thought of political power and authority: "My Kingdom is not of this world. . . ." It is difficult to see how any clear conclusion can be drawn from this about the duty of Christians when, in very different circumstances, they find themselves in a position where they are forced to take some responsibility for the affairs of this world.

It has already been noted that the small pacifist sects who try to follow literally the precepts laid down in the Gospels attempt, as far as possible, to hold themselves aloof from the world and renounce all responsibility for the ordering of its affairs. Other Christian pacifists would not go as far as that. They agree that the precepts laid down by Christ for His immediate disciples are not likely to have been meant to apply literally in detail to everyone in the very different circumstances of today. But they hold that it should be possible to extract certain general principles which express the spirit in which the Christian can approach all the main problems of today or any other time. In particular, they stress the central position given in Christ's teaching to love as the supreme good. And they claim that this is quite incompatible with war against other human beings.

Against this it is sometimes argued that the teaching of Christ as recorded contains reference to justice and punishment as well as to love. A more weighty contention is that, when one is dealing not with the relations between individuals but with public behaviour, it is by no means obvious in all cases what course of action love of humanity would lead us to pursue.

We might consider, for instance, a situation in which warlike action would be necessary to suppress slave raiding and the slave trade. In such a case, if an authority which had the power re-

frained from taking such action, it might be displaying love toward the slave traders but, it might well be argued, it would not be at all an obvious expression of love toward their potential victims. This is a comparatively simple point, but. more generally. when we are dealing with public affairs the meaning of love and the kind of actions in which it would express itself is a highly complicated problem.

Conscientious Objection. — This, then, is a brief statement of some of the main issues that are involved in the debate about pacifism. There is also a practical problem of great importance for nonpacifists when they ask themselves what attitude they would wish their country to take toward conscientious objectors to military service. Of course not all conscientious objectors are pacifists. There may be conscientious objections to participation in a particular war, not to war in general. But the great majority of conscientious objectors base their refusal to serve on their pacifist convictions. The authorities in different states have taken very different attitudes toward this. Some states do not recognize conscientious objection at all and a refusal to undertake military service is treated like any other breach of law. In some, the adherents of certain religious sects which include pacifism as part of their creed have been exempted but no recognition has been accorded to the individual objector. In only one or two countries has an attempt been made to recognize all types of conscientious objector.

But the practical problem of the attitude of a nonpacifist community to the pacifist, particularly in wartime, still presents many difficulties. There are. moreover? wide differences of opinion among pacifists themselves about their attitude toward a community at war: ranging from the very small minority who would refuse to do anything that could help the national effort to those prepared to offer any kind of service short of actual fighting.

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PACK, OTTO VON (*c*. 1480–1537), German conspirator. In 1528 he revealed to Philip, landgrave of Hesse, the details of a scheme agreed upon in Breslau by the archduke Ferdinand, afterward the emperor Ferdinand I, and other influential princes. to conquer Hungary for Ferdinand and then to attack the reformers in Germany. Pack was sent to Hungary to concert joint measures with John Zapolya: but John, elector of Saxony, advised that the associates of Ferdinand should be asked to explain their conduct. and Pack's revelations were discovered to be false. the copy of the treaty which he had shown to Philip proving to be a forgery. Pack was seized in the Netherlands at the request of Duke George. Examined under torture he admitted the forgery, and was executed on Feb. 8, 1537. It is uncertain whether Philip was deceived by Pack or was his assistant in concocting the scheme.

PACKING HOUSE: *see* SLAUGHTERHOUSE.

PACORUS, the name of several Parthian princes, of whom the following deserve notice:

1. PACORUS, son of Orodes II (Orodes I in the obsolete enumeration, king from *c*. 57 to 37/36 B.C.), appears in history in 53 B.C., when the celebration of his marriage to the sister of Artavasdes, king of Armenia, coincided with the news of the Parthian victory over the Romans at Carrhae. Two years later (summer 51 j he was sent to invade Syria with an army of which the responsible commander was Osaces: but Osaces was killed in battle with the Romans under C. Cassius (October); and early next year Orodes, learning that one of his satraps was conspiring to make Pacorus king. recalled his son. In 45. however, Pacorus was allowed to go to the relief of the Pompeian general Q. Caecilius Bassus. He made the Caesarians raise the siege of Apamea, but retired at the onset of winter. When Orodes decided to support the Roman refugee Q. Labienus against the triumvirs in the spring of 40, Pacorus led a great army southwestward across Syria while Labienus occupied Cilicia and overran southern Anatolia down to the Carian coast. In Jerusalem the Parthians mutilated and deposed the high priest Hyrcanus. made his nephew Antigonus Mattathias king and expelled Herod. But in 39, after Mark Antony's general P. Ventidius Bassus had defeated Labienus in the Taurus mountains and a Parthian force on his way into Syria, Pacorus retreated across the Euphrates. Invading Syria again in 38. he met Ventidius at Gindarus. northeast of Antioch, where he was killed in a battle regarded by the Romans as revenge for Carrhae.

2. PACORUS. brother of Vologaeses I (reigned A.D. 51/52–79/80), was made king of Media Atropatene on his brother's accession to the Parthian throne. His kingdom was overrun by the Alani in 72.

3. PACORUS. king of Parthia, successor of Vologaeses I, is little mentioned in ancient historical literature but issued coins (at least intermittently) over a period of 23, if not 38, years from A.D. 78, when he appears as a rival of Vologaeses I (to whom the coins of 77–79 sometimes attributed to Vologaeses II seem rather to belong). The reign that he began by rebellion seems to have suffered constantly from it; Artabanus IV (80–81). Osroes (*c*. 109/110–128/129) and Vologaeses II (105/106–147) were his rivals. The date 110 has been put forward for his sale of Osroene to Abgar VII. If he was alive in 115/116, he may have welcomed Trajan's invasion as directed primarily against Osroes, though he had earlier corresponded with Decebalus of Dacia.

See N. C. Debevoise, *A Political History of Parthia* (1938).

PACUVIUS, MARCUS (220–*c*.130 B.C.), the greatest Roman tragic dramatist before Accius. Bearer of an Oscan name, born in the Roman colony of Brundisium, and educated probably at Tarentum, he must (like his mother's brother, the poet Ennius) have been equally at home in Oscan, Latin and Greek. As a young man he followed Ennius to Rome and after a time joined the circle of the younger Scipio, as his uncle had joined that of the elder. He died at Tarentum, but was still at Rome at the age of 80, when he competed against Accius, his junior by half a century.

Unlike his uncle and teacher Ennius, Pacuvius, who was also known as a painter, confined himself as a writer almost entirely to tragedy, although he is said also to have composed some satires in the manner of Ennius. Apart from one Roman play entitled *Paullus* (celebrating the victory of Aemilius Paullus over Perseus of Macedon at Pydna in 168 B.C.), the titles of 12 plays translated from Greek originals are known, and it seems possible that Pacuvius wrote no more than these. The titles show that he did not share his uncle's preference for Euripides: one is from Aeschylus, four from Sophocles: only one from Euripides and six from post-Euripidean tragedy. Ingenious plots and those that gave ample scope for argument seem to have especially appealed to him. He did not follow his originals slavishly: Cicero praises him for having reduced the moanings of the wounded Odysseus, excessive in Sophocles, and in another Sophoclean play he has inserted, from a play of Euripides, a passage of invective against augury, which is altogether alien to the spirit of Sophocles. Particularly well known among the 400 or so surviving lines are a description of a storm at sea, and the pathetic appeal for burial of the murdered Polydorus.

Varro considers Pacuvius the model of the elevated style, and he and Cicero see in him the greatest Roman writer of tragedy; later Accius is placed beside or above him. Cicero! however, criticizes his Latin and the fragments show a number of peculiarities in the use and formation of words.

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PADANG, the chief port on the west coast of Sumatra and capital of West Sumatra province, Indonesia. The population

in 1956 was estimated at 122.964

Padang, which is 572 mi. from Batavia, prospered exceedingly after the opening up of the Padang highlands with their great mineral wealth, tourist traffic, and the general extension of cultivation in the Sumatra west coast residency The town is overlooked by the Apenberg or Ape mountain, right on the coast. The port, nhich is approached from the sea through a multitude of tiny evergreen islets. lies a short distance south of the town, on the northnest side of Koninginne bay (Queen's bay), and from it are exported rubber, copra, tea, coffee, quinine, cinnamon, hides, rattans and coal from the great Ombilin coal fields.

Padang nas one of the oldest Dutch settlements in Sumatra As early as 1606 an official of the Vereenigde Oost Indische compagnie (United Dutch East India company) was sent from Batavia with orders to appoint residents on the west coast of Sumatra and to found factories there, and Padang seems to have been one of the earliest of these, for in 1664 it was styled the capital of Sumatra's nest coast. and three years later a small fort and some narehouses were erected on the banks of the Padang river to support the resident and his small staff in their tenure. The fortress was demolished by the British in 1793. Later in the same year it was visited by the French buccaneer Lemesme, in his vessel, "La Ville de Bordeaux." In Nov. 1795 Padang and the west coast of Sumatra were captured by a British force. and a garrison. reinforced irom Bencoolen. was maintained at Padang, the town and the district remaining under British control until May 1819.

PADANG HIGHLANDS, the mountainous hinterland of Western Sumatra With magnificent scenery and a salubrious climate. it is one of the chief health and pleasure resorts of Indonesia. It can be reached either from the port of Belawan on the east coast of Sumatra, or from Padang on the west coast, since an excellent motor road runs across the country from Belawan and Medan to Padang which penetrates the heart of the Padang highlands. Bukittinggi, 2,700 ft., the former mountain capital, with rail connection to Padang, has an estimated population (1956) of 53,700. From there can be reached! by road, the Kloof of Harau, the falls of Sungei Puar, the caves of Kamar and Baso, Sungei Jarni and its pond with holy fishes. In the southern highlands are the coal mines of Sawah Lunto. The uplands produce coffee and tea.

PADDINGTON, a northwestern metropolitan and parliamentary (returning two members) borough of London, Eng., bounded east by Marylebone, south by Westminster, west by Kensington and extending north to the boundary of the county of London. Pop. (1951) 125,463. Area 2.1 sq.mi. Paddington finds no place in Domesday Book, but the land belonged to the abbey of Westminster from early times and was granted to the see of London by Edward VI. It remained rural until the beginning of the 19th century when the cutting of the Paddington canal (1801) and the coming of the railway (1838) transformed its character. Development took place through the 19th century and some of London's earliest flats were built there. Hallfield, planned by the borough council, is an example since World War II of the application of high building to residential purposes. The borough contains the terminus of British Railways (Western region), the station having been built for the Great Western railway by I. K. Brunel with the help of M. D. Wyatt and Owen Jones; and St. Mary's hospital. where the drug penicillin was discovered by Sir Alexander Fleming in 1928. The district of Bayswater probably takes its name from "Bayard's watering place"—the stream where horses were watered.

PADDLEFISH, the common name in North America for *Polyodon spathula,* also called the spoonbill sturgeon, of the Mississippi basin. It reaches a length of 6 ft. and a weight of 150 lb., and has dark-green smooth skin (scales occur only on part oi the tail) and a greatly elongate, paddle-shaped snout. It is edible; the roe is made into caviar. Another species is found in China. See STURGEON.

PADDLE TENNIS, is a small-scale form of tennis which had its beginnings in a shipboard game originated by the British about 1890. In 1924 Frank P. Beal. then secretary of the Community council of New York city, introduced a game similar to the British one to the city's playgrounds, calling it paddle tennis. The miniature character of the play area necessary for the game meant that many more children could be simultaneously accommodated on a small playground. Instead of racquets, short-handled rectangular wooden bats, called paddles. were used with a slow bouncing ball of sponge rubber. Courts at first were 39 ft. × 18 ft.. one quarter the size of a regulation tennis court, and many remained that size. Official measurements appear in the accompanying diagram. The net is 2 ft. 7 in. at the side posts and is pulled taut to not less than 2 ft. 6 in. Rules and scoring are similar to tennis, except that adults are required to serve underhand and are allowed only one serve. Children aged 13 and under may take two serves overhand and have a smaller service court.

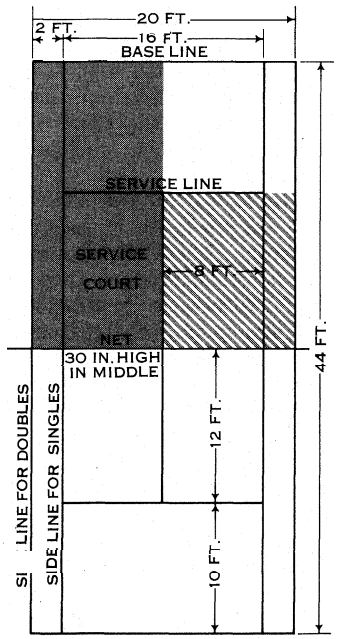

DIAGRAM OF PADDLE TENNIS COURT
Shading (left) indicates area of adult service court; (right) children's service court

PADDY (PADDYBIRD), the name given in India to *Ardeola grayii,* a small heron (*q.v.*) that feeds in the rice paddies. It has a pied plumage of drab and white. The name paddybird is used by whalers to denote the sheathbill (*q.v.*).

PADERBORN, a town and episcopal see in North Rhine-Westphalia, Germany. 63 mi. N.E. from Dortmund. Pop. (1950) 40.270. Paderborn owes its early development to Charlemagne, who held a diet there in 777 and made it the seat of a bishop a few years later. The city about the year 1000 was surrounded with walls. It joined the Hanseatic league, obtained many of the privileges of a free imperial town and endeavoured to assert its independence of the bishop. The citizens accepted the reformed doctrines, but the older faith was restored in 1604. The bishopric of Paderborn formed part of the archdiocese of Mainz, and its bishop became a prince of the empire about 1100. It was secularized in 1803 and was given to Prussia. The town derives its name from the springs of the Pader, a small affluent of the Lippe, which rise in the town under the cathedral to the number of nearly 200. A large part of the town was rebuilt after a great fire of 1875. It possessed a university, founded in 1614, but this was closed in 1819.

Paderborn manufactures agricultural machinery, precision instruments, textiles, glass, leather goods, organs and beer.

PADEREWSKI, IGNACE JAN (1860–1941), Polish pianist. composer and statesman, was born on Nov. 18, 1860, at Kurylowka, Russian Podolia. He studied music at Warsaw, Berlin and at Vienna, where he was a pupil of T. Leschetizsky (*q.v.*). He made his first public appearance in Vienna in 1887, in Paris in 1889 and in London in 1890. His brilliant playing created a furor which went to extravagant lengths, and his triumphs were repeated in America in 1891. He was a great virtuoso player, and as such commanded popular applause, but he was much more than that; he brought to bear on the music he played a highly trained and original mind. The Paderewski renderings often countered tradition but they were the fruit of profound and serious study. In 1899 he married Baroness de Rosen, and after 1900 he appeared but little in public until 1920–23 when he gave recitals in England and in America as well as on the continent.

Paderewski's first considerable work was the opera *Manru,* played at Dresden, May 29, 1901, and in 1902 at New York. Besides numerous works composed for his own instrument, including a concerto for pianoforte and orchestra in A minor (op. 17), he wrote a symphony (in B minor), which was played with success at Boston, Mass., and in London in 1909.

Paderewski's unprecedented success as a pianist all over the world never caused him to forget his own country. In 1910, on the 500th anniversary of the victory of Grunwald over the Teutonic Knights, he presented a memorial, which was unveiled at Cracow.

When World War I broke out in 1914, he dedicated himself heart and soul to his country's service. He was honorary president of a nonparty group of Poles who met at Vevey in the autumn of 1914 to organize a "General Committee of Assistance for the Victims of the War in Poland." The committee was definitely founded in Jan. 1915 under the presidency of H. Sienkiewicz. Paderewski established branches in Paris and London; he then went to the United States, where he remained nearly four years, giving numerous concerts and championing the cause of Poland. He collected enormous sums, and created a powerful pro-Polish movement in the U.S. The value of his propagandist work was realized when, on Jan. 22, 1917, Pres. Woodrow Wilson alluded to a "united. independent and autonomous Poland." By Nov. 1916 every Polish organization in the U.S., except the small Socialist group, was represented in the Polish National Department of Chicago. Up to 1918 Paderewski guided the political and military destinies of 4,000,000 Poles in the U.S.

Foreseeing in Feb. 1917 that the U.S. would soon enter the war, Paderewski induced the Polish National alliance to found a preparatory school for Polish officers at Cambridge Springs. After the decree which authorized a Polish army to be raised in France. Paderewski obtained on Nov. 1917, from Newton Baker, permission to recruit volunteers. He secured from the Canadian government a vast military camp, Niagara on the Lake, where more than 22,000 Polish volunteers were trained by Canadian officers. In Aug. 1917 the Polish National Guard committee, founded at Lausanne, chose him as its representative at Washington.

After the victory of the Allies, Paderewski visited London and afterward proceeded to Poland by sea in the company of a British mission under Colonel Wade, disembarking at Danzig on Dec. 24, 1918. On reaching Warsaw he declared himself independent of all political parties, and after difficult negotiations, during which an attempt was made on his life, he succeeded on Jan. 17, 1919, in forming a coalition ministry, of which he became prime minister as well as minister of foreign affairs. He obtained for Poland official recognition by the various powers, and thus regularized its international position. He suppressed the various military groups which hindered national unity, and at the first meeting of the diet demanded and obtained the formation of a national army. He went to Paris on April 6, 1919, as Poland's first delegate to the peace conference. On two different occasions the diet renewed its vote of confidence in him and expressed the gratitude of his country. But, as it was impossible for him to make a national union a reality, and, above all, to conclude peace with the Soviet government, in view of the violent opposition of the military party, he resigned office (Nov. 27, 1919).

He abandoned his political career in Feb. 1921 and retired to his California estate, returning afterward to resume his musical career. Later he established his home at Morges, Switz. When Germany attacked Poland in 1939 and Pres. I. Moscicki hastened to Rumania, Paderewski was asked to succeed him, but declined because of ill-health. In Jan. 1940, in France, he became president of the new Polish parliament in exile. In Dec. 1940 Paderewski went to the United States. He died in New York city, June 29, 1941.

See Robert Lansing, *The* ***Big Four*** *and Others of the Peace Conference* (1921); Frank W. Davis, ***Time*** *Exposures* (1926); *My Story* (New *York, 1938;* London, 1939) by Paderewski and Mary Lawton.

PADIHAM, an urban district in the Clitheroe parliamentary division of Lancashire, Eng., on the Calder river, 18 mi. E.N.E. of Preston by road. Pop. (1961) 9,893. Area 1.5 sq.mi. The church of St. Leonard (15th century) was rebuilt in 1866–68. In 1211 Padiham was the manor of Edmund de Lacy. Industries include cotton and rayon weaving, engineering, the manufacture of gas appliances, electronics, abrasives and furniture.

PADILLA, JUAN LOPEZ DE, insurrectionary leader in the *"guerra de las comunidades,"* in which the commons of Castile made a futile stand against the arbitrary policy of Charles V and his Flemish ministers. Eldest son of the *comendador* of Castile, he was born in Toledo toward the close of the 15th century. After the cities, by their deputies assembled at Avila, had vainly demanded the king's return, due regard for the rights of the *Cortes* and economical administration, to be entrusted to the Spaniards, they resolved to resort to force, and the "holy junta" was formed, with Padilla at its head. They captured Tordesillas and sought to establish a national government in the name of the imbecile Joanna. Tordesillas was recaptured by the nobles, and Padilla took Torrelobaton and other towns, but his army was completely routed at Villalar (April 23, 1521), Padilla being made prisoner and executed on the following day. His wife, Maria Pacheco de Padilla, defended Toledo against the royal troops for six months afterward, but ultimately had to flee to Portugal.

PADISHAH, the Turkish form of the Persian *pndshah,* a title — equivalent to "lord king" — of the reigning sovereign. In Europe it was applied to the sultan of Turkey. The Persian *padshah* is from *pati,* "lord," "master," and *shah,* "king."

PADSTOW, a seaport. market town and urban district in the North Cornwall parliamentary division of Cornwall, Eng., 15 mi. N.W of Bodmin by road. Pop. (1961) 2,676. Area 5.2 sq.mi. It lies on the north coast, 2 mi. from the mouth of the estuary of the Camel river. The Padstow region (especially Harlyn bay) has many prehistoric associations. Padstow (Padristowe. 1351) and St. Ives are the only tolerably safe harbours on the north coast of Cornwall and to this fact they both owed their selection for early settlement. St. Petrock, called the patron saint of Cornwall, is said to have landed there and to have died there in the 6th century. Until the Danes plundered Padstow (981) it is said to have possessed a monastery, which was then transferred to Bodmin. The town was included in the bishop of Exeter's manor of Pawton, annexed to the see of Crediton, but two manors of Padstow are mentioned later, both of which were eventually acquired hy the family of Prideaux. Padstow appears to have been a port of considerable repute in the 14th century and in 1580 John Norden describes it as an incorporation and market town. A document in the possession of the Royal Institution of Cornwall provides proof that the corporation of Padstow was in existence in 1592. The church of St. Petrock (Petroc), with a massive roodstone in the churchyard. is mainly Perpendicular, with an Early English tower. Within are a 15th-century octagonal font, a canopied piscina and a timber roof over the nave and aisles. The church of St. Enodoc, built amid dunes bordering the eastern shore of the estuary, in place of a more ancient oratory, was long buried beneath drifts of sand. Restored in 1863, it now stands in a dip in the ground and from a little distance only the 13th-century spire can be seen. Pentire point shelters Padstow bay on the northeast, but the approach to the estuary is dangerous during northwesterly gales. The river channel is narrow and much silted but dredging is carried on and the sand, which is rich in carbonate of lime, is used as, fertilizer. The town is an important lifeboat station and two lifeboats are maintained by the Royal National Lifeboat institution, one for local rescue work and a large-type boat which is continually afloat for wider operations in the Bristol channel. Industries include fisheries, shipyards and some agricultural trade, and imports are coal, flour, cement, fertilizers and timber. On May day the townsfolk of Padstow hold festivities during which a great hobbyhorse is displayed to commemorate the one erected on the headlands outside Calais to alarm the French during the siege of that town in 1346.

PADUA, a city of northern Italy (Lat. PATAVIUM; Ital. PADOVA), on the Bacchiglione river. 2j mi. W. of Venice and 18 mi. S.E. of Vicenza. Pop. (1957 est.) 186,845 (commune). The city is picturesque, with arcaded streets and many bridges crossing the various branches of the Bacchiglione, which once surrounded the ancient walls. The Palazzo della Ragione (1218–19) has a great hall on the upper floor; its length is 267½ ft., its breadth 89 ft. and its height 78 ft.; the walls are covered with symbolical paintings in fresco, originally by Giotto; the building stands upon arches, and the upper story is surrounded by an open loggia. In 1306 Fra Giovanni, an Augustinian friar, cov-

ered the whole with one roof curved like the hull of a ship; originally there were three roofs, spanning the three chambers into which the hall was at first divided; the internal partition walls remained till the fire of 1420, when the Venetian architects who undertook the restoration removed them. In the Piazza dei Signori, now called Unità d'Italia, is the beautiful loggia called the Gran Guardia (1493–1526) and close by is the Palazzo del Capitanio, the residence of the Venetian governors, with its great door, the work of Falconetto of Verona, 1532.

The most famous of the Paduan churches is the basilica dedicated to Saint Anthony, commonly called I1 Santo; the bones of the saint rest in a chapel richly ornamented with carved marbles, the work of various artists, among them of Sansovino and Falconetto; the basilica was begun after his death in 1231 and completed in the following century; it is covered by seven cupolas. In the piazza in front of the church is Donatello's magnificent equestrian statue of Erasmo da Narni, the Venetian general (d. 1443). The Eremitani is an Augustinian church of the 13th century, containing the tombs of Jacopo (1350) and Ubertino (1345) da Carrara, lords of Padua, and the chapel of SS. James and Christopher, with Mantegna's frescoes. Close by the Eremitani is the small church of the Annunziata, known as the Madonna dell' Arena; the interior is entirely covered with paintings by Giotto. Padua has long been famous for its university, founded in 1222. Among the professors and alumni were Bembo, Sperone Speroni, Veselius, Acquapendente, Galileo, Pomponazzi, Pole, Scaliger, Tasso and Sobieski. In 1938–39 it had 3.328 students. The presence of the university attracted many distinguished artists, such as Giotto, Lippo Lippi and Donatello; and for native art there was the school of Squarcione (1394–1474), whence issued the great Mantegna (1431–1506). There is an important picture gallery. The botanical garden (1545) is the oldest in Europe. Corn and saw mills, distilleries, chemical factories, breweries, candleworks, inkworks, foundries, agricultural machine and automobileworks flourish. At the diet of Aix-la-Chapelle (828) the duchy and march of Friuli, in which Padua lay, was divided into four counties, one of which took its title from that city. At the beginning of the 11th century the citizens established a constitution, composed of a general council or legislative assembly and a credenza or executive; and during the next century they were engaged in wars with Venice and Vicenza for the right of waterway on the Bacchiglione and the Brenta—so that, on the one hand, the city grew in power and self-reliance, while, on the other, the great families of Camposampiero, D'Este and Da Romano began to emerge and to divide the Paduan district between them. The citizens, in order to protect their liberties, were obliged to elect a podestà, and their choice fell first on one of the D'Este family (c. 1175); but in 1237 Frederick II established his vicar Ezzelino da Romano in Padua and the neighbouring cities.

When Ezzelino met his death, in 1256, Padua enjoyed a brief period of rest and prosperity: the university flourished; the basilica of the saint was begun; the Paduans became masters of Vicenza. But this advance brought them into dangerous proximity to Can Grande della Scala, lord of Verona, to whom they had to yield in 1311. As a reward for freeing the city from the Scalas, Jacopo da Carrara was elected lord of Padua in 1318. From that date till 1405, with the exception of two years (1388–1390) when Gian Galeazzo I'isconti held the town, nine members of the Carrara family succeeded one another as lords of the city.

Padua passed under Venetian rule in 1405, and so remained, with a brief interval during the wars of the League of Cambray, till the fall of the republic in 1797. The city was governed by two Venetian nobles, a podesti for civil and a captain for military affairs, each elected for 16 months. Under these governors the great and small councils continued to discharge municipal business and to administer the Paduan statutes of 1276 and 1362

PADUCAH, a city of southwestern Kentucky. U S , and seat of McCracken county, is located at the confluence of the Ohio and Tennessee rivers. An important market for tobacco, straaberries, corn and livestock, it made rapid industrial progress. Products include hosiery, shoes, shirts, textile machinery, locomotive and steam engine parts, whisky barrels, radiators, radios, electronic devices. bee hives, batteries, leather goods and marine products. The city is located in one of the world's greatest power-generating areas. The Tennessee Valley authority and the Atomic Energy commission added greatly to the city's industrial growth, while recreational facilities provided by Kentucky Lake and Kentucky Dam Village State park made the area a tourist attraction. The town is the seat of Paducah Junior college (1932). The council-manager form of government was adopted in 1934. The site, known as Pekin, was part of a grant to George Rogers Clark, American Revolutionary hero. At his death his brother William, coleader of the Lewis and Clark expedition, received the land, laid out the town in 1827, and named it for Paduke, a Chickasaw Indian chief who lived in the vicinity. It was chartered as a city in 1856. During the American Civil War, because of its strategic river facilities, the city mas occupied by Union forces under Gen. Ulysses S. Grant, and was raided by Gen. Nathan B. Forrest, Confederate cavalry leader. Paducah was the home of Irvin Shrewsbury Cobb (*q.v.*), who is buried there.

For comparative population figures see table in KENTUCKY: Population. (J. C. CR.)

PAEAN, in Homer's Iliad, is the physician of the gods. It is not known whether he was originally a separate deity or merely an aspect of Apollo. Homer leaves the question unanswered; Hesiod definitely separates the two, and in later poetry Paean is invoked independently as a health god. It is equally difficult to discover the relation between Paean or Paeon in the sense of "healer" and paean in the sense of song. L. R. Farnell referred to the ancient association between the healing craft and the singing of spells, and said that it is impossible to decide which is the original sense. Such songs were originally addressed to Apollo, and afterward to other gods, Dionysus, Helios, Asclepius. It was the custom for a paean to be sung by an army on the march and before entering into battle, when a fleet left the harbour and also after a victory.

Paeans were sung at the festivals of Apollo (especially the Hyacinthia), at banquets and later at public funerals. Later, especially in Hellenistic times (first by the Samians to Lysander) they are addressed to more or less deified men. The word paean is used of any song of joy or triumph.

PAELIGNI, a people of ancient Italy, first mentioned as a member of a confederacy which included the Marsi, Marrucini and Vestini (*qq.v.*), with which the Romans came into conflict in the second Samnite War, 325 B.C. (Lily, viii, 29). On the submission of the Samnites (*q.v.*) they all came into alliance with Rome in 305–302 B.C. (Livy, ix, 45; x, 3, and Diod. xx, 101). Each of them was an independent unit. Thus the Vestini issued coins in the 3rd century; each of them appears in the list of the allies in the Social War (Appian, B.C., i, 39). The mountain fortress of Corfinium was chosen as the rebel capital. It was renamed Vitellio, the Oscan form of Italia, a name which appears, written in Oscan alphabet, on the coins struck there in 90 B.C.

The inscriptions show that the dialect spoken by these tribes was substantially the same from the northern boundary of the Frentani to some place in the upper Aternus valley not far from Amiternum (mod. Aquila). This dialect closely resembled the Oscan of Lucania and Samnium, though presenting some peculiarities of its own, which warrant, perhaps, the use of the name North Oscan. The clearest of these is the use of postpositions, as in Vestine Poimunie-n, "in templo Pomonali"; pritrom-e, *i.e.*, in proximum, "on to what lies before you." Others are the sibilation of consonantal *i* and the assimilation of *-di-* to some sound like that of English *j* (denoted by Ð in the local variety of Latin alphabet), as in vidadu, "viamdõ," *i.e.*, "ad-viam"; *Musesa*=Lat. *Mussedia;* and the loss of d (in pronunciation) in the ablative, as in aetatu *frata* fertlid (*i.e.*, aetate fertili *finita*), where the contrast of the last with the other two forms shows that the *-d* was an archaism still occasionally used in writing.

The name *Paeligni* may belong to the NO-class of Ethnica, but the difference that it has no vowel before the suffix suggests that it may rather be parallel with the suffix of Lat. *privignus*. If it has any connection with Lat, *paelex*, "concubine," it is conceiv-

able that it meant "half-breeds," and was coined in contempt by the conquering Sabines, who turned the *touta Marouca* into the community of the *Marrucini* (*q.v.*). For the history of the Paeligni after 90 B.C. *see* the references given in C. I. L., ix. 290 and 296. None of the Latin inscriptions of the district need be older than Sulla, but some of them both in language and script show the style of his period (*e.g.*, 3087, 3137); and, on the other hand, as several of the native inscriptions, which are all in the Latin alphabet, show the normal letters of the Ciceronian period, there is little doubt that the Paelignian dialect lasted down to the middle of the 1st century B.C.

Paelignian and this group of inscriptions generally form a most important link in the chain of the Italic dialects, as without them the transition from Oscan to Umbrian would be completely lost. The unique collection of inscriptions and antiquities of Pentima and the museum at Sulmona were both created by the late Professor Antonio de Nino, who rescued every Paelignian monument that we possess.

For further details and the text of the inscriptions, the place-names, etc., *see* R. S. Conway, *The Italic Dialects*, pp. 235 et seq., and the earlier authorities there cited.

PAEONIA, the land of the Paeonians, the boundaries of which, like the early history of its inhabitants, are very obscure. The Paeonians are regarded as descendants of the Phrygians of Asia Minor. According to the national legend they were colonists from Troy, and Homer (*Iliad,* ii. 848) speaks of Paeonians from the Axius fighting on the side of their Trojan kinsmen. Before the reign of Darius Hystaspes, they had made their way as far east as Perinthus. When Xerxes crossed Chalcidicē on his way to Therma (Thessalonica) he is said to have marched "through Paeonian territory." They occupied the entire valley of the Axius as far inland as Stobi, and the valleys to the east of it as far as the Strymon. In consequence of the growth of Macedonian power their territory was considerably diminished, and in historical times was limited to the north of Macedonia from Illyria to the Strymon. The Paeonians included several independent tribes, later united under a single king. They adopted the cult of Dionysus, known amongst them as Dyalus or Dryalus, and Herodotus (iv. 33) mentions that the Thracian and Paeonian women offered sacrifice to Queen Artemis (probably Bendis). They worshipped the sun in the form of a small round disc fixed on the top of a pole. They drank barley beer and various decoctions made from plants and herbs. The country was rich in gold and a bituminous kind of wood. The women were famous for their industry. Herodotus (v. 12) tells the story that Darius, having seen at Sardis a beautiful Paeonian woman carrying a pitcher on her head, leading a horse to drink, and spinning flax, all at the same time, enquired who she was. Having been informed that she was a Paeonian, he sent instructions to Megabyzus, commander in Thrace, to deport two tribes of the nation without delay to Asia. At the time of the Persian invasion the Paeonians on the lower Strymon had lost, while those in the north maintained their independence. They frequently made inroads into Macedonian territory until they were finally subdued by Philip, who permitted them to retain their government by kings. The daughter of Audoleon, one of these kings, was the wife of Pyrrhus, king of Epirus, and Alexander the Great wished to bestow the hand of his sister Cynane upon Langarus who had shown himself loyal to Philip. In 280 the Gallic invaders under Brennus ravaged the land of the Paeonians. After the Roman conquest, Paeonia east and west of the Axius formed the second and third districts respectively of Macedonia. Under Diocletian Paeonia and Pelagonia formed a province called Macedonia *secunda* or *salutaris*, belonging to the prefecture of Illyricum.

See W. Tomaschek, "Die alten Thraker," in *Sitzungsberichte der* k. *Akad. der Wissenschaften,* xxviii. (Vienna, *1893).*

PAEONIUS, of Mende in Thrace, a Greek sculptor of the latter part of the 5th century, B.C., is known for his statue of the goddess of victory at Olympia. The statement of Pausanias that he executed one of the pediments of the temple of Zeus at Olympia is doubtful.

There does exist an important original work of Paeonius in the Nike ("Floating Victory"), found at Olympia. Probably set up in memory of the battle of Sphacteria, 424 B.C., it bears the inscription "Dedicated to Olympian Zeus by the Messenians and Naupactians as a tithe of the spoil of their enemies. Paeonius of Mende made the statue, and was a successful competitor in the construction of the acroteria for the temple." It was on a triangular base, 30 ft. high, which still stands in front of the temple of Zeus. The statue itself is in the museum. Copies of the head are in the Hertz collection in Rome and in the Vatican.

See G. M. *A.* Richter, *The Sculpture and Sculptors of the Greeks,* new ed. (1950, 1951). (D. M. **R.**)

PAEONY: *see* PEONY.

PAËR, FERDINANDO (1771–1839), Italian composer, was born at Parma on June 1, 1771. His first opera, *La Locanda de' vagebondi,* was published when he was only 16; and others rapidly followed. In 1797 he went to Vienna, where his wife, the singer Riccardi, had obtained an engagement at the opera; and here he produced another series of operas, including his *La Camilla ossia il Sotteraneo* (1799) and his *Achille* (1801). In 1803 he was appointed composer to the court theatre at Dresden. At Dresden he produced *Il Sargino* (1803) and *Leonorn* (1804), based on the same story as Beethoven's *Fidelio.* In 1807 Napoleon saw him in Dresden, and took him with him to Warsaw and Paris at a salary of 28.000 francs. In 1812 he succeeded Spontini as conductor of the Italian opera in Paris, but in 1823 he retired in favour of Rossini. He died May 3, 1839. Paër wrote 43 operas.

PAESTUM, an ancient Greek city in Lucania (Gr. Ποσειδωνία; mod. Pesto), near the sea, with a railway station 24 mi. S.E. of Salerno, 5 mi. S. of the river Silarus (Salso), founded by Troezenian and Achaean colonists from Sybaris, probably about 600 B.C. for it was flourishing about 540 B.C., when the neighbouring city of Velia was founded. For many years the city maintained its independence against the Lucanians but at last fell into their hands; and in 273 B.C. it came under Roman rule, the name being changed to Paestum. It successfully resisted the attacks of Hannibal. Under Augustus and Tiberius, the neighbourhood was healthy, highly cultivated, and celebrated for its flowers; the "twice blooming roses of Paestum" are mentioned by several Latin poets. Its present deserted and malarious state is due to the silting up of the mouth of the Silarus. In 871 Paestum was sacked and partly destroyed by Saracen invaders; in the 11th century it was further dismantled by Robert Guiscard, and in the 16th was finally deserted.

The ruins are among the most interesting and imposing of the Hellenic world. The earliest temple is the so-called Basilica. Terra cottas of the first quarter of the 6th century B.C. have been found, and also a fragment of a dedication to Poseidon, so that his name should be applied to this, and not to the great hexastyle temple. It is of unique plan, with nine columns in the front and eighteen at the sides, $4\frac{3}{4}$ ft. in diameter. A line of columns runs down the centre of the cella. The columns and the architraves upon them are well preserved, but there is nothing above the frieze existing, and the cella wall has entirely disappeared. Next in point of date comes the so-called temple of Ceres, a hexastyle peripteros (after 540 B.C.). The columns are all standing, and the west and part of the east pediment are still in *situ.* In front stood a sacrificial altar as long as the temple itself.

The temple hitherto attributed to Neptune was built about 420 B.C. It is a hexastyle peripteros with fourteen columns on each side, and is remarkably well-preserved, both pediments and the epistyle at the sides being still *in situ.* The cella, the outer walls of which have to a great extent disappeared, has two internal rows of seven columns $4\frac{2}{3}$ ft. in diameter, upon which rests a simple epistyle, supporting a row of smaller columns, so that the interior of the cella was in two stories.

The temple of Peace (2nd century B.C.) was excavated in 1830, but is now covered up. Traces of a Roman theatre and other buildings, as well as of the main street (*cardo*) have also been found. The circuit of the town walls, well built of squared blocks of travertine, and 16 ft. thick, of the Greek period, is almost entire; they are about 3 mi. in circumference, enclosing a roughly rectangular area. There were four gates, that on the east with a

single arched opening being well preserved. Outside the north pate is a street of tombs (contents are in Naples museum). (T. A.)

PÁEZ, JOSÉ ANTONIO (1790–1873), Venezuelan patriot and politician, a leader in the independence movement and first president of the country, was born in Aricagua near New Barcelona on June 13, 1790, of part-Indian parents. As a youth he worked as a peon. In 1810 he joined the revolutionary movement against Spain as the leader of a band of mounted plainsmen. He became a valued lieutenant of Simon Bolivar (*q.v.*) and was instrumental in the victories of Carabobo (1821) and Puerto Cabello (1823). In 1826 he rebelled against the central authorities of Gran Colombia, of which Venezuela was a province; Bolivar personally negotiated the settlement which left Páez as military and civilian head of Venezuela. In 1829 he led the separatist movement which resulted in Venezuela's becoming a sovereign nation.

Elected president in 1831, he gathered about himself members of the old elite and those enriched by the war. As leader of the new nation Páez showed considerable political ability in balancing the antagonisms existing between the articulate elements. As a moderate dictator fulfilling the dual role of chief of government and a moral power above and beyond the law, he ruled directly or through lieutenants until 1846, when one of his personal choices for the presidency turned against him and he was imprisoned. He was sent into exile in 1850. In 1858 and again in 1861 he heeded the call to return and give direction to the oligarchy; each time he mas forced after a few months to seek asylum abroad, the last time in 1863. He spent the remainder of his life in exile, mostly in New York city, but he also visited Argentina. Uruguay. Bolivia, Peru and Colombia. He died in New York on May 7, 1873. His autobiography was published while he was living in New York (1867–69). (J. J. J.)

PAEZ, PEDRO (1564–1622), Spanish Jesuit missionary, who has been called the second apostle of Ethiopia, was born at Olmedo in 1564. He entered the Society of Jesus in 1582, and sailed for Goa in 1588. On his way to Ethiopia in 1589 he was captured by Turkish pirates and enslaved until 1596, when he returned to Goa, but set out again for Ethiopia in 1603. He learned the two chief dialects of the country, translated a catechism and wrote a treatise on the theological errors of the Ethiopian Church. He also wrote (in Portuguese) a history of Ethiopia (published in *Biblioteca historica de Portugal e Brasil*, serie ultramarina, vol. v, 1945–46). He converted the emperor Za Denghel, who wrote to the pope and the king of Spain for more missionaries. This action led to civil war which cost the emperor his life (1604). Paez continued his work under Za Denghel's successors, with such success that Ethiopia became in large part Catholic. Paez was the first European to visit the source of the Blue Nile. He died of fever at Gorgorà on May 20, 1622.

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PAGAN, a town and former capital, in Myingyan district, Burma, 92 mi. S.W. of Mandalay. It was founded by King Pyinbya in 847, and remained the capital until the extinction of the dynasty in 1298.

Pagan itself is a village of 2,825 population (1953), but hundreds of pagodas in various stages of decay meet the eye in every direction. A number of them were built by King Anawrahta, who overcame the Peguan king. Manuha of Thaton. It was Anawrahta who introduced the Buddhist religion in Upper Burma, and who carried off nearly the whole Thaton population to build the pagodas at Pagan like those of Thaton.

PAGAN, a heathen, one who worships a false god or false gods, or one who belongs to a race or nation which practises idolatrous rites and professes polytheism. In the early Christian church *paganus* was applied to those who refused to believe in the one true God. It thus, of course, excluded Jews. In the middle ages, at the time of the crusades and later, "pagan" and "paynim" (O.F. *paienisme*, Late Lat. *paganismus*, "heathenism or heathen lands") were particularly applied to Mohammedans, and sometimes to Jews. It was in the rural districts that the old faiths lingered, and thus it is assumed that the Latin *paganus* (villager) arose after the establishment of Christianity, but Tertullian (*c.* 202, *De corona militis*, xi), has a sentence suggesting that the "soldiers of Christ" dubbed the non-Christians *pagani*, referring to the raw, half-armed rustics.

See also *E.* Gibbon, *Decline and Fall of the Roman Empire*, ed. by J. B. Bury, ch. 21 (1896).

PAGANINI, NICCOLÒ (1782–1840), Italian violinist and composer, the principal violin virtuoso of the 19th century and one of the creators of the aesthetic of extravaganza in musical romanticism, was born Oct. 27, 1782, at Genoa. He studied there with Giacomo Costa. Following his first appearance in 1793, he studied with Alessandro Rolla and Gasparo Ghiretti at Parma, and in 1797 toured Lombardy with his father. Gaining his independence soon after, he indulged in gambling and romantic love affairs.

Between 1801 and 1807 he wrote the 24 *Capricci* for unaccompanied violin, displaying the novel features of his technique, and the two sets of six sonatas for violin and guitar. He reappeared in Italy as a violinist in 1805, and was appointed director of music at Piomba by Napoleon's sister, Elise Bonaparte Bacciochi. He later gave concerts of his own compositions in many towns in Italy, and in 1815 formed an attachment with the dancer Antonia Bianchi.

In 1828 Paganini's success in Vienna resulted in his becoming a popular idol, and his appearances in Paris and London in 1831 were equally sensational. In 1833 he settled in Paris where he inspired Berlioz to write his symphony *Harold en Italie*. Following the failure of the Casino Paganini. with which he was connected, he went to Marseilles in 1839. He died at Nice on May 27, 1840.

Paganini's romantic personality and adventures created in his own day the legend of a Mephistophelean figure, though his inner nature was devoured by melancholy and depression. His violin technique, based on that of his works, principally the *Capricci*, the violin concertos and the sets of variations, demanded a wide use of harmonics and pizzicato effects, new methods of fingering and even of tuning.

Paganini's innovations revolutionized violin playing and became the basis for later virtuosi, notably Pablo de Sarasate and Eugène Ysaÿe. Though the musical value of his work was limited, the influence of his virtuosity extended to piano and orchestral music, and themes from the *Capricci* inspired works in a brilliant style by Liszt. Rachmaninoff and others.

See A. Codignola, *Paganini intimo* (1935); G. I. C. de Courcy, *Paganini the Genoese*, 2 vol. (1957). (E. LR.)

PAGE, SIR FREDERICK HANDLEY (1885–1962), British aircraft designer and pioneer in civil air transport, was born at Cheltenham, Gloucestershire, Nov. 15, 1885. After studying electrical engineering at City and Guilds Engineering college, London, he became interested in the problem of flight and founded Handley Page, Ltd., in 1909. This was the first British company devoted solely to aircraft construction, and the first successful aircraft designed by Page flew in 1910. During World War I he produced the world's first twin-engined heavy bomber, which was shortly followed by the four-engined V-1500, designed for the bombing of Berlin, a project stopped by the armistice. In 1919 he formed Handley Page Transport, Ltd., which pioneered airline services to France, Belgium, the Netherlands and Switzerland, and later merged to form Imperial Airways.

Between World Wars I and II and up to the late 1950s, Handley Page, Ltd., continued to design successful bombers and transport aircraft, including the Victor crescent-wing, a four-jet bomber.

Handley Page died in London on April 21, 1962. (D. CR.)

PAGE, JOHN (1744–1808), governor of Virginia, was born at Rosewell, an estate built by his grandfather, in Gloucester county, Virginia. He was educated at William and Mary college, from which he graduated in 1763, and while attending school there became acquainted with Thomas Jefferson. who remained his lifelong friend. He served for a short time with Washington against the French and the Indians and then entered politics as a mem-

ber of the Virginia house of burgesses and of the colonial council. With the outbreak of the Revolutionary War he took an active part in the defense of the colonies, serving as a delegate to the Virginia constitutional convention, as a member of the committee of public safety, as head of a regiment he himself raised and finally as lieutenant-governor of Virginia. In 1789 he was elected a representative to congress, where he remained until 1797, having been re-elected three times. In 1802 he was elected to take James Monroe's place as governor of Virginia and served three one-year terms. From 1805 until his death he was U.S. commissioner of loans for Virginia, a post to which he was appointed by Jefferson. He died in Richmond. Oct. 11, 1808.

PAGE, THOMAS NELSON (1853–1922), U.S. author, one who did most to build up the romantic legends of the southern plantation, was born on Oakland plantation, Hanover county. Va., April 23, 1853. He attended Washington college (now Washington and Lee university), taught for a year, and in 1874 graduated in law at the University of Virginia. He practised until 1893, when he moved to Washington, D.C., and devoted himself to writing and lecturing. He began by writing dialect verse, but first won notice with the story "Marse Chan" in the *Century Magazine.* This and similar stories were collected in what is probably Page's most characteristic book, *In Ole Virginia* (1887), reflecting his formative years amid the glamorous life of the old regime and the tumults of the Civil War. His essays and social studies have the same tone as his fiction. From 1913 to 1918 Page was ambassador to Italy. He died on Nov. 1, 1922, at Oakland, Va.

Page's works include *Two Little Confederates* (1888); *The Burial of Guns* (1894); *The Old Gentleman of the Black Stock* (1897); and *Red Rock* (1898). The Plantation edition of his works (12 vol.) was published in 1906.

See Rosewell Page, *Thomas N. Page* (1923); J. Hubbell, *The South in American Literature, 1607–1900* (1954).

PAGE, WALTER HINES (1855–1918), U.S. writer and diplomatist. who played an important part in British-U.S. relations during World War I, was born at Cary, N.C.. Xug. 15, 185j. At 16, after a preparatory course at the Bingham military school at Mebane, N.C., and a year at Trinity college (now Duke university), at Durham, N.C., Page entered Randolph-Macon college at Ashland, Va. The greatest and most lasting influence in his life there, Thomas Randolph Price, became deeply attached to Page, and obtained his appointment as one of the first 20 fellows of the new Johns Hopkins university at Baltimore. There under America's great classical scholar. Basil L. Gildersleeve. Page acquired a knowledge of antiquity and a feeling for Greek literature that influenced all his subsequent habits of thought as well as his own literary style. Page's health, always frail, caused him to leave Johns Hopkins without a degree. A winter (1878–79) spent in teaching English at the high school at Louisville, Ky., convinced him that he wanted an active life among men, and in 1880 he became editor of the' *St. Joseph* (Mo.) *Gazette.* St. Joseph did not hold his interest long. He left in the summer of 1881 to make a tour of the southern states, writing a series of brilliant articles that were simultaneously printed in several leading U.S. newspapers. The next two years Page spent as literary editor of the *New York World,* but in 1883 he resigned and returned to Raleigh, N.C. For two years he edited the *State Chronicle,* a weekly newspaper. as distinguished for the vivacity of its editorial style as for the unconventionality of its opinions. Page ridiculed the tendency to regard a Confederate war record as almost the exclusive qualification for public office; he advocated primary education for both whites and Negroes, the development of scientific agriculture. the building of modern highways, and the creation of local industries. All these changes North Carolina has since introduced; the youthful Page. however, was ahead of his time, and after two rather tempestuous years, in which he found himself denounced as a "Southern Yankee," he had to confess failure, dispose of his paper and resume his life in New York.

His Literary Career.—Page's opportunity came in 1887, when he joined the staff of the *Forum.* In four years he transformed a bankrupt property into a profitable one and made it an influential organ of public discussion. He resigned his editorship in 1895 and entered the Boston publishing house of Houghton, Mifflin & Co. For two years he was literary adviser and associate editor of the *Atlantic Monthly,* and in 1898 became editor in chief. In 1899 he joined Frank N. Doubleday in establishing the publishing house of Doubleday, Page & Co. and founding the *World's Work* magazine, on which he served as editor from 1900 to 1913. Both in his writing and in his lectures, he continued to advocate his favourite causes. *The Rebuilding of Old Commonwealths* (1902) gives in eloquent language Page's aspirations for the revitalization of the southern states. *A Publisher's Confession* (1905) gives his creed for his trade. In 1909 Page also published under the name of "Nicholas Worth" *The Southerner,* a semi-autobiographical novel interpreting his ideas on the south. Page's literary fame will rest on his letters. Of these the leading one was popular education, especially in the backward south. As a member, first of the Southern Education board and afterward of the General Education board, he aided in distributing the Rockefeller millions for this purpose. By initiating the movement for the eradication of the hookworm, he started the work that has since taken shape in the International Health board. He served on Pres. Theodore Roosevelt's Country Life commission, and was a leader in introducing the demonstration work of Seaman A. Knapp (*q.v.*) in agricultural areas. All these years he closely followed political affairs, and in 1911 he was one of the first to proclaim the presidential qualifications of Woodrow Wilson. One of Wilson's first acts, after his inauguration, was to appoint Page ambassador to Great Britain.

Ambassador in London.—For his five years in London Page's life had been a preparation. His passion for democracy, his belief that British institutions and literature formed the most solid basis of civilization, his long advocacy of British-U.S. co-operation as the most satisfactory method of solving world problems—all were put to the severest test in the arduous years of his ambassadorship. He had established familiar and congenial relations with the British public and British officialdom when World War I began. Up to that time Page had also worked in complete harmony with President Wilson. It was owing mainly to Page's prompting that President Wilson persuaded congress to repeal the discriminating Panama tolls.

In the war Page, unlike Wilson at first, saw above all an attempt of Germany to grasp the hegemony of Europe and to substitute the Prussian conception of autocracy for the democratic ideal which he regarded as the true path of human progress. It was mainly this difference that caused the historic divergence between Page and Wilson. To the outside world Page maintained an attitude of strict neutrality; in his private communications to the president, however, he made no secret of his complete sympathy with the cause of the Allies and his general disagreement with the policy of the administration. When the "Lusitania" was sunk, Page in his letters and cablegrams to Wilson strongly advocated a U.S. declaration of war against Germany. He insisted then, as he did afterward. that U.S. intervention at that time would have brought the war to an early end with an Allied triumph. Page's great moment came on April 2, 1917, when President Wilson asked congress to declare the existence of a state of war with Germany, and used arguments that Page had been forcing on his attention for two and a half years.

Page had never been in robust health; and the anxieties and labours of a terrible period gradually exhausted him. He had meditated resignation many times, and consented to remain only at the earnest request of President Wilson. In Aug. 1918, however, he became so ill that the president acquiesced in his retirement. In early October he sailed on the "Olympic" and reached New York so weak that it was necessary to carry him from the ship. His one wish was to return to "the sand hills" of his early home in North Carolina. There he died on Dec. 21, 1918.

BIBLIOGRAPHY.—The chief authority on Page's career is B. J. Hendrick, *The Life and Letters of Walter H. Page,* 3 vol. (1922–25); *The Training of an American: The Earlier Life and Letters of Walter H. Page, 1855–1913* (1928); Charles Seymour (ed.), *The Intimate Papers of Colonel House,* 2 vol. (1926); Viscount Grey, of Fallodon, *Twenty-Five Years, 1892–1916,* 2 vol. (1925). (B. J. H.; X.)

PAGE, WILLIAM (1811–1885), U.S. portrait painter, was

born at Albany, N.Y., on Jan. 3, 1811. He studied for the ministry and in later life became a Swedenborgian. He received his training in art from Samuel Morse and in the schools of the Nation Academy of Design, and in 1836 became a National Academician. From 1849 to 1860 he lived in Rome, where he painted portraits of his friends Robert and Elizabeth Browning. He died at Tottenville, Staten Island, N.Y., on Oct. 1, 1885.

Page's portraits of Charles W. Eliot and John Quincy Adams are at Harvard university.

PAGE, a term used of a boy or young male person in various capacities, positions or offices. The etymology is doubtful. *(See* KNIGHTHOOD AND CHIVALRY.)

PAGEANT, a spectacular show or outdoor drama. In medieval England the pageant was a biblical scene performed on a wooden scaffold usually rolled on wheels through the streets of a town on certain feast days. The productions of the several pageants, presented in a series, were undertaken by craft guilds, and an effort was made to have the assignment in each case suit the nature of the guild. Thus the shipwrights acted out the building of the ark, the watermen portrayed the flood, the goldsmiths were responsible for the gifts of the magi, the bakers showed the miraculous multiplying of the loaves, and so forth. *(See* DRAMA: *Medieval Drama.)*

By the time Queen Elizabeth I ascended the throne pageantry had lost its scriptural imagery and had turned largely into mock tournaments and lavish processions devised to honour or to court royal favour. The queen had a great fondness for spectacle. She enjoyed the sight of fireworks and the noise of cannon, and when she entered a town on one of her frequent journeys about England she liked to be greeted by angels singing in a cloud above the archway, or to see groups of actors posed in allegorical pictures and fountains splashing real wine.

One of the old pageantic processions which became firmly established as a tradition was the parade of elaborate floats along the Strand or, in the form of barges, along the Thames, on the day the lord mayor of London went to the law courts to take his oath of office. This procession, called the Lord Mayor's show, is still an annual event.

Other traditional periodic pageants were those given in Coventry celebrating the famous ride of Lady Godiva and the Orange Day processions in Northern Ireland. The Corso del Palio in Siena, Italy, is a well-known horse race with many elements of a pageant; jockeys are dressed in medieval costume, the horses are blessed at various churches, and the race takes place in front of the ancient city hall.

THE PAGEANT IN THE 20TH CENTURY

Dramatic storytelling, which had largely disappeared from the pageant between the 13th and 19th centuries, returned to it at the beginning of the 20th century. Louis N. Parker (1852–1944) has been credited with being the "father of the modern pageant." His pageant of Sherborne in 1905 set a pattern for a long series of similar outdoor plays in England and America Among the notable shows in England were the Gloucester Historical pageant at Cheltenham, the York pageant (in which 6,000 persons participated) and the English Church pageant of 1909. The distinguishing features of the "Parkerian pageant" are its arrangement into historical episodes, as accurate as possible in detail; its use of a natural setting with little or no artificial scenery; its reliance throughout on the help of amateur actors and stagehands taken from the community in which it is presented; and its emphasis on mass effects supported by music.

Among the most famous of the early American productions influenced by Parker's methods was *The Pageant and Masque of St. Louis,* prepared by Thomas Wood Stevens and Percy MacKaye in 1914 to celebrate the 150th anniversary of the founding of St. Louis, Mo. The pageant traced the history of the area through the period of the wild forest and the Indians, the coming of the French traders and settlers and the Spanish intruders, the planting of the American flag, the coming of the German immigrants, and the turmoil of the Civil War with the peace that followed it; while the masque, making use of figures of Indian gods, white knights and priests. pioneers and earth spirits. attempted to symbolize forces of geography and history past and present. The masque ended with a glimpse of an airplane and a display of fireworks. The whole performance was presented on a 1,000-ft. stage with 7.500 local actors and cost $125,000. Another successful pageant was George Pierce Baker's *The Pilgrim Spirit,* a tercentenary pageant at Plymouth, Mass., in 1921.

Among the most interesting developments in later years was the historic spectacle presented at state, national and world fairs. Typical was the great *Cavalcade of Texas* at the Texas centennial in Dallas in 1936 and the *American Jubilee* at the New York World's fair in 1940. A high level of excellence in industrial pageantry was reached at the same fair by Edward Hungerford's *Railroads on Parade* with music by Kurt Weill.

By the middle of the 20th century the Parkerian form of pageant had largely gone out of fashion. A few educational, religious and commercial groups were still presenting on special occasions serial historical scenes elaborated and decorated with spectacular elements, but much more common everywhere were pageantic processions, or processions mixed with mummery, such as those associated with the Mardi gras at Nice and Cannes and, in the United States, at New Orleans. Somewhat similar were the shows connected with the Apple Blossom festival in Virginia and the Cotton festival in Memphis, Tenn., but still more in the Rose Bowl parade in Pasadena, Calif., before the annual championship football game, and the Gasparilla parade and festival commemorating the early pirates at Tampa, Fla.

Of a more traditional nature was the annual celebration at Orleans, France, on the anniversary of the raising of the siege of the city by Joan of Arc, a pageantic activity in which the church, the university and the army participated. Much pageantry still survives in England in such official ceremonies as those attending the annual opening of parliament and the daily changing of the guard at Buckingham palace.

PAGEANT INTO DRAMA

The pageant took a long step in its progress from loosely knit entertainment to a tight literary form when Paul Green's *The Lost Colony* was produced on Roanoke Island, North Carolina in 1937. Written to commemorate the coming to the new world of the first full band of English settlers assembled by Sir Walter Raleigh in 1587, it concentrated its principal attention on just four characters and limited the action to four years of struggle in England and the wilderness. The well-knit story had a definite beginning, middle and end. The play took from the older pageant form the use of mass effect, spectacle, choral singing and dancing, but the several episodes had a close continuity and the author, while he remained true to the spirit of history, used some imagination to fill out the drama, especially in the closing part. Following the success of *The Lost Colony,* Green wrote a number of other outdoor plays in the same mold *(The Common Glory, Faith of Our Fathers, Wilderness Road,* etc.) and stimulated other authors, notably Kermit Hunter (*Unto These Hills, Forever This Land, Horn in the West, Chucky Jack,* etc.). All of these dramas dealt with aspects of U.S. history—the Indians' struggle for the rights to full citizenship, the movements of the pioneers and the epic struggles of the Revolutionary and the Civil wars. Produced in beautiful, large amphitheatres during the summer months, they drew hundreds of thousands of spectators annually. The term "symphonic drama" has sometimes been employed to describe this new form.

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PAGET, SIR JAMES, BART. (1814–1899), British surgeon, who, together with his friend Rudolf Virchow (*q.v.*), may truly be called the founder of the science of pathology, was born at Yarmouth on Jan. 11, 1814. In 1834 he entered St. Bartholomew's hospital, London, and during his first winter session he detected

Trichina spiralis, a minute parasite infesting human muscles. Richard Owen (*q.v.*), who gave these parasites their scientific name, is usually credited with the discovery, but he merely confirmed what Paget had detected. By 1851, when he was elected a fellow of the Royal society, Paget was known as a great physiologist and pathologist. His lectures on physiology were a turning point in the fortunes of St. Bartholomew's school.

In 1851 Paget began practice, and seven years later he was appointed surgeon extraordinary to Queen Victoria. He specialized in the pathology of tumours and diseases of the bones and joints, and was the first to urge enucleation of the tumour instead of amputation in cases of myeloid sarcoma. He gave original accounts of a precancerous affection of the areola and nipple (Paget's disease), mammary cancer and *osteitis deformans.* In 1871 he resigned his surgeoncy to the hospital and received a baronetcy. He was president of the Royal College of Surgeons (18751, Hunterian orator (1877) and president of the International Medical congress (1881) ; in 1883 he became vice-chancellor of the University of London. He died in London on Dec. 30, 1899.

See S. Paget, *Memoirs and Letters of Sir Jcntes Paget,* 3rd ed. (1903); F. Garrison, *Introduction to the History of Medicine,* 4th ed. (1929).

PAGET, VIOLET: *see* LEE, VERNON.

PAGET OF BEAUDESERT, WILLIAM PAGET, 1ST BARON (*c.* 1506–1563), English statesman, was born in London about 1506 and was educated at St. Paul's school, at Trinity hall, Cambridge, and at Paris. He was employed by Henry VIII in several important diplomatic missions; by Oct. 1531 he was a clerk to the signet and on Aug. 1.0, 1540, was appointed clerk of the privy council.

He became secretary to Queen Jane Seymour in 1537 and to Anne of Cleves in 1540, and in 1543 he was sworn of the privy council and appointed secretary of state. Paget supported the duke of Somerset during the minority of Edward VI. In 1547 he was made comptroller of the king's household, chancellor of the duchy of Lancaster and a knight of the Garter; and in 1549 he was made Baron Paget of Beaudesert. About the same time he obtained grants of lands in Staffordshire and the residence of the bishops of Exeter in London.

Paget shared Somerset's disgrace, being committed to the Tower in 1551 and degraded from the order of the Garter in 1552. He was restored to the king's favour in 1553, however, and was one of the 26 peers who signed Edward's settlement of the crown on Lady Jane Grey in June.

He made his peace with Queen Mary, who reinstated him as a knight of the Garter and in the privy council in 1553 and appointed him lord privy seal in 1555. On the accession of Elizabeth I in 1558 Paget retired from public life and died on June 9, 1563.

PAGODA, a towerlike, storied structure of stone, brick, or wood, usually associated with the Buddhist temple complex in Indian Asia, China and Japan. It derives ultimately from the stupa (*q.v.*) of ancient India. which was a domical funeral mound erected over the remains of a holy man or king. Perhaps the most celebrated pagoda in India was the multistoried tower erected by Kaniska I near Peshawar to enshrine a notable collection of the Buddha's relics. This famous tower, built up in the 2nd century of the Christian era. was the inspiration for the later pagodas of China and Japan, where the design always consisted of the repetition of a basic story unit (circular, square, polygonal) in regularly diminishing proportions. Each unit had its own projecting roof and the whole pile was capped by a prominent mast and disks.

The pagoda! like the stupa, was at first thought of as an architectural diagram of the cosmos. The great pillar which runs up the core of the building is symbolic of that invisible world axis which joins the centres of earth and heaven. The Japanese still refer to the four columns at the corners of wooden pagodas as the pillars of the sky. The separate stories, diminishing in size as they mount upward, may be thought of as the many terraces of the mythical world mountain. The disks which crown the structure correspond to the various heavens of the gods. The cosmic diagram, thus fixed in architectural forms, was thought to be animated by the precious relics which were enshrined within. The concept of the building as a magic diagram and its animation by the enshrining of relics probably had its origin in the altar of Vedic India.

The word pagoda, first used by the Portuguese in the 16th century in India, is a corruption of the Persian *but Kadah,* "idol house," or the Sanskrit *bhagavat,* "blessed."

Pagoda, or pagod, is also the name given to a gold coin once current in South India. *Plumiera acutifolia,* a tree indigenous to India and bearing yellow and white flowers, is known as the pagoda tree. *See* also CHINESE ARCHITECTURE; INDIAN ARCHITECTURE; JAPANESE ARCHITECTURE. (D. K. D.)

PAHARI LANGUAGE (properly Pahāṛī, the language of the mountains), a general name applied to the Indo-Aryan languages (*q.v.*) or dialects spoken in the lower ranges of the Himalayas from Nepal in the east to Chamba of Himachal Pradesh in the west. These forms of speech fall into three groups: (1) Eastern, consisting of the various dialects of Khas-kura, the language of Nepal; (2 j Central: spoken in the north of Uttar Pradesh, in Kumaon and Garhwal; and (3) Western, spoken in the country around Simla and in Chamba.

In Nepal, Khas-kura is the language only of the Aryan population, the mother tongue of most of the inhabitants being some form or other of Tibeto-Burman speech. Khas-kura is mainly differentiated from Central Pahari through its being affected by Tibeto-Burman idioms. Central and Western Pahari have not been brought into close association with Tibeto-Burmans; their language is therefore purely Aryan.

Khas-kura, as its speakers themselves call it, passes under various names; it is called Nepali or Naipali (*i.e.,* the language of Nepal), Gorkhali, or the language of the Gurkhas, and Pahari or Parbatiya, the language of the mountains.

Central Pahari includes two dialects, Garhwali, spoken mainly in Garhwal and the country around Mussoorie, and Kumaoni, spoken in Kumaon, including the country around Naini Tal.

Western Pahari includes a great number of dialects. In the area formerly included in the Simla Hill states alone no fewer than 22, of which the most important are Sirmauri and Keonthali (the dialect of Simla itself). were recorded.

To these may be added Jaunsari, spoken in the Jaunsar tract of Dehra Dun; Chambiali and Churahi, of the district of Chamba; Mandeali of the district of Mandi; Gadi of Chamba and Kangra; Kuluhi of Kulu; and others.

But the Aryan language of the whole Pahari area is now a form of Rajasthani, exhibiting at the same time traces of the old Khaśa language which it superseded, and also, in Nepal, traces of the Tibeto-Burman forms of speech by which it is surrounded.

Khas-kura shows most traces of Tibeto-Burman influence. The gender of nouns is purely sexual, and, although there is an oblique case derived from Rajasthani, it is so often confounded with the nominative that in the singular number either can be employed for the other. Both these are due to Tibeto-Burman influence, but the non-Aryan idiom is most prominent in the use of the verb. There is an indefinite tense referring to present, past or future time according to the context, formed by suffixing the verb substantive to the root of the main verb, exactly as in some of the neighbouring Tibeto-Burman languages.

In Eastern and Central Pahari the verb substantive is formed from the root *ach,* as in both Rajasthani and Kashmiri. In Rajasthani its present tense does not change for gender; in Pahari and Kashmiri it is a participial tense and does change according to the gender of the subject. This is a relic of the old Khaśa language, which seems to have been related to Kashmiri. Other relics of Khaśa are the tendency to shorten long vowels, the practice of epenthesis, or the modification of a vowel by the one which follows in the next syllable, and the frequent occurrence of disaspiration.

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PAHLAVI (formerly Enzeli), the principal port of Iran on the Caspian sea, 14 mi. N. of Resht, in 37° 29' N., and 49° 28' E. It has a mixed population of 31,328 (1956), including many Armenians, Turkmans and Caucasians. The port lies in the channel between two sandpits forming the entrance from the Caspian sea to a great *murdab* or lagoon (20 mi. by 7 mi.). The entrance, about 800 yd. wide, is protected by two breakwaters 500 yd. long. The harbour is entered by vessels up to 15 ft. draft except in bad weather. On both sides of the channel are wharves, piers, tanks for oil steamers and storehouses. There is a weekly passenger steamer service for Baku (20 hours), besides other irregular services.

The tonnage of the trade of Pahlavi was 133,585 in 1925–26, or almost twice as much as all the other Caspian ports put together, carried by 319 steam vessels, of which 305 were Russian. The value of the total trade in the same year was 188,223,000 krans (£ St. = 45 krans), of which 68,283,000 krans were exports, the chief items being rice (21,499,000 krans), hides and skins (12,310,000 krans), raisins (11,678,000 krans), raw cotton (8,649,000 krans), fresh and dried fruit, gums, textiles and raw silk. This trade greatly increased and an enormous volume of lend-lease material has passed through Pahlavi on its way to Russia. Pahlavi is the principal centre of the rice trade of Gilan. The port is connected with Tehran (247 mi.) via Resht and Kazvin by a road suitable for heavy motor traffic.

In 1926 the Junkers company was granted a concession covering all types of air transport between Pahlavi and Tehran, connecting with Europe via Baku (terminated in 1933). During World War I Pahlavi, then known as Enzeli, was held by the Russians. See RESHT.

PAHLAVI LANGUAGE is the name given by the Persians to the language of Sassanian Iran (see IRANIAN LANGUAGES). The name, which means the same as Parthian, is used in a broad sense by the poet Firdausi (10th century A.D.) in speaking of the pre-Islamic sources of his epic poem. Strictly speaking only that form of Middle Persian found in Zoroastrian books, on coins and in inscriptions is commonly called Pahlavi.

The script of the Pahlavi books is difficult to read and ambiguous, for the original 22 consonants of the mother Aramaic alphabet have been combined into only 14 in the Pahlavi descendant. The inscriptional alphabet is more archaic, and hence not as condensed and difficult to read as the book script.

Another difficulty and a peculiarity of the language is the use of Aramaic words which, however, are not to be read in their Semitic form but as Iranian. Thus MN, "from," which in Aramaic would be read as min, would be read as *hač,* the Iranian form. Not only nouns and verbs, but Aramaic numerals, pronouns and particles are used side by side with Iranian words. It was once thought that Pahlavi was a mixed language with a large foreign vocabulary, but it is now recognized that the Aramaic words are only ideograms, as in English "£" (libra) is pronounced "pound"; or "&" (et) is pronounced "and." This system, of writing in ideograms and reading them in their Iranian form, was called *Uzvārišn* or "interpretation." The system goes back in Iran at least to Achaemenid times when secretaries throughout the empire wrote messages in Aramaic, but read or interpreted them in the local language.

The *Uzvārišn* peculiarity of Pahlavi was known to medieval Arabic authors, and the explanation of it by Ibn Muqaffa' (8th century) was repeated in the Fihrist of Ibn Nadim, in Yaqūt's geographical dictionary and elsewhere. A preserved glossary, the Frahang-i-Pahlavik, gives the Aramaic ideograms in Pahlavi with their Iranian equivalents, but the defective, consonantal script of Pahlavi frequently makes the interpretations dubious. The Pāzand texts of Zoroastrian religious books, in which Aramaic words are replaced by their Iranian equivalents with vowels, are an important help to the reading of the ideograms since these texts are written in the clear Avestan alphabet.

The major part of Pahlavi literature is religious, including translations from the Avesta and commentaries on it. Little has survived from pre-Islamic times, and the *Bundahishn* and *Dinkart,* both religious works of the Zoroastrians, date from the Islamic period. There are a few epics and some short secular tracts in Pahlavi, but the preservation of any Pahlavi literature at all after the Arabic conquest of Iran is the result of the efforts of Zoroastrian priests who continued to write the old tongue after the victory of a new religion (Islam) and a new form of the language (New Persian) in the Arabic alphabet. Pahlavi manuscripts were preserved by the Parsees (Zoroastrians) of Bombay and elsewhere (including those in Iran).

It was Silvestre de Sacy in the early 19th century who began the decipherment of the inscriptions and laid the foundations for future work in Pahlavi. The discovery in Turfan, Chinese Turkistan, at the beginning of the 20th century of a Christian Psalter in Pahlavi, and other fragments, has greatly facilitated the understanding of the Zoroastrian Pahlavi texts. Other inscriptions of great importance for both language and history have also been found in Iran.

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PAIGNTON, urban district and seaside resort of Devon, Eng., on Tor bay, 25¾ mi. S. of Exeter by road. Pop. (1951) 25,553. Area 8.1 sq.mi. Although it was a market town as early as 1294, only during the 20th century did Paignton develop as a popular holiday place. Near St. John's church (mostly 15th century) is a ruined remnant of a former palace of the bishops of Exeter. It is known as the Bible tower from an erroneous tradition that Miles Coverdale translated the Bible while staying there in 1651.

Oldway mansion, built about 1900 by Paris Singer, of the United States, was modeled on the palace of Versailles. It is now Paignton's civic, social and recreational centre.

PAIN, BARRY ERIC ODELL (1865–1928), English humorous writer, was educated at Sedbergh and at Corpus Christi, Cambridge, where he was a prominent contributor to the Granta. James Payn inserted his story "The Hundred Gates" in the *Cornhill* Magazine in 1889, and he became a contributor to Punch, the Speaker and other papers. Discerning critics had already seen the authentic touch of comedy in his earlier work when Pain suddenly achieved fame with Eliza (1900). In Eliza's fussy, pompous husband he had found the matter for more than local comedy. Eliza had sequels, carrying on the tale of the family, and other excellent studies of London life followed, as well as some ghost stories. Pain possessed a rare gift of parody, and found subjects for his skits in many best sellers. One of the first of his essays in this kind was Another *Englishwoman's* Love Letters, and one of the last Madge Askinforit. He died at Watford on May 4, 1928.

PAIN. Pain is a specific sensory experience mediated through nerve structures which are separate from those which mediate other sensations such as touch, pressure, heat and cold. It is true that single stimuli which may excite one of these other sensations may also induce pain, but they do so by exciting the mechanism for pain as well as that for the other sensation. Evidence indicates that the adequate stimulus for pain is tissue damage, slight and altogether reversible, perhaps. but nevertheless damage.

The role of pain in the bodily economy seems to be chiefly as a warning of danger—the first evidence of tissue damage which, if continued or allowed to increase, might ultimately be irreversible. Pain, nevertheless, is not an essential accompaniment of tissue damage. Indeed, fatal illnesses and even injuries may be asso-

ciated with little or no pain. Neither is pain essential to human adjustment. There have been persons who congenitally lack the capacity to feel pain and who yet give no evidence of being handicapped by their sensory deficiency. Over the centuries man has learned to react to many warning signals besides pain. In fact the bulk of the alarm or defense reactions involved in common experience are initiated by stimuli which do not cause pain.

Pain as a Sensory Experience.—Pain on the surface of the body usually has a pricking or burning quality. From deeper tissue it is felt as aching. Variations in the aching quality depend mainly upon timing, location and intensity. Aching pains may be throbbing, wavelike, steady or intermittent. Also pain may radiate from one spot to another. Other factors which appear to lend "quality" to pain are those which ,characteristically aggravate or relieve it. Assuming that they remain intact, the nerves which subserve pain continue to conduct the sensation as long as the stimulus is applied. Thus, for painful stimuli, no true adaptation occurs as it does for touch. There may be apparent adaptation, however, when during prolonged stimulation the local situation in the painful part is altered so that the mechanism for pain is interrupted. For example, an injury to the skin may result in the formation of local oedema and thus increase the distance between stimulus and receptor.

Pain differs from other commonly experienced sensations such as sight, hearing, smell, touch and vibration in that its perception may be modified by analgesic agents. Morphine, codeine and alcohol do not affect the threshold or intensity of sensory experience other than pain. Pain has other individual qualities. It differs from heat and cold sensations in that it does not display the phenomenon of spatial summation. That is, when the area exposed is increased, the intensity of stimulus required to produce pain shows virtually no change. Furthermore, the intensity of two pains existing separately at the same time is no greater than that of the more intense of the two. In fact, the existence of one pain actually raises the threshold for perception of another arising in another region of the body. This effect was early noted by Hippocrates and is made use of when persons in pain bite their lips or drive their fingernails into their palms.

Threshold for Perception of Pain.—Pain of intensity so low as to be barely perceptible has been called threshold pain. As indicated above, it appears that the adequate stimulus for pain perception is tissue injury. It is not established, however, whether nerve endings per se have to be injured by the noxious stimulation. Neither is it certain that they need be stimulated directly. It appears rather that nerve endings may be stimulated as a result of liberated products of injury to other tissues.

Pain Pathways.—Neural impulses from noxious stimulation may be conveyed by nerve fibres of many sizes which follow a rich variety of peripheral nerve channels to the dorsal root ganglia where the cell bodies send projections into the dorsal horn of the spinal cord. From here secondary neurons carry the impulses across the anterior commissure to the opposite side and through the lateral spinothalamic tract to the brain, where the sensation is registered, interpreted and reacted to. The fibres involved in aching and burning sensations are anatomically and physiologically different from those involved in pricking pain. The latter, phylogenetically more recent, are myelinated, larger and conduct impulses more rapidly. Quantitative measurement of pain threshold became possible when an instrument was devised which could induce pain without major tissue damage by a stimulus whose intensity could be accurately measured in physical units. The available evidence indicates that all persons whose bodily structures are healthy have approximately the same capacity for perceiving pain. The weakest standard stimulus required to produce a recognizable sensation of pain in one person will have, roughly, the same intensity in all other healthy persons. Moreover, in the same person there is little variation from day to day or from year to year in the threshold for the perception of pain.

Threshold for Reaction to Pain.—Certain automatic responses to noxious stimuli which occur without awareness of pain are mediated through reflex axes in the spinal cord and brain stem. These reactions are characteristically inhibited and variously modified by impulses from higher centres set in motion as a result of perception and interpretation of the painful experience. Since most pains are interpreted as unpleasant, they give rise to a reaction of aversion on the part of the affected subject. What he thinks, feels or does about it constitutes his reaction to pain. Thus the threshold for reaction to pain, unlike the threshold for perception, varies within wide limits for given persons and for the same person under differing circumstances.

Distinction Between Pain Perception and Reaction to Pain.—The ability to perceive pain depends upon the intactness of relatively simple and primitive nerve connections. Reaction to pain, on the other hand, is modified by the highest cognitive functions and depends in part upon what the sensation means to the person in the light of his past life experience. This simple distinction between perception of pain and reaction to the experience was not at once appreciated by investigators, and consequently confusion existed regarding the nature of pain. Some held that it was not a sensation at all, but a "passion of the soul" which did not require separate neurologic pathways. However, this notion was dispelled by the experimental demonstration of a specific apparatus for the mediation and bringing to consciousness of painful impulses.

Range of Pain Intensity.—As already mentioned, distinguishably different sensations carried by nerve fibres which differ from one another in size are commonly classified together as painful. Not only are there distinguishable qualities of pain, but there are recognizable differences in intensity. It was found possible to recall with reasonable accuracy the intensity of a given pain from one day to the next. In the case of radiant heat focused on a spot in the blackened skin. maximal pain was induced by a strength of stimulus twice that of the threshold value. At this level, major tissue damage occurred. Further increase in the strength of stimulation failed to enhance the intensity of the pain felt. Thus a ceiling exists for pain intensity. It has been shown that there are approximately 21 distinguishable increments of intensity between threshold pain and pain of maximal intensity.

Referred Pain.—Often painful sensations from deep-lying structures within the body are felt in areas other than the site of stimulation. This effect has been called referred pain. It depends on the development of an excitatory state in the spinal cord at the level of the incoming noxious impulses. Depending upon their intensity, the excitatory state spreads by way of the neurons of the dorsal horn of the spinal cord and the association pathways to segments adjacent to the ones into which the impulses were originally conducted. In turn, fresh impulses travel to higher levels in the nervous system where the neural activity is ultimately felt as pain.

Hyperalgesia.—A second aspect of the deep pain experience is the local tenderness, superficial or deep, felt in the neighbourhood of the original noxious stimulus or in an area of referred pain, as in the abdominal wall over an inflamed appendix. The threshold for pain perception from the skin is not altered. but ordinarily non-noxious stimuli become capable of inducing pain owing to the effects of the central excitatory state referred to above, and noxious stimuli produce pain of greater intensity than they ordinarily would.

The term "hyperalgesia" is also used to describe the exaggerated sensory experience of pain which results from local tissue injury. This type of hyperalgesia is typically encountered in peripheral nerve lesions, where not only is the intensity of a noxious stimulus enhanced but the actual threshold of one type of cutaneous pain is lowered. In the case of the hyperalgesia which is characteristic of peripheral neuritis, for example, the threshold for the slowly conducted cutaneous burning pain may be greatly lowered when that for the more rapidly conducted pricking pain is elevated.

Characteristics of Central Excitation.—The damaging of tissue may initiate central hyperexcitation requiring little additional peripheral stimulation for its maintenance. Such hyperexcitation may become self-perpetuating but once interrupted may not recur spontaneously. Central excitatory phenomena are furthered and hindered by a variety of factors in the internal and external environment, and only in part are they dependent upon im-

pulses from the area initially damaged. However, heightened excitation in cerebral cortical and subcortical structures may be built up by prolonged, mild noxious stimulation, either from the periphery or from lesions within the brain itself.

Short, intercallated neurons within the segments of the cord and brain stem and probably in the cerebral cortex are essential to the phenomenology of pain, since they are responsible for the maintenance of augmented central excitatory states such as produce itching, hyperalgesia, altered discrimination of intensity, emotional excitement and complicated behaviour patterns.

Influence of Sustained Hyperaemia and Inflammation.— It is common experience that minor, ordinarily non-noxious stimuli applied to inflamed areas on the body are painful. In the reddened skin following exposure to ultra-violet light, a lowering of pain threshold as much as 50% was found. In the mucous membranes of the nose a similar lowering of pain threshold was found with hyperaemia, as well as in the mucosa of the viscera, including the oesophagus, stomach, colon and bladder. In fact, erroneous beliefs that these visceral mucous membranes were insensitive to pain arose because noxious stimuli, painful in the skin, failed to elicit pain when they were applied to the viscera. It is now clear that pinching, pricking or stimulation with faradic current induces pain in the mucous membrane of the turgid hyperaemic stomach, colon or bladder. Hyperaemia may have special importance with regard to the pain of peptic ulcer, since the stomach in this condition is known to be overactive and engorged with blood. When the stomach is in such a state, normal, forceful contractions are found to be painful.

Influence of Attitude and Suggestion on Pain Threshold. The ability to perceive pain is profoundly influenced by attitude and suggestion. By hypnosis, the threshold for perception of pain was raised 40%. Distraction induced by the clanging of a loud bell induced approximately the same effect. Autosuggestion and placebos thought by the subject being tested to be analgesic drugs had similar but less powerful effects.

Factors Involved in Reaction to Pain.—As noted above, it has been observed that under ordinary circumstances the threshold for pain perception remains relatively constant from one person to another and in the same person from day to day. In contrast, thresholds for reaction to pain were found to be highly variable. It has been found that neurotic patients in general have reaction thresholds which are significantly lower than those of healthy persons. Drugs such as alcohol and morphine which induce in the subject a feeling of freedom from anxiety may raise enormously the threshold for reaction to pain, thus exerting an effect several times greater than, and in addition to, their influence on pain perception. It has also been found that prize fighters and American Indians, as groups, fail to react to noxious stimuli of intensity great enough to induce a reaction of discomfort in the average white city dweller.

Surgically induced brain damage, notably of the frontal lobes, may profoundly alter reactions to pain without modifying its perception. Thus, a lobotomized patient with a lesion causing low-intensity noxious stimulation, when asked about his experience, may say, "I feel the pain, but it doesn't bother me."

Control of Perception of and Reaction to Pain by Drugs. —Therapeutically it is as important to deal with a patient's reaction to pain as it is with his perception, since it is the complaint of pain which the patient brings to the physician. In the case of headaches and other painful states, it has been shown that certain persons overreact to minor disturbances at the end organ and thus may become incapacitated by a sensation which another person might ignore. Drugs which interrupt the mechanisms responsible for pain must be distinguished from analgesic agents which modify sensory perception or reaction. Examples of the former group are atropine, which may relieve the pain of smooth muscle spasm by relieving the spasm, and ergotamine, which interrupts the mechanism for migraine headache by constricting overdistended arteries. Neither of these drugs is, strictly speaking, analgesic.

Among analgesics several drugs have been tested for their effect on pain threshold in man. Spme, such as acetylsalicylic acid, acetanilid, acetophenetidin and aminopyrine, act primarily on the threshold for pain perception, having relatively less effect upon the reaction to pain. In the case of each agent, an optimal dosage was found which afforded close to maximum pain-reducing action.

Another group of analgesics, including opiates and alcohol, owes its effectiveness to its ability to control reaction to pain as well as to raise the threshold for perception of pain. Furthermore, the relaxation, apathy and freedom from anxiety which follows the administration of morphine long outlast its effects on the threshold for pain perception.

In reviewing concepts concerning pain, it will be noted that until the end of the 19th century pain was considered to be exclusively a feeling state. Later. with the discovery of special anatomic equipment and mechanisms, interest was focused on the perceptual aspects of pain. Pain, to be sure, is a sensation, and yet because of its intimate linkage with strong feelings and other reaction patterns, the latter may be dominant in the experience. It is known that reactions to pain may be modified by strong beliefs. Although the common analgesics actually raise the pain threshold, they have a major function also in changing the attitude and feelings. Thus. we may support the old conviction that the feeling state is, to the one who suffers, perhaps the most relevant aspect of pain. Yet we can support as well the inference that pain is a specific sensation with its own structural and functional properties. It becomes apparent that these two concepts do not oppose each other; both formulate fundamental aspects of the pain experience.

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PAINE, ROBERT TREAT (1731–1814), American politician, a signer of the Declaration of Independence, was born in Boston, Mass., on March 11, 1731. He graduated at Harvard in 1749 and was admitted to the bar in 1759. In 1768 he was a delegate to the provincial convention which was called to meet in Boston, and conducted the prosecution of Capt. Thomas Preston and his men for their share in the famous "Boston massacre" of March 5, 1770. He served in the Massachusetts general court (1773–74), in the provincial congress (1774–75) and in the Continental Congress (1774–78), and was speaker of the Massachusetts house of representatives in 1777. a member of the executive council in 1779, a member of the committee which drafted the constitution of 1780, attorney general of the state from 1777 to 1790 and a judge of the state supreme court from 1790 to 1804. He died in Boston on May 11, 1814.

See John Sanderson, *Biography of the Signers of* ***The*** *Declaration* of *Independence,* vol, ii (Philadelphia, **1823).**

PAINE, THOMAS (1737–1809), English-American author and humanitarian, who was one of the most influential formers of colonial public opinion just prior to and during the American Revolution, was born at Thetford, Norfolk, the son of a Quaker corset maker. His early hardships as sailor, teacher and exciseman, and the death of his first wife along with his unhappy second marriage, help to explain his lifelong sympathy for the poor and unfortunate and his emigration to America (Nov. 1774) on Benjamin Franklin's recommendation. There he edited the *Pennsylvania Magazine* for 18 months successfully, coming to know such influential people as Pres. John Witherspoon of the College of New Jersey (later Princeton), the scientist David Rittenhouse and Benjamin Rush, who encouraged him to publish *Common Sense,* Jan. 10, 1776. The latter pamphlet, voicing with emotional fervour most of the persuasive arguments for independence from England, is credited by Washington with having "worked a powerful change in the minds of many men!" and it had enormous vogue, combining appeals to both the idealists and those interested in the colonies' economic advancement. While serving in the army as Gen. Nathanael Greene's volunteer aide-de-camp, Paine began his series of influential tracts called *The Crisis,* opening with the inspirational lines, "These are the times that try men's souls." As secretary of the congressional committee of foreign affairs in 1779 Paine became involved in the controversy regarding Silas Deane's agency

in obtaining French aid; Paine's indiscretion in publishing secret documents in the hands of the committee made it necessary for him to resign his secretaryship. His later position as clerk of the Pennsylvania assembly acquainted him with many revolutionary leaders, and he accompanied John Laurens to France in 1781 to secure aid. Paine's *Public Good* (1780) included one of the first calls for a national convention (looking toward something like the federal constitution) to remedy the ineffectual Articles of Confederation; this work also illustrates his pervasive advocacy of a strong union to which states' rights were to be subordinated.

The same direction of thought is apparent in his six letters (essays) to Rhode Island (1782–83), designed to get that state to pay its 5% impost. Having at first attacked rich men such as Robert Morris. he now accepted pay from him and his committee to write to persuade the people to accept restraints, notably in the *Dissertations on the Bunk* (1786) and other writings. attacking paper money as a balm to debtors, defending the Bank of Pennsylvania to prevent monopoly and enlarge the market for all. His public services were rewarded by the state of New Tork through the gift of a 300-ac. farm at New Rochelle, and by other gifts from congress.

From 1787 to 1802 he was in England and France, initially to perfect and market a pierless iron bridge (one of his many inventions), but mainly to act as a propagandist to get France and England to become republics. His *Prospects on the Rubicon* (1787) attacked Pitt's war policy. The hostile *Reflections on the Revolution in France* by Edmund Burke, whom Paine knew slightly, was answered by Paine in *Rights of Man,* part i appearing March 13, 1791, and part ii the next year, Feb. 17, 1792. Since these not only defended the early events of the French Revolution but provided a persuasive exposition of the principles of republicanism, large numbers of the *Rights of Man* were circulated among the common people by the Society for Constitutional Information and the London Constitutional society. Pitt, privately admitting the rightness of some of Paine's arguments, feared the masses would be incited by Paine to "a bloody revolution" and had him indicted for treason, but Paine escaped to France before the trial and was triumphantly elected to the revolutionary French Convention. On July 1, 1791, Paine led in the placarding of Paris with demands for a republic. With his friend Condorcet, Paine was consulted about framing a French constitution, although this was not adopted. Having courageously advocated the exile rather than execution of Ring Louis XVI, Paine incurred the suspicion of Robespierre and was imprisoned from Dec. 28, 1793, to Nov. 4, 1794, when with the fall of Robespierre he was readmitted to the Convention. Paine's *Age of Reason* (part i, 1794; part ii, 1796) was actually written, he said, "lest in the general wreck of superstition" in France "we lose sight of morality, of humanity, and of the theology that is true"—*i.e.*, that which seeks to prove the existence of a divine designer by the mechanistic design of the cosmos. However, the orthodox opponents of political reform both in America and England falsely accused Paine of being an atheist, and such charges, along with his hostile *Letter to Washington* (1796). enabled the U.S. Federalists to make a scapegoat of Paine in a vain attempt to undermine his friend Thomas Jefferson.

While Paine had begun by minimizing the need for government, he came in *Rights of Man,* part ii, *Address to the Addressers* (1792) and *Agrarian Justice* (1797) to advocate that government should become a beneficent agent with a positive humanitarian program including such measures as a progressive income tax to provide for the helpless and the aged. Paine expressed most completely the ideals of the Enlightenment, involving faith in the immutable law and order of nature as a divine revelation; the omnipotence of reason when there is freedom to debate all questions; tolerance; the equal rights and dignity of the individual; a religion of good deeds and humanitarianism; and peaceful cosmopolitanism. Jefferson, who had *Rights of Man* published in the U.S. to counteract Federalistic "heresy," said that he "professed the same principles," and hence Jefferson's election in 1800 would appear to prove that the majority of Americans at that time approved of those principles, which had been widely disseminated by about 40 Democratic-Republican societies in the U.S.

Paine failed, of course, to persuade the British to turn their monarchy into a republic, but it is possible that the immense discussion his principles aroused helped to sow the seeds which later flowered in the Reform bill of 1832. Despite the eventual triumph in the U.S. of his political principles, and the partial triumph of his religious principles in Unitarianism, however. Paine's tactlessness and occasional drunkenness (which he confessed to his friend and biographer T. C. Rickman) rendered him unpopular during his last seven years in America. He died in New York city on June 8, 1809. and his bones were removed in 1819 to England by William Cobbett.

His great success as a propagandist is partly accounted for by his literary program. He said he sought to write simply, candidly and clearly; to be bald and forthright in order to shock readers into attention, partly by sharp contrasts; to use wit and satire to bring opposing ideas into ridicule; to appeal not only to reason but to the heart; to balance imagination with judgment; "to fit the powers of thinking and the turn of language to the subject, so as to bring out a clear conclusion that shall hit the point in question and nothing else"; and to reduce "complicated things to method and orderly connection."

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PAINLEVÉ, PAUL PRUDENT (1863–1933), French mathematician and prime minister, was born in Paris on Dec. j, 1863. Educated at the École Normale Supérieure, he took his doctorate in mathematics in 1887 and became a professor of the Sorbonne where he won eminence as a brilliant mathematician. The Dreyfus case aroused his interest in politics and as an independent Socialist deputy for Paris from 1906 onward he took a special interest in military matters. In Aristide Briand's government of 1915 he became minister of public instruction and of inventions, and in \ Ribot's ministry of 1917 he served as minister of war. In Sept. 1917 he formed his own ministry, continuing as minister of war. In October, after reconstructing his ministry. he agreed to the setting up of the Supreme Allied council at Versailles and chose Gen. Ferdinand Foch to represent France. The next month his government was replaced by Georges Clemenceau's great war government.

With Edouard Herriot he helped to form the Cartel des Gauches which won the general elections of 1924, and he became president of the chamber until, in April 1925, he succeeded Herriot as prime minister. When Alexandre Millerand was forced to resign from the presidency of the republic in 1924 an attempt was made to get Painlevé elected in his place, but he was defeated by Gaston Doumergue. As prime minister he was confronted with acute financial difficulties arising from depreciation of the franc and the bad fiscal system. He summoned Joseph Caillaux to help as minister of finance, but his proposals were rejected by the Socialists and in October Painlevé had to dismiss Caillaux and take personal charge of finance. When his proposals for another capital levy and a moratorium on certain debts were also rejected he resigned in Nov. 192;. In the succeeding ministries of Briand and Raymond Poincark he served as war minister; and in 1930–31 and again in 1932–33 he served as air minister. Although he proved never to be more than a mediocre politician he was internationally recognized as a mathematician of outstanding ability. His many works on the subject include *Leçons sur le frottement* (1895) and *Leçons sur la théorie analytique des dquations différentielles* (1897). He was elected a member of the French Académie des Sciences in 1900, and was also a member of the academies of science of Bologna, Stockholm and Uppsala and of the Reale Accademia dei Lincei in Rome. He died on Oct. 29, 1933.

See G. André-Hesse, *Painlevé* (Paris, 1933). (*D.* TN.)

PAINT. A paint may be defined as a fluid suspension of finely divided solids which, when applied to a surface, will "dry" or set to an opaque film, either by oxidation or evaporation.

A paint consists of a mixture of (1) solid pigment (or a mixture of pigments) and (2) a liquid medium (known as the vehicle). The vehicle may be linseed or other drying oil; a water solution of casein or glue; a natural or synthetic resin solution in volatile solvents; a cotton ester solution in volatile solvent; or a natural or synthetic oil varnish base reduced for application with volatile solvent. The oil or other film-forming material is added to furnish a binder for the pigment, and the volatile material to give the paint the proper flowing consistency and to promote ease of application. When an oil paint is applied, the solvent, being volatile, rapidly evaporates from the painted surface, leaving behind the pigment and oil mixture as a wet coating; this mixture gradually dries into an elastic solid skin as a result of the oil's absorbing oxygen from the air. The solidified oil acts as a binder for the pigments and holds them in their place; a tough paint film is thus formed which adheres firmly to the surface and serves to protect and decorate.

A good quality of paint should be easily applied, cover well and be opaque or, as it is generally described, possess good hiding power. The hiding power of a paint is dependent on the amount and nature of the pigments it contains in suspension; and, as a rule, the finer the state of subdivision of the particles of the pigment the greater the hiding power. The durability of a paint is influenced greatly by the nature of the liquid portion, hence only pure drying oils or compounded vehicles of known performance should be used in its preparation. It is sometimes stated that the oil is the life of the paint. If this were true, oil alone should be more durable than paint, which is far from being the case, since, in fact. oil films do not wear as well as paint films because the addition of pigments to the oil films tends to reinforce them and to make them dry harder and become more impervious to air and moisture. Ordinary paints should dry with a glossy surface, but they can be made to dry with a flat finish by decreasing the oil content and increasing the proportion of turpentine or other volatile thinner.

The durability of an exterior paint can best be determined by practical exposure tests over a period of years. While raw or untreated drying oil is generally recommended. there are many special cases where oil processing and the addition of special resins is advantageous. On the other hand, the use of mineral oils, rosin oils, rosin varnishes or other soft resin varnish mediums may cause the rapid deterioration of paint films on exposure, resulting in the paint's cracking and chipping off after a comparatively short exposure.

The protective and anticorrosive properties of paint vary greatly with its pigment as well as its vehicle composition. For example, house paints are most satisfactorily formulated from lead, zinc and titanium oxide mixtures, properly balanced with lesser amounts of extender or suspending inerts. Where it is desired to protect ironwork, it is advisable to take advantage of the rust inhibitive properties of such pigments as red lead or the lead and zinc chromates.

Paints on exposure over a period of years may chalk (powder off), check, crack, blister or peel; the colour of the original paint may also change or even completely disappear. A high-grade durable paint for outdoor use should wear well over a period of four or five years, retain its colour, and chalk only to a moderate degree. Paints which blister or crack are unsatisfactory, inasmuch as it is then necessary to remove completely all the loose and badly adhering paint before any repainting can be done.

Pigments.— These are finely divided, insoluble white or coloured powders obtained from naturally occurring earth colours or prepared by chemical manufacturing processes. In the manufacture of paint, it is essential that the colours or pigments used should be in the form of a fine dry powder; this result is achieved by subjecting them before use to a grinding and sieving process, the final particle being generally less than two microns in size.

The pigments which are commonly used in the manufacture of paints are as follows: white pigments—basic carbonate and basic sulphate white lead, leaded zinc, zinc oxide, titanium oxide, zinc sulphide, lithopone and, to a lesser extent. antimony and zirconium oxides; inert pigments or extenders—barite. blanc fixe, gypsum (terra alba), magnesium silicate, Paris white (whiting), China clay, silica; yellow pigments—lead chrome and zinc chrome yellow, ochre, sienna, ferrite: cadmium sulphide, organic lakes and toners; *blue* pigments—ultramarine, iron blue (Prussian, Chinese, milori), cobalt oxide, copper phthalocyanine, organic lakes and toners; green pigments—chrome green (iron blue–chrome yellow), chromium oxide and hydroxide, phthalocyanine, organic lakes and toners, Paris green; red pigments—iron oxide, Venetian red! Tuscan red, red lead, organic lakes and toners (para, toluidine, lithol, alizarine), cadmium selenide; brown pigments—umber, sienna, iron oxide, Vandyke; black pigments—carbon black, lampblack, bone black, iron oxide, organic black graphite; metallic *powders*—aluminum, copper, zinc, lead.

For a fuller description of pigments, see PAINTS, CHEMISTRY OF.

Mediums or Vehicles.— These are the liquid portions of paints which act as binders for pigments. The vehicle of ordinary ready-mixed oil paint consists of raw linseed oil—or a mixture of raw and processed linseed oil—with a small proportion of turpentine, which is added to make the paint more fluid and to promote ease of working. As turpentine is rather expensive, turpentine substitutes, made from a petroleum distillate (white spirit), are often used as a thinning agent. A small proportion of liquid driers (terebine) is usually incorporated in the medium; these driers are solutions of salts of lead, manganese and cobalt, and they increase the rate of drying of the oil by what is known as catalytic action. The medium used in the preparation of varnish paints, which dry with a high-gloss surface, consists of an elastic natural or synthetic resin varnish. (See VARNISH.) Artists' oil paints are usually made in the form of a stiff paste and sold in tubes; the vehicle consists of either poppy-seed oil or sun-bleached linseed oil, which is used in order to retain the purity of colour of the pigment. A less satisfactory medium is megilp, composed of linseed oil and mastic varnish. The vehicles for artists' water-colour paints are chiefly solutions in water of gum arabic. albumen, isinglass and size. Distemper and water paints are made with emulsified glue or casein vehicles. The mediums of the modern cellulose paints or enamels consist of a solution of cellulose esters, in acetone, amylacetate or other suitable mixed solvents.

Manufacture of Paint.— The process of manufacturing oil paint consists in mixing the dry fine pigment with sufficient medium to convert it into the form of a stiff paste. This stiff paste is then transferred to a roller mill, or other grinding machine, finely ground and finally. conveyed to special paint-mixing machines, where it is thinned to the right consistency.

Usually a small proportion of paste driers or liquid driers is added at this stage to accelerate the drying of the paint.

As an immense variety of paint products are manufactured for industrial uses, it would be impossible to give more than a brief description of the most important varieties in common use.

Ready-Mixed Paint.— The commonest and most generally used paint is ordinary ready-mixed oil paint. This paint consists of pigments ground and mixed in a vehicle consisting of a mixture of raw and processed linseed oil, with a small proportion of turpentine. Pure pigments only are used in the preparation of many of these paints, but a proportion of some inert pigment or extender is sometimes added to aid in suspension and improve durability. These paints are manufactured in a large variety of colours. The most commonly used white paints are white lead and zinc oxide and titanium oxide paints.

Other pigments used in the manufacture of nonpoisonous white paints are lithopone and zinc sulphide. Titanium white was not introduced as a paint pigment until the second decade of the 20th century, but it came rapidly into favour because of its remarkable permanence and stability under all atmospheric conditions and also because of its obliterating power or opacity.

A white paint made with a mixture of zinc oxide and titanium white pigment as the base, and a vehicle consisting of processed oil or synthetic resin varnish, proved to give an excellent, durable paint suitable for exterior use.

The large variety of light shades or tints in common use are obtained by the addition of a small proportion of various-coloured pigments to white paint; thus, for example, white paint and a suit-

able black give grays from the lightest to the darkest hue. depending on the proportion of white and black used. Buff is obtained by tinting white with yellow ochre, cream colour results from adding a touch of chrome yellow to white and so on.

The amount of oil required to convert a pigment into paint form varies with the specific gravity of the pigment; a heavy pigment such as white lead (specific gravity 6.; j) requires considerably less oil than a bulky pigment such as zinc oxide (sp.gr. 5.47) or vegetable black (sp.gr. 1.72).

Enamel or Varnish Paint. — Enamel paints dry to a brilliant surface of varying degrees of gloss. They are made by finely grinding the selected pigment or mixture of pigments in a varnish medium, and their nature and properties depend on the type of varnish used. A quick-drying variety is made from a synthetic resin-base varnish (phenolic or alkyd). It dries in two to four hours and, contrary to experiences of earlier days when such quick-drying enamels were made from short oil, natural resin or rosin varnishes, these quick-drying enamels have a high degree of toughness and abrasion resistance, retain their gloss and fullness against repeated cleaning and have proved themselves highly suitable for all interior work. For outside enamelling. slow-drying processed oil base enamels continued to be used to some extent. but certain synthetic base enamels became increasingly popular and practically displaced the processed oil and copal varnish enamels of an earlier day.

Flat Paint. — This type of paint is really a flat-drying enamel. It is made in the same way as the gloss enamels, except that the pigment is less finely ground and the vehicle contains less varnish and more volatile solvent than ordinary enamel. Because of their pleasing decorative effect; these paints are used for interior decorations. but they are not suitable for outside use.

Anticorrosion Paints. — These paints are largely used for protecting iron and steel structures from rusting, A good antirust paint is red lead paint, which is made by mixing red lead with raw linseed oil. As red lead in linseed oil rapidly sets into a hard mass if kept for any length of time, it is necessary to mix it just before use. A nonsetting red lead was introduced which obviated this defect and would keep. when mixed in linseed oil, in a liquid condition for any length of time. The use of inhibitive pigments, such as lead and zinc chromates, also became quite general, as did the use of a preliminary phosphoric chromic inhibitive wash. Graphite paints, red oxide paints and paints made from basic sulphate of lead are also used for the preservation of ironwork. Bituminous paints are also extensively used for painting ironwork, such as gas holders, bridges, docks, etc., because of their comparative cheapness and anticorrosive properties. They are composed of an asphalt or bitumen base dissolved in coal tar or naphtha solvent. They are usually black, but other colours can be obtained, which are made by the addition of strong staining pigments to the base.

Antifouling Paints. — These paints are used on ships' bottoms in order to prevent the growth of barnacles and weeds.

They are as a general rule quick-drying iron oxide paints, to which a proportion of poisonous material. such as white arsenic, copper suboxide, mercury oxide, etc., has been added. In contact with sea water, these poisonous materials gradually dissolve and thus inhibit any deposit or growth forming on the ship's bottom.

Metallic Paint. — Metallic paints, such as aiuminum, copper, bronze and gold paints, are prepared by mixing the finely powdered metals or alloys with suitable varnish mediums. The metals must be in an exceedingly fine state of subdivision, and are manufactured from the metal leaf by special processes involving the use of intricate grinding machinery. The mediums used may be either thin varnishes or pyroxylin solutions.

Fireproof Paint. — These paints are made for use on woodwork, composition boards and other inflammable material. They are usually ordinary oil paints containing a proportion of fine asbestos, borax, sodium tungstate and other fire-retarding materials.

Automotive and Other Industrial Enamels.--A special class of exterior enamel for automotive or other vehicle finishing was developed on a quick-drying basis to replace the older multicoat slow-drying systems.

The lacquer-base (nitro cotton in suitable solvent) enamel introduced in the early 1920s was applied by spraying, dried in a few minutes; it could be polished to a high gloss, possessing exterior durability much superior to the copal varnish and processed oil enamels formerly used.

Synthetic resin enamels, mostly of the alkyd (glycerol phthalate) type, became increasingly popular for automotive and other industrial finishing. because of their superior gloss retention and general economy of application.

Synthetic base enamels of the phenolic, alkyd and urea resin types proved satisfactory in the finishing of household appliances. These are force dried at fairly high temperatures, have a beautiful lustre and are resistant to mechanical and chemical (washing powder, ammonia, grease, water, alcohol) abuse.

(J. G. Be.; E. E. Wa.; X.)

APPLICATIONS

In painter work the most important fact to remember is that the cost of applying paint is from four to five times the cost of the paint itself, and therefore to use materials of poor quality, because of their relative cheapness, is false economy. The decorative function of paint is ordinarily secondary in importance to its function as a protector of surfaces from decay. The paint used must be selected carefully according to the purpose for which it is to be employed. For outside use it is essential that the paint chosen should resist atmospheric weathering; in paints used for indoor work great durability becomes less important than a pleasing finish. In the article PAINTS, CHEMISTRY OF a detailed description is given of the composition of the paints in common use.

For good work it is essential to use brushes of a good quality. Brushes must be well cleaned after use, though for keeping overnight, it is generally sufficient to wrap them in several thicknesses of paper. Some painters keep their brushes soft overnight by putting them in water. If, however. the brush is not to be used for some time it should be well washed in turpentine and hung up to dry.

Painting Wood Surfaces. — One of the most important considerations is the proper preparation of the surface to be painted. It must be clean. smooth and completely dry before any paint is applied. If the old paint is cracked or in such a condition as to be ready to break loose as soon as a new coat is applied over it, it must be removed before repainting.

New wood requires a priming coat to fill the pores of the wood and to furnish a foundation. After the priming coat is thoroughly dry, all nail holes and cracks in the wood should be stopped with white lead putty; when hard, the surface should be sandpapered to make it smooth and even. Two coats of undercoating and a finishing coat are then applied.

Spraying or Dipping. — The method of applying paints by dipping or spraying is largely used industrially. In the spray process the paint is applied by forcing it under pressure through a spray gun; the dipping process consists in immersing the objects in the paint and subsequently hanging them up to dry.

Painting on New Galvanized Iron. — Paint will not adhere to new galvanized iron, because it has no grip on the smooth, greasy, metallic surface. To overcome this difficulty, new galvanized surfaces should be treated with a solution containing four ounces of copper acetate or copper chloride in one gallon of water.

Paint Troubles. — The quantity of driers required to make a paint dry in a reasonable time depends upon its composition, and also on the weather conditions when the paint is applied. Dark-coloured paints, such as black and purple oxide paints, require more driers than white lead paints; also more driers are necessary in winter than in summer.

Paint blistering is often caused by painting on damp work or timber which has not been properly seasoned. Blisters may also be caused by the use of too much oil in paint exposed to heat, or by the application of one coat upon another before the latter is properly dry. Cracking may be caused by the use of too much oil in the undercoats and too little in the top coats or by the paint's containing insufficient oil or a resin varnish.

If a paint is applied on a porous surface, or one that has not been properly primed, it will dry with a poor gloss. Paint when applied in damp or wet weather often loses its gloss and dries with a dull finish. (J. G. BE.; X.)

PAINTBRUSH, the name given to plants of the genus *Castilleja,* of the figwort family (Scrophulariaceae), parasitic on the roots of other plants. There are about 50 species, natives chiefly of the new world but with representatives in Asia. They are most numerous in the Rocky mountain region and on the Pacific coast. They are annual, biennial or perennial herbs, usually one to three feet high, with alternate, often deeply cleft or parted leaves and showy red, yellow or white flowers, borne in dense terminal clusters (spikes), the bracts of which are often highly coloured.

Hieracium auriantiacum, a member of the Compositae family, is commonly known as the devil's paintbrush.

PAINTER, WILLIAM (*c.* 1540–1594), English author whose collection of tales based on classical and Italian originals, *The Palace of Pleasure,* was a source book for many Elizabethan dramatists, was born *c.* 1540. Educated at St. John's college, Cambridge, he was ordained in 1560. In 1561 he became clerk of the ordnance in the Tower of London, a position in which he appears to have amassed a fortune out of the public funds. In 1586 he confessed that he owed the government £1,000, and in 1591 his son Anthony owned that he and his father had abused their trust, but Painter retained his office until his death in London in Feb. 1594. The first volume of his *The Palace of Pleasure* which appeared in 1566, contained 60 tales: it was followed in the next year by a volume including 34 new ones. An improved edition (1575) contained seven new stories.

The Palace of Pleasure is a collection of short stories or anecdotes, some borrowed from classical writers such as Herodotus or Plutarch, some from continental writers such as Cinthio (Giovanni Giraldi), Ser Giovanni Fiorentino, Straparola, Queen Margaret of Navarre, Boccaccio (probably through a French translation), Matteo Bandello (through the French of Belleforest) and others. To its popularity, and that of similar collections, is due the high proportion of Elizabethan plays with an Italian setting. The early tragedies *Appius and Virginia* by John Webster and *Tancred and Gismund* by Robert Wilmot were taken from Painter's book, and it was also the source for Shakespeare's *Timon of Athens* and *All's Well That Ends Well* (from Giletta of Narboune), Beaumont and Fletcher's *Triumph of Death* and James Shirley's *Love's Cruelty.*

See J. Jacob (ed.), *The Palace of Pleasure,* 3 vol. (1890), with an introduction on Italian *novelle* in Elizabethan drama. *The Palace of Pleasure* was also ed. by H. Miles, 4 vol. (1930).

PAINTING, in art, is the representation of form by colour and line on a two-dimensional surface. (For the technical aspects of paint, *see* PAINT; for its chemical properties, *see* PAINTS, CHEMISTRY OF.) It is probable that the origin of painting is not later than that of the plastic arts, for it is as ancient as sculpture and, within the somewhat narrow limits that confined it, early reached an astonishing perfection. For the story of its prehistoric beginnings, *see* ARCHAEOLOGY and AEGEAN CIVILIZATION (with which should be read the section *Archaeology* in the article CRETE); sections of the articles GREEK ART; ROMAN ART and BYZANTINE ART continue the story; *see* also EGYPT. The article ART treats in a general way many aspects of painting, and for oriental painting *see* CHINESE PAINTING; INDIAN ART; JAPANESE PAINTING AND PRINTS; and PERSIAN ART.

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RENAISSANCE AND MANNERIST PAINTING (14th-16th CENTURIES)

1. Background.—Romanesque painting, like architecture and sculpture, was in the service of the church. It was derived from Hellenistic, Byzantine and Celtic forms but developed new characteristics of its own. The Italian, French and Rhenish artists of the Romanesque period painted powerful religious images—sometimes wild and agitated, at times compellingly hieratic—as frescoes on walls of churches or as illuminations in manuscripts. The mosaic pictures on church malls are closely related to them. (See ROMANESQUE ART.)

The evolution of art in the 12th century would lead one to suppose that France would take the lead in painting as it had taken it in sculpture and architecture. But the development of Gothic architecture, which is one of the greatest glories of France, had as a result the great reduction of the employment of painting. Sculpture flourished on Gothic portals and magnificently adorned the façades of churches; but where, in the interiors of these cathedrals whose aerial construction almost did away with walls and replaced them by tall windows, could painting have been placed? There resulted another French invention, the art of figures in stained glass, which for nearly three centuries produced a series of masterpieces and took the place of monumental painting in those countries to which Gothic architecture spread. (See GOTHIC ART.)

On the other hand, a school of miniaturists was founded in Paris. Through the medium of leaves of parchment it created an art which rivaled glass painting for beauty and richness of colour, and exhibited a freedom and flexibility, a curiosity about nature and a subtlety of expression which was beyond the technique of glass work. Great Britain also experienced this development. (See ILLUMINATED MANUSCRIPTS; STAINED GLASS.)

2. Giotto.—In Italy Gothic architecture did not take root, or at least Italy adopted from it only the original vault while retaining many forms of Roman architecture and, in particular, the plain walls. Thus in Italy, because of this favourable circumstance and because of Giotto, a man of genius, and others of great talent who preceded, accompanied and followed him, the art of the fresco appeared and developed, and a great tradition of painting arose. When Giotto was born (1267) a French miniaturist was decorating with elegant little figures the Psalter *of* St. *Louis.*

In Italy there was a whole movement of art prior to Giotto. Giovanni Cimabue at Florence showed the way to Giotto in passing from the mosaic, still impregnated with Byzantine legacies, to the more free and flexible fresco work. Giotto, as well as Cimabue, was connected with the Roman school of mosaicists turned painters, Pietro Cavallini and the Cosmati, as well as with the work of Giunta Pisano, Nicolas d'Apulia and Coppo di Marcovaldo. But it was his own personal work that brought him glory. While accepting some of the conventions of his time, Giotto introduced into painting a simpler grandeur of conception, a hitherto unknown force of heroic human expression and that equilibrium of the spiritual and of the perceptible, of nature and of thought, which remain an ideal for the art of all time. Therein he is truly a precursor of modem art. His disciples and successors, without recapturing his grandeur, developed and enriched the heritage of their master. In place of the abstract decorations of Giotto, concrete details accumulated, compositions grew more complicated, and great ingenuity was exercised in the choice of dramatic or picturesque accessories ior the scenes depicted. The most justly famous work of the period is "The Triumph of Death," which, with a mixture of brutality and refinement, unfolds its eloquent teachings on the walls of the Campo Santo at Pisa.

3. Sienese School.—Parallel with that of Florence, a school of almost equal brilliancy, less powerful perhaps but more delicate, was developing at Siena from the Byzantine models. The "Maesta" of Duccio di Buoninsegna seemed to the Sienese, when they first saw it, so much of a miracle that the whole town, led by the bishop. bearing lighted candles in their hands, carried it in state to the Duomo. It is composed almost entirely of Byzantine elements: but its precious novelty lies in the gentle smile animating the face of the Queen of Heaven.

Simone Martini (c. 1284–1344) gave an even greater sweetness to his religious compositions while, at the same time, he was the first who dared to employ his art for purposes not wholly religious. On the walls of the Palazzo Pubblico, facing his lovely "Virgin in Glory," he painted the condottiere Guidoriccio da Fogliano riding armed and caparisoned before the palisades fronted by a hedge of lances. Following close upon him Ambrogio Lorenzetti established himself as a painter of civic life. Combining Simone's purely Sienese tradition with the influence of Giotto's more robust style, he celebrated in another room of the same palace the benefits of "Good Government" to town and country.

4. Early Renaissance in Italy.—At the beginning of the 15th century Italy showed signs heralding the Renaissance.

The painters not only mingled scenes of common life with their religious compositions, but they applied themselves with a kind of scientific realism to the study of the human form. Antonio Pisanello (c. 1395–c. 1455) was a marvellous draftsman. Masaccio (1401–c. 1428), a man of genius who died at the age of 27, was already a sort of classic. He, was keenly devoted to the study of anatomy, and the nude made its appearance in painting with his "Adam and Eve" in Sta. Maria del Carmine. Masaccio achieved a plasticity of form by means of modulation of light and shade. He also gives a feeling for space by his use of aerial perspective. The Dominican monk Fra Angelico (1387–1455), who well merited his title of Angelico, seemed destined by his piety to carry on the profoundly religious but abstract and severe tradition of Giotto, or perhaps the gentler one of Guido da Siena. But in everything which concerned him as a painter he showed a preoccupation with the world of nature similar to that of Masolino da Panicale and Masaccio. By a special grace he was able to apply his love of nature to the expression of the purest and most devout soul to be met with in the history of art.

In addition to this group of initiators whose work had already a classic air! more classic even in certain ways than that of their immediate successors who, like Sandro Botticelli, did not escape a certain mannerism, were certain seekers after the scientific spirit. These contributed to the formation of the doctrine of the Florentine school, intellectual and free, which was to become the educator of the great spirits of the full Renaissance. Paolo Uccello made of perspective a kind of mathematical poetry. Others, perhaps under the influence of the great sculptor Lorenzo Ghiberti, laboured incessantly to perfect drawing by the conquest of the third dimension. Andrea del Verrocchio, Antonio Pollaiuolo and Botticelli, who began their careers as sculptors, carvers or goldsmiths, added to draftsmanship, already so penetrating, a kind of trenchant or metallic precision, a sort of precious hardness. The most poetical of them, Botticelli (1444–1510), had also other preoccupations besides that of technical perfection. He was the inventor of a delightful type of Virgin. Better than anyone else of his time perhaps, he translated into painting with a mysterious, and at times rather morbid, grace the reveries of the humanists. The "Birth of Venus" and the "Primavera" opened a new world to painting.

Outside Florence, among the schools which had not had such long and such consistent histories, the fertile finish of the 15th cen-

tury saw the rise of certain men whose peculiar energy or original grace helped to prepare the complete expansion of Italian art in the first years of the 16th century. In Arezzo, Piero della Francesca (c. 1418–92), an independent painter in advance of his time, took up after an interval of 30 or 40 years the researches of Masaccio and invented engaging harmonies in blue and white of which Italian art offers no other example. His frescoes in Arezzo, depicting the "History of the Cross" (1452–66), are perhaps his most famous works. He does not give a picturesque description, but uses his figures and objects for a careful construction of a tectonic composition. His figures, carefully spaced and reduced to almost geometric forms, are composed in much the manner a Renaissance architect would place structural forms. Without ever introducing classical detail Piero comes closer to the true meaning of Greek art than any of his contemporaries who made abundant use of mythological subject matter and classical ornamental detail. Piero felt that harmony and proportion were characteristics of the divine order toward which the artist must strive.

The powerful anatomist Luca Signorelli was a precursor of Michelangelo. Antonello da Messina brought to Italy the brutal but expressive realism he had gained from contact with the Flemings.

Andrea Mantegna (1431–1506), humanist, geometrist, archaeologist, of great intellectual and imaginative intelligence, dominated the whole of northern Italy by virtue of his impervious personality. He had known the Florentine painters and the great sculptor Donatello in Padua. He was the link between Florence and Venice, whose school sprang from him through his more or less direct disciples, the Bellinis and Vittore Carpaccio.

5. France and Flanders. — During the 14th and 15th centuries painting developed through its own strength in the northern countries (France, Flanders and Germany), which came in contact with Italian art in a series of actions and reactions leading to reciprocal exchanges. Largely because of geographical position, France was specially predisposed to serve as a ground of understanding and conciliation between northern and southern influences. With the reservation already made that Gothic architecture did not there encourage the development of mural painting or of fresco, which remained the special province of Italy, France in the 14th century and at the beginning of the 15th century was a centre of artistic inspiration radiating in many directions and receptive of outside influences. Unfortunately, few works, with the exception of the miniatures, have been preserved. The portrait of the king Jean le Bon, in the condition in which it has been preserved, is merely an archaeological curiosity, but its date (c. 1350) is significant. It is a little later than the time when Simone Martini, almost in the same spirit and the same style, painted the condottiere Guidoriccio.

Later (toward 1415) the Trks Riches *Heures* of the duc de Berry, decorated by the three Limbourg brothers, contained little masterpieces, in which the themes of everyday life and of landscapes were treated with as much truth as poetry and, combining the most careful observation of the details of nature with refined fantasy, were executed with meticulous care. Commissioned at the Burgundian court, it is related to the art of Paris, Flanders and Siena.

During this period the disasters and miseries of the Hundred Years' War hampered the development in France of an art which had begun so well. Paris, occupied by the English troops, lost its predominance. The painters worked at Bourges, Dijon and Avignon. At Avignon they came in contact with the Italians, particularly with the Sienese summoned there by the popes.

Only a few important French works have been preserved, the Aix "Annunciation" (c. 1440) and the "Pietà" of Villeneuve-lès-Avignon (after 1450) among those by anonymous artists. They are paintings of extraordinary gentleness of emotion achieved primarily by a highly sensitive line and a subdued glow of colour. Among those by known painters, the "Coronation of the Virgin" by Enguerrand Quarton and the paintings and miniatures by Jean Fouquet (c. 1415–85) stand out. These justify saying that in the midst of its many trials France in the 15th century from time to time still produced original spirits unlike those of other schools and at considerable variance with each other.

Jan van Eyck (?1385–1441) was connected with the duke of Burgundy but he worked mostly in Flanders. He brought Flemish painting from the outset to an extraordinary degree of perfection, as much by his early use of oil paintings as by his aptitude for the representation of people and all manner of things — distant horizons, the bricks and stones of buildings, rich brocades — with an accuracy and precision hitherto unknown. The altarpiece of the "Worship of the Lamb" (the Ghent altarpiece), with its 12 exterior compartments and its 12 interior panels, was carried out between 1427 and 1432. From that moment Flanders dominated all art north of the Alps for almost a century, and was not without an influence on Italy.

There was nothing in the world then to compare with that interior with two standing figures known as the "Portrait of Arnolfini and His Wife" (1434; National gallery, London). This painting is remarkable not only for its careful observation of the visible world, including the painter's skill in representing textures, but also for its design of relating the deeply human figures to the surrounding interior space. Where will anything be found in the history of art superior to the precision and life to which Van Eyck attained from the first? But Van Eyck is more than the genial precursor of the Dutch masters of realism: he is the calm theologian who composes with the logic and authority of a doctor the multiple symbols of the altarpiece of the "Lamb" and who diffuses an equal and white limpidity over the images which unite the mysteries of heaven to the realities of earth.

Rogier van der Weyden (c. 1400–64), whose masterpiece, "The Deposition From the Cross," preserved in the Prado, dates from a few years after the completion of the Ghent altarpiece, is the only Fleming who truly carried on Van Eyck's great conception of art, and he added to it a pathos of which there is no other example in his country save, though with less nobility perhaps, that of Hugo van der Goes toward the end of the century. The other Flemish artists of the 15th century shone neither through their invention nor their emotion. They quickly reached either hardness or mannerism. Hans Memling at any rate charms by his graceful sentimentality. But they are all marvelous craftsmen, and even those least spiritually gifted force admiration of their virtuosity, the brilliance and refinement of their colour, all the characteristics which are not found among the French of the same period or, to the same degree, in Italy.

6. High Renaissance in Italy.—The Italian painters of the 15th century not only created significant works of art but, by their careful investigation of nature and by their conviction of the importance of man, solved many problems such as linear perspective and human anatomy. These artists were followed by other men of genius who achieved an ideal of human grandeur which is now conceived as the embodiment of the Renaissance. (See RENAISSANCE ART.)

7. Leonardo da **Vinci.**—Leonardo (1452–1519) was the first in date of the great men who had the desire to create in a picture a kind of mystic unity brought about by the fusion of matter and spirit. Building on the achievement of his predecessors and belonging to another generation and a changing social order, he was able to pronounce the words which served as a password to all later artists worthy of the name: painting is a "spiritual thing," cosa *mentale*. Leonardo, a man of great curiosity about the nature of the physical world, was a scientist who made important contributions in physics, geology, anatomy and other fields. He was an engineer, a musician and an architect as well as a painter. He developed Florentine draftsmanship and chiaroscuro and was able to give a more three-dimensional aspect to his figures and to integrate them into space and atmosphere. He was concerned not only with physical properties but also with psychological insight for his figures and was able to give them an appearance in which actuality is fused with ideal grace. Among his most important paintings is "The Last Supper" (1494–98) in Sta. Maria delle Grazie in Milan, which in spite of having been in bad repair almost from the time of its completion achieved renown as the typical representation of the scene because of its apparent simplicity of composition and deep human understanding. Leonardo's contributions to painting consist not only of his work as an artist but also of his significant

writings, especially his *Treatise on Painting* and his *Notebooks*. In the "Mona Lisa," the "St. Anne," the "Virgin of the Rocks" and his other masterpieces he even used landscape not merely as a more or less picturesque decoration but as a sort of echo of that interior life and an element of a perfect harmony.

Relying on the still novel laws of both linear and aerial perspective, this scientist and artist substituted for the discursive manner of most of his precursors the principle of concentration which is the basis of classical art. The picture is no longer presented as an almost fortuitous aggregate of details and episodes. It is an organism in which all the elements, lines and colours, shadows and lights, compose a subtle tracery converging on a spiritual: a sensuous centre. On a small panel. that of the "Mona Lisa," Leonardo seems to depict an epitome of the universe, creation and created: woman, the eternal enigma, the eternal ideal of man and the sign of the perfect beauty to which he aspires, nature here evoked by a magician in all its mystery and power. Behind the lovely, calm face, behind the forehead, young and yet thoughtful, appear mountains, glaciers, waters and rocks; and, in this very small portion of the painted surface, a vast revelation, beside the eternal feminine, of the earth.

8. Michelangelo. — Of this same Florentine draftsmanship enriched by Leonardo, Michelangelo (1475–1564), like Leonardo a man of great versatility, sculptor, architect, painter and poet, made the apotheosis of muscular movement and effort, which were to him the plastic equivalent of passion. He molded his draftsmanship, bent it, twisted it, constrained it to the extreme limits of possibility and to the pulsation of his great tormented soul. There are not, so to speak, any landscapes in Michelangelo's painting. All the emotions, all the passions, all the thoughts of humanity were personified in his eyes in the nude bodies of men and women. He never conceived these bodies — or rarely — in attitudes of immobility or repose. His great sculptured figures, his "Night," his "Slaves." his "Moses," whether they dream, meditate or command, give an impression of barely restrained tumult. In his great frescoes in the Sistine chapel of the Vatican he transformed sculptured form into awe-inspiring painting. A superhuman humanity seems to thunder down from the Sistine ceiling. There he re-created the mystery of Genesis with extraordinary power and vision. Later he painted a vast "Last Judgment" of extreme intensity on the wall of the Sistine chapel. Michelangelo's influence on later painters — from his own time until today — was perhaps greater than that of any other painter.

9. Raphael. — Raphael (1483–1520) is the modern artist who most closely resembles Phidias. The Greeks themselves said that Phidias invented nothing but that he carried every kind of art invented by his forerunners to such a pitch of perfection that he achieved pure and perfect harmony. Those words "pure and perfect harmony" express, in fact, better than any others that which Raphael brought to Italian art. From Perugino he gathered all the rather weak graces and the gentle limpidities of the Umbrian school that died out with him, he acquired strength and certainty in Florence, and he created a style based on the fusion of Leonardo's and Michelangelo's lessons under the light of his own noble spirit.

Raphael's compositions on the traditional theme of the Virgin and Child seemed intensely novel to contemporaries, and only their time-honoured glory prevents one now from perceiving their originality. No one before him had treated this holy subject with the poetry of a familiar idyll: with such an air of eternal youth, a limpid gentleness which excludes neither amplitude nor majesty of conception. He has in modern eyes a more magnificent claim to honour in the composition and realization of those frescoes with which, from 1509, he adorned the *stanze* and the loggias of the Vatican. The sublime, to which Michelangelo attained by his ardour and passion, Raphael attained by the sovereign balance of intelligence and sensibility. His two masterpieces, the "Disputa" or "The Holy Sacrament" and the "School of Athens," are self-sufficing worlds created by genius; they are admired for his perfect visualization of great ideas. his suppleness of gesture, ease of composition, the life which circulates everywhere with the light; but, above all, he has placed his figures into exalting spaces, giving an unequaled experience of spatial magnitude.

Rome became for almost two centuries the artistic capital, not only of Italy, but of the entire world.

10. Renaissance in the Northern Countries. — In France, the Italian influence, which had not. withered the freshness of Jean Fouquet's inspiration, became toward the middle of the 16th century so all-pervading that true French painting was in danger of losing its originality and even its vitality. The Fontainebleau school was a school of decorators comprising Italians summoned north by the kings of France, Italianized Flemings and some Frenchmen who were no less enslaved by Italian fashions. The national taste, however. showed itself in the fine psychology of the little portraits depicting in all their delicate elegance the men and women of the Valois court.

In Germany the fact that the greatest artist born beyond the Rhine absorbed Italianism did no more than stimulate his own imagination and perhaps widen its scope. Albrecht Diirer (1471–1528) had a genius too powerful to be conquered. His paintings as well as his woodcuts and engravings remained profoundly original in their intense vitality. In spite of all his tense energy, however, Diirer dominated the conflict of the passions by a sovereign and speculative intelligence almost comparable with that of Leonard~.He too was on the borders of two worlds, that of the Gothic age and that of the modern age, and was perhaps even greater as an engraver and draftsman than as a painter.

His contemporary. Mathias Grünewald (1475/80?–1528), painted religious themes of visionary expressiveness and mystical significance, using intense colours and agitated line.

Hans Holbein (1497–1543) was a cosmopolitan; born in Augsburg, he lived successively in Basle and England. The acute realism of a trenchant and precise draftsmanship combined with a certain Italian elegance to make him an admirable portraitist.

In the Low Countries Italian influence spread almost as widely as in France. But not being, as in France; evoked, sustained and controlled by a monarchical power, it left great individual freedom to the artists. Quentin Massys (1466–1530) was one of the first to look to Italy. The founder of the Antwerp school carried through his conversion to humanism with grace and naturalness.

Still farther north Hieronymus Bosch (c. 1450–1516) revealed hardly any Italian influence. His religious scenes and his allegories are treated with a fantastic vision based on his own pessimistic conviction. In his paintings, executed with most detailed realism, the borderline between the phantom and the real is almost eliminated, making his work appear related to 20th-century Surrealism. He does not seem to fit into the general tradition of Flemish painting, but appears to have exerted a profound influence especially on Pieter Brueghel the Elder (c. 1525–69), who, however, has a much more optimistic attitude toward life and the world. Brueghel painted vigorous scenes of peasant life and some of the finest landscapes in the history of western art.

Surely there was at this period a current of bizarre imagination circulating from south to north whose principal exponents were Grünewald, Bosch and Brueghel. The differences between them are great, but one characteristic was common to them all — the exaggeration and the oddness of the deliberate discord between the apparent subject and the pictorial methods.

In its most rigorous form the Italianist movement produced its own form of Mannerism, a hybrid art which amalgamated, more or less, a remnant of Flemish realism with the scenes, costumes, themes and even the rhetoric borrowed from Italy. Much talent was expended in the assimilation of a magnificent ideal, but one quite contrary to the traditions in which these northern artists were still brought up. The results were not often happy. Sometimes, however. they did not lack a certain composite charm when the true nature of the artist pierced his disguise. It must be remembered that this rather ungrateful school of Mannerists prepared the way for the greatest genius of Flanders after the Van Eycks, Peter Paul Rubens. He, however, was a pupil not of Florence but of Venice.

11. Venice. — Great changes had taken place in Italian art by the early part of the 16th century. After the death of Leonardo and of Raphael, Michelangelo pursued his career, while Andrea

del Sarto (1486–1531), with his scholarly modeling and his almost feminine gentleness; was the last exponent of the purely Florentine spirit. It was no longer in Florence or in Rome that the true heirs of the creators of classical art were to be found. but in Venice; where a school, the last born of the great Italian schools, prolonged with magnificent brilliance the glory of Italy after the disappearance or decadence of the older schools.

The first Venetian masters, the Bellinis and Carpaccio, were closely related to the robust and hard Andrea Mantegna. But they soon turned toward what may be esteemed the original conquests of their school, colour, light and a new conception of the place of the figure in landscape. Of monumental decoration, which has always been one of the principal vocations of Italian art, they evolved a truly new art by the addition of an indefinable quality, sumptuous and triumphant, which had not hitherto been seen in painting. They decorated churches and palaces, the same splendours and a kind of pagan pomp serving for both.

For some time past a profane or human air had been wafted into art; even at a time when painters treated only religious subjects, it was gradually felt, not perhaps in the frescoes decorating the sanctuary, but in the pictures ordered by kings and princes and chosen from such Bible stories as would with the greatest plausibility allow nude figures, or a certain amorous or voluptuous character, or a great display of processions and costumes: Salome, Susanna, Judith. Bathsheba. Indeed when the Olympian divinities appeared in art they found the way prepared for them.

Since its modest and devout beginnings in the shadow of the church, painting had gradually tried to rid itself of the didactic part allotted to it. On the day when the divorce was complete and irrevocable a new era began in art, an era which still exists, developing all that mas germinating in the masterpieces of Giorgione, Titian, Tintoretto and Paolo Veronese — for the Venetians played a preponderating part in this revolution. But this is not to say that either the painters or their paintings were detached from religious feeling. The artists always accepted with pride and joy their task as servants and auxiliaries of the church. But they no longer felt themselves charged with the duties of preaching and instructing. There remained to them the whole vast and multiform domain of sentiment. The delicious and tender Madonnas of Giovanni Bellini and Titian — sometimes familiar, as the "Virgin With the Rabbit," sometimes majestic, as the "Assumption of the Virgin," but always with their eyes glancing affectionately on the faithful spectators — have inspired and accompanied many prayers. As for Tintoretto, in the midst of the brilliant colour harmonies of Venetian painting his feverish and agitated spirit led him to rediscover the pathos of religious drama. Veronese's main preoccupation seems to be the grouping of beautiful young women and noble senators dressed in silk, brocades and gold chains under white arcades. Indeed he once had difficulties with the Inquisition, which inquired whether so many personages of so worldly an aspect were in place at the side of Christ; he replied that he had put them there simply because it looked well.

Because of the original feeling which each of the masters of this privileged school had for colour, and because of their marvelous facility in finding new arrangements, the Venetians were incomparable decorators. Their pictures in the churches, like the detail which for a moment had disturbed the ecclesiastical magistrates, "looked well." It was already a pious action to contribute to the beauty of the house of God. In fine, the least that can be said of these pictures is that they touched the hearts of the faithful.

One is reminded here of the part belonging to music in the celebration of the services of the church. Venetian painting possessed, more than any other painting which had preceded it, a musical quality. In this again it can claim the initiative of a transformation in art which has grown greater and greater up to modern times.

Giorgione's and Titian's beautiful reclining women. whether called Venus or any other name, are among the most original of the creations of the Venetian school. They differ greatly from the Florentine nude, which is generally standing. Venice developed the most complete and perfect subject of profane inspiration, a subject which has thrived in painting through centuries without becoming exhausted. One may describe it as the glorification of female beauty in the beauty of nature. From the first a painter of genius who died at about the age of 32, Giorgione (c. 1478–1510) gave the theme its most poetical and, at the same time, its most human realization in certain canvases attributed to him whose subjects are only the more moving because of their enigmatical quality: for instance, the paintings known as the "Tempest" in the Venice academy and "Concert Champêtre" at the Louvre. This development seems to have been in harmony with the aspirations of his compatriots and contemporaries, for four years after Giorgione's death and before Titian developed the theme and added to it the particular bias of his imagination the old Giovanni Bellini, then nearly 85, painted the noble and delicious "Feast of the Gods" (1514). which contained in embryo not only the "Bacchanal" of Titian but that of Nicolas Poussin. Titian, in the "Three Ages" (National gallery, Edinburgh) and the "Sacred and Profane Love," soon affirmed the various possibilities opened by the new theme to the creative faculties. The painter showed that he could dispense with the semblance of mythological fable which remained in Bellini's picture and which Giorgione had already eliminated: beautiful nude figures and others in rich modern costumes are juxtaposed, nithout any apparent reason, before a vast landscape in which there is a mysterious prolongation of the thought or the dream of the painter, as also of the thought or the dream of these modern deities. From Venice then came the poetry of the nude, of landscape and of the composition of figures in a landscape, as well as a warm tonality in the handling of colour.

This art, emancipated from strict obedience to the church, no longer expressed anything but the nostalgic dream of happiness which exists in the hearts of all men, and which even the worst mortifications and the darkest and bitterest days do not stifle.

The Venetians, particularly Titian, who stands above all the others, and Tintoretto, who sometimes rises almost to the heights of his master, were great portraitists. That melancholy which one perceives floating, as it were, on faces young and lovely imparts to those masterpieces of good painting a spiritual radiation. Between the magnificent nobles and the splendid creatures whom they delighted to deck in silk, velvet, gold and pearls this light shadow from the depth of the heart appears rather on the masculine faces than on those from which the locks of fair hair fall onto bare shoulders. It is this which forms, for example, the haunting attraction of the "Man With a Glove."

12. Italian Mannerism. — Between the Venetians and Rubens, who was their most legitimate and direct heir, were interposed certain eclectic schools in Italy, which could not perhaps boast of geniuses of the highest order but in which the talents were numerous and the activities considerable.

While the Venetian Sebastiano del Piombo became almost Florentine under the influence of Michelangelo, a true master arose near Venice. Is it possible to speak of a school of Parma? It includes only two great names, those of Correggio and Parmigianino. Correggio's art is like a lovely flowering branch detached from the Venetian tree. But Correggio (c. 1494–1534) was an original man who imitated no one. He was a brilliant decorator who was undaunted by the greatest tasks. He was a colourist and a harmonist. He achieved gracè even in vast compositions as the cupola in Parma, and he painted some of the loveliest of Italian easel pictures — "Antiope," the "Marriage of St. Catherine" and the "Education of Cupid." By his natural affinities he recalls at once Titian, Leonardo and Raphael.

Parmigianino (1503–40), one of the leading Mannerist painters, achieved an extraordinary grace and elegance in his work. His distorted figures occupy a compressed space and are a part of an aristocratic ideal of slender and refined proportions — a new and ennobled and spiritualized beauty in place of the more indifferent norm of the High Renaissance.

Correggio's purely instinctive example suggested to the Carracci the reasoned doctrine which the founders of the Bolognese school applied. There had been painters in Bologna before them, even in the middle ages, and in the time of Raphael, Francia had a great reputation. But the true Bolognese school, which set out to create a style common to all Italy, formed of the finest elements derived

from the greatest masters, was the outcome of the initiative of Lodovico (1555–1619), Agostino (1557–1602) and Annibale Carracci (1560–1609). They founded their celebrated academy in 1582 in Bologna. If they were in part responsible for what was later known as academism, that is, an art made of formulas learned by rote, their personal work was by no means negligible. They had ambition and the strength to respond to it. They were great decorators as the Farnese gallery bears witness; and their pupils, Guido Reni, Guercino and Domenichino, deserve almost equal esteem. The "Aurora" of Guido Reni in the Palazzo Rospigliosi is a large decorative work which in his own time was regarded as a worthy return to the ideals of Raphael. Guercino composed large altarpieces with a feeling at once dramatic and picturesque. And Domenichino, less of an improvisor and more unequal than his colleagues, sometimes, as in his charming picture in the Casino Borghese, the "Diana and Her Nymphs," recaptured beyond academism the accent arid the freshness of the great painters of the Renaissance. (See also MANNERISM.)

13. Spanish Mannerism: El **Greco.**—The same years of the 17th century which saw so great an expansion of Flemish and Dutch painting brought into the scheme of universal art a school which until then had remained aloof. Scholars began to study the origins of painting in Spain only comparatively recently and much is still obscure.

It seems that Catalonia was the principal seat of art in the 13th, 14th and 15th centuries. Artists first worked there under the almost solitary influence of the French miniaturists; later this influence was shared by the Sienese painters arriving in Spain by way of Avignon, while Flemish art also became popular. The Late Gothic style of painting in Spain, with its lavish use of gold, its emotional quality and its carefully painted detail, is a local manifestation of an international style which spread over Europe from the Atlantic coast to the Moldau in the 15th century.

The 16th century, in Spain as in Flanders, was an epoch of Mannerism. A cold and scholarly combination was created by the artists, who were theorists more than painters, between the Flemish realism and the classical models of the Italian Renaissance. It is curious that the man who in the 16th century seemed to be the most authentic representative of Spain was Anthony More (Antonio Moro) (c. 1512–75). Born in the Netherlands, and highly favoured by the courts of Brussels, London and Madrid, he painted portraits of admirable truth and dignity. It was yet another foreigner who soon afterward offered to Spain an art in which it could recognize its mystic and chivalrous spirit.

The Cretan Domenico Theotocopuli, called El Greco (c. 1542–1614), studied in Venice, probably in Titian's studio. and his first works bore the marks of their Venetian origin, mingled with the influences of Michelangelo and the Florentines and Mannerists. He arrived in Spain about 1575 and soon settled at Toledo. There was no doubt a mysterious affinity between this former Greek, whose imagination seemed to have preserved the hieratic figures of the Byzantine mosaics and icons, and the strange town, the heart of religious and military Spain, where everything spoke of ardour, secrecy, spirituality and a sort of passionate austerity. El Greco, "the pupil of Titian," preferred the dramatic and tormented inspiration of Tintoretto to the nobly balanced conceptions of his master. Though unequaled he was always sincere to himself. This man, who seems more mystic than most medieval painters, links up with the most modern ideas of the pure essentials of art and the specific attitude of the artist, relying on the unverifiable truth of his emotion. He becomes a prototype of Expressionism. What sensation was to painters from the last third of the 19th century, an impulse of the soul was to El Greco, and in spite of the spiritual abyss between the two principles the plastic effects are sometimes similar. No one perhaps has seemed more indifferent, more disdainful. even, to material truth. His disproportionately long and twisted figures flout the most elementary rules of anatomy, and in spite of his ability as a portraitist his construction of faces is incorrect by physical standards. He twists lines and colours at his despotic fancy, and, with a cool colour scheme of predominating blacks and whites, all tend to an extraordinary intensity of expression. These lines in truth have the trembling elevation of prayer and ecstasy, sustained by a harmony resembling a night sky broken by violet-tinted clouds, silvery pallors, pale yellows and green lights. This man, who seems to care for nothing but what comes from his arbitrary fancy, was, by a miraculous paradox, a portrait painter when he wished to be.

El Greco's "Coronations of the Virgin," his "Assumptions," his "Resurrections" show that he is the only painter who has really spread celestial visions before mortal eyes; he painted them as he saw them. And in the great canvas which is perhaps his most famous nork, the "Burial of Count Orgaz," he achieved, as no one before him had done, an understanding and interrelation, which seem quite natural, between the supernatural and the material. One feels that this marvelous picture must have appeared complete to the imagination of the artist with its composition so bold and, one may even say, so true. Working during the climax of the Counter-Reformation, El Greco's personal mysticism leaves no place for doubt to heretics and skeptics. His figures are caught in a great emotional frenzy. Their elongation removes them from the material world. Religious drama is pictorialized by means of human figures, who themselves have become transfigured into vibrations of light and often appear as the tongues of a cool flame. An almost uncompromising realism and a spontaneous mysticism are thenceforth the two poles of Spanish art. Even in periods in which the desire for realism seems predominant, a sort of mystic vibration is never wholly absent.

II. BAROQUE THROUGH IMPRESSIONIST PAINTING (17th–19th CENTURIES)

1. Caravaggio.—The true original and revolutionary talent of the time grew up outside the schools. Michelangelo da Caravaggio (1573–1610) was as temperamental in his painting as in his mild life. He painted still-life subjects for the pleasure of painting independently of subject, and he carried his robust naturalism, his violent contrasts of bright light and opaque shadow, his taste for unusual and striking scenery and a kind of picaresque style, not without tenderness, into his great religious subjects. Caravaggio was one of the innovators of Baroque painting as well as a mainspring of Realism in painting. His influence was immense, first through those who were more or less directly his disciples, such as Bartolommeo Manfredi and Domenico Fetti, both excellent painters, the latter showing in several pictures a sincere observation of rustic life; but it extended farther. The Genoese and Neapolitan schools derived from him, and the great movement of Spanish painting in the 17th century was connected with these schools. In the following generations the best-endowed painters oscillated between the lessons of Caravaggio and the Carracci. The romantic Salvator Rosa and the fertile improvisor Luca Giordano covered the vaults of churches and the ceilings of palaces with brilliant compositions which heralded the work of Tiepolo. (See also BAROQUE ART.)

2. Venice.—Venice showed during the last period of its splendour the same independence as in its golden age. Neither academism chilled its liveliness, nor the influence of Caravaggio dulled its palette. In the mid-18th century, in the midst of a decadence from which Venice alone in Italy escaped. it gave rise to important genre painters like Pietro Longhi (1702–85), while Canaletto (1697–1768) immortalized the Venetian cityscape. Francesco Guardi (1712–93). a virtuoso of the brush, displayed in his views of Venice a freedom and an accent which were quite modern and seemed to be already of the 19th century. Indeed, his treatment of shimmering colour anticipated Impressionism. Giovanni Battista Tiepolo (1696–1770) was a decorator of the great lineage of Veronese, with a coloration which was less powerful but more delicate, luminous and truly aerial; and he had a flamboyant feeling and a festive liveliness when he portrayed in the Palazzo Labia the "Story of Antony and Cleopatra," his masterpiece.

A. FLANDERS

1. Rubens.—Peter Paul Rubens (1577–1640), a prolific genius, was a great humanist scholar and an important diplomat as well as a painter. His letters show him as an authority on subjects varying from archaeology to philosophy and politics. He was

embroiled in the religious and political struggles of his time, constantly working for the restoration of peace in Europe.

Although he lived the life of an aristocrat, his art shows strong roots in the robust life of the Flemish people. At the same time, however, he was able to absorb the lesson of the Italian Renaissance; he studied Michelangelo and Raphael. the Venetians and Correggio, as well as his contemporaries Carracci and Caravaggio. All this fused in his own personal and dramatic style.

If the Baroque is thought of as powerful, exuberant, sensuous and even explosive, Rubens is its perfect example. He was able to infuse his own astounding vitality into his religious or mythological paintings, portraits and vivid landscapes. He was a painter of never-ending powers of invention, and he organized his complex compositions in wildly moving, dynamic designs. Limitations of form and outlines of shapes are disregarded in favour of a constant flow of movement. His full-blooded, voluptuous women may not be to the taste of a less vigorous age but are related to the full and opulent forms which were Rubens' own ideal of womanhood and life in general.

By no means all of the canvases attributed to Rubens were painted by him. He had established a huge workshop and may have employed as many as 200 assistants and apprentices. But the original inventive designs underlying his paintings are generally his own. Rubens' laborious life was well ordered. The creator of so many delightful pagan feasts went to mass each morning before proceeding to his studio. He is the most illustrious type of a well-balanced genius, who combined passion and science, ardour and reflection. Through his pupil Anthony van Dyck, Rubens exerted an important influence on English painting for several centuries. His successors in France were Antoine Watteau and François Boucher, Eugène Delacroix and Pierre Renoir.

2. Van **Dyck.**—Rarely seen in one school are a great master and a disciple resembling each other so closely as did Rubens and Van Dyck; or such a resemblance, leaving as it did all freedom of invention to the disciple or, indeed, a fine painter educated by a great genius. Anthony van Dyck (1599–1641) inherited Rubens' marvelous facility in both draftsmanship and colour, and his touch has sometimes a charm and elegance beyond his master's. But this facility was not, as in Rubens. the instrument of a great mind which embraced without effort the whole world of art. Like Rubens, Van Dyck tried to amalgamate the influences of Italy and Flanders and he succeeded in some paintings which have a touching grace, notably in his "Madonnas" and "Holy Families," his "Crucifixions" and "Depositions From the Cross," and also in some of his mythological compositions. But his main glory was as a painter of most elegant and aristocratic portraits In this sphere he outdistanced his master and had no rivals save the great English portrait painters of the 18th century whose model he mas. The great "Portrait of Charles I" in the Louvre and the "Prince of Orange" in the National Gallery of Art in Washington, D.C., are works unique of their kind, for their sovereign elegance achieves by means of excellent painting a noble and subtle psychological and historical poetry.

3. Other Flemish Painters. — Around Rubens and Van Dyck a pleiad of excellent painters worked in Antwerp, which. since the first years of the 16th century, had taken the place of Bruges as the capital of Flemish art. Many assisted Rubens in the execution of his great decorative schemes such as the "Life of Marie de' Medici"—Frans Snyders and Paul de Vos, excellent animal painters; Jan Fyt. a still-liie painter. Cornelis de Vos (1585–1651) is a remarkable portraitist, even more realist than his master, Jan Brueghel (1568–1625), an outstanding painter of flowers and animals. Jacob Jordaens (1593–16'78) had a powerful temperament. At his best he rose almost to the level of Rubens, in his nudes.

David Teniers (1610–90) developed entirely from Rubens' "Kermesse" pictures, from which he took his dancing and drinking peasants and his fine landscapes. Their joviality is rather conventional and the somewhat superficial observation turns quickly to caricature. But all the material part of Teniers' painting—the surety of his touch, the transparency of his medium. his brilliant and subtle colour—calls for considerable praise. He shows the greatest faithfulness to nature in his landscapes; his delicate greens and his silvery light sometimes give a real distinction to his pictures when he restrains his too facile humour.

Adriaen Brouwer (c. 1606–38) is closer akin to the Dutch. He was perhaps the most important 17th-century Flemish genre painter. After an early influence of Pieter Brueghel the Elder, he felt the impact of Frans Hals and the Dutch painters, and his resultant work became more luminous, highly animated and fluid in its movement. In his many tavern interiors he shows the poverty and often the dissolute aspects of life. These small canvases are incisive records in which the artist never passed judgment.

B. The Netherlands: 17th Century

In the Netherlands at this time there was unfolding a magnificent and almost unexpected art. At a period when there was not yet any definite political division between the northern and southern parts of the Low Countries, there were few painters who could be regarded as specifically Dutch, for from the last third of the 15th century to the end of the 16th the Dutch could not be clearly distinguished from the Flemings. Geertgen tot Sint Jans (c. 1465–93), whose generally accepted works are rare, is the most remarkable talent in the 15th century. In the following generation Lucas van Leyden (c. 1494–1533) was a real innovator. His portraits are almost as incisive as those of the great Albrecht Diirer, his elder by 23 years. Indeed, without the Reformation, with its political and social as well as its religious consequences, the Dutch school would perhaps have continued to represent only a local variation of Flemish painting. But the Reformation won all the northern provinces of the Low Countries, which soon after called themselves the United Provinces; and Spain, after 40 years of fierce warfare, was obliged to recognize the independence of its former subjects.

The Reformation wanted churches devoid of images. The result was that there was no more religious painting. The current of naturalism which, since the Renaissance, had spread over the world, but which in Catholic countries conciliated itself with religious idealism and even placed itself voluntarily at the service of faith and dogma, reigned thenceforth in the Netherlands without obstacle or compromise. Painters no longer had to submit to the commands of a king, a court or a church. They had only to please the republican bourgeoisie who now enriched themselves and their country as merchants, bankers and ship brokers. Artists therefore painted pictures of dimensions and subjects suitable for the decoration of elegant but rather small houses. Portraits, landscapes, scenes of everyday life formed the themes of Dutch painting, thus foreshadowing the subjects of the 19th century.

An official and civic art existed only in the form of the collective portrait which displayed, around a banquet or council table, a group of town magistrates, professors, syndics of a corporation or officers of a company of volunteers. The Dutch painters immediately excelled in this untried genre. Hals was the first to interpret it; he was succeeded by Rembrandt, and Barthoiomeus van der Helst (*c.* 1613–70) followed worthily in the footsteps of these two leaders. Individual portraiture claimed also skilled craftsmen, Michiel Janszoon van Mierevelt, Paulus Moreelse, Jan van Ravesteyn, Thomas de Keyser and Ferdinand Bol.

Within the limits of a purely prosaic conception the Dutch were inventors, and at once they showed a perfection of a naturalistic technique which has hardly been surpassed or even equaled. It is possible that the first idea of the "Card Players," "The Drinkers," the "Concerts," the "Merrymakers" which were multiplied to infinity during more than two centuries derived from Caravaggio. Indeed the connecting link between the Netherlands and Italy is visible in the person of Gerard van Honthorst (1590–1656), who lived a long time in Rome, where he was called Gherardo della Notte, and who took back to his country two or three themes borrowed from his master Caravaggio, and a taste for interior lighting effects, achieved either by the skillful use of chiaroscuro or by a point of artificial light. But the Dutch painters soon abandoned what remained of the decorative and fanciful intentions of the Mannerist Honthorst. They desired no other muse than truth. To give a faithful and recognizable image of all which

could be seen in their own and their neighbours' houses, in the cultivation of the fields, by the side of and on the sea which was everywhere so close to them and which was perhaps the principal field of activity of this maritime people—such was the ideal of these painters; it was more exactly in harmony with their national spirit and temperament than any other example which might be cited. From thence came a tranquil certitude which is one of the distinguishing characteristics of Dutch art.

1. Dutch Masters.—Landscape had been brought to a high degree of poetry and truth from the time when the Limbourg brothers illustrated the *Très Riches Heures* of the duc de Berry—and later when the Venetians, in works of infinitely prolonged and magnificent resonances, made of it an ample melody uniting man to nature. At the same time when Poussin, assuming the Venetian ideal, added to it his note of noble and high intellectuality, it remained for the Dutch to create for the first time masterpieces which have no apparent ambition beyond the exact rendering of things hitherto deemed devoid of interest—but this superbly. In this connection may be mentioned the work of the two Ruysdaels, Jan van Goyen, the Van de Veldes, Meindert Hobbema, Jan Wynants, Paul Potter, Albert Cuyp, Jan van der Heyden and others.

Their innovations were hardly less great in genre pictures as they conceived them, though the origins of this style can be traced to the greatest of early Flemish painters, Van Eyck, when he painted "Arnolfini and His Wife" in the midst of the familiar setting of their daily life. The Dutch painters of rich or poor interiors, of taverns, artists' studios, fashionable parties in marble-paved halls hung with gilded velvet, gallant conversations over a table bearing wine and a long-stemmed glass, seem once again wholly preoccupied with a care for exactitude. But they compel admiration and even sympathy by the refinement of their colour, the exactness of the lighting, a touch of incredible sureness, at once precise and soft, and also because one may feel in the best of them a secret and intimate pleasure in the subjects they have chosen. of which their extraordinary virtuosity is only an instrument. Adriaen van Ostade, Gerard Terborch, Jan Steen and Gabriel Metsu, Pieter de Hooch and Jan Vermeer of Delft are painters who combine a positive insight into the life of the people with a perfection of rendering and often excellent pictorial qualities. Frequently the scenes are calm and quiet as in the work of De Hooch, Terborch and Vermeer, or they may be filled with unrestrained movement as in the tavern scenes of Adriaen van Ostade (1610–85) and Jan Steen (1626–79). Steen is uneven, but when he is well inspired he lavishes on the scenes of debauchery which he loved to depict the charms of a lively coloration and a sensitive touch. In contrast, Pieter de Hooch (1629–after 1683) has a more structural quality. His simple genre scenes relate interiors to outdoor space by means of glowing sunlight.

2. Vermeer.—While recognized today as one of the giants in the history of art, Jan Vermeer (1632–75) died a pauper and was completely forgotten until the late 19th century when the time was ripe for an appreciation of his work. He painted middle-class Dutch women reading letters, pouring milk, playing the virginal or selecting jewelry in simple rooms, lucid and quiet in their space. Here everything is clearly structured by means of geometric planes, generally rectangles, and unified by a clear and cool light which floods to every corner of his rooms. His subtle colour has also become a structural element. His translucent surfaces are achieved with faultless certainty and assurance, yet without any apparent virtuosity. Here within the period of the Dutch Baroque was a painter who achieved an almost classic serenity and order.

3. Hals.—Frans Hals (?1580–1666), on the other hand, painted genre scenes of great exuberance and free imagination. He is especially famous for his group compositions, as the "Arquebusiers of St. George" or "St. Andrew" which amply made his reputation. These officers in their fine uniforms, escorting the flag of their company, wished to bequeath to posterity a flattering likeness of themselves. Hals, with his vast facility, his unctuous and flexible medium, his gift of broadly touching in a human being in his own likeness, at least outwardly, found the means of introducing movement everywhere into his faces, into the hands about to grasp an object and also into the sumptuous ampleness of the clothes he painted. In his civic pictures the flags furnished him with picturesque backgrounds. But he was still more at his ease perhaps with the popular models who inspired his imaginary figures: the "Bohémienne" (Louvre), the "Guitarist" and the "Hille Bobbe" (Berlin). In these he achieved a great vigour of expression by the vitality of the brush stroke and the bold and cursory treatment of the canvas. Where Vermeer achieved permanence in his work, his contemporary Hals often caught a fleeting impression of his sitters.

4. Rembrandt.—When Rembrandt Harmensz van Rijn (1606–69) painted "The Anatomy Lesson of Professor Nicolaes Tulp" in 1632, he showed himself as a worthy successor of Hals as master of the group portrait. His great interest in the revealing and concealing characteristics of light were already evident. It seems probable that he studied Caravaggio and his style of luminist realism.

Rembrandt was born at Leyden, the son of a miller. At the time he was commissioned to paint the "Anatomy Lesson" he was a highly successful portrait painter, sought after by the well-established citizenry of Amsterdam. He was married to the patrician girl Saskia von Uylenborch and was perhaps the most respected painter of the city. He did not at once find the method of which he had need to express the still uncomprehended things he had to say; the audacious, broad and personal method admired in the masterpieces of his maturity and old age, in spite of its subtlety, was adjudged brutal and certainly helped alienate his public. He first had adopted a polished style similar to the manner of the "Little Masters" of his country which ended by degenerating into those *tours* de *force* of vain minutiae which made the reputation of Gerard Dou. If Rembrandt had only left the large full-length formal portraits which brought him success among the rich burghers of Amsterdam, he would count without any doubt among the excellent painters, but he would not be known as the sibyllic prophet charged with misery as well as blessings, creator of a new tongue for the translation of human sorrow, mercy, goodness and all the contradictions and anxieties of the human spirit.

From the time of his beginnings and of his success, lighting played a major part in Rembrandt's conception of painting, and he made it the principal instrument of his penetration to the essence of humanity. It already revealed to him the poetry of human physiognomy when he painted "The Sacrifice of Abraham" (1635), or that "Holy Family" so deliciously absorbed in its modest intimacy that it was formerly called the "Carpenter's Family," or the "Angel Raphael Leaving Tobias" (both of the year 1637). But soon he asked for something more. The so-called "Night Watch" (1642)—actually a day watch as revealed by the thorough cleaning of the canvas in 1946–47—marks at once the apotheosis of his reputation and the beginning of his fall from favour. Those important personages, the officers of the civic guard, in ordering this large canvas from him, gave him to understand that they regarded him as capable of rivaling the famous civic groups of Frans Hals. Rembrandt believed that he had henceforth enough authority to disregard the rules of this type of work. He painted the portraits and made them richer in profound humanity than the vivacious but superficial effigies of Hals. For the rest, he used imagination and fantasy to relieve a theme he considered too prosaic. Independent of the apparently enigmatic figures like that of the little girl with the cock, he had a genial inspiration which was misunderstood. He applied here fully for the first time his instinct for transfiguring in his own peculiar way even the most banal subject. He illuminates his characters from within as well as from the outside. As Eugène Fromentin said, the invention here consists in "illuminating an actual scene by a light which was not so, *i.e.*, in giving to a fact the ideal character of a vision."

Henceforth Rembrandt knew what he could do. He did not ever attempt to paint light for its own sake as did later the Impressionists. He used it as an instrument of projection and of expression of the invisible and the imponderable. Increasingly, he did not paint what he saw but what he imagined, giving form to his exploration of the human soul. He created a humanity feeble, tortured, miserable but upon which a ray sometimes fell from above, an ineffable pity, a mysterious consolation. A figure at once

divine and human appeared to those who had the eyes to see and concerned itself with the vicissitudes of the life of the humble, the figure of Christ bending over the wounds of soul and body, curing and pardoning, who says, "Remember that I am gentle and humble of heart. . . ." His religious paintings, however, manifest a highly individual moral response and differ significantly from traditional renderings. Like his powerful landscapes, his late biblical paintings reveal a pantheist attitude of mystical oneness. It is no exaggeration to say that, since the middle ages, Rembrandt is, with El Greco, and perhaps more than the exclusively mystic El Greco, the most religious painter. He was religious and human at once. His soul was ennobled by misfortune and his spirit continued to grow more powerful, more inventive, more touching.

According to Fromentin. "All is immersed in a bath of shadow, into which the light itself is plunged, save what is left outside to make it appear more distant, more radiant. turning the dark waves round lighted centres, shading them, crossing them, thickening them, rendering nevertheless the darkness transparent, the half-darks easy to pierce, giving finally even to the strongest colours a sort of permeability which prevents them from being black." Everything is personal invention, but only for his own usage. He had, however, carefully studied the Italians — Correggio and the Venetians as well as Caravaggio. But what he drew from them did not resemble them at all; it resembled nothing but himself.

Rembrandt had pupils. disciples, imitators. Some of them had talent, for example Nicolaes Maes, Govaert Flinck, Ferdinand Bol, Gerbrand van den Eeckhout, Aert de Gelder, Jan Lievens. Carel Fabritius alone was an exquisite painter, but, though a pupil of Rembrandt, he is nearer to Vermeer than to the painter of the "Pilgrims at Emmaus." But what were they beside him? When they rose nearest to him it was only to arrive at the height of his least good and least personal work. For, in the pursuit of an ideal so new and so difficult, how could he avoid partial failures?

Rembrandt suffered lawsuits and bankruptcy and went into debt. But as his official reputation and social standing broke down, he grew in stature as an artist. The ordinary enough portrait painter of the great bourgeois of Amsterdam of about 1640 became the admirable and incomparable painter, unceasingly renewed in the numerous tragic self-portraits of his old age and in those which he made resplendent with the goodness shining in the features of his servant and faithful friend, Hendrickje Stoffels. Then for the first time there is seen, as has been seen frequently enough in modern times, a great artist who renounced the comprehension of the public or even of self-styled connoisseurs, and whose one thought was to satisfy himself, to put the whole of himself and his dreams into his painting.

He never treated the subjects of real life which then formed the repertory of his Dutch contemporaries. But he painted the "Slaughtered Ox," an almost repulsive spectacle before which nearly all specialists in still life would have recoiled. Indeed it is not a still life such as was painted by other painters, even the best, as Jean Chardin. The uncompromising realism of the "Slaughtered Ox" is of the same order, and requires the same effort of imagination, as the pathetic realism of the portraits of old age, his religious scenes or his majestic and awe-inspiring landscapes.

Rembrandt had a universal curiosity. He thought of the great Venetians who breathed a noble and voluptuous liveliness, he borrowed their subjects and made of them an art out of the inner life and full of profound emotion. Mythological and religious subjects were treated as he treated his portraits. For, all that he took from reality and even from the works of others he transmuted instantly into his own substance.

After this magnificent expansion, toward the end of the 17th century the first signs of decadence began in the Netherlands. It was consummated in the 18th century. Nothing remained but a poor ideal of detailed execution which ended in dryness or insipidity.

C. Spain

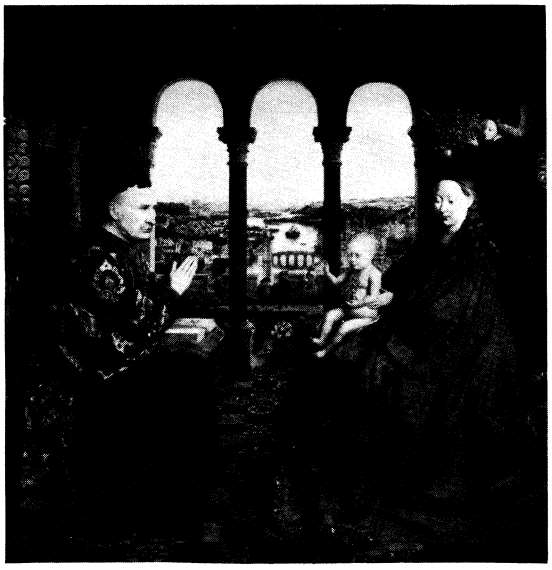
1. Ribera, Herrera and **Zurbarán.**—Spanish mysticism was seen in the work of several great painters who represented various regional tendencies, at Valencia in Jusepe de Ribera (1588–1652), at Seville in Francisco de Herrera the Elder (c. 1576–1656/57) and in Francisco de Zurbarbn (1598–1664). All three had been subjected to Italian influences. Ribera in his early days was a real Neapolitan, and at Naples was nicknamed Lo Spagnoletto. Zurbarán had been in Rome. But the national temperament was so strong in them all that there was no risk of their repeating the experiment of the 16th century and the Mannerists. They had no wish to extract an academic formula from their Italian models. Besides they went by instinct to the masters of naturalism and particularly to Caravaggio. Each in his own way applied to his subjects, whether sacred, profane or even popular, a disdain for convention ahich gives a new accent to traditional themes and a touch of the crude, the direct and the brutal to their vision of reality. but always with a feeling for the picturesque and the dramatic latent in all the scenes of life. The celebrated "Monk at Prayer" in the National gallery of London (officially called "A Franciscan") shows clearly how Zurbarán, the most idealistic and at the same time the most balanced of the three artists, arrived at an extraordinary intensity of spiritual expression by realistic means, as much in the individual character of the half-hidden face as in the striking rendering of the heavy robe and in the violent opposition of light and shade. This contrast of light and shade was carried by Ribera to its maximum of intensity, and he drew from it by turns effects of realism, tragic horror and even suavity. From Ribera's "Clubfoot" and others like it derive the popular types of Velázquez, the beggars of Bartolomé Murillo, the grimacing or burlesque figures of Goya, and even certain early works by Édouard Manet.

2. **Velázquez.**—Diego Rodriguez de Silva Velázquez (1599–1660) owed much to these excellent painters. He studied briefly with Herrera before working with Francisco Pacheco; but his youthful works show most strongly the influence of Zurbarbn and Caravaggio. The life and career of Velizquez recall Rubens. Both represent a magnificent expansion after a period of fruitful preparation. Both led brilliant lives and enjoyed the favour of princes. The duties of the court occupied an even greater place in the life of Velbzquez than in that of Rubens.

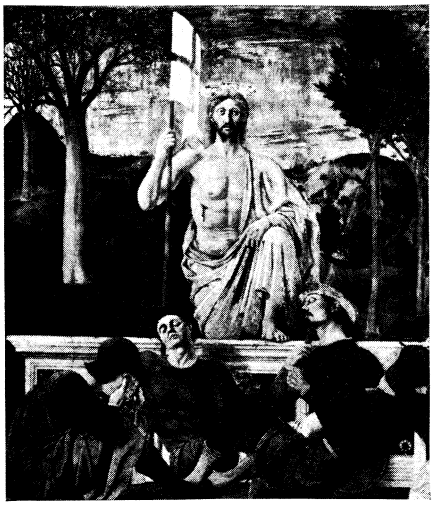
Velbzquez admired El Greco and even possessed some of his canvases He made Rubens' acquaintance during the latter's visit to Madrid. Above all, he had carefully studied the great Venetian and Flemish painters whose masterpieces adorned the royal palace. All this explains the development of the finest artist produced by Spain, one of the best interpreters of the visual experience seen anyahere. But it would have been insufficient without the gift of genius. This intelligent but passionless artist, this accomplished example of civilized man, had an almost limitless power over his own faculties. He wished at first to learn his work by principles; he exercised his eye and hand in the manner of Zurbaran in bodegones, still lifes and pictures depicting popular types. He succeeded from the first with a prodigious facility. He was not more than 19 years of age when he produced that "El Aguador" in which the distribution of light and shade, the truth of types and poses and their naturalness reveal his keen eye and his mastery of the brush. From that moment it was clear that he was destined to be an admirable portrait painter, elegant even in his popular types and his realism.

He might have been content with similar results and pursued the development of his personality with the aid of this quickly acquired and scholarly technique. But, soon after his arrival in Madrid and from the time that he was appointed painter to the king (1624), his style changed. He created for himself, by an act of his intelligence and his will, that facile. rapid and almost faultless technique, in which he combines power, breadth and mellowness. and seems with one brush stroke to render form, expression and light, a truly incomparable manner. It is unique in satisfying at once both the uninitiated spectator and the connoisseur: Velázquez' heads particularly, since he was primarily a portraitist, may be immediately appreciated by the most unlearned spectator, who can admire without effort their truth, their life and nhat seems to him their simple and striking effect. However, the initiate delights in the marvelous science. the subtleties and refinements which permit a gifted artist to realize a creation so similar, indeed so

"Annunciation with SS. Ansano and Judith," triptych by Simone Martini (*c.* 1284–1344) and Lippo Memmi (fl. 1317–57), Italian. Uffizi gallery, Florence



"Virgin of Autun" by John van Eyck (?1385–1441), Flemish. In the Louvre, Paris



"Resurrection" by Piero de' Franceschi (*c.* 1418–92), Italian. In the Palazzo Cornrnunale, Borgo San Sepolcro

"The Annunciation" by Fra Angelico (Giovanni da Fiesole; 1387–1455), Italian. Museum of San Marco, Florence

PAINTINGS OF THE EARLY RENAISSANCE

"The Tribute Money" by Masaccio (1401 – c. 1428), Italian. Brancacci chapel, Sta. Maria del Carmine. Florence

PHOTOGRAPHS, (TOP LEFT, CENTRE LEFT, CENTRE RIGHT. BOTTOM) ANDERSON; (TOP RIGHT) COLLECTION ARCHIVES PHOTOGRAPHIQUES

PAINTING

PHOTOGRAPH. THREE LIONS

Left: "The Kiss of Judas," one panel in a series on the life of Christ by Giotto di Bondone (1267?–1337). Arena chapel, Padua, It.

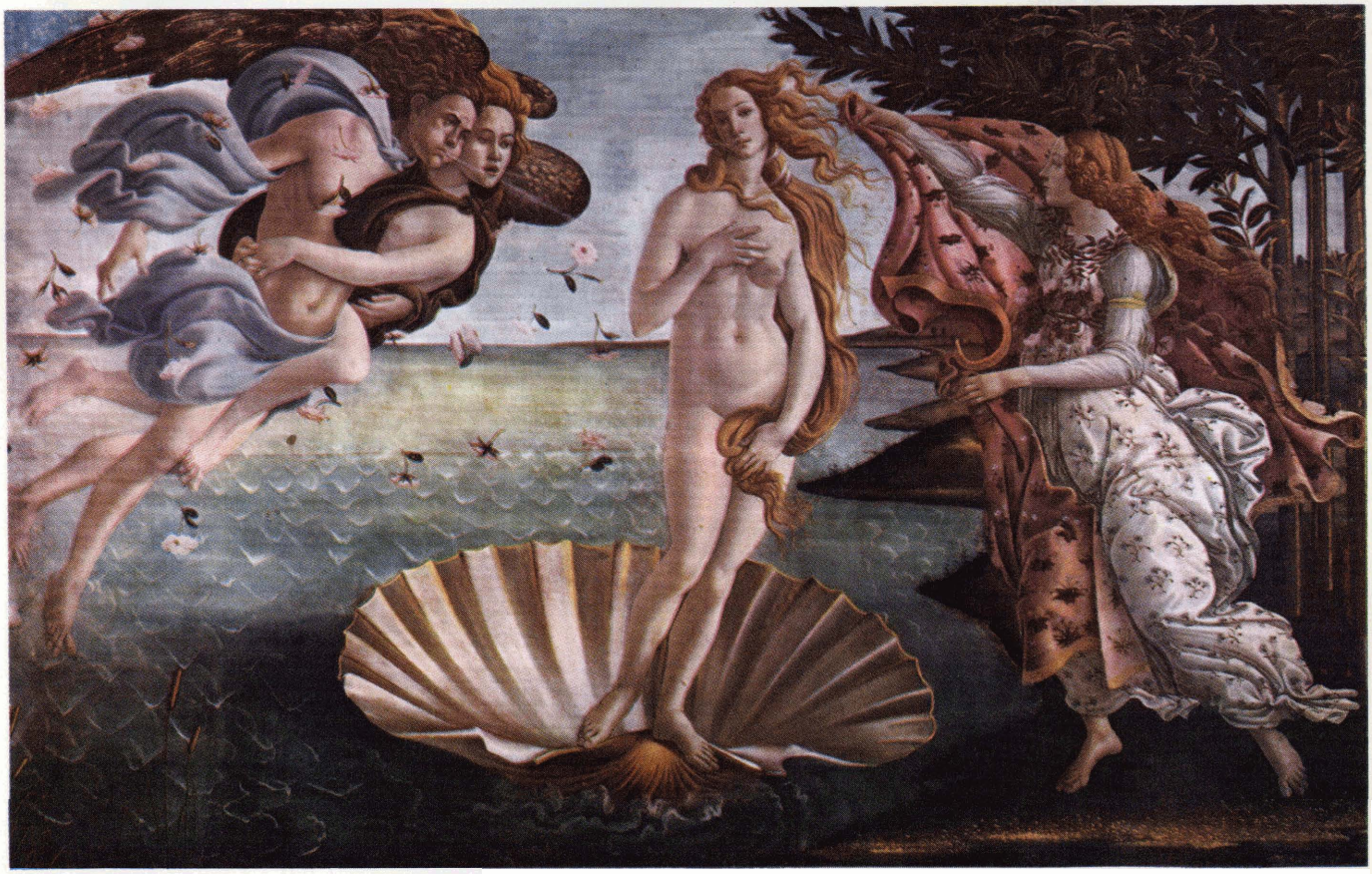
Below: "Pietà" by an unknown artist of the Avignon school, southern France, 15th century. In the Louvre, Paris

PHOTOGRAPH, CAMERA CLIX FROM PUBLIX

TWO MASTERPIECES OF THE ITALIAN RENAISSANCE

"Bridgewater Madonna" by Raphael (1483–1520), Urbino. In the collection of Lord Ellesmere, Edinburgh, Scot.

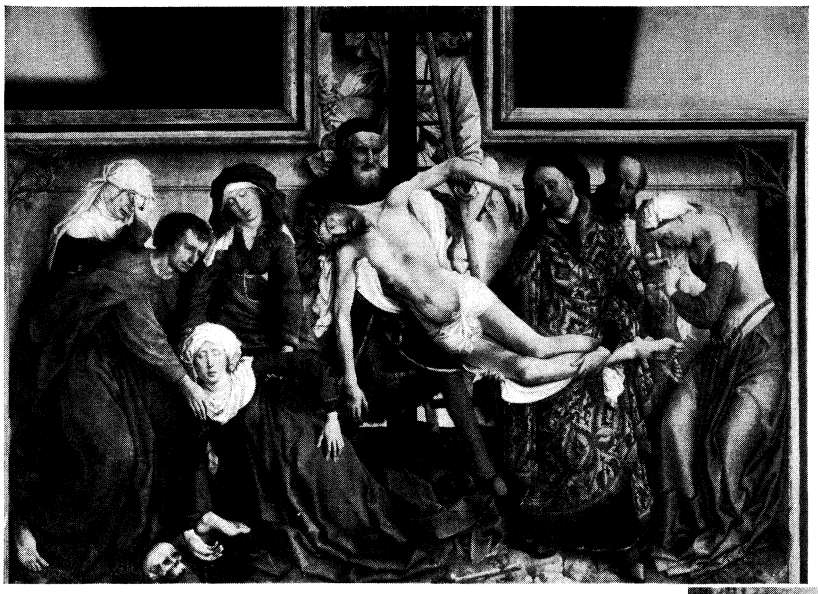
PHOTOGRAPH. CONZETT & HUBER FROM BLACK STAR



"Birth of Venus" by Sandro Botticelli (1444–1510), Florence. In the Uffizi gallery, Florence

PHOTOGRAPH, CAMERA CLIX FROM PUBLIX

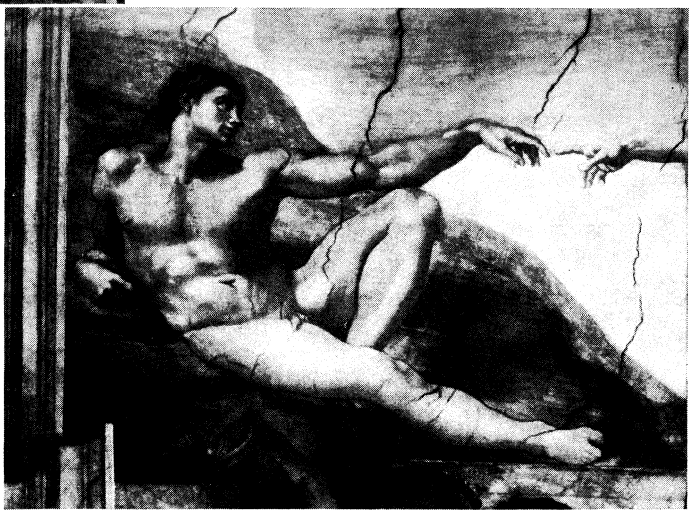
PAINTING



"The Deposition From the Cross" by Rogier van der Weyden (*c.* 1400–64), Flemish. In the Prado, Madrid

"Sir Thomas More" by Hans Holbein (1497–1543), German. The Frick collection, New York city

FLEMISH, GERMAN AND ITALIAN PAINTING OF THE RENAISSANCE



"Adam" detail from "Creation of Man" by Michelangelo (Michelagniolo Buonarroti; 1475–1564), Italian. Sistine chapel, the Vatican, Rome

"John and Peter" by Albrecht Dürer (1471–1528), German. Munich Pinakothek

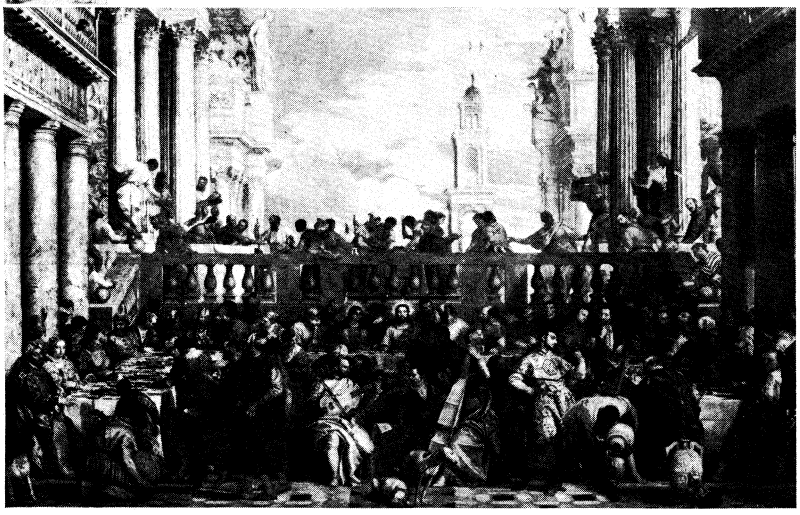
"Madonna della Granduca" by Raphael Sanzio (1483–1520), Italian. In the Pitti palace, Florence

"Mona Lisa" ("La Gioconda") by Leonardo da Vinci (1452–1519), Italian. The Louvre, Paris

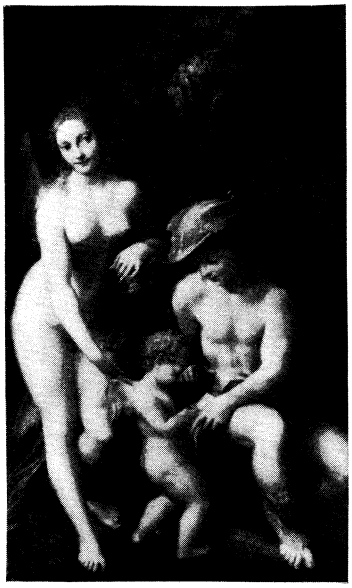
BY COURTESY OF (TOP RIGHT) THE FRICK COLLECTION RIGHT) COLLECTION ARCHIVES PHOTOGRAPH IQUES PHOTOGRAPHS, (TOP LEFT) ANDERSON, (CENTRE RIGHT, BOTTO" "TRE) ALINARI, (BOTTOM LEFT) HANFSTAENGL, (BOTTOM

"St. Francis in Ecstasy" by Giovanni Bellini (*c.* 1430–1516), Venetian. In the Frick collection, New York city

"Concert Champêtre" ("The Pastoral Symphony") by Giorgione (*c.* 1478–1510), Venetian. In the Louvre, Paris



"The Marriage at Cana" by Paolo Veronese (1528–88), Venetian. In the Louvre, Paris

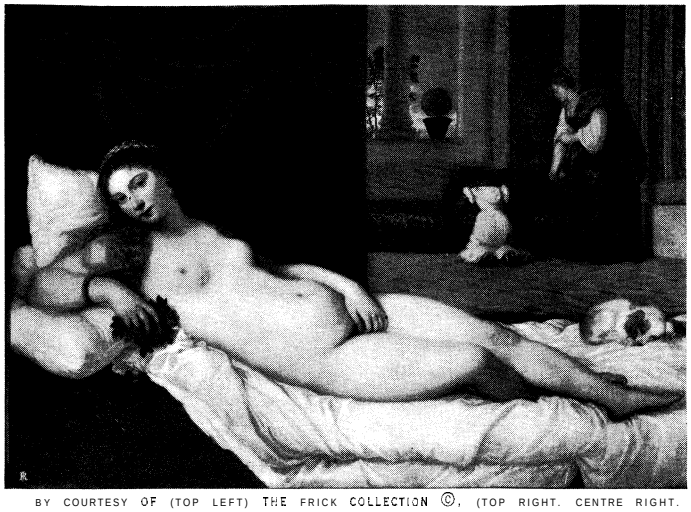


"Education of Cupid" by Correggio (Antonio Allegri; *c.* 1494–1534), north Italian. In the National gallery, London

CORREGGIO, CARAVAGGIO AND THE VENETIANS

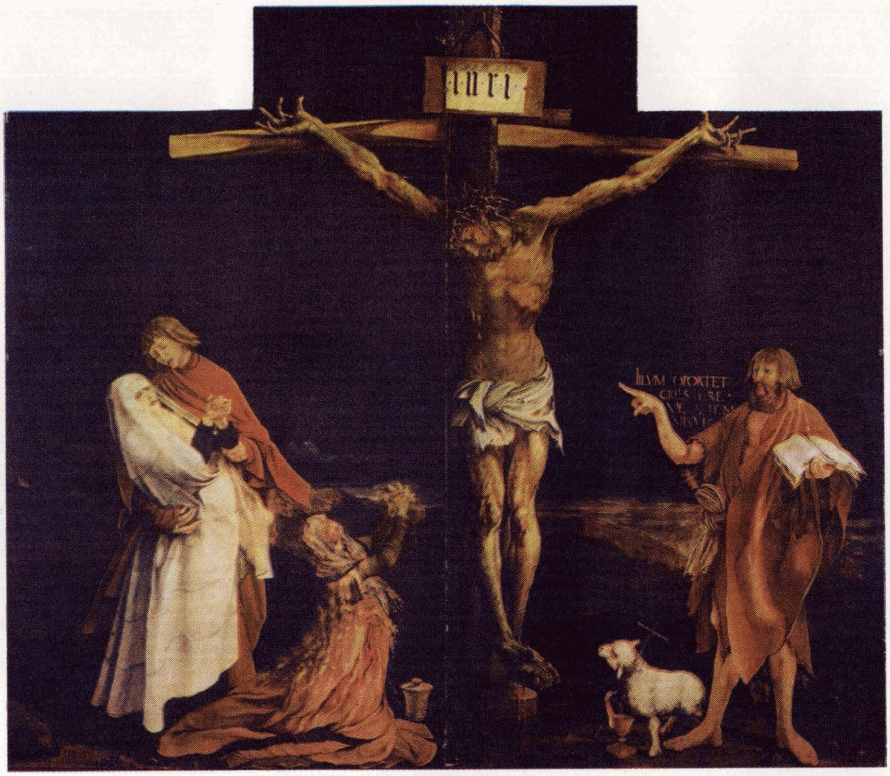
"Death of the Virgin" (detail) by Michelangelo da Caravaggio (1573–1610), Italian. In the Louvre, Paris

"Venus of Urbino" by Titian (Tiziano Vecellio; *c.* 1477–1576), Venetian. In the Uffizi gallery, Florence



BY COURTESY OF (TOP LEFT) THE FRICK COLLECTION ©, (TOP RIGHT, CENTRE RIGHT, BOTTOM RIGHT) THE MANSELL COLLECTION, LONDON, (CENTRE LEFT) NATIONAL GALLERY, LONDON; PHOTOGRAPHS, (TOP RIGHT, CENTRE RIGHT, BOTTOM RIGHT) GIRAUDON, (BOTTOM LEFT) ANDERSON

PAINTING



PHOTOGRAPH, ERIC SCHALL. "LIFE"

"Crucifixion" (centre panel of the Isenheim altarpiece) by Mathias Grünewald (active between 1500 and 1530). German. In the Unterlinden museum, Colmar, Fr.

GRÜNEWALD AND BRUEGEL

"Adoration of the Kings in the Snow" by Pieter Bruegel (1525?–1569), Flemish. In the Reinhart collection, Winterthur, Switz.

PHOTOGRAPH, CONZETT & HUBER FROM BLACK STAR

TWO VENETIAN MASTERS

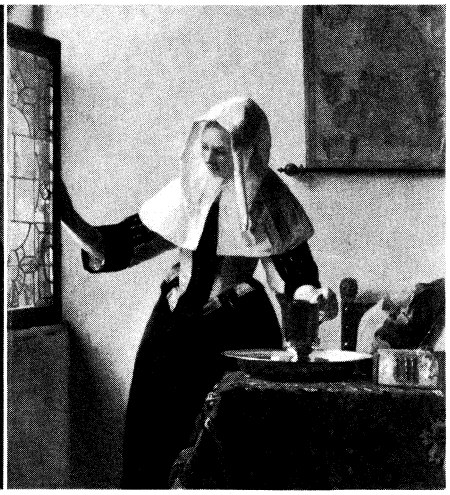
BY COURTESY OF THE ISABELLA STEWART GARDNER MUSEUM

"Rape of Europa" by Titian (Tiziano Vecelli, c. 1477–1576), Venetian. In the Isabella Stewart Gardner museum, Boston

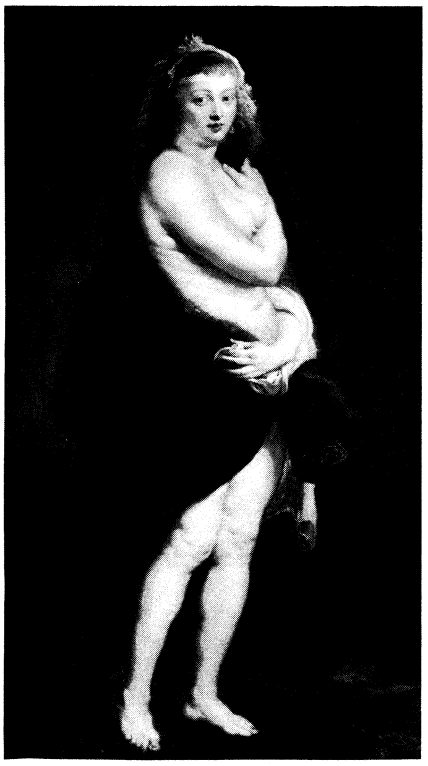
BY COURTESY OF THE NATIONAL GALLERY OF ART

"Christ at the Sea of Galilee" by Tintoretto (Jacopo Robusti, 1518–94), Venetian.
In the Samuel H. Kress collection, National Gallery of Art, Washington, D.C.

PAINTING



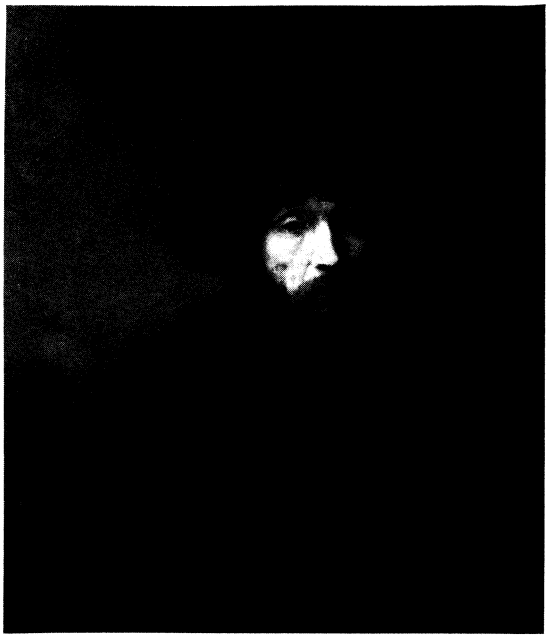
Above: "Frans Snyders" by Anthony van Dyck (1599–1641). Flemish. In the Frick Collection. New York city. *Above right:* "Young Woman With a Water Jug" by Jan Vermeer van Delft (1632–75), Dutch. In the Metropolitan Museum of Art, New York city



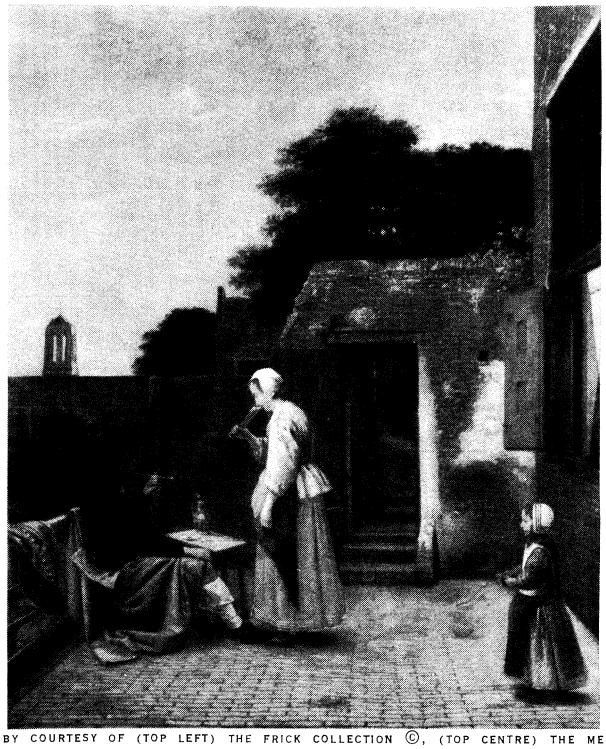
"Portrait of Helena Fourment" by Peter Paul Rubens (1577–1640), Flemish. In the State gallery, Vienna

"Bohémienne" by Frans Hals (?1580–1666), Dutch. In the Louvre, Paris

FLEMISH AND DUTCH PAINTINGS OF THE 16TH AND 17TH CENTURIES



"A Jewish Rabbi" by Rembrandt (Rembrandt Harmens van Rijn; 1606–69), Dutch. In the National gallery, London



"Courtyard in Delft" by Pieter de Hooch (1629–after 1683), Dutch. In the Mauritshuis, The Hague

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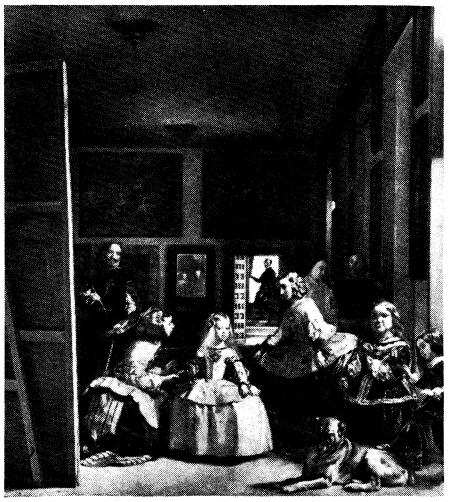
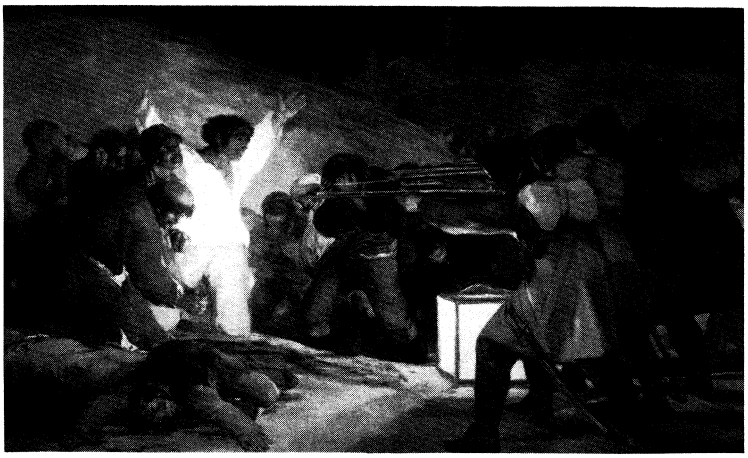
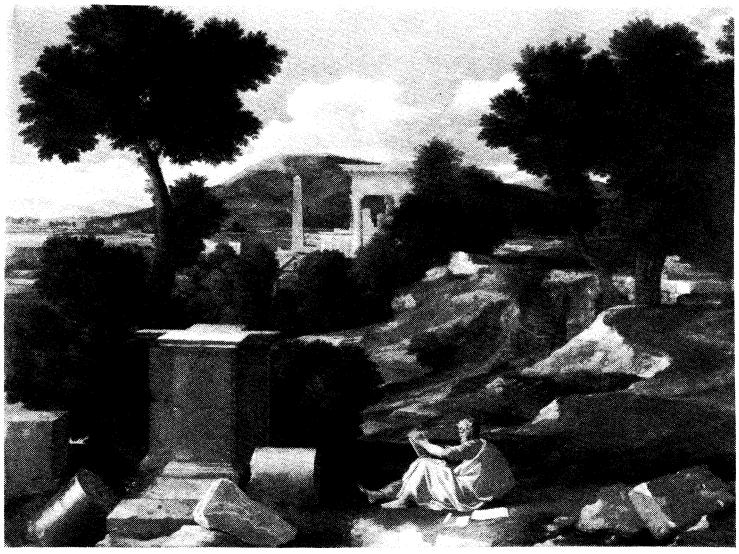


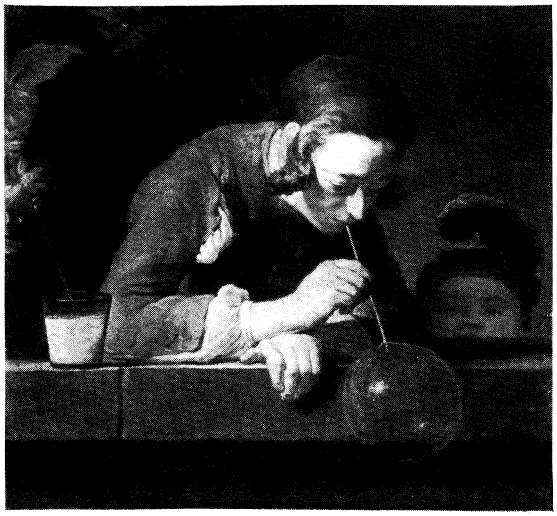
"Las Meniiias" ("The Maids of Honour") by Diego de Silva y Velázquez (1599–1660), Spanish. In the Museo del Prado. Madrid



"Shooting of the Rebels" (detail) by Francisco Goya y Lucientes (1746–1828), Spanish. In the Museo del Prado, Madrid

"St. John on The Isle of Patmos" by Nicolas Poussin (1594–1665), French. In the Art Institute of Chicago



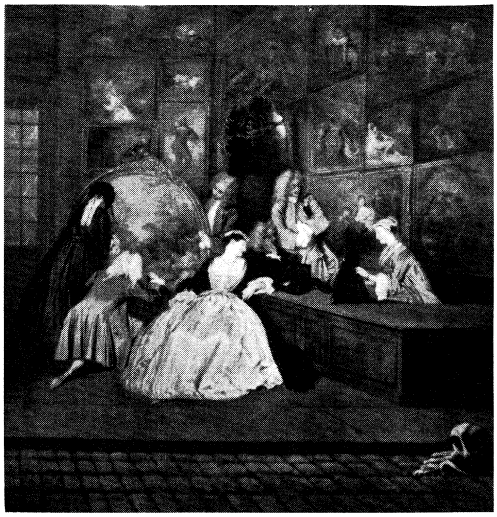


"Blowing Bubbles" ("Les Bouteilles de Savon") by Jean Baptiste Simeon Chardin (1699–1779), French. In the Metropolitan Museum of Art, New York city

SPANISH AND FRENCH PAINTING, 17TH–18TH CENTURIES

"Les Baigneuses" ("The Bathers") by Jean Honoré Fragonard (1732–1806), French. In the Louvre, Paris

Sign for Gersaint's shop by Antoine Watteau (1684–1721), French. In the Kaiser Friedrich Museum, Berlin



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PAINTING

RUBENS AND REMBRANDT

BY COURTESY OF BAYERISCHE STAATSGEMÄLDESAMMLUNGEN

"Rape of the Daughters of Leucippus" by Peter Paul Rubens (1577–1640), Flemish. In the Bayerische Staatsgernaldesarnrnlungen (Bavarian state art gallery), Munich, Ger.

BY COURTESY OF THE NATIONAL GALLERY OF ART

"A Girl with a Broom" by Rembrandt van Rijn (1606–69), Dutch. In the Mellon collection,. National. Gallery of Art, Washington, D.C.

BY COURTESY OF THE METROPOLITAN MUSEUM OF ART

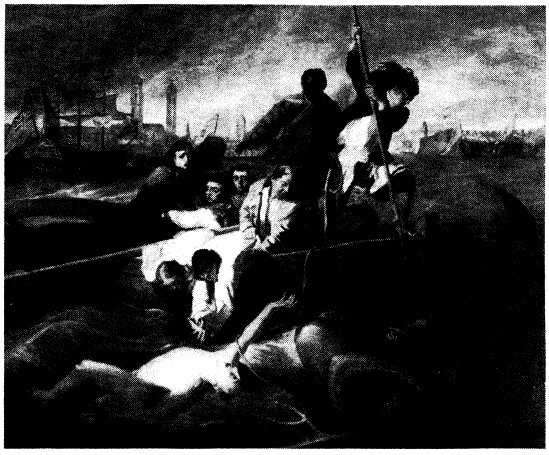
"VIEW OF TOLEDO," BY EL GRECO

El Greco (Domenico Theotocopuli, c. 1542–1614) was born in Crete but lived and painted in Spain. In the Metropolitan Museum of Art, New York city

PAINTING

"Shortly After the Marriage" (from "Marriage *à la mode*") by William Hogarth (1697–1764), English. In the National gallery, London

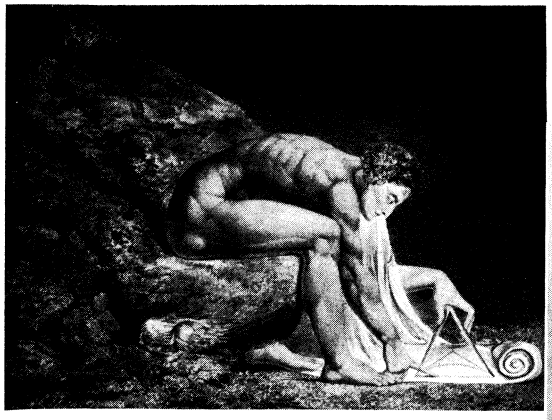
"Mrs. Siddons as the Tragic Muse" by Sir Joshua Reynolds (1723–92), English. In the Henry E. Huntington library and art gallery, San Marino, Calif.



"Watson and the Shark" by John Singleton Copley (1737–1815), U.S.-English. In the Metropolitan Museum of Art, New York city

18TH-CENTURY PAINTINGS BY ENGLISH AND U.S. ARTISTS

"Sarah Siddons" by Thomas Gainsborough (1727–88), English. In the National gallery, London



"Isaac Newton" by William Blake (1757–1827), English. In the Tate gallery, London

"Salisbury Cathedral" by John Constable (1776–1837), English. In the National gallery, London

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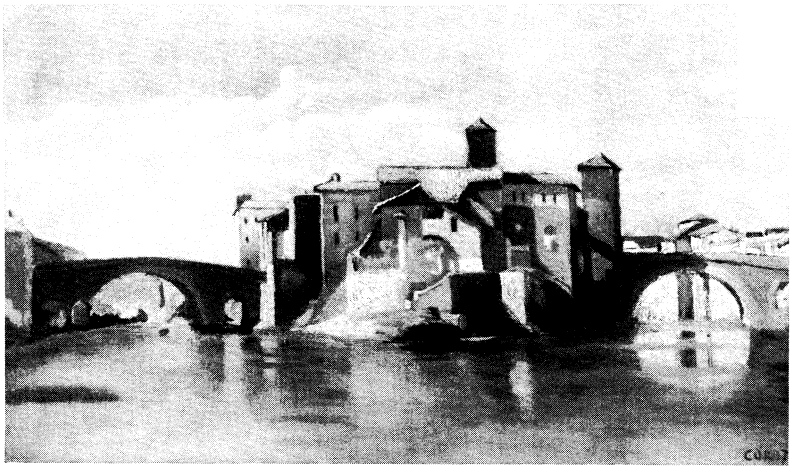
Top: "Portrait of Madame Sériziat" by Jacques Louis David (1748–1825). In the Louvre, Paris
Above: "Madame Rivière" by Jean Auguste Ingres (1780–1867). In the Louvre, Paris

"Radeau de la Meduse" ("The Raft of the Medusa") by Jean Louis Géricault (1791–1824). In the Louvre, Paris

FRENCH PAINTING OF THE 19TH CENTURY

"Island of San Bartolomeo, Rome" by J. B. C. Corot (1796–1875). In the Louvre, Paris



"The Third-Class Carriage" by Honoré Daumier (1808–79). In the Metropolitan Museum of Art, New York city

"Ladies on the Banks of the Seine" by Gustave Courbet (1819–77). In the Petit Palais, Paris

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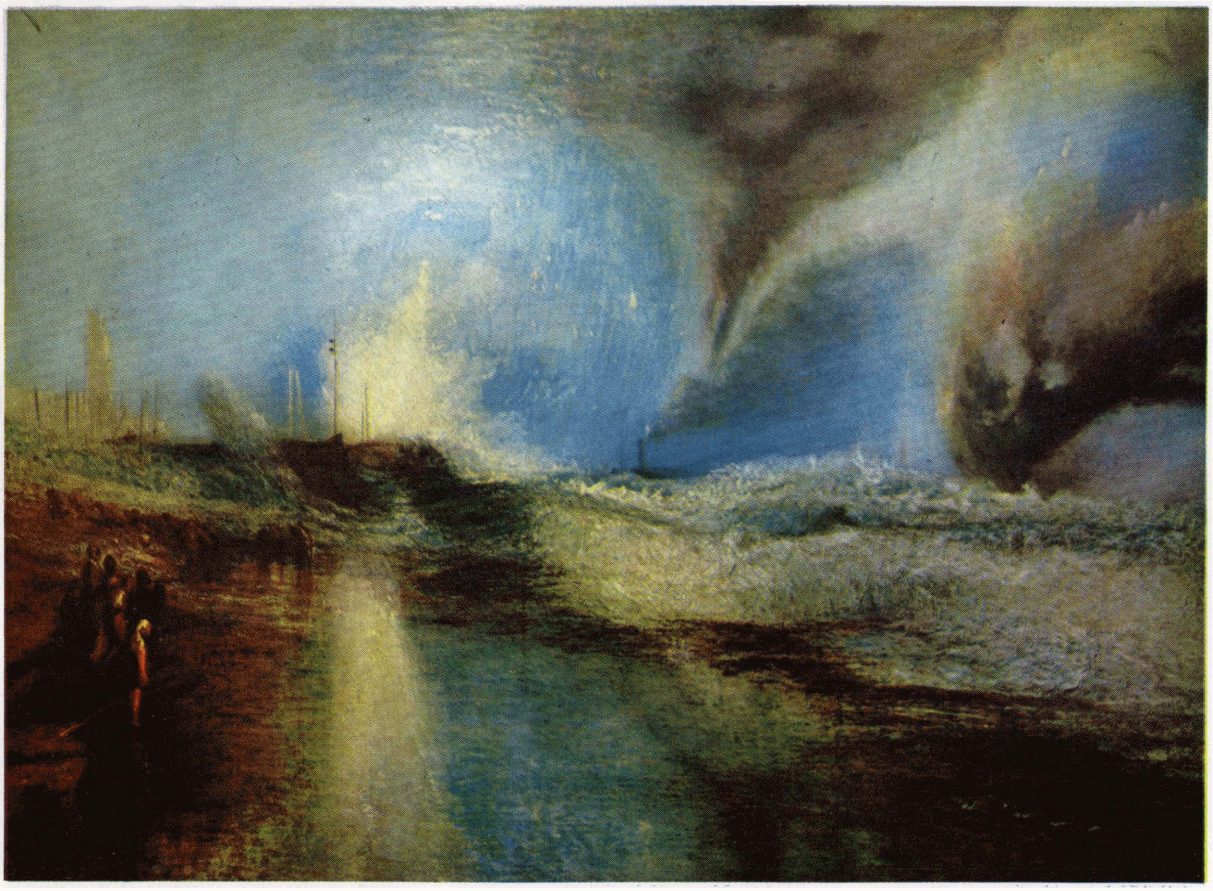
DELACROIX AND TURNER

BY COURTESY OF THE ART INSTITUTE OF CHICAGO; PHOTO BY RICHARD J. BRITTAIN

Left: "Arab Rider Attacked by a Lion" by Eugène Delacroix (1798–1863), French. In the Art Institute of Chicago
Below: "Rockets and Blue Lights" by Joseph Mallord William Turner (1775–1851). English. In the Sterling and Francine Clark Art Institute, Williamstown, Mass.

BY COURTESY OF STERLING AND FRANCINE CLARK ART INSTITUTE



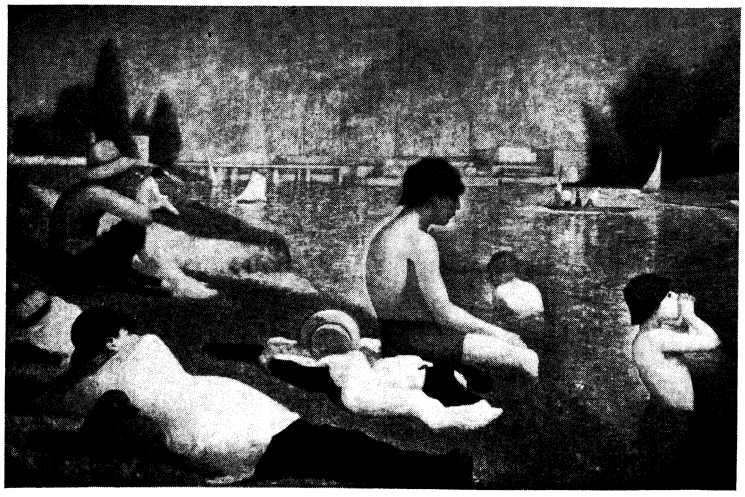
"DANSEUSE SUR LA SCÈNE," BY DEGAS

An example of the work of Edgar Degas (1834–1917), a French painter of the Impressionist school, best known for his many paintings and drawings of ballet dancers. In the Louvre

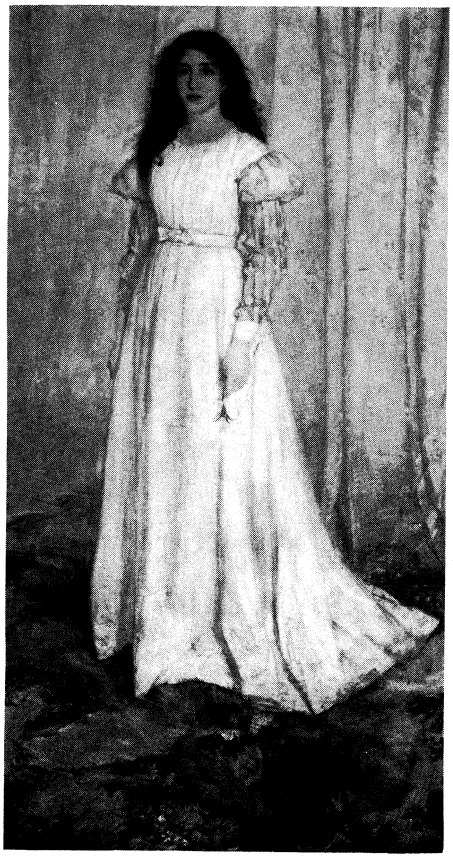
PAIhTTING

Above: "Bar at the Folies-Bergère" by Edouard Manet (1832–83), French. In the Courtauld Institute of Art, London

Below: "Une Baignade" by Georges Seurat (1859–91), French. In the Tate gallery, London



"At the Moulin Rouge" by Henri de Toulouse Lautrec (1864–1901). French. In the Art Institute of Chicago



"The White Girl" by James A. McNeill Whistler (1834–1903), American-English School. In the National Gallery of Art, Washington, D.C.

19TH-CENTURY FRENCH AND ENGLISH PAINTING

"On the Terrace" by Pierre Auguste Renoir (1841–1919), French. In the Art Institute of Chicago

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equivalent. to a work of nature. Rubens and the Venetians taught Velázquez much; he would not have denied it; but of the generations of painters who also have studied them, none has drawn a style of painting comparable to that of Velázquez. It may be said that the man who found all things easy, save the expression of passion. doubt and anguish, deliberated clearly on the different obligations of his life. With court duties and ceremonies encroaching more and more on his time he had need to evolve a sort of script appropriate to the circumstances. Thus necessity gave the enchantment which one feels in the works of this painter who is, as Manet said, "the painter's painter"—not painting for the sake of mystic expression as with El Greco, but painting for the sake of painting.

Some may say: "But this tremendous imitator of life has no imagination." These captious critics are perhaps right if they mean by imagination the faculty of translating plastically legendary themes, fables and mythology, of composing allegories and covering a ceiling with winged or floating creatures making gestures unrelated to terrestrial usage. But is it not imagination, and that of an order most appropriate to a painter, to compose an original range of colours, full of distinction and subtlety as well as force, and to play on it with the faultless touch of an accomplished musician? These harmonies, at once sober, refined and peculiar to him, contribute to the highly individual impression one may experience before Velizquez' masterpieces, whether they be portraits or compositions in which the portraiture is the essential element.

However, if the picture takes hold of the viewer. it is not only because it makes him see what his eyes ought to have seen and have missed. but because it opens an unknown world created by art, before which he stands thunderstruck. Velázquez was continually painting portraits of the king, the infantes and infantas, and the same princes and nobles. In spite of his loyalty as a courtier, nhich amounted to devotion, he used no artifice to embellish his models, he hid none of their awkwardnesses or oddities. He painted the dwarfs and buffoons of the Spanish court with the same objective realism. Both his princes and his dwarfs hold one's attention as the artist's vigorous use of pigment is admired.

It may be that Velizquez was not entirely successful in his various essays in religious painting. There again may be noted a trait peculiar to him at a time when the old Ribera and the young Murillo, the one with dramatic intensity, the other with suavity, enjoyed so much success in devotional Spain with their interpretations of Christian themes. Still it may be said that if Velázquez' "Coronation of the Virgin" lends itself to some extent to the reproach of coldness, its composition is of perfect and original elegance, and his type of Madonna resembles no other. If he had executed no more than his large "Christ on the Cross" (in the Museo del Prado), that would have been enough. It is a beautiful image of the Divine crucified, simply conceived from the indications of the liturgy, painted for all the faithful, great and small, and with all the resources of a skilled technique.

Finally three great compositions set the seal to Velázquez' glory; his originality as well as the sovereign elegance of his genius in invention is completely affirmed in them. These compositions are the "Lances" or the "Surrender of Breda," the "Maids of Honour" and "Tapestry Weavers." The "Lances" was an official picture ordered by the king in honour of a military event regarded as glorious for the monarchy. This noble and easy composition overspread with a fine light. this chivalrous air, these fine portraits, this blue and silver sky striped by the line of lances, all is the invention of a supremely intelligent artist.

The "Maids of Honour" and the "Tapestry Weavers," however, are his most significant contributions. There is nothing calculated or arranged in these two canvases. One represents a corner apparently chosen at random in the tapestry-weaving factory of Santa Barbara, the other a room in the royal palace in which Velázquez himself may be painting the portraits of Philip IV and his second wife, Mariana of Austria. They had no precedent and have been followed by no equivalent, though they contain inexhaustible lessons for modern painting. The word realism with its signification of preconceived ideas and deliberate demonstration fails to express them. It is true that the "Tapestry Weavers" is one of the first paintings with a proletarian subject, but the painter here had no fixed intention; he was neither for nor against what he saw, the action he depicted, the human beings, royal personages, children, dwarfs or workers who participated in the action. It seems that he experienced no feeling at all. Is there even a subject—properly speaking—in these two pictures? In the foreground of the one the weavers are occupied by their work and take the various poses necessitated by it. But in the background, under a quite different light, on a different level, some ladies, whose presence seems fortuitous, have just entered the factory and are looking at the tapestries being shown; and they resemble, one does not quite know why, a fairy apparition. There is no discord, however, and above all no striving for effect. In the other picture the whole foreground is occupied by three elegant and charming figures, the little infanta stiff in her rich robes and two maids of honour eager to serve her. In the shadows are two dwarfs and a large dog. It is quite right that the picture has become known as the "Maids of Honour," though the subject is supposed to be Velázquez painting the portraits of the king and queen. Velázquez is indeed there, but in the middle distance and in shadow, and before him is an immense stretcher on which he paints the composition almost life size. As for his august models, one has to look for them. Right in the background, shown in a dim light still further obscured by the curtains of the windows, there are side by side two rectangles of light, one brighter than the other; the brighter is a door opening on a staircase on which a courtier turns toward the viewer, and the other is a mirror reflecting the distant image of the king and queen evidently posing for the painter. Thus there is a problem of subject and intention, or rather the apparent absence of the painter's intention is itself a problem, But his art has the effect of a magical invocation of truth and life.

Good craftsmen worked in Madrid for some time under the influence exerted by Velázquez: his son-in-law Juan Bautista Martinez del Mazo (?1612–67), to whom is now attributed the charming little picture the "Meeting of Thirteen Gentlemen" (Louvre), and Juan Carreño de Miranda (1614–85), a good portraitist.

3. Murillo.—To the eyes of his contemporaries Bartolomé Esteban Murillo (1617–82) perhaps appeared more admirable than Velázquez himself. Murillo's sentimental and popular art was certainly better calculated to touch the heart than were the lucid intelligence, the aristocracy, the apparent insensibility and the infallible mastery of Velázquez. But above all Murillo was legitimately admired with enthusiasm and gratitude by the devout of Spain, to whom, after the reign of the great court painter, he offered an art capable of expressing in easily comprehensible language the tendernesses, the ecstasies and the adoration of a naïve and profound faith. He began, however, much as did Velázquez, in a realist manner more or less directly derived from Zurbarán. Even a little later he did not give up the picaresque and picturesque subjects offered to him by the life of Seville. The "Young Beggar" in the Louvre and other pictures of the same genre show clearly the foundation of solid observation of nature on which he built his ideals. His first pious compositions, for example the "Miracle of San Diego" (Louvre), show that he had found how to associate in an apparently spontaneous harmony a realistic execution with mystic feeling, the faithful depicting of the most humble things with the shimmering vision of miracles and the supernatural.

After Murillo little important painting occurred in Spain. By the 18th century there were hardly any painters in Spain save Frenchmen of secondary talent summoned by the Bourbon-kings; the German neoclassicist Anton Raphael Mengs, a good portraitist; and the dazzling decorator Tiepolo, the last of the great Venetians, nho went from Italy to decorate the royal palace and died in Madrid. These splendid rococo decorations, dazzling in their dramatic space and colour, certainly had a great influence on the young Goya.

4. **Goya.**—Francisco José de Goya y Lucientes (1746–1828) was in his way Velázquez' heir, and it was in him that the fine tradition of Spanish painting was renewed after nearly a century and a half. He was equally original as a draftsman, an etcher, a lithographer and a painter. Unlike Velázquez, he did not arrive

easily and from the beginning at mastery. If he had died before he was 40 years of age he would not perhaps have left a single one of the works on which today his reputation rests. He is one of those who, having invented a new form of art, created a new world, cannot have other masters than themselves and their own experiences of life.

This extraordinarily versatile man is the painter of the finest nude in Spanish painting (the "Nude Maja"). To complete the universality of his genius, this roué and libertine had his hours of Christian inspiration. The "Last Communion of St. Joseph Calasanz" is perhaps the finest 18th-century religious painting. It recalls Rembrandt. The mystery does not come, however, as in Rembrandt, from a source of light springing from shadow, but from the infinite gradations of a twilight gray. The frescoes of San Antonio de la Florida which Goya painted in 1798 are less religious in the accepted sense but a masterpiece of pictorial decoration. Those grays and blacks which play the part of a *sotto voce* bass in light and aerial harmonies are unequaled.

Goya is the outstanding genius of Spanish painting. And, even more than the great Velazquez, he reminds one of the most illustrious name in the literature of his country, Miguel de Cervantes Saavedra, because of the combination in both of lyricism and comic verve, of pathos and satire. Like El Greco and Velázquez he is an admirable portraitist. One may go so far as to say that the portrait is the basis of his art and that, even in his works of pure imagination, the peculiar vision of the portraitist is everywhere manifest. This is also true of the typical masterpieces by El Greco and Velázquez, the "Burial of Count Orgaz" and the "Maids of Honour." The "Family of Charles IV" belongs to the same order of plastic creation. The lively handling. the iridescent and mysterious coloration are already enough to distinguish this unique example among court portraits and formal pictures. But all the admirable inventions of the colourist and the virtuoso would lose half their beauties if one did not see in them brilliant and subtle variations on a heroic-comic theme of psychology.

In all directions Goya renewed and innovated. Whether he worked for the churches or painted patriotic pictures he always did something unexpected. His cartoons for tapestries show that he had studied François Boucher and Jean Honoré Fragonard as well as Tiepolo. But there was nothing conventional about him. In scenes of gallantry or merriment, some even dramatic, all—costumes, types, attitudes—have the accent of popular truth. His inexhaustible verve and the profoundly original turn of his sensibility found an even more favourable field in his little genre pictures. But how insufficient is the term genre pictures for these little masterpieces of invention, observation, emotion and irony. There are carnival scenes such as "El entierro de la Sardina," street processions like the "Flagellants," interiors of prisons and madhouses, fête days in the country; like the celebrated "Pradera de San Isidro," and many other strange subjects, melodramatic, romantic, anecdotal and satiric, every time they are a surprise and revelation, for inevitably one thinks what such subjects would have become in the hands of another painter, and appreciates the more fully what marvels of poetic fantasy and mysterious, almost enigmatic emotion the magician Goya made of them. Goya's own sickness, the death of his close friend the duchess of Alba and then the death of his wife, all may have contributed to his turning inward. After his colourful rococo pictures he paints pungent commentaries on the life of his country, overrun by Napoleon's troops and torn by civil war. And unlike Velazquez he takes sides in the struggle. The "Execution on the Third of May, 1808" shows the heroes of the revolution in irregular arrangement, in terrified and deeply human disorder as they are mercilessly shot by the faceless and regular firing squad. The final gesture of the dying hero is that of the crucified Christ, and there Goya expresses his deepest religious feelings which were those of freedom and humanity.

Goya is the father of 19th-century art and of all modern art. In his own country he left only one expert, a servile imitator, who had, however, animation, Eugenio Lucas (1824–70). His best and truest heirs are to be found in France. In the course of the 19th century, however, outside the brilliant but harsh and petty art of Mariano Fortuny y Carbo, one feels that Spain still keeps its capabilities of favouring again the development of a great painter (see *Picasso,* below).

D. France: 17th and 18th Centuries

The first half of the 17th century was, in France as in almost all the countries where art has flourished, a period of rich development which saw the birth of geniuses of the most diverse types and the most marked originality.

Simon Vouet (1590–1649) was exceedingly precocious. At 14 years of age he already enjoyed such a reputation as a portrait painter that he was invited to pay a visit to England in order to paint the portrait of a lady of quality. He was successful also at Constantinople, at Venice, at Rome. where he received the title of "Princeps" of the Academy of St. Luke, and finally at Genoa, where he decorated the Doria palace. Recalled to Paris by Louis XIII in 1627, he was loaded with honours and for 15 years held sovereign sway over the arts. It is obvious that he was too much carried away by his facility and eclectic style which set the style for French academic painting for centuries. He had more influence than Poussin himself on Eustache le Sueur, Charles le Brun and Pierre Mignard and through them on the great work of Louis XIV's reign, the decoration of Versailles.

1. Poussin.—Although Nicolas Poussin (1594–1665) was only four years younger than Vouet, his influence made itself felt in France only later. He was not precocious like Vouet but may be numbered among those great men who have need of reflection and meditation, whose inspiration comes only with maturity of mind and body. Although earlier work by Poussin has been discovered, his career begins, historically speaking, in 1624 with his arrival in Rome at the age of 30. He had gone to Italy in quest of Raphael, whose genius he had discerned from the engravings of Marcantonio while still in Paris. Raphael did not disappoint him. But Titian was a profound surprise to him, and from that time onward his constant preoccupation was to reconcile the spirit of these two great men. At times in pursuance of his cherished theory he seemed to prefer a method hovering between these t o and was able to fuse the linear element derived from Raphael, with the warm and coloured atmosphere which he admired in Titian to produce a new synthesis which is peculiarly his. This clear-sighted and impassioned study which Poussin devoted to Raphael and Titian appears perfectly natural today, but this was not so in 1624, when the foreign artists at Rome had no eyes except for the academic art derived from the Bolognese or from the brutal naturalism of Caravaggio's followers. Poussin felt an equal detestation for both, and with his robust philosophical frankness condemned both unsparingly.

Whether he studied Raphael, Titian or the Romans, Poussin derived from them only salutary inspiration. The first aspect of Poussin's genius is that he put into his masterpieces more thought than it was ever given to any other painter to express, and that he found for that thought, poetic and philosophical by turns, an original and plastic interpretation. He was basically an intellectual painter who strove toward well-ordered design and whose paintings are lucid and clear in their tectonic structure. Like the classical French theatre of the same period he achieves ordered repose even in scenes of great passion, such as "The Rape of the Sabine Women." It is above all when he invents compositions where nature and humanity appear in closest unison that he moves, and, despite his gravity, charms one. It is there that the memory of Titian and Giorgione inspires him to find new treasures.

Poussin was certainly one of the greatest landscape painters, creating landscapes such as the marvelous Homeric and Virgilian poem which forms the background of his "Polyphemus," the Elysian glades welcoming his "Bacchanal" and shading the repose of his sleeping nymphs or biblical themes as "St. John on the Isle of Patmos." These landscapes are invented to give an ideal vision of an ordered Arcadian world, a world which has a lofty spirituality and an indefinable touch of the heroic.

In 1640 Poussin returned to Paris on the invitation of Cardinal Richelieu. The intrigues of the court, however, caused his removal two years later to Rome, where he continued his study of classical antiquities and his painting of religious and mythological

subjects in the grand manner, by which he established his hegemony in French painting.

Poussin had an incomparable prestige, but for the most part his influence was remote and except for his immediate disciples, Gaspard Dughet ("le Guaspre Poussin") and Jacques Stella. was felt only as an aspiration, more or less precise, toward an intellectual and classical ideal. Some, because they died too young or for other reasons, escaped this influence entirely, for example, Valentin de Boulogne, called Le Valentin (1591–1634).

2. Claude Lorrain. — Claude Gellée, called Claude Lorrain (1600–82). was neither a great man nor a lofty spirit like Poussin. His genius, however. cannot be denied, and like Poussin he was a profoundly original inventor within the limitations of a classical ideal. While he too almost spent his life in Rome, the art he created was not specifically Italian, but French. For more than two centuries afterward everyone in France who felt called upon to depict the beauties of nature was to think of Claude and study his works. whether it was Claude Joseph Vernet in the 18th century or Jean Baptiste Corot in the 19th. Outside France it mas the same.

There is an element of mystery in the vocation of this humble and almost illiterate peasant whose knowledge of French and Italian was equally poor and who used to inscribe at the bottom of his drawings notes in a strange broken French-Italian. What attracted him to Rome and what held him there? Might he not have produced his masterpieces at Nancy, Paris or elsewhere? For this admirable landscapist drew from within himself the greatest number of his pictures. He made sometimes from nature drawings so beautiful that several have been attributed to Poussin, but in his paintings a romantic imagination predominates; it may even be said that it predominated more and more in proportion as Claude realized his genius. Without needing to reason, without any loss of his instinctive poetry, he understood by listening to Poussin and watching him paint that a sort of intellectual background would be an addition to his own visions and reveries.

3. Portraitists. — The French school has always numbered good portrait painters. In the 16th century when the fate of painting in France seemed so gravely compromised, only this feeling for portraiture remained active. Later, at the end of the 17th century, when an academic convention was threatening to stifle originality among painters, Nicolas de Largillière and Hyacinthe Rigaud painted portraits full of force and veracity. Even in the ceremonial portrait. where the subject is mythologically disguised, one feels that the painter will not renounce his rights as an interpreter of human physiognomy. Two men a generation apart, Philippe de Champaigne (1602–74) and Robert Nanteuil (1623–78), were neither of them brilliant painters, virtuosi of the brush as Largillière and Rigaud, yet they rose above them in the quality of their portraits.

Together with Nanteuil must be cited another engraver, a freelance draftsman of genius. Jacques Callot (1592–1635). One cannot be certain of any painting in oils. This is surprising in view of the strictly pictorial qualities with which he was the first to endow etching, and the fact that it was painters most supremely and essentially worthy of the name, Watteau and Goya, who seem, long afterward, to have been most mindful of his lyric masquerades and his "Miseries of War."

4. De La Tour. — Georges de La Tour (1593–1652), like Callot, was active in Lorraine. Although he had been painter to the dukes of Lorraine, his name had been lost and was not rediscovered until the end of the 19th century. Only in the 20th century, in fact, was there real interest in his remarkable painting because of the parallels between his work and modern art.

De La Tour worked with bold, sharply defined contrasts of light and shade, a technique probably derived from Caravaggio by way of the Dutch painters Honthorst and Hendrick Terbrugghen. But instead of the dynamic movement achieved by light and dark patterns in Caravaggio, De La Tour's world is still. Like Poussin he was more concerned with pictorial structure than with the subject matter of his religious paintings. His figures are static, their faces expressionless. An important painter in the French classic tradition. De La Tour built his pictures with large, abrupt planes, stylized in a proto-Cubist manner.

5. The Brothers Le **Nain.**—For long it appeared impossible to allocate individually among the three brothers Le Nain the works which survived under their common signature. V. P. Jamot among others contributed to the elucidation of this problem. Antoine le Nain (1588–1648). who studied at Laon under a foreign painter (probably from Flanders), painted, in a manner and with a colouring more or less derived from Flemish models, little panels in which persons are assembled in interiors, modest, but rather of the town than of the country. His style was still slightly archaic, but in him already may be discerned that love of humble truth from which springs the inspiration of the most original works bearing the signature, those of Louis (1593–1648), the man of genius, the breaker of new ground. He produced (1640–48) those gatherings of peasants which are painted with such freedom, filled with such dignity. sobriety and humanity and which, in a word, are so different from treatments of similar subjects by contemporary Spanish and Italian followers of Caravaggio on the one hand and by the Flemish and Dutch on the other. Mathieu (1607–77). the youngest of the brothers, who survived the others by almost 30 years, had less depth but painted family gatherings in which he shows himself almost as good a judge of human physiognomy and expression as his brother Louis.

6. Royal Patronage. — After this generation of creative artists, the condition of French art was completely changed by the action of the absolute monarchy in setting out to patronize and develop but also to organize, discipline and centralize this force, among others, for the furtherance of its great designs. King and nation became one. The French saw no better way of advancing their own reputation than by making themselves the architects of the royal glory. Charles le Brun (1619–90) had none of the qualities by which true lovers of painting set most store. Although he gave proof of merit in every genre, not one of his works provides that emotional satisfaction which inspires such affection for more unassuming work, Nevertheless his role was important because he codified the academic tradition. At Versailles he was the master brain commanding an army of architects, painters, sculptors. goldsmiths and cabinetmakers. He had the true genius for decoration; the Galerie des Glaces at Versailles and the Galerie d'Apollon in the Louvre bear witness to it, and, secure in the king's esteem, he reigned for 20 years over the kingdom of the arts. Pierre Mignard (1610–95) on his return from Italy, where for 22 years he had enjoyed brilliant successes, alone sought to dispute his supremacy. It was. moreover, a purely personal rivalry, for both were steeped in Italianism and, while claiming descent from Poussin, were followers of the Bolognese. Le Brun possessed the energy, ambition and clear-sightedness of a leader.

Le Brun had no sooner disappeared than signs were manifested of a reaction against academic and Italianate art. This is what is called the "struggle between the Rubenists and the Poussinists," Poussin's name having been wrongfully invoked by the followers of Le Brun. A part of the French school then discovered that the Italian ideal was not the only one possible, that colour is as important as design, and that grace, intimacy and freedom have their place in art as well as sublimity and grandeur.

Jean Jouvenet (1644–1717), Antoine Coypel (1661–1722) and Charles de Lafosse (1636–1716) were all pupils and collaborators of Le Brun, but as regards colour and feeling were already precursors of the 18th century. This reaction was equally marked among the portrait painters, from Jean François de Troy (1679–1752) to Jean Marc Nattier (1685–1766). The animal painters Alexandre François Desportes (1661–1743) and Jean Baptiste Oudry (1686–1755) render Frans Snyders' hunting scenes in French idiom; their greatest merit is perhaps an already very modern sense of landscape.

7. Watteau.—Antoine Watteau (1684–1721) incarnates all the grace, all the intelligence, all the poetry of the 18th century, when French taste was triumphant throughout the whole of Europe. He, like Poussin, stood alone; he typified a new attitude in French art, the charming and graceful style of the rococo. its delight in dreamlike and decorative elements. These characteristics also can be observed in the transformations of architecture. The immense galleries and stately apartments beloved by the Grand *Roi* were then

succeeded by salons and boudoirs designed with a view rather to elegance and convenience than to display.

Watteau was born in Valenciennes in the Flemish provinces of France; he certainly had a Flemish atavism which fitted him peculiarly to understand the lesson of Rubens, and he found the first idea of his *fêtes galantes* in Rubens' charming variants of the "Garden of Love." When he was employed in Claude Audran's studio at the Luxembourg he studied Rubens' "Life of Marie de' Medici"; later at Pierre Crozat's he copied his drawings and placed them side by side with those of the most illustrious Venetians, of which that amateur of unerring taste possessed an incomparable collection. "Jupiter and Antiope" (Louvre) shows how Watteau succeeded in blending and adapting the influences of Antwerp and Venice. But all that may hereafter be said about Watteau's youth, all that may be added about his teacher Claude Gillot, who himself drew and painted masquerades, will be completely inadequate to account for his work. His landscapes—tall trees in parks and glades with marble fountains and statues—and the drooping glance of lovers' eyes, that high-born grace of his young men and women clad in satins and laces, that fairyland, play acting, with its actors and actresses, fantastic disguises and clandestine serenades, fair unknown ladies wooed by tremulous swains uncertain of their bliss, walks without aim and departures for unexplored isles, all this is lovelier than everyday life and just as true and sufficed to establish his fame. But only two or three years before his death this young genius who had no time to lose showed himself more and more audacious. "The Embarkation for Cythera" is an end, not a beginning; it is the masterpiece of romantic fairyland. Watteau was not content to remain the painter of the *fêtes galantes;* he felt that he could create poetry with subjects drawn from everyday life. He painted "Gilles": still a character from the stage, but the spirit has changed. Then came the "Sign for Gersaint's Shop." Persons in the dress of the period are inspecting pictures in a shop, a scene which might have made a genre picture. Watteau aimed much higher, and at the first attempt achieved, in a masterpiece that was without precedent and that bore no fruit until long afterward, the new manner of which the 19th century dreamed and to which it came back incessantly with Gustave Courbet, Edgar Degas, Manet. French taste succeeded in reconciling style with the realism inherited from the old Flemings.

8. **Boucher.**—François Boucher (1703–70) cannot be placed on the same plane as Watteau. If Watteau is essentially a man whose works have a mysterious meaning and who himself, urged by the power within him, has visions stretching beyond that mystery, Boucher is, on the contrary, typical of the artist whose ambitions are clearly defined and exactly proportioned to his capacity: he desired to please his contemporaries, to decorate walls and ceilings for them, and, in his better moments, realized perfectly what he had set out to do. Thus it is he who best sums up the taste of his century. He had decorative talent and the gift of composition, facile, elegant and always perfectly balanced. As a decorator he had gifts in no way inferior to those of his fascinating contemporary Tiepolo; he could also paint excellent portraits such as the "Mme. de Pompadour" (Louvre), or render with brilliance and deftness intimate scenes such as the "Déjeuner" (Louvre) or the "Modiste" (Stockholm).

Even among the court a strain of realism, visible in Oudry's, Michel Lépicié's and Étienne Jeaurat's works, made its appearance in France side by side with gallant mythology and decorative pastorals.

9. Chardin and **Greuze.**—Jean Baptiste Siméon Chardin (1699–1779) in 1728 gained admittance to the French academy with two large canvases which were merely still lifes: "The Ray" and "The Buffet." Their technical merit is immediately apparent: in these pieces, handled with extraordinary tact and felicity, are found all the riches and subtlety of oil painting. But there also appears, even thus early, the sense of intimacy and the poetry of humble things which give to Chardin a place apart from even the best still-life and genre painters. His still lifes do not bulge with appetizing foods but are concerned with the objects themselves and with the treatment of light. He carefully constructs his still life. He was far nearer to the feeling of meditative quiet which animates the rustic scenes of Louis le Nain a century earlier than to the spirit of light and superficial brilliance surrounding him, even in the so-called realism of his time. In his genre scenes he does not, as his predecessors, seek his models among the peasantry; he paints the petty *bourgeoisie* of Paris. But manners have been softened, and his models seem to be far removed from Le Nain's austere peasants. The housewives of Chardin are simply but neatly dressed and the same cleanliness is visible in the houses where they dwell. Everywhere a sort of refinement and good-fellowship constitute the charm of these little pictures of domestic life, unique in their way and superior, both in feeling and subject, to the masterpieces of the lesser Dutch masters. Equidistant in point of time from Louis le Nain and Corot, Chardin also attained through truth a wholesome and honest poetry, truth as seen through selective eyes, without rhetoric or pretensions.

Already, however, there was creeping into the work of more than one of his contemporaries the ideology which at that time invaded literature and was one of the worst enemies of good painting. The same causes then proceeded to bring forth the same effects both in England and in France. Jean Baptiste Greuze (1725–1805) corresponds to William Hogarth. Not that he felt the immediate influence of the painter of "Marriage a la mode"; it is perhaps Chardin, imperfectly understood, who awakened him to his vocation, and whom he desired to surpass by a choice of subjects to him more interesting and a setting to him more moving. "The Father's Curse," "The Son's Punishment," these overly ingenious compositions, where every detail is characteristic of an actor playing a part, seem borrowed from some contemporary melodrama. Nor does any technical novelty afford relief from the mawkishness and falsity of sentiment. The mordant quality of his satire saved Hogarth; nothing of the kind could be expected from the mediocre temperament of Greuze, who showed, in the opinion of some critics, the first example in painting of a brilliant success which was not ratified by posterity.

10. Pastelists.—Portrait painters, during the 18th century, formed a remarkable galaxy headed by Louis Tocqué; his lieutenants were not to be disdained, particularly Jacques Aved and Joseph Duplessis. But pastel then assumed an unexpected importance under the stimulus of an observer of genius, Maurice Quentin de la Tour (1704–88), and a charming colourist, Jean Baptiste Perroneau (1715–83). La Tour was rather a draftsman than a painter, and for a man thus inclined—as already seen in the case of Robert Nanteuil and as was to be seen again in that of Degas, pastel was the chosen medium which freed the artist from the limitations of oil painting. But for La Tour, drawing, pencil, pastel, all these were means, in themselves indifferent, to seize upon the personality of his model. Human faces, human expressions, he cared for nothing else, but loved them passionately with a sort of disinterested frenzy. No one equaled La Tour in rendering the vivacity, mobility and sparkle of wit in a French face of the 18th century.

Perroneau was neither impeccable in the structure of his faces nor impassioned in his analysis of expression; but at its best his work possesses great charm. He was a born colourist, and had not the same reasons as his illustrious predecessor and rival for preferring pastel. He painted a number of excellent portraits in oils. But La Tour had made pastel fashionable, and Perroneau and many others followed suit. Pastel, which charmed all by its lightness and unalterable freshness, seemed an invention peculiarly suited to the spirit of the times, the light woodwork of interiors and pale dresses. But Perroneau alone had the gift of making it subserve his charming discoveries in colour.

In this women's century, it was natural that women painters would win a place which had not yet been accorded to them. Their talents were principally devoted to portraiture. In Watteau's time the Venetian Rosalba Carriera (1675–1757) won a great success in Paris and helped to create a fashion for pastel. She subsequently carried her chalks and amiable mannerisms into every European capital. In Fragonard's time it was a Frenchwoman, Marie Anne Vigée-Lebrun (1755–1842), who immortalized in her pictures of queens and great ladies, and especially in those canvases where she depicted herself with her own daughter, the graces of the dying century.

11. Fragonard.—In the gay society of 18th-century Paris there suddenly arose one who was, at least in some respects, a great painter. Jean Honoré Fragonard (1732–1806) closed with delicate hedonism the curve of the 18th century opened by Watteau. Watteau's work is aerial and profound; Fragonard's is merely light. He amused others while amusing himself; he was never moved. But he understood the art of pleasing, and he imparted charm to everything he touched. He had so much grace as to be forgiven the daring gallantry of certain subjects which would be intolerable from another artist. Sometimes he dashed off a canvas in an hour, with the flair of improvisation, sometimes he pursued to the point of the most delicate affectation a little picture full of charm and mystery. Then at Grasse he decorated a house with five great panels in which he showed himself the worthy rival of Tiepolo and Goya. the Goya of the cartoons for tapestries.

In landscape Fragonard almost had a rival in the person of his fellow sojourner in Rome, Hubert Robert (1733–1808). Robert conceived landscape principally as a decorative theme more or less derived from the views of antique ruins of the Italian Baroque painter Giovanni Panini, but he imbued it with a romantic charm unknown to the latter and with luminous harmony, a distant reflection of Claude. In spite of the residue of convention in his pleasing works, they contain the first signs of a change. A return to simplicity and truth heralded a new conception of landscape which was to be that of the 19th century. Claude Joseph Vernet (1714–89) in his "Ports of France" and numerous other pictures was a brilliant and facile narrator; his seascapes and marine scenes were popular. Vernet was an eclectic painter relying greatly on the work of Claude Lorrain and Salvator Rosa, but he also became an important link with 19th-century romanticism.

12. Neoclassicism: David.—In France first signs of the return to the antique were already visible in the discourse on the life of Watteau pronounced in the French academy by the comte de Caylus, an old friend but at the same time a good archaeologist. This was in 1748, about the time of the discoveries of Herculaneum (1738) and Pompeii (1748), which roused the artistic and literary world to enthusiasm; earlier even than the first publications of Johann Joachim Winckelmann (1717–68), the German archaeologist who restored to the world the sense of Greek art. There he found "noble simplicity and silent grandeur"—a true standard of beauty for the neoclassical movement. Winckelmann, working in Rome and approaching antiquity with more information and a more knowledgeable attitude than that of the Renaissance, became the arbiter of taste for Europe during the late 18th century. He was the father of the neoclassicism which ruled Europe and the American colonies for some 50 or 60 years. An extraordinary interest in antiquity and classicism spread through England and is perhaps evident in English architecture. In France Mme. de Pompadour copied books of reproductions from the antique under the tutelage of the engraver Gay, and encouraged the great change which was taking place in furniture and architectural form. The style which has been christened Louis XVI sprang up in the middle of Louis XV's reign, while that destined to be called Empire was already almost fully formed under Louis XVI. In painting, Joseph Marie Vien (1716–1809) caught the fashion with his "La Marchande d'Amour" and "Belisarius." Jacques Louis David (1748–1825) passed through Vien's studio and had been Boucher's pupil before coming to Vien. Until his departure for Italy, when after long and determined effort he had won the Prix de Rome (1775), he painted like a docile enough imitator of Boucher. At Rome he suddenly adopted, with the uncompromising and inflexible enthusiasm natural to him, the doctrine of Winckelmann.

Winckelmann's doctrine was amplified and codified for the French by a writer whose pen was no less authoritative than David's brush, Quatremère de Quincy (Antoine Quatremkre). Between them they laid down the principles of the new aesthetic. It was admitted that true beauty, as realized by the Greeks in their masterpieces, is a creation of reason capable of satisfying the needs of all men in all ages. Greek painting having disappeared (at least that of the great painters of the classical period), they were driven to ordain that painters should draw their inspiration from antique statuary: by way of consequence the superiority of design over colour was proclaimed and it was decided that the only noble arrangement m s grouping in bas-relief. The "Oath of the Horatii" (1784–85), illustrating these principles with a vigour and austerity hitherto unknown, forthwith exalted David's reputation. His contemporaries saw in it the promise of a rebirth of art through a heroic ideal suited to a humanity uplifted by what were called the republican virtues: severity, simplicity and heroism. David was therefore the author of the most fundamental breach which has ever occurred in French tradition. His paintings, such as the "Oath of the Horatii" and "Brutus," not only reflect the political situation of his times but were able actually to exert an influence on political events. David himself, as a delegate to the national assembly, became one of the leaders of the French Revolution. He abolished the old academy in the name of freedom. but he soon thereafter established its successor which permitted even less free expression in the name of the revolutionary state.

David himself possessed the means of combating to some extent the dangers of the uncompromising doctrine despotically preached to his pupils, so that he did more harm to others than to himself. When one looks at the sketches by Pierre Guérin or Girodet Trioson. who. whether or not they had passed through his studio had subjected themselves to his rules, one recognizes the light and pleasant touches that denote the real artist of which, however, they were obliged to divest themselves when painting their huge canvases, in order to conform to the rigid aesthetic of their master. David was saved by that love of a somewhat rugged truth, which was natural to him and from pre-Revolution days onward made him an excellent portraitist. The false antique ideal was, mercifully, entirely absent from the numerous and admirable portraits which he painted at all periods of his life, from the old people dressed up in their Sunday best of the Louis XV style "M. et Mme. Pecoul" down to that canvas dating from his last years, his exile at Brussels, "Mme. Morel de Tangry and Her Daughters." Perhaps his greatest portrait is "The Death of Marat" (1793), u-here the tragedy is presented by means of the simplest severity in terms of a basic structure of horizontal and vertical shapes and large, even colour planes.

His gift of portraiture enabled David to paint "The Coronation of Napoleon," a pretentious official picture, and to breathe life into a huge ceremonial composition. It is no small achievement to have arranged and animated this immense composition, the only canvas which can, in a certain measure, be compared to Veronese's "The Marriage at Cana." David had not, moreover, awaited the commissions which made him the historiographer of the empire, before deserting, at least intermittently, the Greeks and Romans in order to paint the doings of his contemporaries. At the beginning of the Revolution he outlined in large canvas the "Oath of the Tennis Court." then painted Marat dead in his bath, and another murdered man, "Last Moments of Lepelletier de Saint-Fargeau." Without necessarily sharing the revolutionary passion which was his inspiration, one cannot help admiring unreservedly in his works, then so novel. the striking atmosphere of truth and the style, truly heroic in its grandeur and simplicity. Thus this doctrinaire had a deep-seated love for classical form; and, although his successors were obliged, in order to restore to French painting its essential liberties, to react against the doctrines of David's school, one may yet find in him the source of the chief currents which stirred 19th-century art. (See also NEOCLASSICAL ART.)

E. BELGIUM

After the return of the Bourbons, David, as a regicide, spent the last eight years of his life in Brussels. He then created a new school in a country in which art appeared to be on the verge of extinction. If the ascription Flemish is reserved for the art of Van Eyck, Van der Weyden, Brueghel, Rubens and Van Dyck, one may say that Flemish art was dead. But just when Belgium was winning independence, a Belgian school was about to be born. David was its father, or at least its godfather.

When David arrived in Brussels in 1815, the young painters gathered around the famous exile. The most gifted among them, an excellent portraitist, François Navez (1787–1869), had for a long time admired David, whom he had known in Paris. The

highest possible praise of his talent is to say that, as a disciple of David, he did not give up his own freedom. Outside France, it was in Belgium that the soundest element of David's art was best understood, while elseuhere — notably in Switzerland with Leopold Robert (1794–1835) — the Davidian influence with the assistance of a mild romanticism led to an anecdotic genre which stiffened in a pretension little approximating to the style.

Once embarked on this course, development of the Belgian school synchronized almost exactly with the stages of French painting. Unfortunately Belgium produced no Delacroix. There the development of romanticism was confined to the externals, to archaeological or historical imagery. Instead of the poet who, heedless of material exactitude, interprets the emotion he experiences in meditating on the great events of life, the heroes of history, legends or fiction, these were annalists, who, by all sorts of detail in costume and decoration. claimed to reconstitute the past by presenting the illusion of authentic evidence. Their errors spread almost throughout Europe, beguiling the masses and producing immense success for painters who today are relegated to obscurity. The movement started in France with Horace Vernet (1789–1863) and Paul Delaroche (1797–1856). In Germany it gave rise to the schools of Diisseldorf and Munich, and was continued to the end of the century by the Viennese Hans Makart (1840–84), the Pole Jan Matejko (1838–93) and the Hungarian Michael von Munkacsy (1844–1900).

Of all the champions of romanticism Louis Gallait (1810–87), who studied at the Tournai academy under Philippe Hennequin (himself a pupil of David), most closely resembled Delaroche. In a similar style. also literary and pseudohistorical in origin, Hendrik Leys (1815–69) demonstrated, by the genuine qualities of his work, that the old Flemish heritage was not entirely lost. At times he painted historical pictures of a decorative pageantry, while in some of his less pretentious works he used an almost Impressionist freshness of approach. Henri de Braekeleer (1840–88) brought ancestral Flemish desire for finished workmanship. Others include Charles de Groux (1825–70), Constantin Meunier (1831–1905) and Alfred Stevens (1828–1906). Stevens was the most Parisian of the Belgians, an intimate of Manet and of French men of letters. He did much to direct his countrymen to the study of modern life and to what was called, after the name of a review upholding it, the Free Art movement. Among landscape painting must be noted the works of Hippolyte Boulenger (1837–74) followed by L. Artan de St. Martin (1837–90) and Albert Baertsoen (1866–1922). Artists concerned with the realistic representation of social and human problems were Léon Frédéric (1856–1940), Émile Claus (1849–1924) and Eugène Laermans (1864–1940). In the following generation painters such as Théo van Rysselberghe (1862–1926). Henri Evenepoel (1872–1899) and Rik Wouters (1882–1916) came under the influence of Impressionism and Post-impressionist trends. James Ensor (1860–1949) similarly had experienced the impact of the most recent experiments in Paris but created a fantastic imagery of extraordinary violence which brought him into the heritage of Bosch and Brueghel and at the same time characterized him as precursor of Expressionism and Surrealism. Ensor is also the father of the Flemish Expressionist movement of the 20th century.

F. The Netherlands: 18th and 19th Centuries

From the middle of the 18th century, the Dutch school seemed to linger in the final stages of anemia. No other name worth mentioning is to be found after the death of Cornelis Troost (1697–1750), who was rather amusing in his comedy scenes but a poor painter. Nevertheless the genius of painting was still alive in the country of Rembrandt, of Ruysdael and of Vermeer. In the 19th century the Netherlands was to give the world of art two powerful personalities whose work had great influence on the fate of modern painting: Johann Barthold Jongkind (1819–91) and Vincent van Gogh (1853–90; see *Postimpressionism,* beloa), but it was nithin the orbit of French painting that their work found its true place. Jongkind prepared the Impressionist landscape and — in the best possible way — without having wished to do so; and, though so original in the modest limits he set himself, he was no theorist.

Already in the period of romanticism, Ary Scheffer (1795–1858) also adopted France as his country. However, his romanticism bears a particular stamp of mystic sentimentality; Jozef Israels (1824–1911), Jacob Maris (1837–99) and his brothers William (Willem) and Matthew (Matthijs), with Anton Mauve, Johannes Bosboom, Bernardus Blommers and Hendrik Mesdag did not escape the irradiating influence of French art but retained that discreet and somewhat enigmatic melancholy that was characteristic of their national spirit.

G. Italy

In Italy classicism had no need of David to become known; it was in Rome that the movement had immediately encountered an illustrious native adept in the person of the great sculptor Antonio Canova. No painter of that time. be it Andrea Appiani (1754–1817), Pietro Benvenuti (1769–1844) or even the romantic Francesco Hayez (1791–1882), produced any painting comparable with Canova's masterpieces, in spite of Canova's own tendency toward an academic grace.

Generally, neither neoclassicism nor romanticism had much effect on Italian art. After the great outburst of Italian rococo painting on the part of the last Venetians — Tiepolo, Canaletto and Guardi — in the late 18th century, Italian art did not really come into its own again until the latter half of the 19th century with a group of painters in Florence and Naples who were called I *Macchiaioli,* after *macchia* or "patch." These artists reacted against the academies and their rules and looked to nature for instruction.

The *Macchiaioli* felt that the patch of colour was the most significant aspect of painting. The effect of a painting on the spectator was thus to derive from the painted surface itself rather than from any ideological message or narrative. The *Macchiaioli* used a sketch technique to record their initial impressions of nature — often as seen from a distance — by means of colour and light. Their theory was certainly similar to that of the French Impressionists, but they were still more concerned with the colour structure of their painting than were the Impressionists.

During a short period of 20 years (about 1865–85) the *Macchiaioli* produced some startlingly fresh and vivid paintings. The most outstanding painter among them was the Florentine Giovanni Fattori (1825–1908), who sometimes attained amazing effects of light and colour by means of the strong colour patch. Other important painters were Telemaco Signorini (1853–1901), the critic and theoretical leader of the group, who employed the patch with great sensitivity in his usually socially significant scenes; Silvestro Lega (1826–95), who combined a clearly articulated handling of the patch with a personal poetic feeling; and Raffaello Sernesi and Giuseppe Abbati, also artists of original creativity.

But the continuous tradition of Italian art had been broken. Just as there was no significant painting in Italy during the first half of the 19th century, there was again little of more than local importance until the Futurist movement just prior to World War I.

H. Germany

Anton Raphael Mengs (1728–79) worked in Rome during the greater part of his life and was one of the leaders of the neoclassical movement in its early stages. In Germany itself a special and often mystical romanticism sprang up. Philipp Otto Runge (1777–1810) was concerned not only with allegorical subjects but also with the symbolic aspects of colour and form. His contemporary, Caspar David Friedrich (1774–1840), stands out as the most important painter in Germany during the first half of the 19th century. A landscape painter imbued with mysticism, he interpreted his melancholy and moody landscapes as symbols of the universe, reflections of the human soul. In most of his paintings solitary human beings are confronted with vast expanses — the experience of the infinite.

Under the leadership of Johann Friedrich Overbeck (1789–1869) and Peter von Cornelius (1783–1867), a group of painters, the Nazarenes. moved to Rome where they came under the influence of both Winckelmann's classicism and the neo-Catholic movement. In strong revolt against the rococo they emphasized linear draftsmanship and devoted themselves to Christian and Germanic

scenes. Their style generally tended to be dry and pedantic. Later, as directors of the academies of Diisseldorf, Munich and Berlin, the Nazarenes exerted an enormous influence on German 19th-century painting, especially on the more popular style of such painters as Wilhelm von Kaulbach (1805–74), Moritz von Schwind (1804–71), Alfred Rethel (1816–59), Karl von Piloty (1826–86) and Emanuel Leutze (1816–68), who attained fame in the United States.

Around the middle of the 19th century Realism became as important in Germany as in France. Adolf von Menzel (1815–1905), a superb draftsman and brilliant colourist, painted historical and genre scenes with an astonishing economy of means. Perhaps incidentally, perhaps under the influence of John Constable's landscapes, Menzel was utilizing an Impressionist technique before paintings by the French group could have traveled across the Rhine. While Menzel worked in Berlin, Wilhelm Leibl (1844–1900) painted his peasant subjects and portraits mith a slow and deliberate Realism which is at times reminiscent of Gustave Courbet. Realism in Germany came to a climax in the work of Max Liebermann (1847–1935), who developed toward Impressionism in the 1880s. The Realist-Impressionist trend was carried on during the final years of the century in the sensuous canvases of Lovis Corinth (1858–1925) and the light improvisations of Max Slevogt (1868–1932).

At the same time the neoclassical tradition was fused with romantic overtones in the large history paintings of Anselm Feuerbach (1829–80), the grotesque, modernized mythology of the Swiss-born Arnold Bocklin (1827–1901) and the pseudo-Wagnerian idea painting of Max Klinger (1857–1920). Bocklin and Klinger dressed fantastic subject matter in naturalistic and conventional garb and produced some startling, although not always successful, works.

Hans von Marées (1837–87), on the other hand, created mythological compositions of severe architectural structure and measured serenity. He achieved a monumentality of form comparable with the work of Pierre Puvis de Chavannes and even occasionally with that of Paul Cézanne.

I. Great Britain

Of all the countries of Europe, England was perhaps the least subject to French influence at a time when that influence was so important throughout the continent. The reason was not that the English were indifferent to painting in general or to the merits of French painting in particular. From early times they were as great collectors as travelers. English amateurs welcomed French artists, whether summoned or arriving of their own accord, with every sign of favour, and London saw in succession Nicolas de Largillière, Charles de Lafosse, Watteau and Maurice de La Tour, but there was almost no patronage for domestic painting in England.

Some of the greatest foreign masters were attracted there, loaded with honours and even in some sort received into the nation by the titles of nobility conferred upon them. Holbein, Anthony More, Rubens and Van Dyck were almost English painters during a longer or shorter period of their lives. The last-named in particular, who was called in England Sir Anthony Vandyke and who married the daughter of a lord and died in London, was really in virtue of the supreme elegance and aristocratic poetry of his portraits the father of the English school. He trained a few English pupils, William Dobson, George Jamesone and the miniaturist Samuel Cooper. Nevertheless his principal imitators and successors were also foreigners settled in London: the German-born Sir Godfrey Kneller (1648–1723) and especially the Dutchman Pieter van der Faes, who became in England Sir Peter Lely (1618–80). There was no important painter who was truly English until William Hogarth (1697–1764). Van Dyck set before the English school an aristocratic ideal; Hogarth was a curious observer of men and manners. noted for his frank, robust personality and vigorous technique. His first works date from 1730. For rather more than a century England was to see a brilliant succession of painters. Sir Joshua Reynolds, Thomas Gainsborough, William Blake, Thomas Lawrence, John Constable and Joseph Turner. No country has had so exclusive and strongly marked love of the portrait. England and Holland were deprived of religious painting by the Reformation, and mythology met with no better fate. Scarcely any decorative painting is found, and what little survives is mediocre. Holland compensated by inventing the small genre picture, street scene or interior which was brought there to refinement. But England practised genre painting only from the beginning of the 19th century, in imitation, moreover, of the Dutch, though diluted with sentimentality and humour in the little school of anecdotal painters, Gilbert S. Newton, Charles Leslie: George Morland, Sir David Wilkie and William Mulready. The three last named were the best. by reason of their preference for rustic scenes combined mith landscape. If portrait painting is one of the glories of English art, landscape is another; in both directions it rose to supreme heights.

Characteristic of the English school is the moral strain emanating from the old Puritan tradition. It sometimes favours a conception of art closely akin to that of the novel, which from the 18th century onward is so living and original a part of English literature. An example of this is the narrative and descriptive method of Hogarth. Sometimes, as in the work of Blake, it presents apocalyptic visions—in aim always profoundly moral—and sometimes it results in movement which is to all appearances entirely poetic, such as that of the Pre-Raphaelites, but with a poetry that is more literary than visual and in which the idea of purification is applied almost as much to the intentions of art as to its specific processes and sensible effects.

1. Hogarth and **Reynolds.**—Hogarth's case is a strange one. The famous series of paintings, "A Harlot's Progress" (1731), "A Rake's Progress" (1735) and "Marriage à la mode" (1745), are pictorial moralities of a kind which seems completely outside the domain of art; for Hogarth considerations of morality counted infinitely more than those of art and beauty. He himself said he created "painted comedy" and considered it as a work "of public utility." His morality was founded on good sturdy practical truths not stirred by any breath of heroism. but he imbued it all mith verve and powerful vitality; he paraded and set in motion such a gallery of types, of characters whose blatant truthfulness is so prominent, that criticism is silenced and reservations of the fastidious melt away.

This autodidactic personage, disdainful of all culture, this Englishman who desired to be nothing more! was not without influence on the most refined, intelligent, learned and cosmopolitan of the great English painters, the instigator and first president of the Royal Academy of Arts, a great amateur and collector and perfect gentleman, and author of remarkable writings on art and the training of artists—Sir Joshua Reynolds (1723–92). It is impossible to imagine a greater contrast between two men and their works; but it may be said that Reynolds was, in his fashion, the legitimate heir of Hogarth, not of Hogarth the moralist and satirist, but of Hogarth the aesthetician and author of the treatise *Analysis* of Beauty, and Hogarth the portrait painter. The painter of "Marriage & la mode" and the "Shrimp Girl" gave a decisive impetus to the national temperament. But the original school thus created still needed to be brought into line with the great continental tradition. This youngest school had a long leeway to make up and Reynolds was the man to assist it. He attempted to lead English painting away from anecdotal pictures toward a plastic art "in the grand manner," a feat to be achieved by enabling English art to profit by the treasures of experience accumulated during centuries by the other schools. Reynolds was never a pupil of Hogarth, but certainly owed more to him than to Thomas Hudson (1701–79), his official master, who has no other title to fame. But his debt to the great masters of the past, Titian, Rembrandt, Raphael, Michelangelo and the Bolognese, not to mention Rubens and Van Dpck. was still greater. He studied them not as an amateur but as a craftsman and student of aesthetics, in order to assimilate everything in their genius and technique. In his writings, he outlined the essence of the grand style and suggested pedagogical means of achieving it. His *Discourses* remain among the most important critical writings of his century. His own painting, while often impressive, was perhaps a little too calculated and eclectic, but it attained a supremely aristocratic quality which appealed to his

contemporaries and which accounts for his success. He seems at his best in his less pretentious paintings when he forgets all his calculations and abandons himself to inspiration.

2. Gainsborough and Wilson.—Thomas Gainsborough (1727–88), four years younger than Reynolds, rivaled him in fame. He was no theorist, teacher or leader of a school; he never thought of combining in his art skillful borrowings from the greatest artists of various foreign schools. Unlike Reynolds he never left England and after several years of apprenticeship in London passed most of his life successively at Sudbury, Ipswich and Bath, before returning to London, where he died.

Gainsborough was not so studied a draftsman, his compositions were not so carefully balanced as those of Reynolds, and his figures often seem disposed haphazardly on the canvas. But his work is not contrived. He never lost his attitude of detachment. Although he painted some good portraits of men he was pre-eminently the painter of women and children. A profound admirer of Van Dyck, he took him for model; but this admiration did not detract from his originality, which has a unique quality of seductiveness, and retains the directness of his own visualization. On Van Dyck's themes—such as that of the boy clad in costly satin, with the woman's face, long and delicate in its aristocratic grace—he composed entirely new variations. His "Sarah Siddons," lacking the rhetorical grandeur of Reynolds' portrait, has the vitality of original artistic vision. Because of his passionate enjoyment of the landscape, he was the veritable creator of the great English school of landscape painters.

England had long shown a great appreciation of natural beauty. Connoisseurs had collected in their London salons and the galleries of their country houses the works of Jacob van Ruysdael, Cuyp. Canaletto, Guardi, Claude; but it was not without good reason that no work bearing an English signature was ever seen there. It was still in imitation of Canaletto that Samuel Scott, the companion of Hogarth, painted his views of London, valuable as historical records. He was one of the founders of that Society of Water-Colour Painters which was to have such important developments. The real creators of English landscape, however, were Wilson and Gainsborough. Richard Wilson (1714–82) took to landscape somewhat late, having first devoted himself with success to the portrait, whereas Gainsborough started as a landscape painter. It was at Rome, where he lived for six years, that, encouraged by Francesco Zuccarelli and Claude Joseph Vernet, Wilson painted his first landscapes. Having returned to England, he pursued his career as a landscape painter in the Roman style, sometimes interrupting his reminiscences of Italy to paint the beauties of Wales, where he was born. Wilson's landscapes combine a classicist serenity with picturesque effects: wide skies shed a limpid light upon the waters of a lake surrounded by the harmonious lines of mountains. While Wilson went to Claude for inspiration, Gainsborough was influenced by the Dutch when he painted Harwich harbour or the country around Sudbury. But from the start Gainsborough announced much more clearly than Wilson the road to be followed by English landscape. His canvases painted between the ages of 20 and 25 already heralded Constable's earliest works. His "The Watering Place" and "Return From the Market" show a rustic poetry and a receptivity to atmospheric conditions altogether new at that time.

3. Norwich School.—After Gainsborough and Wilson, there was no lack of landscape painters in Great Britain. The Scotchman Alexander Nasmyth (1758–1840) and Thomas Barker of Bath (1769–1847) deserve mention; John Crome, called Old Crome (1768–1821), was an artist of different calibre. Except for the journey to Paris in 1814, from which he brought back a work of great beauty, the "Boulevard des Italiens," he never left his native county of Norfolk, although he was certainly strongly influenced by the 17th-century Dutch landscape painters, especially Van Ruysdael and Hobbema. He was the glory of Norwich, which on his account gave its name to the Norwich Society of Artists, responsible for a new conception of landscape which was to be, with a few modifications, that of the 19th century, both in Great Britain and abroad.

Of Crome's pupils, John Sell Cotman, James Stark and George Vincent, who continued to shed lustre on the Norwich school, the most gifted was Cotman (1782–1842). Simultaneously with Thomas Girtin and John Robert Cozens he brought about the revival of that water-colour painting which assumed in England the character of a national institution.

During this time, three men, working on diverse lines, made themselves felt as far more original personalities. Two of these were geniuses. Constable and Turner, and the third a charming painter and colourist, Richard Parkes Bonington, who should have gone far had he lived longer.

4. Constable.—John Constable (1776–1837) was the first English landscape painter to ask no lessons from the Dutch. He was instead indebted to the landscapes of Rubens, but his real model was Gainsborough, whose landscapes, with great trees in well-balanced masses planted on land sloping upward toward the frame, have a rhythm often found in Rubens. His originality did not lie in choice of subjects, which frequently repeat themes beloved by Gainsborough. Nevertheless, Constable seems really to belong to another century; he ushered in a new era and this difference resulted at once from technique and feeling. He no longer calculated picturesque effects but painted nature with great humility and sincerity. Constable was the first landscape painter to consider as a primary and essential task the sketch made direct from nature at a single sitting, an idea which contains in germ a great part of the destinies of the modern landscape, and even perhaps of modern painting. It is this momentary and spontaneous impression—of all things the most irreducible and individual, the least susceptible of voluntary reproduction—which is preserved in his paintings. He discovered the exuberant abundance of life in the simplest country places where there is a sky across which the white or gray clouds hasten, where trees rustle their innumerable leaves and waters glide between tall weeds starred with dewdrops and flecks of light; and he expressed all these primitive things which enchanted him with the palette of a creative colourist and a technique of vivid hatchings heralding that of the French Impressionists. He audaciously and frankly introduced green into painting, the green of lush meadows, the green of summer foliage, all the greens which, until then, painters had refused to see.

Constable recognized light as the all-pervading element in the landscape and saw the visual interrelationship of all objects which was due to their mutual reflection. In order to capture the movement of light he broke up his colour areas and introduced white high lights. His rough textures also add to the spontaneous vitality of his paintings. Then so as to impress the academy, he would later elaborate on his first visual impressions and create a replica which was actually a careful and conventional machine. By doing this he was able to succeed in being elected a member of the Royal academy toward the end of his life.

Constable's technique and particularly his method of securing the freshness and intensity of his greens by the juxtaposition of multifarious tones were a revelation to Delacroix, as is evidenced by his *Journal* and *Correspondence*. After seeing the works of the illustrious English landscapist he repainted, it is said, the whole background of his great canvas "Massacre of Chios." Of great landscapists who occupy so important a place in 19th-century art Jean Baptiste Corot probably was the only one to escape the influence of Constable. All the others are more or less direct descendants of the master of East Bergholt.

5. **Bonington.**—Richard Parkes Bonington (1801–28), who spent most of his too short life in France, was to a still more marked degree another connecting link between England and France. He painted water colours which are little masterpieces of brilliance and limpidity, and oil paintings no less attractive. He brought the force of English landscape painting to France and at the same time he became a disciple of the budding French romanticism with a grace, fantasy and freshness of colouring all his own. In some few landscapes such as his water colours and oils of Versailles, Venice or Normandy he shows a breadth of vision and a sureness of touch foreshadowing the greatness he might have achieved had he not died at the age of 27.

6. Turner.—At 15 years of age, Joseph Mallord William Turner (1775–1851) was already exhibiting a "View of the Archbishop's

Palace, Lambeth." He soon acquired the reputation of an immensely clever water colourist. A disciple of Girtin and Cozens, he showed in his choice and presentation of theme a picturesque imagination which seemed to mark him out for a brilliant career as an illustrator. He traveled, first in his native land and then on several occasions in France, the Rhine valley, Switzerland and Italy. Soon, even in works in which one is tempted to see no more than picturesque imagination, there appears his dominant and guiding ideal of lyric landscape. He chose a single master from the past and studied profoundly such canvases of Claude as he could find in England, copying and imitating them with a marvelous degree of perfection. His choice of Claude as a master never failed. He desired his "Sun Rising Through Vapour" and "Dido Building Carthage" to be placed in the National gallery side by side with two of Claude's masterpieces; and there one may still see them and judge how legitimate was this homage.

It was only, and this is worthy of note, in 1819 that Turner went to Italy, to go again in 1828 and 1843. These journeys did not serve the purpose of direct representation, but certainly Turner experienced emotions and found subjects for reflection which he liter translated in terms of his own into dynamisms of light and colour. Where Constable expressed his experience of nature, Turner. after absorbing nature's lessons, recreated it from his imagination.

The logic of reason does not count for this northern imagination. But no southern painter had the logic, which to him would appear almost monstrous, of the Englishman who was consumed by a solitary and royal dream, indefinable and full of marvels, and who, thus possessed, did not distinguish reality or life, even his own, from the pictures he created to reflect at least some traces of the dream. The dream of most southern painters is one of happiness, at once heroic and human. Ardour is tempered with melancholy, as shadow strives with light. Melancholy finds no home in Turner's protean fairyland; what place could it have in a cosmic dream? Humanity does not appear there, except perhaps as stage characters at whom one hardly glances. Compare his "Ulysses Deriding Polyphemus," one of his masterpieces, with Poussin's. Turner's picture fascinates the viewer and yet he thinks of nothing precise, nothing human; only unforgettable colours and phantoms lay hold on the imaginations. Humanity really only inspired him when linked with the idea of death. but strange death, a lyrical dissolution—as the finale of an opera. In his "Rain, Steam and Speed" the balance is disturbed, design is dissolved, and there seems to be no harmony. There is an almost completely abstract composition of pictorial elements conceived as forces of energy and light.

7. Blake.—The England of that day also had other visionaries; none was comparable with Turner as a craftsman. Johann Heinrich Füssli, of Zürich, Switz., known in London as Henry Fuseli (1741–1825), was a writer and painter who belonged by his life, work and successes to the English school. He pursued the painting of fantasies with an uninspired brush and a coldly complicated imagination. John Martin (1789–1854) illustrated John Milton's *Paradise Lost* and showed, perhaps, more talent in mezzotints than in painting.

William Blake (1757–1827), poet, draftsman, engraver and painter, created work made up of a strange array of elements—medieval art, the Bible, Milton and Shakespeare, to which mere added Dante and a certain taste for linear design, which, resembling a geometrical diagram, relates him, through Fuseli and John Flaxman, to the great classical movement inspired by Winckelmann and propagated by David. This is the sole point of contact discernible between the classicism of David and English art, and it is fugitive, indirect and different in spirit. Blake was the most mystic of the English painters, perhaps the only true mystic who existed at that time among painters the world over. He was ingenious and his inner imaginations and interpretations of the ancient and modern poets reveal as true and candid a spirit as the title of his first work—poems composed, illustrated and set to music by himself, the *Songs of Innocence* and *Songs* of *Experience*. His drawings were not based on an experience of the visible world, however. He found his reality with the mind's eye rather than the retina. His illustrations to Dante's *Divine Comedy* and the Book of Job seem to be indeed hallucinatory inventions of the unconscious mind, expressed with a baffling vehemence. While he is often compared with Michelangelo, he altered High Renaissance form to an abstract linear style reminiscent of early Celtic manuscripts.

8. Portraitists.—Side by side with isolated figures such as Turner and Blake flourished the second generation of portrait painters, George Romney (1734–1802), John Hoppner (1758–1810), Sir Henry Raeburn (1756–1823), all excellent painters who are relegated to the second rank only by the achievements of Reynolds and Gainsborough. The first left numerous and impassioned pictures of the celebrated Lady Hamilton and displayed talent and distinction in his family groups. The pictures of young men and maidens painted by Hoppner are full of charm and refinement. Raeburn's colour is rich and warm, and his touch broad and vigorous; he had the gift of posing his sitters with decision, and possessed some of the attributes of a great painter. Sir William Beechey (1753–1839), a skillful technician, but more commonplace, should also be mentioned. At this moment virtually all English painters produced fair and sometimes even good portraits, even the historical painters whose heavy compositions, once so fashionable, now appear so poor and uninteresting. Among these were Benjamin West (1738–1820), born in the American colonies and Reynolds' successor in the presidency of the Royal academy, and John Opie (1761–1807). John Russell (1745–1806) was the pastellist of this school.

Sir Thomas Lawrence (1769–1830) was the painter of kings, of princes, of great diplomats and generals; the pope himself sat for him. All these are presented in large full-dress portraits painted with sovereign verve and elegance. Lawrence was an important figure at Aix-la-Chapelle and at Vienna during the famous congresses which settled the fate of Europe after the downfall of Napoleon. The Holy Alliance is mirrored in the 24 canvases which adorn the walls of Windsor castle—a collection of official portraits forming a unique historical document. There is, moreover, in Lawrence's work something more than a mere caprice of fashion. His success was greater than that of Reynolds; though he had not the thoughtful learning and the rich and refined taste of his more illustrious predecessor, he excelled him in facility. At the age of ten he was already a portraitist. Before he was 22 he had painted the ravishing full-length portrait of Miss Farren, later the countess of Derby. Lawrence at once leapt into fame, becoming an associate of the Royal academy and a favourite of the king. Henceforth he lavished on his portraits, and especially on his portraits of women, his facility of execution, his fluid touch, his rich and always highly distinguished colour, his talent for depicting the pearly bloom of flesh, the sparkle of bright and limpid eyes, the moist quiver of parted lips, the light softness of muslins, the gleam of silks and of velvets. There is superficiality and artifice, but artifice handled with such vitality and verve becomes second nature. It is nonetheless true that the painter of George IV and his court could lay claim at a critical moment to an important influence on the destinies of painting, not so much, moreover, in his own country as in France and through France to the whole world. When Delacroix arrived in London he was seeking, as Gericault had already sought some years before, to fight against the systematic desiccation of the school of David. Lawrence showed him that by a return to harmony, richness of colouring and beauty of touch founded on the example of the great masters of the past it was possible to create a modern art full of vigour and capable of every expression. Thus Lawrence stimulated the energies of French painting almost as efficaciously and opportunely as Constable. Later, in France, England or elsewhere, every time that the need was felt of a supple and brilliant execution to express the quality of life, it was more or less consciously to Lawrence that men turned.

9. Pre-Raphaelites.—After English painting had shed its lustre over a great part of the world, England withdrew within itself in an effort, praiseworthy in its intentions but, in spite of a few incontestable talents, slight in its results and adding little to the treasures of universal art. This movement must nevertheless have responded to some general spiritual need, for it is impossible to deny the sentimental and intellectual analogies which produced

Böcklin in Germany, Gustave Moreau in France and the Pre-Raphaelites in England. To a certain extent it may be said that Pre-Raphaelitism was a continuation and transformation of the idealist movement, fantastic and mystic by turns. which produced at the beginning of the century Fuseli and Blake. Thomas Stothard (1755–1834). with his pictures from Shakespeare and Chaucer, which were painted in a style imitated to some extent from medieval illuminations: continued this movement in his own way. A little later Ford Madox Brown (1821–93) painted his first Gothic pictures filled with an arid precision, a scrupulous attention to minute detail, a harsh colouring, in a word almost everything which was to become the rule in Pre-Raphaelitism. In 1848 the new school found its name; it might rather be said the new brotherhood. for under the influence of John Ruskin — an imperious aesthetician with a passion for French cathedrals and the quattrocento Italians, a poet in his way but impregnated with the spirit of puritan asceticism — the group assumed an almost religious character and each of its members had to append to his signature the initials P.R.B. ("Pre-Raphaelite Brotherhood"). Their intention was to react against the facile frivolity of the Lawrence tradition in art, but they traced its decadence farther back to the remote effect of the academic style for which Raphael himself has to be the first to answer. There must be a return to the simplicity of the primitives and a pious copying of nature which carried craftsmanship to the point of compulsiveness. Yet in spite of all this naïveté to which they ardently aspired, the works of the Pre-Raphaelites were everywhere filled with artificiality — and an artificiality more literary than plastic. This is not surprising. since from the start the new school was influenced by two men of letters, the critic Ruskin and Dante Gabriel Rossetti (1828–82), who was poet and journalist before becoming a painter, and always pursued his two callings simultaneously. The Pre-Raphaelites believed that painting must convey a moral message, and that true morality could be found only in Christian teaching. They mere truly shocked by the excesses and human suffering caused by the Industrial Revolution, but their answer was an escape from it. Their art was related to the contemporary revivals in architecture and in theology. The group included William Holman Hunt (1827–1910), Sir John Millais (1829–96) and Sir Edward Burne-Jones (1833–98).

George Frederic Watts (1817–1904), who was older than the first Pre-Raphaelites and even than Ford Madox Brown. and who outlived for a considerable time the youngest disciples of the brotherhood, had a career parallel to theirs. But while he too believed that art should serve a moral function, he made no pretense of restoring the nai've and scrupulous technique of the primitives. His portraits are the best part of his work. Frederic Leighton (1830–96) and Sir Lawrence Alma-Tadema (1836–1912) retain, on the other hand, some of the careful precision of the Pre-Raphaelites. While Burne-Jones was still painting his reveries, other artists were attracted by new currents of thought.

J. America

Painting in the American colonies reflected generally the portrait styles in the mother countries, though with a tang of provinciality. In the late 17th and early 18th centuries the Dutch colony of New Amsterdam (New York) had painters whose names today are forgotten. Their work lives on and is signified by names such as the "Master of the De Peyster Boy" and others. Gustavus Hesselius (1682–1755), Swedish born, was painting in Maryland and Jeremiah Theus (c. 1719–74), a Swiss, was at work in South Carolina. Peter Pelham (c. 1695–1751) and John Smibert (1688–1751) arrived from England, and in the second quarter of the 18th century were painting portraits in Boston, Mass. These two limners were succeeded by John Wollaston (active in America 1749–67) and Joseph Blackburn (c. 1700–60); Robert Feke (?1705–?1750), a native American, realized his forms more solidly and with greater originality.

Another native American, John Singleton Copley (1737–1815), working in Boston until 1774. when he went to live permanently in England. was responsible for the finest painting produced in the American colonies. His portraits are racy, original, decidedly un-European in conception.

Benjamin West, another important figure in the history of American painting, settled in London in 1763 and there helped to mold the styles of two generations of American painters. Charles Willson Peale (1741–1827), John Trumbull (1756–1843). John Vanderlyn (1775–1852), Washington Allston (1779–1843), Samuel F. B. Morse (1791–1872) and Rembrandt Peale (1778–1860) all benefited from West's hospitality and teaching in London. Some of their portraits have decided merit (*e.g.*, Morse's "Lafayette," in the city hall, New York), but their pretentious historical pictures were generally unsuccessful. An exception is Vanderlyn's "Ariadne," one of the finest achievements in American figure painting.

Almost a generation older than these painters but younger than West was the portrait painter Gilbert Stuart (1755–1828), who went to England in 1775 and returned to America after 12 years. In London he appear2 to have spent some years in West's studio and to have been influenced by Gainsborough's work. On his return to America his style became highly individual, and his portraits, polite in spirit, were deftly handled and fresh in colour, the flesh having an extraordinary silvery beauty.

Other popular portrait painters were Thomas Sully (1783–1872) and John Neagle (1796–1865) in Philadelphia, Pa., and Henry Inman (1801–46) in New York city. Sully's fluent style was based on Lawrence, but he developed his own colour and handling.

Landscape painting. which became an important expression of the mild, poetic idealism of America, began about 1825 with the work of the indigenous Hudson River school. Thomas Cole (1801–48), Asher B. Durand (1796–1886) and Frederick E. Church (1826–1900) being some of the most notable masters. Out of this movement came George Inness (1825–94). His early landscapes have a classic spaciousness which gradually gives way to a formless but effective resonance. Others were William Morris Hunt, George Fuller, Elihu Vedder, John La Farge and somewhat later Frank Duveneck and William Merritt Chase.

Picturesque James A. McNeill Whistler (1834–1903) went to Paris as a young man and soon settled in London. He was influenced by Courbet and Ignace Henri Fantin-Latour but especially by Japanese colour prints. His paintings transform people and familiar scenes into colour harmonies of exquisite subtlety. Such portraits as those of his mother and Thomas Carlyle are masterpieces.

Another distinguished painter was the thoroughly American Winslow Homer (1836–1910). He was concerned with life in the open, especially with the sea, and his water colours of such subjects constitute the most powerful expression in American painting.

Thomas Eakins (1844–1916) was another strong personality. His portrait subjects and figures are observed with superb scientific self-discipline, but there is a forbidding renunciation of sensuous appeal. His temperamental opposite was Albert Ryder (1847–1917), who escaped from dingy actuality into dreams. The 19th century closed on the work of the thoroughly expatriate member of the French Impressionist group, Mary Cassatt (1844–1926); of Childe Hassam (1859–1935), exponent of crisp Impressionism; and of the famous John Singer Sargent (1856–1925), whose precocious bravura astonished the English-speaking world.

K. France: 19th Century

At the risk of oversimplifying, French 19th-century painting may be considered as a series of movements or schools representing differing points of view that are common to the other arts of architecture, sculpture, literature and music. Neoclassicism in the late 18th century persisted as the first of the major 19th-century styles. It was followed by a strong trend toward romanticism and that in turn was superseded by Realism. Impressionism. an intense form of Realism limited mainly to the representation of colour and light, gave rise to the Postimpressionist styles which were, in effect, a revolt against the limitations of Realism and Impressionism. Modern art stems from the variety of Postimpressionist painting.

The new art movements, as they first appeared on the scene, seemed to flaunt their differences from the current, prevailing movement. In addition to schools of painting there were painters

such as Honoré Daumier who fit into none, and yet seemed to have overtones of several.

The Salon, or public exhibition of painting under government auspices, was another important factor in art in France. In the Salon the conflicts of the schools can be seen in sharp focus. With few exceptions, it was held every year and was under the control of the reigning artists and prevailing styles of the day. The younger artists, the new schools, had to struggle for admission. Classicism was the first of the 19th-century schools, and its first master was Jacques Louis David (see above).

The pupils of David were in general marked with an indelible stamp. Some knew how to retain, in one way or another, part of their freedom. Franqois Gérard (1770-1837) in his allegorical or mythological compositions did not escape academic frigidity. But when he painted his celebrated picture "Cupid and Psyche," he accomplished elegance and grace. Antoine Gros (1771–1835) had a stronger personality. a sense of drama and an aptitude for expressing it by composition and colour. In the "Pest House of Jaffa" and the "Battle of Eylau" he showed himself as the authentic forerunner of romanticism and of Delacroix. But a strange return of fidelity to the teaching of David paralyzed his natural impulses in the second part of his career.

Jean Louis Géricault (1791–1824). who had the makings of a great artist, was alone capable of finding in David the solid basis of a classic art, and infusing this with passion and life. Unfortunately he died prematurely. "The Raft of the Medusa" (1819) proves that he would have been capable of the highest achievements and the boldest efforts. It deals with a contemporary event but is extremely strained and intense in its emotional power. At once romanticist and Realist it is a forerunner of both movements as well as one of the finest paintings of the first half of the 19th century.

1. Ingres.—Jean Auguste Dominique Ingres (1780–1867) continued the classic Davidian tradition in an age of romanticism. But he looked at Raphael and Poussin rather than at copies of Greek sculpture. He continued history painting in the grand manner but the results lack pictorial unity and are often thin and mannered. In his more modest works, in his nudes and portraits, he attained an astonishing beauty of undulating line. He was only 26 years of age in 1806 when he painted "Madame Rivikre" and he already had emancipated himself from David's more static composition. The dynamic movement of the intersecting circles of this portrait, the relationship of interior lines to the oval frame, the swirling flow of drapery make an exciting and vivacious characterization. More than that, the sweeping lines take on an almost independent life of their own. His contemporary opponents were attacking archaic and singular taste when they dubbed him Gothic and Chinese. The sculptor Xntoine Auguste Préault, celebrated for his witty sayings, called him a "Chinaman lost in Athens."

One may perceive eccentricity in some of the most beautiful of Ingres' works. A pedant, seeing the back of the "Odalisque," the neck and arm of Thetis in the picture of "Jupiter and Thetis" (Aix museum), the shoulders of "The Bather" in the Louvre, and various exaggerations of form in the "Turkish Bath," would point to this incomparable draftsman's faults. But are not these merely the means by which a great and extremely sensitive artist interprets his passion for the beautiful female form? Ingres has an impeccable sureness, original taste, a fertile and appropriate invention, especially in the pictures where he deals with only a single volume and not with the intricacies of pictorial space. He remains the supreme master of the rhythmic contour line.

2. Delacroix.—Eugène Delacroix (1798–1863), who had learned much from Géricault, became the master of the romantic movement and the unswerving adversary of Ingres. The champions of Davidian classicism claimed to defend order, and accused the romanticists of introducing anarchy and revolution into art. In reality, romanticism, taking the word in its widest sense. prevailed everywhere in the atmosphere of the time, as an aspiration to liberty, poetry and lyricism. There is romanticism in Ingres himself, especially regarding subject matter. As for Delacroix he always repudiated any claim to being the head of a school and liked to pose as a pure classic. Yet if one thinks of romanticism as the transference of the artist's personality in its most intimate, emotional and secret aspect into his work, Delacroix embodies in himself its vital principle. But he had no liking either for painters or men of letters who paraded romanticism. Seen as a whole his work is strong and sound, notwithstanding his tragic sadness, because it aims at great objectives and uses the most rational and efficacious means to attain them. In short. it happened by good fortune that the two men whose influence was to succeed that of David, the one more instinctive and more enamoured of form, the other more intellectual and more preoccupied with dramatic expression, were champions of order, deserving each in his own way the name of classic.

If Ingres had difficulty in the handling of large and complex compositions, it is generally in the relationship of several figures that Delacroix found the natural and striking expression of his ideas. His work is an immense and multiform poem. at once lyrical and dramatic, on the violent and murderous passions which fascinate and dominate humanity. In elaboration and execution, Delacroix does not forego any of his faculties as a man and an artist of vast intelligence standing on a level with the thoughts of the greatest in history, legend and poetry, but he makes use of a feverish imagination always controlled by lucid reasoning and cool will power, of expressive and lifelike drawing, strong and subtle colour, sometimes composing a bitter harmony sometimes overcast by that sulfurous note, already observed by contemporaries, producing an atmosphere of storm, supplication and anguish. With Delacroix as with Rubens, there hovers over the saddest representations, over tumults, horrors and massacre, a kind of serenity which is the sign of art itself and the mark of a mind master of its subject. Delacroix was willing to take a stand regarding the political events of his time, as in the dynamic "Liberty on the Barricades" (1831), where allegory is fused with social realism, and he also exploited the possibility of exotic subject matter and lush Mediterranean colour in his lion hunts and scenes of oriental life.

Delacroix, who hardly ever painted isolated figures, did paint some portraits of friends. The best is the fine portrait that he made of himself. His *Journal* shows his acute ability at critical analysis and psychological introspection. • It is only a series of fragments of which many are made up of careless and unfinished phrases. Nevertheless, this book, unique in being the work of a painter, shows his extraordinary capacity for sensitive understanding of the world of music and poetry as well as of painting.

3. Landscape Painters. — The development of landscape is one of the most salient facts in the history of French painting in the 19th century. David had secured for landscape painters the recognition of their right of citizenship in official art, and at his initiative what mas called historic landscape became one of the sections for the Prix de Rome. But this academic and conventional landscape painting was soon renounced by the young men of the generation born around 1810—Louis Cabat, Théodore Rousseau, Jules Dupre, Paul Huet, Jean François Millet, Alexandre Decamps, Camille Flers, Narcisse Diaz de la Peña, Constant Troyon. Antoine Chintreuil, Charles François Daubigny. With unequal merits and varying aspirations they conquered, after many trials, the right to represent nature in either its grandiose or familiar aspects.

The leader of the French landscapists of this period was Théodore Rousseau (1812–67). He profited by the lesson of the English, especially Constable and Bonington, and also by the examples of Delacroix. But he had a philosophic individual mind which gives his meticulous works an aspect of austere grandeur. Starting from an almost scientific analysis, Rousseau terminates in generalizations which out of the fringe of a forest, a chaos of rocks, form a microcosm, mirroring innumerable terrestrial activities.

4. **Corot.**—J. B. C. Corot (1796–1875), 16 years older than Rousseau, remained aloof from the disputes between Ingres and Delacroix, between the classic and romantic camps. He spent many years in Rome and painted landscapes not unrelated to Poussin's, but actually closer to a still life by Chardin. In his early paintings, as "Island of San Bartolomeo, Rome," plastic volumes are composed carefully, the planes defining the picture space, while the whole landscape is flooded with carefully controlled light. His

figure compositions attain a similar monumentality. His later landscapes, painted in the forest of Fontainebleau, became more hazy and gray in tone, and—they often included dancing nymphs—sentimentally romantic in feeling. Yet it was these late landscapes with their soft, cottonlike trees that became most popular. Corot, owing tribute to the 17th-century painters Poussin and Claude, became a major influence on succeeding generations of Impressionists, who admired his sensitivity to nature and his mastery of light effects.

5. Millet.—At the time when landscape attracted to itself free inquirers in large numbers Jean François Millet (1814–75) and Daumier had the merit of introducing the representation of contemporary life not in the anecdotic form of the tableau de genre, which had reached its apex with Ernest Meissonier (1815–91), one of the most prodigious, precious and impeccable virtuosi of soulless painting. Millet sought an epic style in order to paint peasants, their fields, their work, their domestic life and referred to himself as the "peasant of peasants." Having begun with paintings in the romantic fashion high in tone, he turned gradually to simplified design and muddy earth colour, still keeping contact through his studies with this nature which he so religiously loved. His paintings, always and entirely composed in the studio, are the acts of a considered wish, assisted by a methodically exercised memory. "The Gleaners" and "The Angelus," his most famous paintings, while new in subject matter, are actually academic in form, as well as sentimental in content. His drawings, water colours and etchings show a greater sensitivity.

After 1865 the mannerism but not the spirit of his work altered a little, evolving toward more liberty, more suppleness, more cleanness. His pastels multiplied and landscape occupied a larger and larger place. In "Spring" the artist, for the first time, meant not so much to picture a certain site arranged in a certain may as to seize, as the Impressionists were to do, an effect of light not yet observed or rendered with so much truth.

6. Daumier.—Honoré Daumier (1808–79) was best known as a graphic artist during his lifetime. He produced nearly 4,000 lithographs and his prints probably had a wider public than have the works of any other modern artists. But his paintings remained unknown during his time, aside from the recognition of a few exceptional critics such as Charles Baudelaire. Daumier was an illustrator and a deeply human caricaturist who understood the psychological implications of his political and social subjects. Where Millet might strike one as being theatrical, Daumier's more sincere drama profoundly moves one, perhaps because of his magnificent sense for the evocative possibilities of a quickly drawn line and the powerful plastic volume of his figures. His paintings were inspired with such animation and built on a framework of such expressive drawing, the brush handled the colour with such vigour that their vital force is astounding. Daumier explored the action in the law courts, the theatre, and even in the railway carriage—a subject no other painter considered proper for the art of painting. In his "Third-Class Carriage" he developed formal means to bring a haphazard combination of people into a pictorial unity. Yet each individual remains carefully characterized by the artist's personal insight and mastery of form.

7. Courbet.—Gustave Courbet (1819–77) called himself a Realist and was equally opposed to romanticists and classicists for the faraway and long-ago subjects adopted by the painters of both groups. Like Daumier he was highly conscious of social conditions. He believed that instead of dealing with ideas and concepts, or instead of glorifying the past, the painter must represent only both visible and tangible objects. While his pictorial form was rather traditional, his subjects were often strong social commentaries such as "The Stone Breakers" of 1849. He felt that it was incumbent upon the artist to be a spokesman for the people in their social and political struggles and he allied himself with the progressive forces of his day. Yet most of his paintings—nudes, portraits, landscapes, flower pieces—have no political overtones. His work is important for its clarity of statement and his break with the tradition of history painting. It is admirable for its audacity and robust strength, his understanding of formal relationships, and its sheer delight in the material reality not only of its subject but also of the paint itself.

8. Academicians.—The painters discussed were only on the periphery of the Paris art world, while the widely recognized and popular painters continued to adhere to eclectic academic doctrines. Alexandre Decamps (1803–60) and Meissonier were greatly admired for their extremely skillful and deceiving genre paintings. Thomas Couture's (1815–79) vast and tedious canvas, "Romans in the Decadence of the Empire," was considered officially to be the masterpiece of the time. Jean Léon Gérôme (1824–1904), Alexandre Cabanel (1823–89) and Adolphe Bouguereau (1825–1905) combined the now stale classical style with just enough erotic overtones to titillate the Parisian public. Heaped with official awards and commissions, they were able to retain control of French art and the Salon until the end of the century. Pierre Cécile Puvis de Chavannes (1824–98), while basically a conservative painter steeped in the Renaissance tradition, developed a unique style of mural painting in which diffuse light, a unified tonality, an almost geometric order create a slow, measured rhythm of human form and gesture. His murals in Amiens, the Pantheon and city hall in Paris, and the Boston (Mass.) public library constitute a successful approach to an association of painting and architecture. Gustave Moreau (1826–98) created a cycle of fantastic visions and was concerned with the world of thought rather than with appearances. The teacher of many of the Fauve painters (see below) including Georges Rouault and Henri Matisse, Moreau, while still using academic form, can also be considered a precursor of the Surrealist movement.

9. Manet.—After Courbet there arose an even more outstanding personality, that of Édouard Manet (1832–83). Then commenced violent press campaigns which little by little inspired the public with horror, disgust and even a kind of incredible hatred for the young artists whom they considered as revolutionaries. Those young artists were first Manet, then the whole group of comrades of whom he was the eldest, and who used to meet in the Café Guerbois: Degas, Cézanne, Renoir, Monet and the others. Even Manet's person was scandalously misinterpreted; most Frenchmen thought that the author of the "Luncheon on the Grass" and "Olympia" not only ignored the first rudiments of the art of painting and that his pictures were ridiculous, but that he himself was a kind of coarse, extravagant, unconventional Bohemian. Until his premature death, the charming, witty and elegant, but also nervous and irritable Manet could not become reconciled to this injustice. He knew the fascination that he exercised on his friends, and he would have liked to please everyone: conscious of his exceptional gifts, he felt he was destined for the acclamations bestowed on Rubens or Velazquez. As they had done he developed a new visual form. He abandoned all shadows and gray tones and simply laid on light and dark immediately next to each other without soft traditional modeling. Forms were kept flat and colour areas were applied solidly much as in Japanese woodcuts which were just coming to the attention of European painters and which exerted an enormous influence on Manet and his Impressionist and Postimpressionist followers. While critics and public both exhibited only animosity to Manet's painting, the younger (Impressionist) artists rallied around him, and he himself was to be influenced by their light palette and interest in the quick and momentary impression. Toward the end of his life, in a masterpiece such as the "Bar at the Folies-Bergère" of 1882, he documented a contemporary scene, and here showed his great interest in a complex space structure and in harmonies of colour and sparkling light.

10. Monet and the Impressionists.—Impressionism was a movement which carried the realist and pragmatist ideas of the period to their logical conclusion. The Impressionist painter like the Realist was concerned with the visible aspects of reality, but was also interested in the immediate appearance at a momentary glance. He was fully conscious of the continuous change in nature and felt that the changing appearance was due to changes in light. Colours became brighter than ever before in the history of painting because they were conceived of as a function of light. The Impressionists wanted to achieve the brightness of sunlight on their canvases. They soon realized that even a bright yellow could be reinforced by placing it next to its complementary, violet. Colour

and light were to create shape and space. Space as it had been known since the Renaissance was abandoned as an important structural factor. Reality, to be sure, has many faces, and the Impressionists were concerned almost exclusively with the way reality appeared to their eyes. Inner reality, thought and vision had no place in their theories except insofar as the painters were concerned with their personal reaction to visual facts. Claude Monet (1840–1926), the originator and most complete protagonist of the Impressionist movement, made dozens of different paintings of the same subject, always completed outdoors. In his series of haystacks, cathedrals or water lilies he was not interested primarily in his subject—one painting would have sufficed if he had been—but in the light reflections on the subject. He therefore had to paint many pictures of the same subject, but the content had become the reflected light and this, in a way. is an abstract concept. Monet's energy and passion made him to a certain extent a visionary, and it is surely not the characteristic of a narrow conception of art to close a career of landscapist with that unprecedented and unclassifiable work, "Le Bassin aux Nymphéas," a vast cyclic poem of the water, flowers, leaves and light, to which he devoted in solitude at Giverny the last 20 years of his long life.

Alfred Sisley (1839–99) was no theorist; once provided with the technique acquired from Monet, his only ambition was to be a charming minor painter of the countryside. Camille Pissarro (1830–1903) was the oldest member of the group. He had the greatest admiration for Corot and in certain pictures where at first glance only the technical preoccupations are seen, there may also be discovered a desire for order and organization, which the doctrine of Impressionism did not encourage. Pissarro wandered more than once beyond the horizons of pure Impressionism, and was able to play the curious and glorious role of teacher to Cézanne, Paul Gauguin and Georges Seurat, the three men who, with different means, were to lead French art into new paths.

11. Renoir.—Pierre Auguste Renoir (1841–1919) studied under Charles Gleyre at the French academy, where he met Monet and Sisley. Leaving the atelier he came under the influence of Courbet, but he soon dissolved his colour areas and began to work outdoors. As a leader of the Impressionist group, he helped develop the Impressionist technique for the representation of the human figure which was to remain his prime interest. The contours of his figures were dissolved. His people became an integral part of their natural environment, and a dancing light pattern is created on them from the effect of sunlight coming through foliage. Renoir used a warm, sensuous palette for the movement of leaves, water and the human figure. After 1880 Renoir felt that momentary effects were not enough and that the painter had to draw and compose. He disciplined and tightened his painting under the inspiration of Raphael and Ingres. Finally, at the turn of the 20th century, Renoir evolved a unity of colour, line, volume and light for his glorious paintings of large nudes set into rich landscapes. Almost intuitive in his technical accomplishments, Renoir was the least conscious theorizer among his contemporaries. His love for colour and his insistence upon the sensuous elements of nature counteracted much of the subjective and overanalytical tendencies of the art of his own time, and contributed immeasurably to a painter such as Matisse who was later to appear as the leader of *Les* Fauves.

12. Degas.—Hilaire Germain Edgar Degas (1834–1917) was still less an Impressionist, if it is possible, than Renoir. An incisive designer and prodigiously accurate, he was indebted to Holbein and Ingres. The public called him the painter of ballet dancers. Degas was no more a specialist of dancers than he was of modistes or jockeys. What attracted him successively or simultaneously to these subjects of study mas the desire to grasp in an extraordinarily precise and expressive stroke gestures and movements which the eyes of painters until then had ignored. He loved the disciplined movement of the ballet dancer and the race horse. It was with the same preoccupations that, during 10 or 15 years, he made himself a portrait painter. The impression of truth conveyed was secured by the drawing with its closed form and unusual composition. Finding entirely new types of composition was a great part of his research; his inventions in this field were most original and bold, and have had capital consequences for modern painting and photography. He did not share the Impressionists' love for light and colour. and the disdain he had for the open air was a final trait contrary to the process and convictions of the orthodox Impressionist. He did share with the Impressionist his intention to convey a momentary scene, but while Monet would be satisfied with the impression of the object, Degas caught the essence of action itself.

III. MODERN PAINTING (LATE 19th AND 20th CENTURIES)

A. Postimpressionism

1. Toulouse-Lautrec.—Henri de Toulouse-Lautrec (1864–1901), descendant of one of the oldest families of the French nobility, became a great admirer of Degas and chose similar subject matter and related means of expression. In his paintings, drawings, lithographs and posters he developed an evocative line which expressed his understanding of human action. He frequently used large bold planes of colour and was likely to tilt his space upward. Toulouse-Lautrec lived in Montmartre and painted the cabaret, theatre, dance hall and circus—the entertainers and the customers. A dance hall by Toulouse-Lautrec, such as the famous "At the Moulin Rouge," was no longer the pleasant, graceful and gay garden party seen by Renoir; it became a joyless place where people seek escape and where Toulouse-Lautrec could observe them with deep psychological insight. He was less concerned with the play of light and shadow and much more with the human comedy or tragedy.

2. **Seurat.**—Among the Postimpressionists, the contributions of Georges Seurat (1859–91) were many. He never concealed how much his inventive technique owed to Monet. He personified an intellectual reaction against the dispersive and undisciplined tendencies of Impressionism. He possessed a sense of order and grandeur and he found a technique and style to convey this sense of disciplined form. Along with his exacting colour science, his classic sense of composition and space division was almost unrivaled since that of Piero della Francesca and Paolo Uccello. His formality of design, discipline of pattern and understanding of space interval were executed in a refined colour scale broken into tiny, perfectly matched strokes, which earned this movement the names of Divisionism, Pointillism and Neoimpressionism. Seurat's contribution is largely summed up in his masterpiece, "Sunday Afternoon on the Isle of Grande Jatte." He was also one of the immediate ancestors of both the Cubists and Les Fauves (see below). Followers of Seurat who stylized his idiom of brush stroke and broken colour to various points of exaggeration, though their work is not without charm and sometimes importance, were Paul Signac (1863–1935j, Henri Edmond Cross (Delacroix) (1856–1910) and Van Rysselberghe. Of all Seurat's followers Signac was the best known and is credited with actually having originated the colour system practised by Seurat, mainly that of painting in tiny mosaics of warm and cool colour and of uniform stroke, which were perfectly adjusted according to preconceived theories based upon the writings of Michel Chevreul, Hermann von Helmholtz and Ogden N. Rood. In Seurat's case there was perfect balance of hue, value and intensity. Signac's contribution lies not in his overstylization of this colour theory in his oil paintings but rather is to be seen in his water colours, which have a lyrical and compelling charm.

3. Van **Gogh.**—Vincent van Gogh (1853–90), appearing as a meteor at the time when Impressionism began to triumph, did not dwell upon repetition. He made use of the conquests, but only as instruments for the lyricism and mysticism through which his sparkling genius looked on nature. In Feb. 1886 he arrived in Paris! and at once his originality burst forth like an explosive placed too near a fire. Brief was the period of his short life in which was created all that made him a great painter. He had become acquainted with Degas, Seurat, Toulouse-Lautrec and Gauguin, and owed much to each of them. He shared their passion for the Japanese print.

Van Gogh had an intense empathy with natural forces and with human emotions. Where the Impressionists were interested in sunlight, Van Gogh became a worshiper of the sun. He went to Arles

in the south of France where there was little haze and the bright sunlight isolated all details in the landscape and gave it pronounced outlines. In his mature paintings, done during four or five years, he used line, colour and brush stroke with extreme intensity, employing them arbitrarily and rather abstractly to make them yield the greatest force. He set out to recreate the feeling evoked by a field, a poolroom, a starlit sky; his work succeeds in stimulating the spectator into a complete emotional response. The ecstasy of his colour and the vigour of his surfaces communicate to the observer a heightened awareness, which: after all, may be considered the essence of the aesthetic experience. When Van Gogh committed suicide in 1890 he left a remarkable body of work to stimulate future generations of artists as well as that public which had shown no appreciation of him during his lifetime.

4. Gauguin.—Both Van Gogh and Paul Gauguin (1848–1903) were able to raise subject matter of their own choosing, through intensity of colour and breadth of design, to the power of a symbol. These two painters had the greatest influence on the parallel movements of Expressionism which developed in France and Germany during the first decade of the 20th century. Van Gogh created a type of frenetic, spiritual Expressionism through temperamental violence expressed in intensity of colour and impassioned calligraphy. The elements of Van Gogh's art are perhaps more personal and direct than are those of his associate. Gauguin found his point of departure in the combined influences of Puvis de Chavannes and Impressionism. His character, his life and his work are nothing but contrasts. Gauguin threw himself into his work with a wild vehemence and with a mixture of brutality, refinement, impulsiveness and reflection. He searched for the primitive and savage in Tahiti, where, after years of rage and disillusionment, he died miserably. But it was not only idyllic savagery that he went so far to find, but also order. Introduced by Pissarro to Impressionist vision and technique, he felt the need to control form. Together with a group of disciples in Pont Aven in Brittany he developed a style called Synthesism or Cloissonism. Here the artist flattened out space, simplified design, and heightened colour by using large, flat colour areas bounded by dark lines. The final composition was rather arbitrary or synthetic and no longer determined by the visual forms of nature. The evocative force of line, shape and colour to suggest broad ideas and thoughts was considered more important than the imitation of nature. Gauguin finally left the sophisticated art world of France altogether for the South Sea islands. He reflected a growing trend in modern painting with his return to the primitive in both art and nature! and his measurement of great areas of colour with their subsequent symbolic effects. He disagreed with the minute brush strokes and the disintegration of recognizable physical forms through colour, practised by the Impressionists. He cried for "a metre of green," rather than the stroke by stroke vibration of mingled hues pursued by the original Impressionists. But even in the works composed during his Tahiti period the colour scale which he used for synthetic effects is traceable more or less directly to that handed down by Pissarro as an instrument of analysis. But, in proportion to the development of his singular personality, he withdrew farther and farther from Impressionism, while, underneath the brown skin of the South Sea "Vahines," the relationship of his Maori dream with the imaginary world of the Greco-Latin Puvis de Chavannes shines through.

5. Redon.—While Gauguin's influence on the succeeding generation of painters in France and in Germany was enormous, his contemporary Odilon Redon (1840–1916) had less effect. Redon as well as Gauguin was close to the Symbolists in French poetry and was preoccupied with the power of suggestion and inference. The artist, they felt, must "clothe the idea in visible form" and explore the world of the imagination. Redon was an artist who was essentially a visionary and a colour poet, in some ways related to mystical painters of inner vision such as William Blake and Gustave Moreau. The Surrealists, who were also concerned with the meaning of the symbol, were to pay homage to Redon.

(P. JA.; P. H. S.)

6. Cézanne.—The greatest revolutionary figure of Postimpressionism and acknowledged father of modern art was Paul Cézanne (1839–1906). Cézanne was typically a French painter in the historical, traditional sense, inasmuch as his art and spirit both consummately derived from studying the masterpieces in the museums. Many historians have noted that the most revolutionary figures in modern French painting have been largely trained through intense study in the museums and picture galleries, principally the Louvre. Cézanne's ideal was to make the art of the Impressionists "something solid and enduring, as the art of the museums." He also stated in spite of his ardent admiration of Delacroix that he wished "to re-do Poussin after nature." While always deeply concerned with the analysis of the object, he still liberated painting from imitation or narration. In discussing Cézanne's water colours, Lionello Venturi noted that his conception of the true nature of painting as distinct from that of reality made him unique. This, in a sense, described the complete difference between the concepts of painting in the 20th century and those of any other time; that is, the artist re-created the world, and it lay definitely and abstractly within the limitations of the picture frame or the boundaries of the canvas or paper.

Added to this theory of painting for its own sake is Cézanne's often-quoted advice to his friend and pupil, Émile Bernard, that he "Interpret nature in terms of the cylinder, the sphere, the cone; put everything in perspective, so that each side of an object, of a plane, recedes toward a central point." Though the Cubists were to use this as their justification for laying bare the geometric essentials of nature, it should be noted that nowhere did Cézanne speak of the cube as such, nor in his desire for "realization of the subject in nature" was there any indication that he would have adopted, let alone approved, Cubism itself. Cézanne's formal contributions became of increasing value and interest to other artists after his death in 1906. His conception of reality was based on the fundamental structure of the subject in nature which he often called the motif. For this aspect of structure, which was of an architectonic nature, he sacrificed all literary and most personal overtones, along with incidental, naturalistic detail. Consequently his still-life compositions, landscapes, portrait studies and figure compositions achieve a singularly monumental and often austere quality. In recreating an image or object, Cézanne's physical or plastic forms are analyzed in planes of colour, in which he, to quote his own term, "modulates" the colour, rather than modeling or blending it in the conventional sense, or using chiaroscuro.

Cezanne used the prismatic colour scale of Claude Monet and that of his close friend and teacher, Pissarro, painting in planes of warm and cool colour. However, he often sacrificed the purity and intensity of the local colour (*i.e.*, the essential redness of the apple) for reflected colour and refracted colour. He would change also the local or natural colour to establish a unity or synthesis, thus establishing a definite colour balance. He constantly reinforced the contours of various parts of the composition to create emphases and tensions within the picture plane. In relation to his pattern forms, there is a tremendous tension between the surface of the picture and the implied depth or what might be described as acoustical space.

Cézanne conceived a composition in which all solids contain a certain inherent energy made up of many faceted forms or planes. Each form in the composition exerts an influence as it impinges on another form, often resulting in distortion and tension. The spatial relationship between forms was more important to Cézanne than the individual forms themselves. The physical forms themselves seem to exert certain tensions against the surrounding space, whereas the intervals of surrounding space are modulated, measured and timed with counter force in relation to the forms. This approach alone is enough to suggest the beginnings of both analytical and synthetic Cubism. This contributed to Futurism, which was in turn related to Cubism.

From the various aesthetic points of view of his contemporaries, such as the Impressionists, along with their reinterpretation of the old masters, Cézanne created a new kind of pictorial composition or organization in which the vertical was used to give a greater depth. He also created a new architecture of landscape as well as of still-life painting. He evolved a symbolic attitude which was the integrity of painting for painting's sake, vastly different

from the ivory tower art for art's sake.

7. Early 20th-Century Trends.—During the first half of the 20th century Paris uas no longer the only significant art centre of the world. The all-important Expressionist movement had its nucleus in Germany. and nonobjective painting began in Germany and Russia. Yet Paris maintained its position as the most important focal point at least until the outbreak of World War II.

Modern painting, in one sense, began with the closing years of the career of Cézanne. Actually, Cézanne's personal preoccupation was to achieve a new kind of realism, but many of his remarks, especially when lifted from context, pointed toward abstraction, for he was almost obsessed with the geometric understructure of natural forms. There can be little doubt that this led quite directly to many of the formulations contained in Cubist painting. The use of Cézanne as the authority, along with the discovery on the part of Maurice de Vlaminck, Ernst Ludwig Kirchner, André Derain and Pablo Picasso of African sculpture with its ultrasimplified forms, led the Cubists, Fauvists and Expressionists into an entirely new manner of representation. Beginning with Cézanne each movement was in a sense first a revolt against Impressionism and second a revolt against the preceding rival group.

However, there were several other acknowledged masters of the late 19th century who extended their influence and laid the foundations of the various trends which made up the movement known generally as Postimpressionism, a journalistic term used both by Roger Fry and by Clive Bell, English critics. Included among the Post-impressionists were Van Gogh, Gauguin, Seurat, Renoir and Redon. Added to these was Henri Rousseau (1844–1911), the so-called primitive or naif, whose example led to a whole school of untutored modern primitives flourishing both in Europe and America. Few of these, however, attained the force of design and intensity of fantasy found in the work of Rousseau.

In addition. the more isolated figures of the Belgian James Ensor and the Norwegian Edvard Munch had an influence on 20th-century painting.

B. Intimism

The tradition of Impressionism (*q.v.*), which began officially with the first exhibition in Paris held in 1874, continued in the careers of tno outstanding artists, Pierre Bonnard (1867–1947) and Jean Edouard Vuillard (1868–1940), generally referred to as the Intimists. Bonnard was famous for his burning landscapes and arrangements of luscious fruits that seemed to burst with the intense sunlight of southern France. He also brought the luminous touch and iridescent colour scale of the Impressionist landscape painters to the tender and familiar studies of women placed in the quiet surroundings of garden or boudoir. Vuillard. with a lighter staccato touch and conversational intimacy. through many adroit considerations of space and the placing of his figures in richly patterned surroundings, created a new decorative art with the genre of interior painting. Vuillard, in particular, carried over the orientalism of the 19th century along with an original and sensitive feeling for the same unusual spatial elements that imparted such vitality and commanding vision to the posters of Toulouse-Lautrec. The importance of Bonnard and Vuillard lies in their ability to partake of the tradition of the Symbolists (*q.v.*) and of the Nabis, a group led by Maurice Denis. Bonnard and Vuillard maintained much of the intensity of Gauguin's colour, at the same time keeping the perennial "innocence of the eye" often used to characterize the original Impressionists. It may be considered that Bonnard in particular added essentially to the history of modern colour usage, whereas Vuillard called attention to new combinations of space interval and subtle relationships of values even in the most humble and unpretentious vignette.

C. Fauvism

The first significant revolt against Impressionism occurred in 1906 in the autumn Salon. By that time Impressionism had become a nearly international formula and was soon to be a vehicle for merely sketching from nature. With the discovery of African sculpture and the growing activity in fields of archaeological research, artists found a wealth of new inspirational material. Among these sources of inspiration were Persian and Indian miniature painting. all the arts and crafts which appeared to be exotic and a revaluation of the Gothic. The artist turned to the anthropological and archaeological collections and drew directly. Beginning with Whistler and other painters working in France, generous use had been made of oriental material, particularly the Japanese print, along with Chinese porcelains and textiles. The Impressionists continued the exploitation of these sources, whereas Gauguin went a step further and established the cult of the primitive.

Both Fauvism and Cubism were respectively named as derisive comments and supposedly each by leaders of the opposing movements. Les *Fauves,* variously called the "Wild Beasts" or the "Wild Men," were distinguished by a general freedom of colour usage and design elements. Actually the entire movement was a form of subjective Impressionism, in which the formal elements of painting appeared to be used quite arbitrarily. The leaders of the movement were Henri Matisse (1869–1954), Georges Braque (1882–), Raoul Dufy (1877–1953), Maurice de Vlaminck (1876–1958), André Derain (1880–1954), Émile Othon Friesz (1879–1949), Kees van Dongen (1877–), Georges Rouault (1871–1958), Charles Dufresne (1876–1938) and André Dunoyer de Segonzac (1884–). Some of these painters, such as Braque and Derain, also worked along with the Cubists. Braque especially was the most consistent master of Cubism among French painters. Derain occupied the position of a museum painter since he was the most apparent in self-conscious scholarship and the revival of historical styles and mannerisms.

1. Mathe.—The greatest contribution of the group centred in Matisse, whose use of colour alone completely revolutionized its decorative and emotional values in modern painting. In point of view of colour Matisse many times revised the practices of the interior decorator, elevating him to the position of a "colour engineer." Matisse, first academically trained under Adolphe Bouguereau, became an official copyist in the Louvre, supplying for the government replicas to be placed in provincial museums and for sale to private buyers. He was invited by Moreau to work in his studio along with Rouault. Later he worked in the Impressionist manner, and it was then that he turned to Japanese prints and Persian sources. Along with Derain he discovered Cézanne, and also began to make personal variations on old master themes which he had successfully copied. About the time of the first showing at the autumn Salon Matisse began to establish a definite style of intense, unmixed colour, broadly applied on a flat, two-dimensional surface. He later stated. "What I am after above all is expression . . . the whole arrangement of my picture is expressive . . . composition is the art of arrangement in a decorative manner . . . for the expression of what the painter wants . . ."; but also. "What I dream of is an art of balance, of purity and serenity, devoid of any troubling subject matter . . . like a good armchair in which to rest from fatigue." Matisse may be regarded as the most important successor to Renoir, inasmuch as his long procession of still-life arrangements, interiors with figures, odalisques and compositions taken from the Riviera form an unbroken sequence of colourful essays in sensuous objectivity. The work of Dufy ran closely parallel to that of Matisse, conditioned, of course, by his personal temperament and marked by a witty and highly personal calligraphy which described vignettes of the race track, the château country, the yacht harbour. To all of these and to even conventional subjects Dufy lent his gay and descriptive handwriting and feeling for playful decoration.

2. **Rouault.**—The other painters of this group are discussed as members of the School of Paris, but Rouault must be singled out. Long considered the most significant painter of religious subject matter in the 20th century, Rouault was a solitary master following a mystic line of inner vision. At one time keeper of the collection of Moreau, he absorbed from his teacher much of the intensity and hallucinatory atmosphere that so inspired Moreau's literary friends, the novelists Gustave Flaubert and Joris Karl Huysmans. Once a designer of stained glass windows, he inter-

preted the troubled passion of the Gothic with deeply felt religiosity. The vivid and heavily encrusted colour and leaded black line used to interpret rather than depict the martyrdom of mankind—whether the subject be that of Christ, clowns or prostitutes—came close to the actualities of medieval life and sentiment. His is a strange, sorrowful, sometimes bitter and strident note in the modern world.

3. **Dufy** and **Vlaminck.**—Both Dufy and Vlaminck were still young painters at the time of their association with the Fauvists, neither of them having arrived at the individual style that marks their mature work. Dufy painted with simple, solid and brilliant colour. Vlaminck, who is credited with creating a sudden enthusiasm for African primitive sculpture. freely improvised with both structure and colour, and for a time was perhaps the wildest of the Fauvists. However, his mature style which identified him with the School of Paris is represented by a series of vigorous and impetuous landscapes and still-life studies largely painted in dramatic colour contrasts and an irregular, heavy impasto applied with the palette knife. But he finally settled down to a constantly repeated formula of stormy landscapes. Another painter sometimes associated with Les Fauves was Albert Marquet (1875–1947), who usually worked in a quiet colour key, but whose simplifications of natural forms relate him to phases of the earlier Matisse.

D. Cubism

Pablo Picasso is generally considered the first painter to produce an important Cubist composition—"The Ladies of Avignon," painted in 1906–07, partially based upon Negro sculpture as well as Iberian masks, and related also to the structural simplifications of Cézanne. It is perhaps more of a document than a completed masterpiece.

There are many classifications of Cubism. However, three aspects of the movement largely dominate its history: (1) Negroid, which is combined with (2) analytical Cubism (seeking the geometric understructure of natural forms) and (3) synthetic Cubism, in which a freedom of improvisation is introduced with a suggestion of timing and space relations and a greater variety of colour and texture. In this latter phase mixed mediums played a part and foreign substances were introduced. Sometimes sand was mixed with pigment to ensure a variety of surface textures. This slowed down the colour vibration and helped create dissonances of various kinds from passage to passage. Bits of paper, cloth, playing cards, wire, wood, string and other materials were introduced. The final result was a *papier collé* or collage.

Both the Cubists and the Italian Futurists (see below) used a device. known as simultaneity—the practice of combining various parts of an object, or profiles of face and figure, within a design concept. This succession of various points of view, of attempting to present all aspects of the object or figure—back, front and sides—simultaneously, had its origin in many primitive arts including Egyptian painting, the designs of the northwest Indians, and some of the *santos* of the United States southwest, in Negroid and Oceanic sculpture, as well as in Chinese bronzes. The most famous example to show motion and simultaneity of timing is Marcel Duchamp's "Nude Descending a Staircase," painted in 1912. This technique of indicating motion in space, used by both the Cubists and Futurists as well as subsequent schools, developed before the elaborate technique of the animated cartoon or the motion picture.

Aside from Georges Braque, the real leader of this movement, other members of the group were Albert Léon Gleizes (1881–1953), Jean Rletzinger (1883–1956), Marcel Duchamp (1887–), Francis Picabia (1879–1953), Fernand Léger (1881–1955), Juan Gris (1887–1927), Louis Marcoussis (1883–1941) and Roger de La Fresnaye (1885–1925).

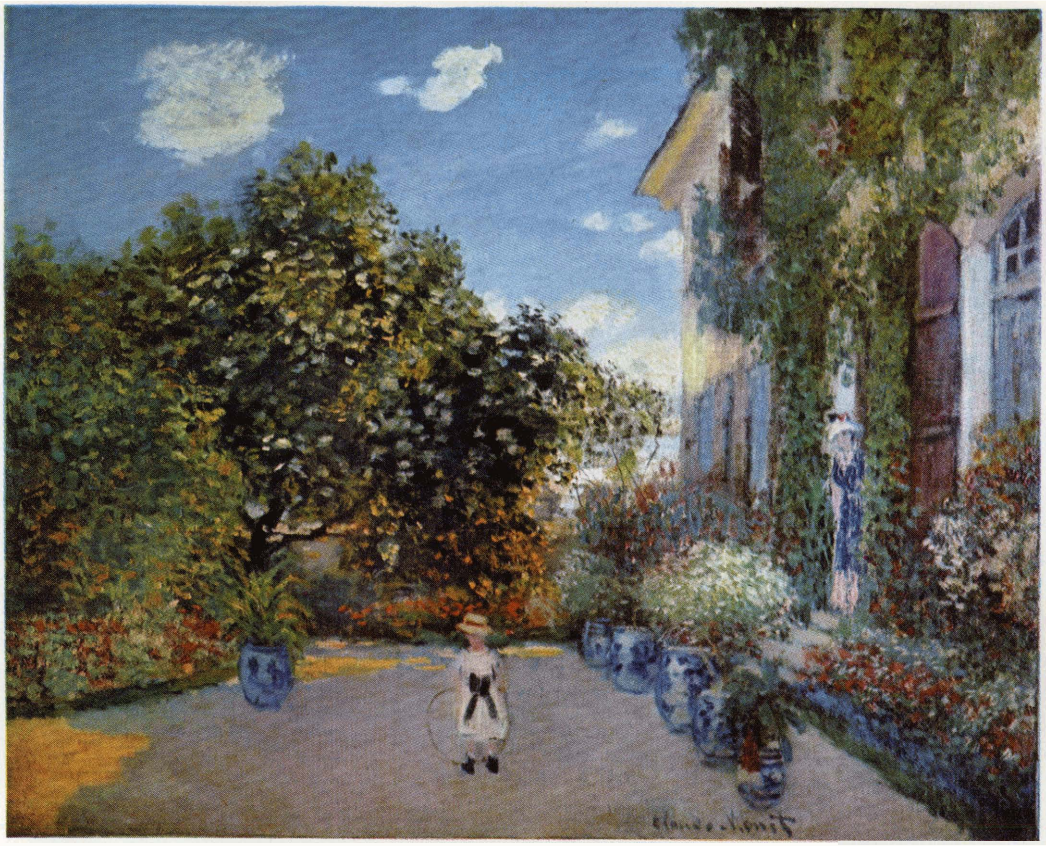
The analytical Cubists kept to a rigid geometric discipline, presenting their subjects in structural plane patterns without losing the basic likeness of the subject. They also reduced their colour scale to a series of neutral tones of browns and grays in what may be considered almost a puritanical protest against the colour of the Impressionists. Gradually the Cubists created a pictorial vocabulary composed of bottles, newspapers, playing cards, wine goblets and guitars, that became personal to them. Contrasting with this to a certain degree, the synthetic Cubists, led by Braque in 1910, complicated the original forms of Cubism not only by adding imitation textures and foreign substances to their paints, but by borrowing freely from other techniques such as Pointillism; they also introduced softer and more decorative elements than formerly, and used organic forms along with geometric shapes and patterns in a kind of counterpoint of passage which moved from the static to the dynamic.

1. Picasso.—Along with Braque, Pablo Picasso (1881–) evolved the painting of natural and inanimate forms reduced to more or less geometric shapes, which Matisse in a moment of derision labeled Cubism. In the beginning Cubism appears to have derived from two sources: from nature itself and from geometric patterns and solids. Later the feeling of tempo, simultaneity of phrase, the disintegration of the physical object and its reconstruction came into practice. Also, great means of time and dimension expression were realized by the illusion created through the use of superimposed and crisscrossed planes. Through his rich inventiveness and his constant experimentation with new mediums, as well as expression, Picasso provided the nervous force and stimulation which largely provoked the development and persistence of Cubism. Since he was the greatest single influence in painting since Cézanne, he is considered more fully later in this article. (See also Further *Contributions* of *Picasso,* below.)

2. Brawe.— It was in 1908, after several years of identification with *Les* Fauves, that Georges Braque with Picasso founded Cubism. More than any other artist he gave it a permanent place in contemporary painting. His experimentation was bold yet sure, and in all matters of taste he was unexcelled. His joyous colour combinations were equaled only by those of Blatisse. At his best in his still-life paintings, pure colour pattern welded into design is substituted for chiaroscuro. There are striking dislocations of realistic intervals within his rigidly disciplined patterns. Colour is placed flatly, almost vertically, on the surface; yet through changes of touch and pressure it is given body and weight and actually modeled without resorting to the devices of tonal gradation. Braque creates a lyrical and controlled feeling of dissonance that always bears a delicate sense of shock and a delightful feeling of surprise. His bold patterns are in contrast to his almost loving handling of paint and materials. He is essentially in the French tradition in his understanding of still life's being composed of objects that have energy and magic of themselves and also in his mastery of the beautiful surface. He never loses the wonder of the eye nor destroys the magic of the object.

3. **Gris.**—Perhaps the most quoted statement by the Spanish Cubist Juan Gris is: "Cézanne makes a cylinder of a bottle; I begin with the cylinder in order to create an individual unit of a special type. Of a cylinder I make a bottle—a particular bottle." Gris, along with Picasso and Braque, was able to raise the highly disciplined and severely mathematical art of Cubism into an individual pictorial-plastic expression. In spite of his order and formality there is no astringency in his art; rather it is lyrical, poetic and at times even sonorous. He synthesizes many complexities of pattern, texture and object shapes without losing their individual painterly and pictorial identity and significance. Every foreshortening, every cross section of an object, every contour seems freely related and yet held together in a type of irregular repeat that takes cognizance of the importance of space interval.

4. **Léger.**—The machine as an aesthetic tool was one of the preoccupations of Léger, one of the founders of Cubism. Severity of machine-turned forms, metal spinnings, the slow curves of the structural engineer, the precise adjustments of the gun bore, all seem to have something to do with more-or-less mechanized forms of Léger's art. His severely stylized forms remain always close to the objects from which they are taken. Force rather than subtlety and power rather than sensitivity motivated his long series of paintings, many of them variations on similar themes. Along with this treatment, which at times became as hard and polished as a metal casing, Leger gave great considera-



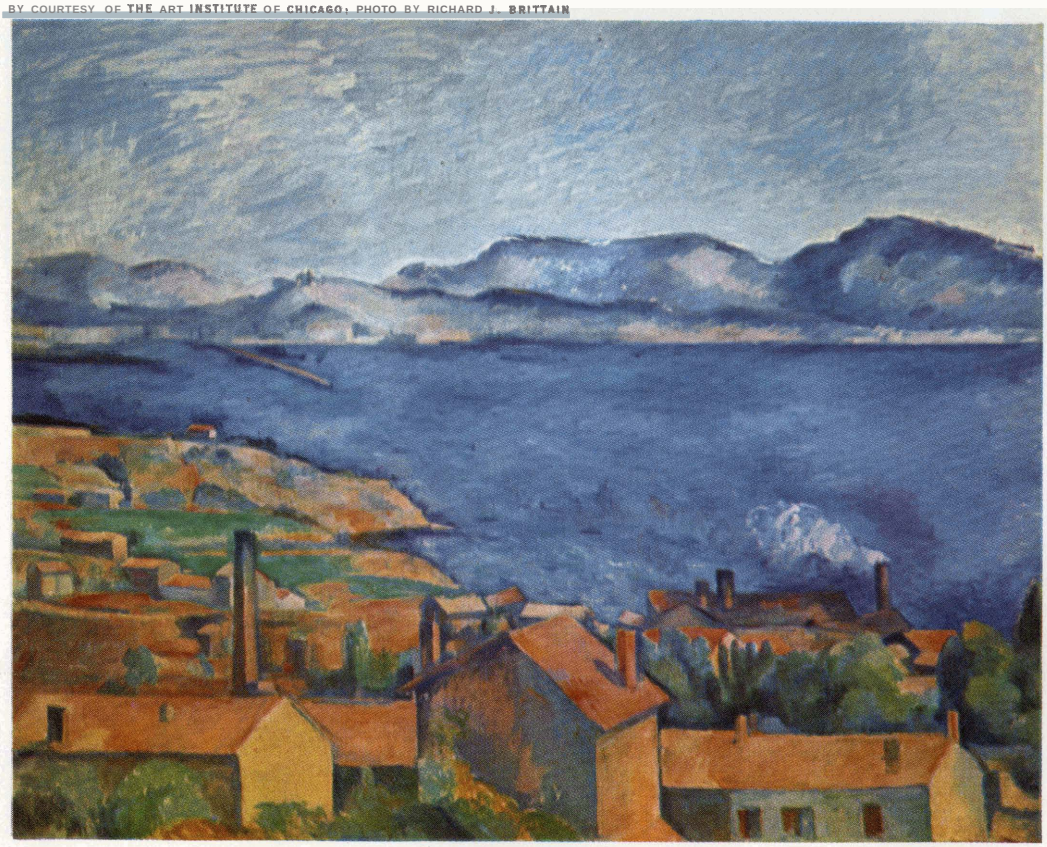
BY COURTESY OF THE ART INSTITUTE (IF CHICAGO; PHOTO BY RICHARD J. BRITTAIN

"Artist's Garden at Argenteull" by Claude Monet (1840–1926), French. In the collection of Mr. and Mrs. Martin A. Ryerson, Art Institute of Chicago

MONET AND CÉZANNE

"Gulf of Marseilles, Seen from L'Estaque" by Paul Cézanne (1839–1906), French. In the collection of Mr. and Mrs. Martin A. Ryerson, Art Institute of Chicago

BY COURTESY OF THE ART INSTITUTE OF CHICAGO; PHOTO BY RICHARD J. BRITTAIN



PAINTING

BY COURTESY OF THE MINNEAPOLIS INSTITUTE OF ARTS

"Tahitian Landscape" by Paul Gauguin (1848–1903), French. In the Minneapolis Institute of Arts

GAUGUIN AND VAN GOGH

"Boats at Ste. Maries" by Vincent Van Gogh (1853–90), Dutch. In the V. W. Van Gogh collection, Stedlijk museum, Amsterdam, Neth.

BY COURTESY OF STEDLIJK MUSEUM

BY COURTESY OF THE MINNEAPOLIS INSTITUTE OF ART

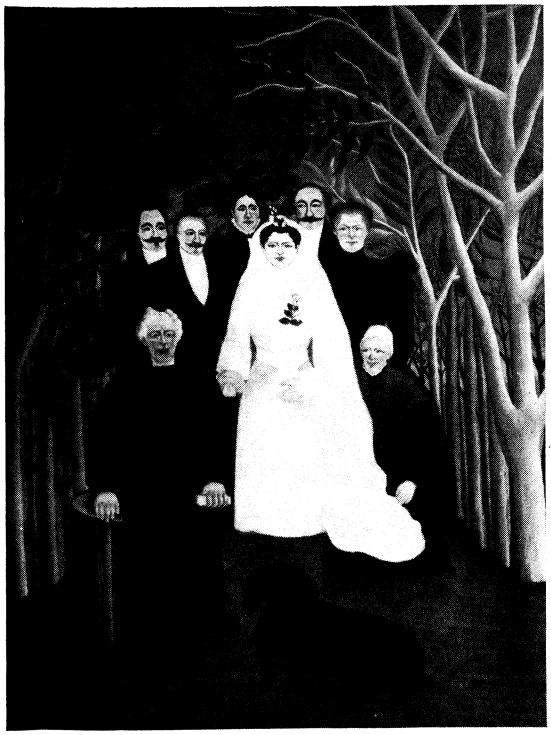
"Dining Room in the Country" by Pierre Bonnard (1867–1947), French. In the Minneapolis Institute of Art

BONNARD AND MATISSE

"Red Studio" by Henri Matisse (1869–1954), French. In the Museum of Modern Art, New York aity

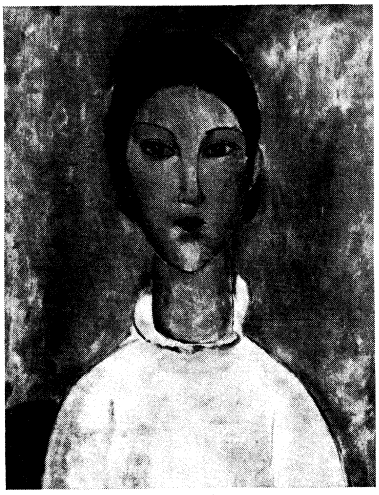
BY COURTESY OF THE MUSEUM OF MODERN ART, NEW YORK; MRS. SIMON GUGGENHEIM FUND

PAINTING



"La Noce" ("The Wedding") by Henri Rousseau (1844–1911), French. In the collection of Mme. Jean Walter, Paris

"Figure in an Interior" by Henri Matisse (1869–1954), French. In Crowningshield collection



"Portrait of a Girl" by Amedeo Modigliani (1884–1920), Italian.

EARLY 20TH-CENTURY EUROPEAN PAINTING

Above: "Les Amoureux" ("The Lovers") by Pablo Picasso (1881–), Spanish-French. In the National Gallery of Art, Washington, D.C.

Right: "The Old King" by Georges Rouault (1871–1958), French. In the Carnegie institute, Pittsburgh

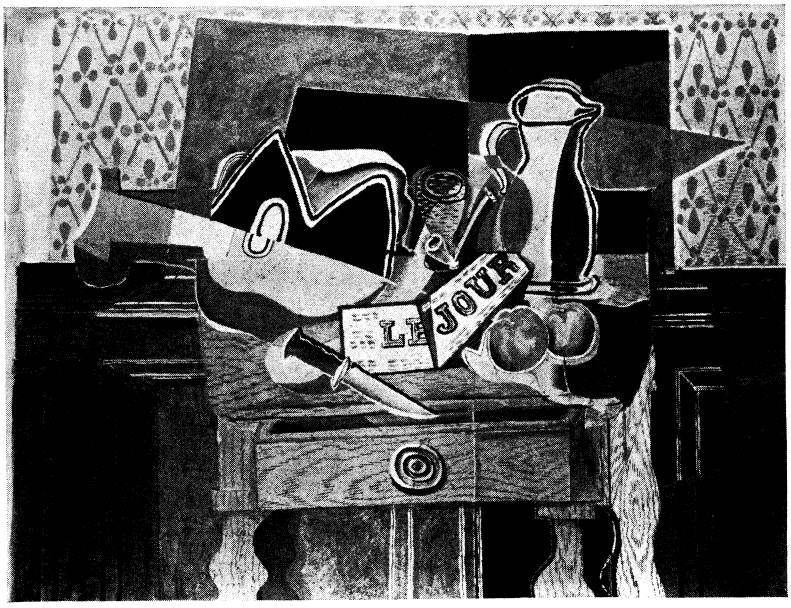
BY COURTESY OF (TOP LEFT) THE MANSELL COLLECTION, LONDON, (TOP RIGHT. CENTRE RIGHT. BOTTOM LEFT) THE REINHARDT GALLERIES. (BOTTOM RIGHT) CARNEGIE INSTITUTE, PITTSBURGH: PHOTOGRAPH. (TOP LEFT) GIRAUDON

BY COURTESY OF THC MUSEUM OF MODERN ART

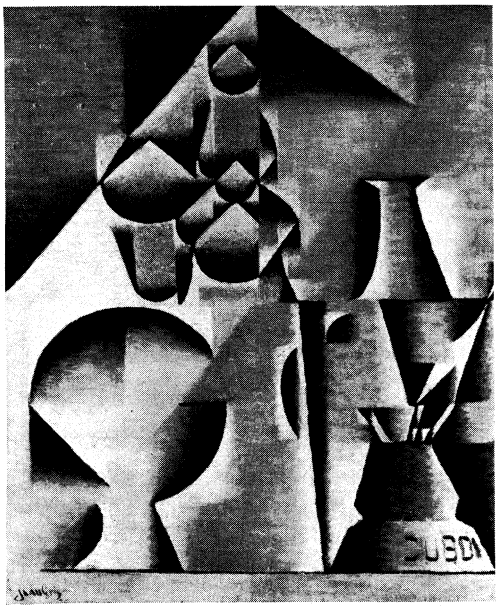
"GIRL BEFORE THE MIRROR," BY PABLO PICASSO (1881–)

A painting of 1932 by the Spanish-born artist. In the Museum of Modern Art, New York city (gift of Mrs. Simon Guggenheim)

PAINTING



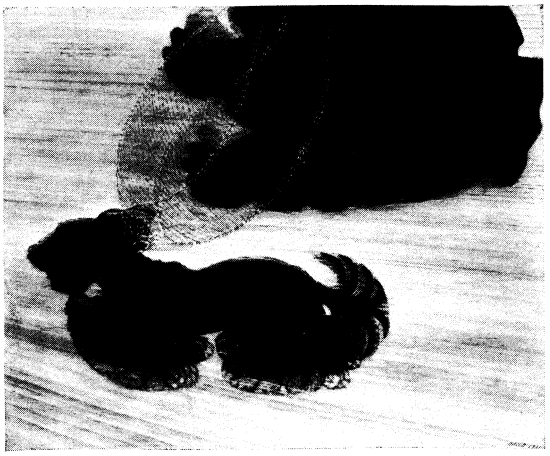
"Still Life: Le Jour" by Georges Braque (1882–), French. In the National Gallery of Art, Washington, D.C.



"La Table du Café, Abstraction in Gray" by Juan Gris (1887–1927), Spanish-French. In the Art Institute of Chicago

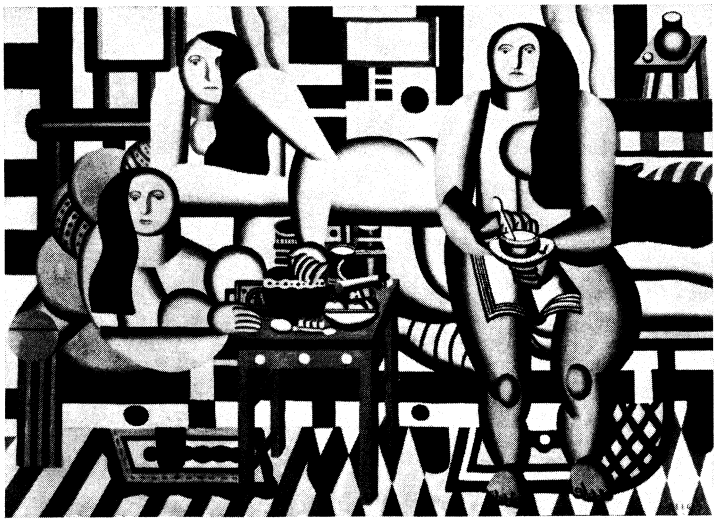
CUBISM AND EXPERIMENTAL PAINTING OF THE 20TH CENTURY

"Nude Descending a Staircase" by Marcel Duchamp (1887–), French. In the Philadelphia Museum of Art



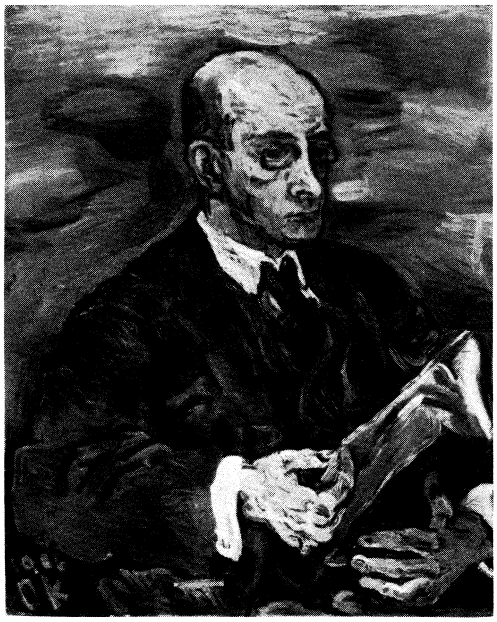
"Dog on a Leash" by Giacomo Balla (1871–), Italian. In the Museum of Modern Art, New York city

"Le Grand Déjeuner (Three Women)" by Fernand Léger (1881–1955), French. In the Museum of Modern Art. New York city



BY COURTESY OF (TOP LEFT) NATIONAL GALLERY OF ART, WASHINGTON, (TOP RIGHT) THE ART INSTITUTE OF CHICAGO. (CENTRE RIGHT) A. CONGER GOODYEAR, (BOTTOM LEFT) PHILADELPHIA MUSEUM OF ART, (BOTTOM RIGHT: THE MUSEUM OF MODERN ART. NEW YORK CITY; PHOTOGRAPHS (CENTRE RIGHT) THE MUSEUM OF MODERN ART BY SOICHI SUNAMI, (BOTTOM RIGHT) SOICHI

"The Street" by Ernst Ludwig Kirchner (1880–1938). German. In the Museum of Modern Art, New York city

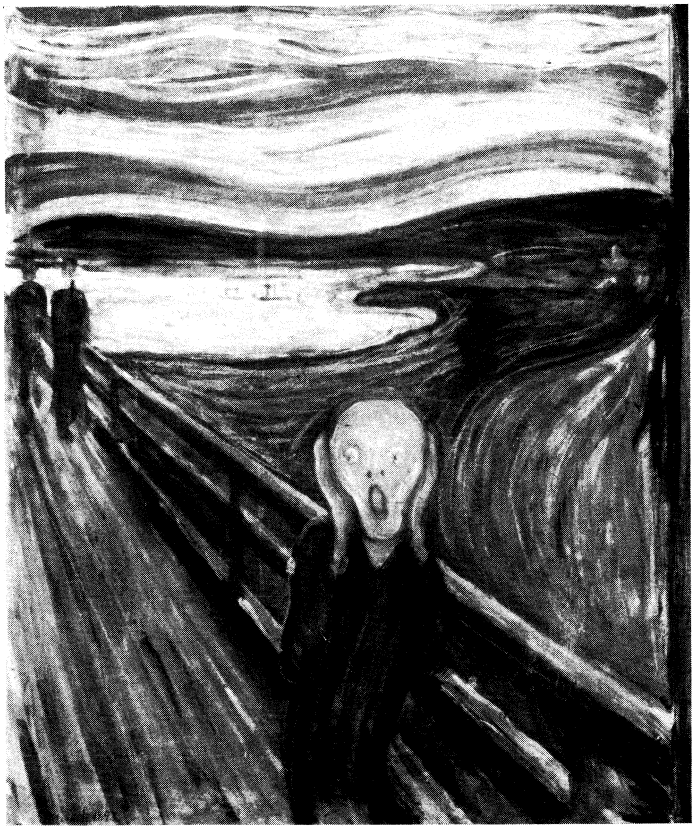


"Portrait of Dr. Schwarzwald" by Oskar Kokoschka (1886–), Austrian. In a private collection, Krefeld

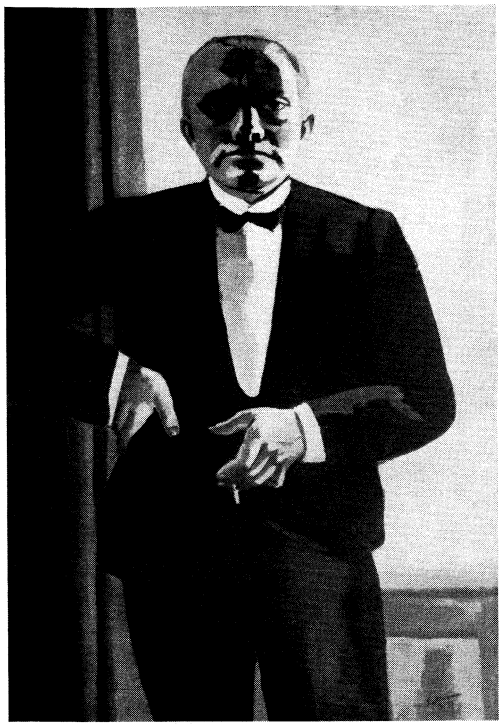
EXPRESSIONISM AND THE GERMAN SCHOOL

"Masks" by Emil Nolde (1867–1956), German. In the William Rockhill Nelson Gallery of Art, Kansas City, Mo.

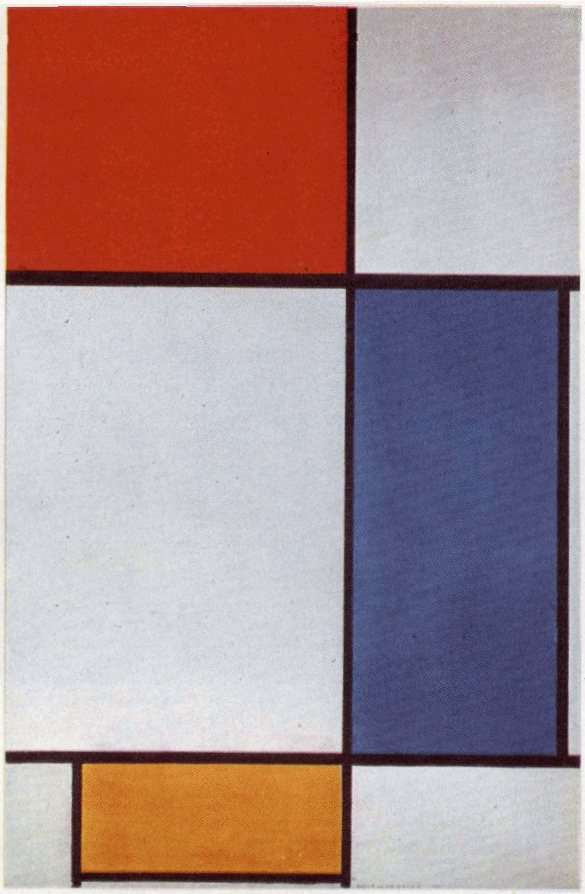
"The Cry" by Edvard Munch (1863–1944), Norwegian. In the National gallery, Oslo



"Self-Portrait" by Max Beckmann (1884–1950). German. In the Busch-Reisinger museum, Harvard university



BY COURTESY OF (TOP LEFT) THE MUSEUM OF MODERN ART, NEW YORK CITY, (TOP RIGHT) PAUL CASSIRER, (CENTRE LEFT) WILLIAM ROCKHILL NELSON GALLERY OF ART, KANSAS CITY, MO., (BOTTOM LEFT) BUSCH-REISINGER MUSEUM, HARVARD UNIVERSITY, (BOTTOM RIGHT) NASJONALGALLERIET OSLO. PHOTOGRAPH (TOP LEFT) SOICHI SUNAMI



BY COURTESY OF JOHN L. SENIOR, JR.; PHOTO FROM TIME, INC.

MONDRIAN

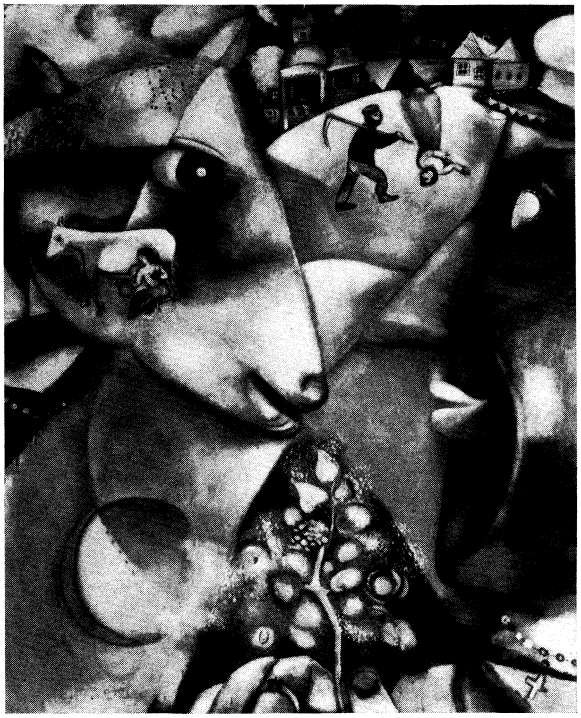
AND

KANDINSKY

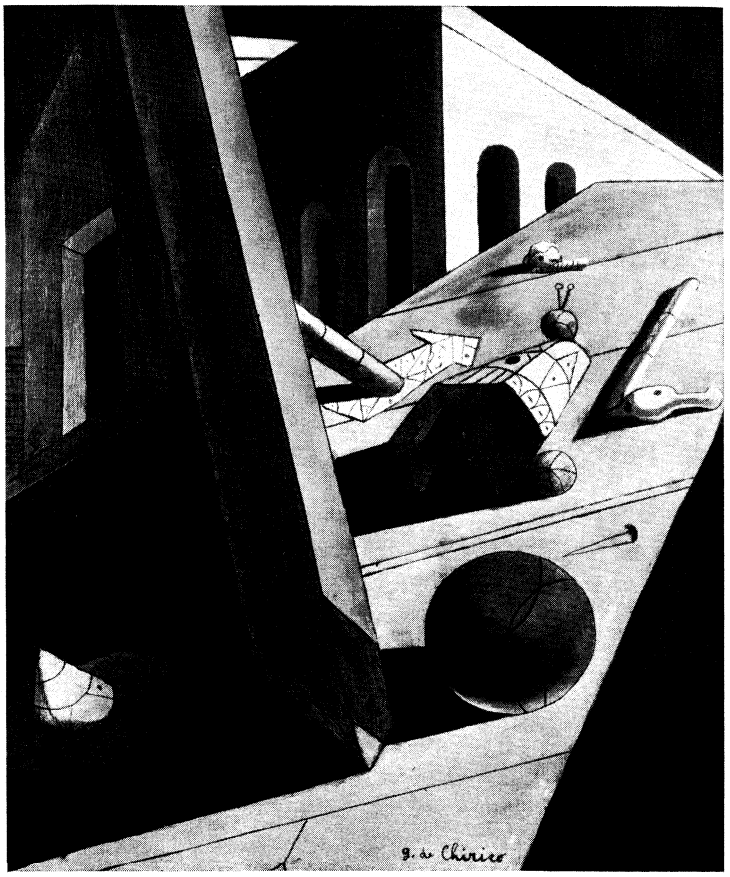
Left: "Large Composition with Red, Yellow, and Blue" (1928) by Piet Mondrian (Pieter Cornelis Mondriaan, 1872–1944), Dutch. In the collection of John L. Senior, Jr.

Below: "Black Lines" by Wassily Kandinsky (1866–1944), Russian. In thr Solomon R. Guggenheim museum, New York city

BY COURTESY OF THE SOLOMON R. GUGGENHEIM MUSEUM



"I and the Village" by Marc Chagall (1887–), Russian. Museum of Modern Art, New York city



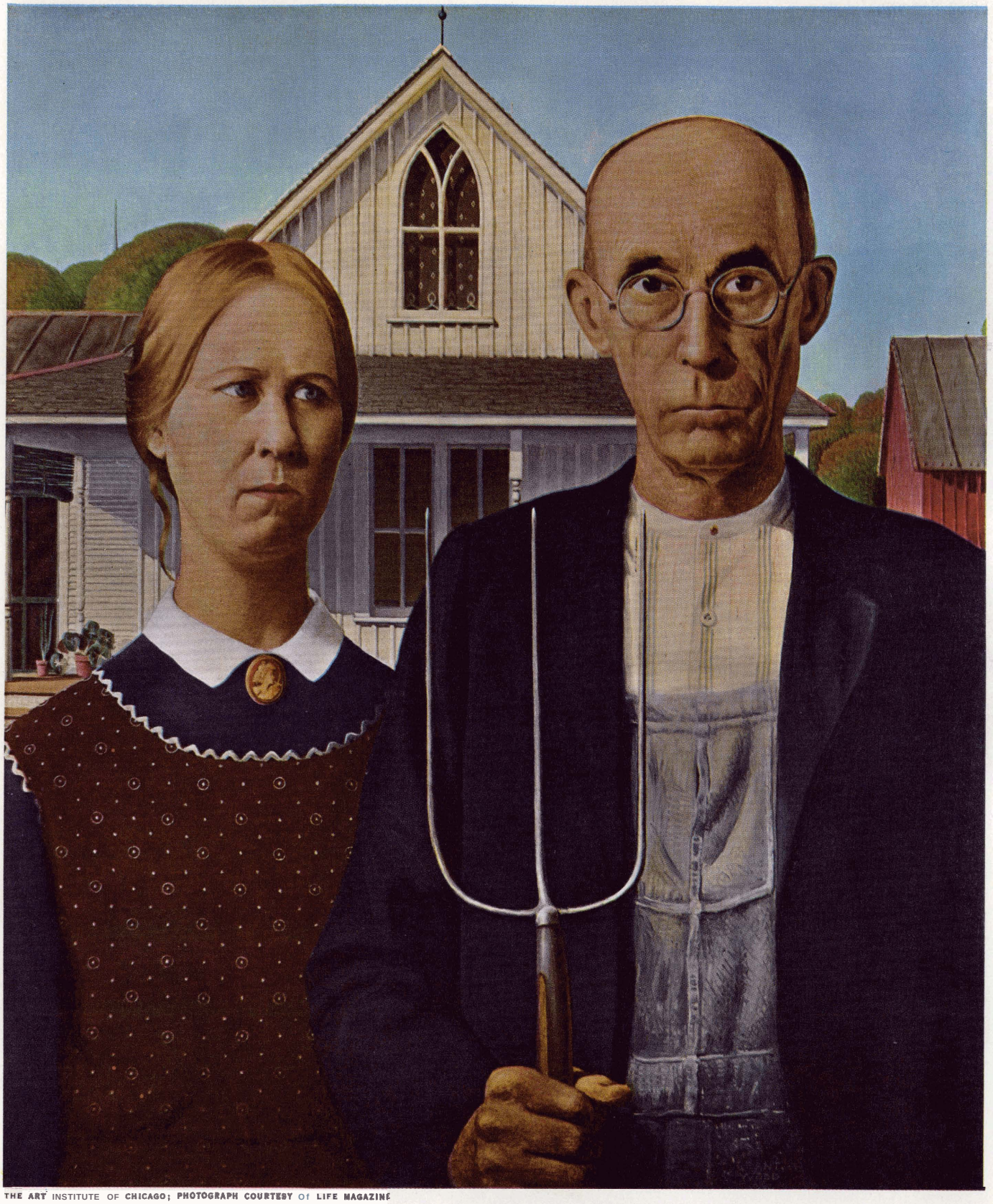
"Evil Genius of a King (Toys of a Prince)" by Giorgio de Chirico (1888–), Italian. Museum of Modern Art, New York city

"Soft Construction With Boiled Beans; Premonition of the Civil War" by Salvador Dali (1904–), Spanish. Philadelphia Museum of Art.

FOUR PAINTERS OF FANTASY

"Person Throwing a Stone at a Bird" by Joan Miro (1893–), Spanish. Museum of Modern Art, New York city

BY COURTESY OF (TOP LEFT) THE MUSEUM OF MODERN ART, N.Y.; MRS. SIMON GUGGENHEIM FUND, (TOP RIGHT, BOTTOM RIGHT) THE MUSEUM OF MODERN ART, N.Y., (CENTRE LEFT) PHILADELPHIA MUSEUM OF ART; ARENSBERG COLLECTION; PHOTOGRAPHS (TOP LEFT, TOP RIGHT, BOTTOM RIGHT) SOICHI SUNAMI

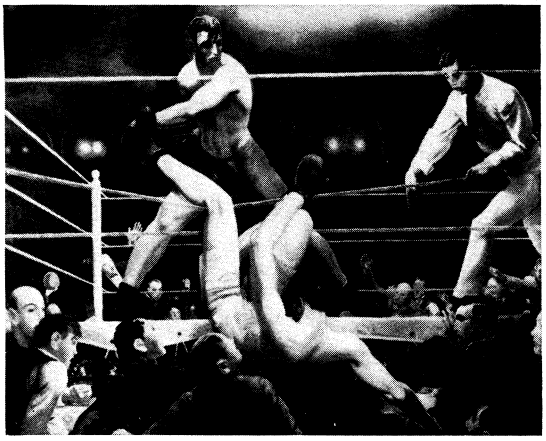


THE ART INSTITUTE OF CHICAGO; PHOTOGRAPH COURTESY Of LIFE MAGAZINE

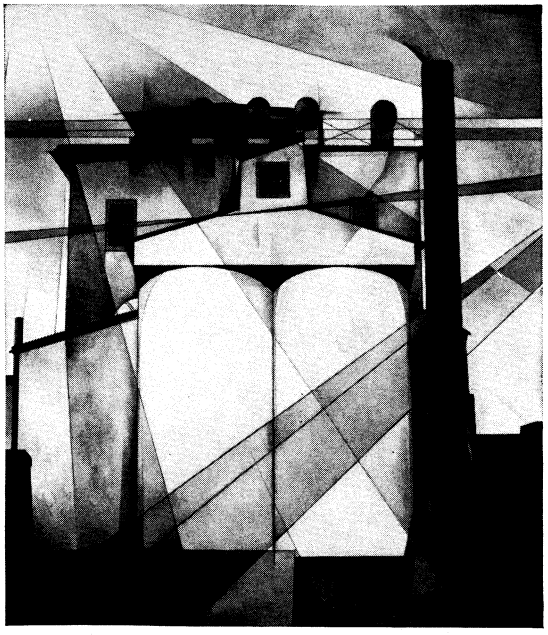
"AMERICAN GOTHIC," BY GRANT WOOD (1892–1942)

Oil on panel, painted in 1930. In the collection of The Friends of Ameriaan Art, The Art Institute of Chicago

"Toilers of the Sea" by Albert P. Ryder (1847–1917). In the Addison Gallery of American Art

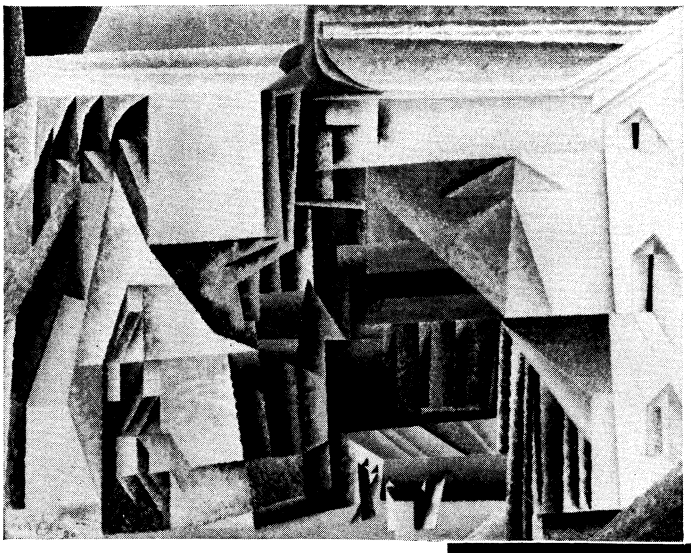


"Dempsey and Firpo" by George Bellows (1882–1925). Whitney Museum of American Art

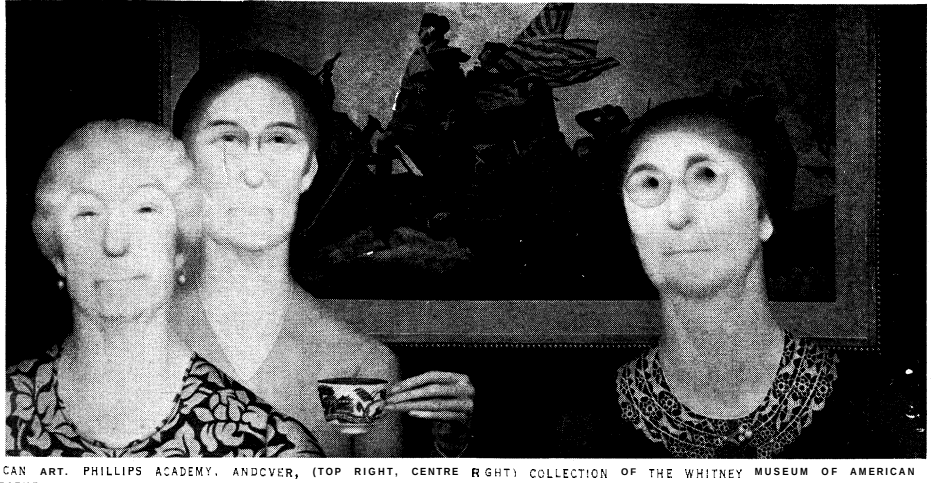


"My Egypt" by Charles Demuth (1883–1935). Whitney Museum of American Art

"The Church" by Lyonel Feininger (1871–1956). Städtisches Museum, Wuppertal-Elberfeld, Ger.



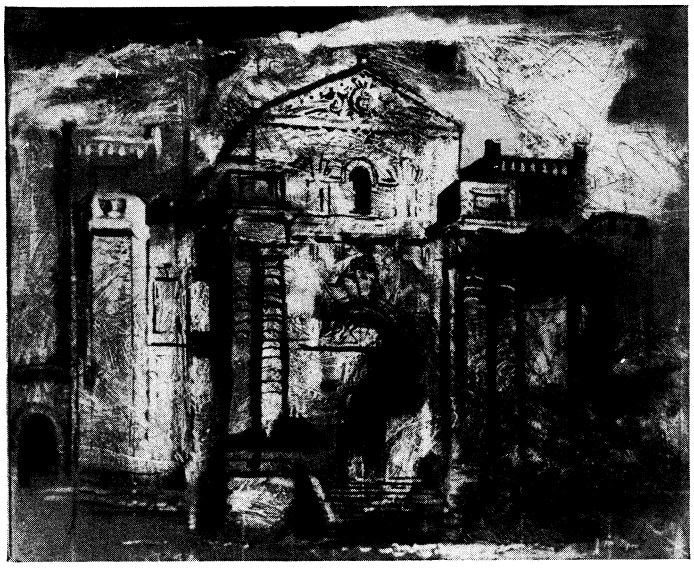
U.S. PAINTINGS, 19TH AND 20TH CENTURIES



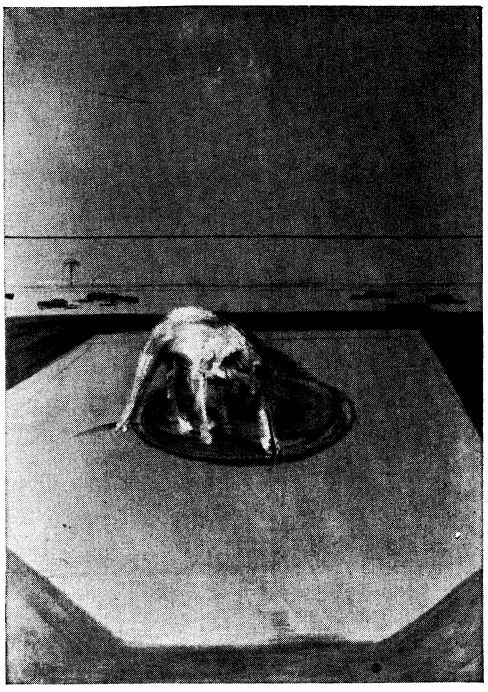
"Daughters of the Revolution" by Grant Wood (1892–1942). Private collection

BY COURTESY OF (TOP LEFT) ADDISON GALLERY OF AMERICAN ART. PHILLIPS ACADEMY, ANDOVER, (TOP RIGHT, CENTRE RIGHT) COLLECTION OF THE WHITNEY MUSEUM OF AMERICAN ART, NEW YORK (BOTTOM, EDWARD G. ROBINSON; PHOTOGRAPHS, (TOP LEFT) ANDOVER ART STUDIO, (CENTRE RIGHT) SOICHI SUNAMI, (CENTRE LEFT) HANFSTAENGL, (BOTTOM) INTERNATIONAL

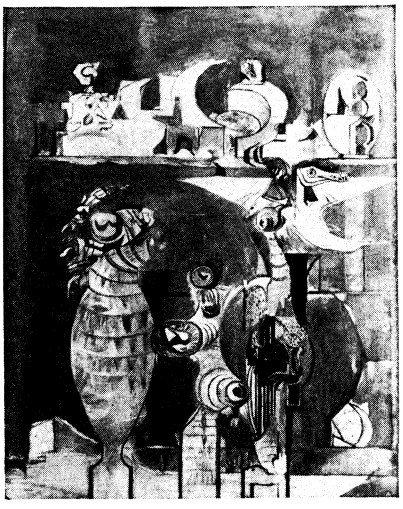
PAINTING



"Seaton Delaval" by John Piper (1903–). In the Tate gallery, London



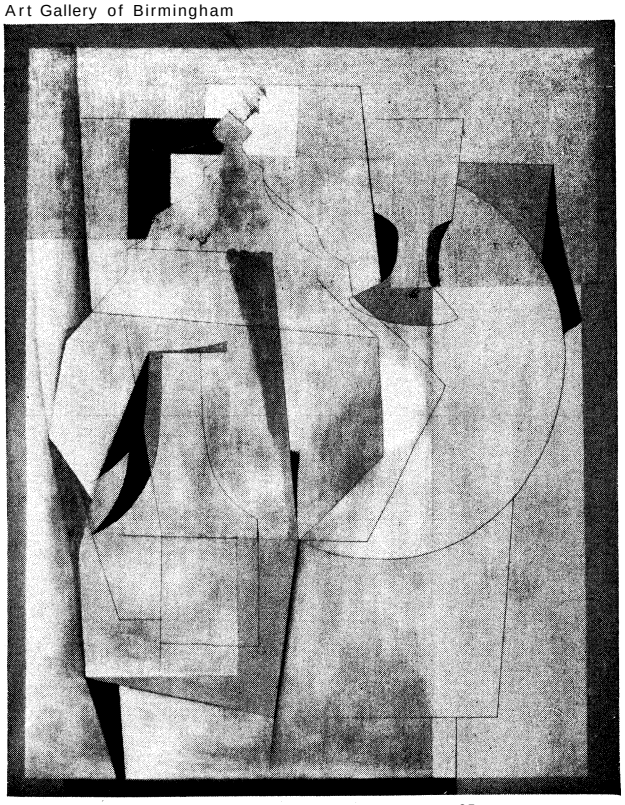
"Study of a Dog" by Francis Bacon (1910–). Tate gallery



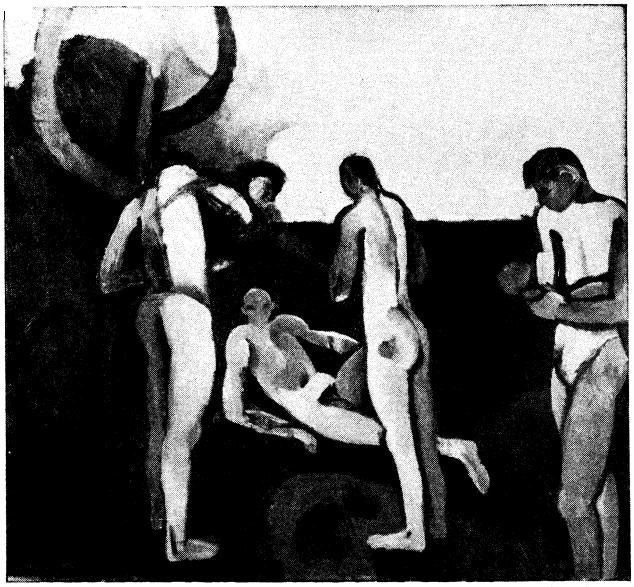
"The Origins of the Land" by Graham Sutherland (1903–). Tate gallery

20TH-CENTURY ENGLISH PAINTING

"Still Life (Dolomites)" by Ben Nicholson (1894–). Museum and Art Gallery of Birmingham



"Small Assembly of Figures" by Keith Vaughan (1912–). Tate gallery



BY COURTESY OF (TOP LEFT, TOP RIGHT, CENTRE LEFT, BOTTOM LEFT) THE TRUSTEES OF THE TATE GALLERY, LONDON, (BOTTOM RIGHT) MUSEUM AND ART GALLERY OF BIRMINGHAM.

BY COURTESY OF THE ART INSTITUTE OF CHICAGO; PHOTO BY RICHARD J. BRITTAIN

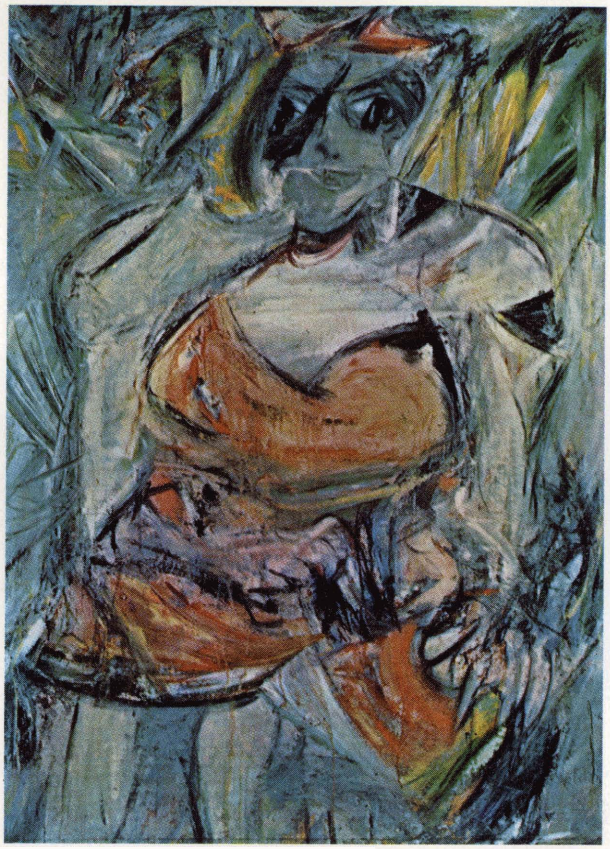
"The Herring Net" by Winslow Homer (1836–1910), U.S. In the collection of Mr. and Mrs. Martin A. Ryerson, Art Institute of Chicago

HOMER AND HOPPER

"Nighthawks" by Edward Hopper (1882–), U.S. In the Friends of American Art collection, Art Institute of Chicago

BY COURTESY OF THE ART INSTITUTE OF CHICAGO; PHOTO BY RICHARD J. BRITTAIN

PAINTING



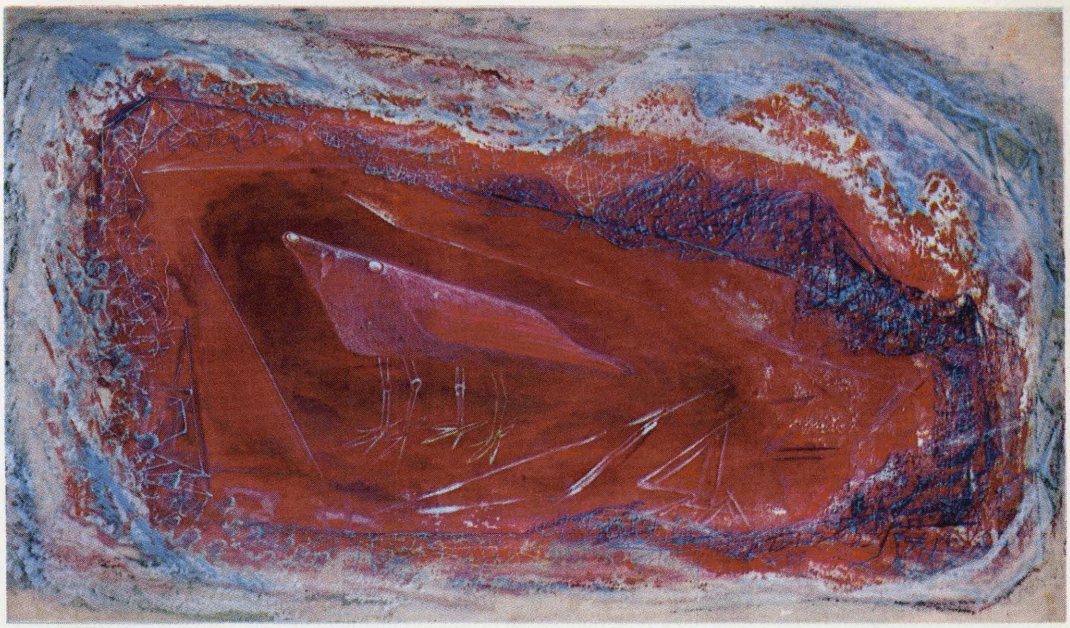
BY COURTESY OF SIDNEY JANIS GALLERY, NEW YORK

"Woman 11, 1952" by Willem deKooning (1904–), U.S. In the Sidney Janis gallery, New York city

BY COURTESY OF THE ARTIST

"Transit" by Mark Tobey (1890–), U.S. In the Metropolitan Museum of Art, New York city

"No Turns Permitted" by Reginald Marsh (1898–1954), U.S. In the collection of Mrs. Reginald Marsh, New York city



BY COURTESY OF THE MUSEUM OF MODERN ART, NEW YORK; PHOTO BY "LIFE" MAGAZINE

"Little Known Bird of the Inner Eye" by Morris Graves (1910–), U.S. In the Museum of Modern Art, New York city

GRAVES AND SHAHN

BY COURTESY OF ALBRIGHT ART GALLERY, BUFFALO, N.Y.

"Spring" by Ben Shahn (1898–), U.S. In the Room of Contemporary Art, Albright Art gallery, Buffalo. N.Y.

tion to the positive architectural elements depicting space. His interest in modern architecture led to his association with Le Corbusier and Amédée Ozenfant. Léger's painting contains the precision and the vulgarity of the machine world.

The most consulted document on the philosophy of Cubism is Guillaume Apollinaire's *The Cubist Painters—Aesthetic Meditations—1913,* in which the writer traces the complicated variations of the movement, creating a poetic and exalted atmosphere of growth and spirit.

E. Futurism

In 1909 Filippo Tommaso Marinetti (1876–1944), Italian poet and dramatist, published in *Figaro,* of Paris, the first official manifesto of Futurism. This proclaimed in general the love of danger, the admiration for speed in the machine, the glorification of war and general destruction of the past, including the museums, in order to free a rising generation of Italian painters, sculptors and literary men. The movement gathered a number of writers along with three young painters, Umberto Boccioni (1882–1916), Carlo Carrà (1881–) and Luigi Russolo (1885–). In 1910 this group was joined by two other artist friends, Giacomo Balla (1871–) and Gino Severini (1883–). The same year this group published a further manifesto which embodied the ideals of the painter and sculptor and was a further glorification of dynamism, war and the machine. Typical of their sentiments is the statement: "We proclaim . . . that universal dynamism must be rendered as dynamic sensation; that movement and light destroy the substance of objects." The Futurists felt indebted to the Cubist break-up and reassembly of form but wished to introduce dynamic movement. Futurist pictures have been compared with a frozen motion picture, a series of superimposed candid camera stills, or the later stroboscopic photography. Perhaps the simplest and most direct example of Futurist painting was the well-known "Dog on Leash" by Balla, 1912, depicting a small dog with many legs and tails being walked. Each man contributing to the movement, which actually ended with the beginning of World War I, was a distinguished artist, and the work they produced as Futurists, though quite uneven in quality, nevertheless had distinction.

F. Orphism, Synchromism and Vorticism

In 1912 Robert Delaunay (1885–1941) founded a movement which Guillaume Apollinaire named Orphism. Delaunay applied to his canvases spots or patches and, later, swirls of intense contrasting colours, hence the designation simultaneousness; *i.e.,* simultaneous contrast. He was probably the first nonobjective painter in France. In his painting colour is both form and object.

In 1913 Morgan Russell (1886–1953) and Stanton Macdonald-Wright (1890–), two U.S. painters, under Delaunay's influence started the movement known as Synchromism. In some aspects. Synchromism became an almost nonobjective art, using passages or rhythms of pure colour moving from the primaries through many gradations to the secondary or intermediary colours. The later paintings are lyrical and poetical, those by S. Macdonald-Wright often combining the use of pure colour with draftsmanship and subject matter related to that of the Chinese and Japanese masters.

In England, in 1914, the magazine *Blast,* published by Percy Wyndham Lewis, a painter and writer of some accomplishment, heralded and championed a new movement called Vorticism. Vorticism related loosely to German Expressionism, Cubism and Futurism. Altogether it was more of a literary philosophy whose iconoclasm was short-lived. However, it did act as a stimulus to a number of painters, including Lewis himself and C. R. W. Nevinson.

G. Expressionism and the German School

Two general ideas appeared to dominate German painting. The first was an ideal literary composite of both neoclassicism and 19th-century romanticism in its more sentimental aspects. The second, which comes under the general heading of Expressionism, revealed the German psychology and temperament at its best and in its greatest intensity. German Expressionism had a marked influence on world painting, permeated the countries of middle Europe, had some influence on the Russian school and was in turn slightly influenced by it. In 1900 the predominating influence on German painting was the newly founded *Berliner Sezession.* It was organized by Max Liebermann and Paul Cassirer, a prominent art dealer. The main interests of their exhibitions from 1900 to 1908 were provided by the paintings of Manet, Monet, Degas, Renoir and Liebermann. Their influence caused the formation of the German Impressionists under Lovis Corinth and Max Slevogt.

Lovis Corinth developed a freedom of individual style which fell just this side of bombast but was saved by the integrity of his gifts as a colourist and his discipline as a draftsman. He developed a broad, loose technique which is essentially painterly, and his late landscapes and portraits are related to the truly Expressionist work of Oskar Kokoschka.

Expressionism exhibits many varieties of interpretation. Basically, the artists linked the background of German medieval feeling for characterization—which at times amounted to caricature—to a tremendous inner tension of struggle and individualism which demanded perfect freedom in the use of colour and line for the exposition of subject matter. These men sought to express by any means—heightened colour, distortion of the figure and a general disregard for perspective—a range of personal emotions which ran from a tender mysticism to harsh, often violent graphic statement The Impressionist—distort as he might according to the tenets of the academies—was still preoccupied with the object he painted. The Expressionist infuse? his own personality even into inanimate objects. He looked at the object and then in the mirror—to examine its effect upon himself.

1. Die Brücke.—The first real manifestation occurred in Dresden in 1905 with the formation of an artists' group called *die Brücke* ("the bridge"), which included Ernst Ludwig Kirchner (1880–1938), Karl Schmidt-Rottluff (1884–), Erich Heckel (1883–), and was soon joined by Max Pechstein (1881–1955), Emil Nolde (1867–1956) and Otto Müller (1874–1930). Kirchner and Nolde stand out as the most important painters in this north German group which developed a vehement language to express a fervent and agitated imagination. The particular interest of the *Brucke* painters centred on the forces of nature. the erotic. the primitive and the antibourgeois. The aims of this group influenced and to a certain extent involved many of the inventive painters of the time who were concerned with the problem of finding an adequate expressive form for their personal insights.

About 1910 there were various exhibitions in Germany of the French Cubists which were of lasting influence. A new secession group, known as the *Sonderbund* ("special league"), formed in Cologne. Soon all manifestations of 20th-century painting from every country could be compared in the *Sturm* ("Tempest") under the avant-garde leadership of Herwath Walden. The influence of Cubism figured strongly in the painting of the Blue Rider.

2. Der Blaue Reiter.—Two painters, the Russian Wassily Kandinsky (1866–1944) and the German Franz Marc (1880–1916), published an important book *Der Blaue Reiter,* in Munich in 1910, and by 1911 the first Blue Rider exhibition was organized. This group was comprehensive in its interests. It attracted painters from all over Europe, especially Russia and France. Among the most active participants were Alexi von Jawlensky (1864–1941), August Macke (1887–1914), Heinrich Campendonk (1889–), Lyonel Feininger (1871–1956) and Paul Klee (1879–1940). Kandinsky, who was the guiding force of this group, found his way toward complete liberation from the object by 1910. He established thereby a new basis for art, free from traditional bonds, be they the limitations of material reality or considerations of accepted formal values. His paintings, with titles from the world of music such as "Composition No. 3," followed the dictates of the "inner necessity of the spirit." The other painters remained much closer to the figurative and rewresentational. Marc found a unique mystic expression in rendering animals and plants. He left a series of pictures of horses, deer and enchanted landscapes that have the glow of colour inspired by Gauguin and a stylization of planes and patterns derived from the Cubists. The influence of Rlee arid

Feininger was of such importance that it will be considered in subsequent developments.

3. Die **Neue Sachlichkeit.**—A revival of realism in Germany during the 1920s was known as ***die Neue Sachlichkeit*** ("the New Objectivity"). This group was largely dominated by Max Beckmann (1884–1950), Otto Dix (1891–) and George Grosz (1893–1959). Each used the power and freedom of a latent Expressionism for a heightened, almost brutal objectivity. Beckmann gave epic significance to his imaginative figure compositions and landscapes, often based upon almost trivial subject matter such as domestic scenes and carnival incidents. Later he was to move toward a monumental pantomime of figure composition that recalls the stark and terrible quality of Greek tragedy. He evolved an equivocal iconography, based on the condition of man, which raised him to the position of one of the most significant painters of the first half of the 20th century.

George Grosz, who had been associated with all the new movements in Germany, was relentless in his social criticism of the German war profiteer, the politician and the military caste. In his graphic social commentaries he followed naturally in the line of Goya, Daumier and Toulouse-Lautrec, Otto Dix turned his talents to a meticulous super-real or highly naturalistic rendering of his subject. He was also relentless in his contrast of youth and old age, of the horrors and decay of war presented with the tender flowering of nature, which often occurred in the details of his composition. Both Beckmann and Grosz later moved to the United States, where they became influential teachers.

4. **Kokoschka.**—Oskar Kokoschka (1886–) first worked in Vienna under Gustav Klimt (1862–1918), one of the leading Austrian painters of his day, whose work shows a certain affinity to Toulouse-Lautrec, Redon and Aubrey Beardsley. However, Kokoschka was soon to develop a highly individual form of portraiture in which the apparent distortions of both the heads and hands of his sitters developed into a recognizable style of almost neurotic intensity. In this series of portraits and in the drawings of that period his use of line, exploding in punctuations of ornament, produced a highly personal type of nervous calligraphy. Later he took part in the advanced movements of German painting, and the result was a series of landscapes and other compositions done in broad, irregular planes of intense colour contrasts. After some service in the Austrian army during World War I, he visited Paris, London and other cities. These visits left a definite impression on his style, it being especially influenced by the pictures of Turner which he saw in London. His violence was modified toward a more lyrical statement. He developed a unique style for the cityscape, capturing the mood and atmosphere of an entire city. During World War II he left first Vienna, then Prague, fled to London, later visited the United States, and finally returned to his native Austria after the war.

5. Bauhaus Group.— In 1919, as part of the reconstruction of post-World War I Germany, the architect Walter Gropius (1883–), encouraged by the grand duke of Saxe-Weimar, established a comprehensive laboratory school for the purpose of developing artist-craftsmen who could work in conjunction with the engineer-architect. The aim was to reintegrate the artist into society and to make him a functional member of a technological culture. Attention was given to materials, both the usual and the new and experimental. Emphasis was laid upon textures as well as combinations of materials.

All art forms were experimented with and exploited, not only painting, sculpture and architecture, but also the dance and the stage. Yet the house as the nucleus of man's life was the focal point of attention. Each student was expected not only to become a master craftsman, but to become familiar with all the arts, with special recognition of the machine as a tool. They believed that the products of the machine should be guided by the artist craftsman who was fully aware of the limitations and possibilities of both the individual and the machine. It is interesting to note that both abstract films and musiclike scores for the projection of colour on a Iinen screen were a part of this experiment.

The Bauhaus was a reaction to the melancholy and subjective individualism of Expressionism. It also tried to correct some of the mistakes of the group which earlier surrounded William Morris in England, by making use of the machine as a tool, rather than trying to compete with it. The English had striven to revive the crafts spirit of the middle ages as a protest against the machine. The Bauhaus suffered by being misinterpreted as being narrowly "functional," and many of its discoveries were misappropriated. In 1926 the school was moved to Dessau. where it flourished until 1928. It was completely dissolved in 1933 after Adolf Hitler's rise to power, and its members scattered throughout the world. Klee and Feininger returned to their native countries, Switzerland and the United States, Kandinsky went to Paris, László Moholy-Nagy (1895–1946), Josef Albers (1888–) and Herbert Bayer (1900–) went to the United States. Similar schools were established in Chicago, Ill. (Institute of Design of Illinois Institute of Technology), and in North Carolina (Black Mountain college), as well as at Harvard and Yale universities. Other painters who worked within the group were Johannes Itten (1888–) and Oskar Schlemmer (1888–1943).

6. **Klee.**—Paul Klee stands apart from all groups, yet his work reflects many diverse art forms, including drawings of children. If Expressionism can be considered as the "direct visualization of individual emotion," Klee belongs to this movement. He was able to create a new language of colour, form and space and to develop a private symbolism which communicates deeply. To Klee "art was a symbol of creation, an example much as the earth exemplifies the cosmos." He proceeded to create his own reality, which does not represent the familiar reality but penetrates to a reality that is not known until one sees his paintings. The present state of things, he felt, is only a momentary and accidental arrangement, and he attempted to communicate a world as it might once have been or is in the process of becoming. If a work of art is able to be more than a pleasing decoration, if it is able to give insight and perhaps change lives, then it may be understood why Klee is one of the most admired artists of one of the most creative periods in the history of art.

7. German Art After **1933.**—Hitler's government assumed complete direction of German creative activity, including the censorship of art criticism in all its forms. Artists sought exile when possible, or stayed on in Germany, either submitting to the controls or going into the concentration camp. But no man worked freely.

There was little immediate development in the arts in Germany after the termination of World War II in 1945, largely because the nazi regime had successfully interrupted the thread of creative tradition. However, gradually a number of imaginative painters, such as Theodor Werner (1886–), Ernst Wilhelm Nay (1902–) and Fritz Winter (1905–)—all working in the abstract idiom—began within a decade to gain international reputation.

H. Nonobjective Painting

Following the inception of Cubism there developed a number of minor movements that were more or less abstract. Some of these were of short duration and are known through a few pictures only. It is difficult to define them with any exactitude, since they used influences and ideas of concurrent experimental groups working in other countries. For instance, even the serious work conducted by the Bauhaus was influenced to a certain extent by Dadaism. Cubism and Expressionism sometimes mingled to produce new forms, as in the work of Feininger. Often the influences of these movements were of even greater significance in the theatre, experimental literature, architecture or design.

1. Rayonism, Suprematism, Constructivism.— From 1910 to 1920 Moscow was one of the great artistic centres of Europe and carried on a series of exhibitions brought from Paris. Comprehensive private and public collections were formed. No less than a half dozen short-lived experimental movements put in their appearance within a few years. Abstract art in Russia had begun under the tsarist regime and was carried over until its influence was generally diffused. The first completely nonobjective painting was created by a Russian painter working in Munich, Wassily Kandinsky (see above). Kandinsky also evolved an aesthetic theory of abstract painting.

Rayonism, created by Mikhail Larionov (1881–), an important nonrepresentational experiment, had something in common with Futurism and started with the reduction of forms in figure and landscape composition into rays of light. It had some influence upon the settings for the Diaghilev ballets through Larionov and his wife, Nathalie Gontcharova (1881–).

Suprematism was originated by the Russian-Polish painter Kazimir hlalevich (1878–1935). He was the first artist to establish a system of nonrepresentational composition in terms of pure geometric shapes and patterns. His most important picture, painted in 1918, was "White on White" (a white square set on an angle within a white square). His influence on graphic design and typography was especially important.

Aleksandr Rodchenko (1891–), an associate painter who became a rival to Malevich, formed a group under the general title of the Nonobjectivists. His best-known picture, also painted in 1918, was "Black on Black" (a circular pattern crisscrossed by two pointed ellipses, all in black). This picture was sent to the 1919 Suprematist-Nonobjectivist exhibition as an answer to Malevich's famous "White on White." Later Rodchenko worked in the Constructivist manner.

El Lissitzky (1890–1941), one of the best-known of the Russian abstract painters, spent much time in Germany between 1921 and 1928 and exerted a considerable influence on the development of design, especially at the Bauhaus.

For a time the influence of Russian Constructivism was far-reaching, particularly in the theatre, where attempts to build various settings of an abstract nature were carried on bv all the small advanced groups. This activity carried into the rest of Europe and America. Constructivism was largely instigated by the brothers Naum Gabo (1890–) and Antoine Pevsner (1886–1962). It must be remembered also that the Hungarian Moholy-Nagy made intelligent use of every possible innovation suggested by these experiments. Constructivism was largely inspired by the collage of the French Cubists and literally carried it into three dimensions in which wood, wire, sheet metal, glass and even concrete were used. The brilliant constructions by Pevsner and Gabo, however, belong legitimately in the realm of sculpture.

2. De **Stijl and Neoplasticism.**—The year 1917 marked the formation of the *de Stijl* group in the Netherlands. It included the painters Piet Mondrian (1872–1944), Theo van Doesburg (1883–1931) and others, along with the sculptor Georges Vantongerloo (1886–) and the architect J. J: P. Oud (1890–). Alfred H. Barr, Jr., in *Cubism and Abstract Art,* wrote of this group: "Two elements formed the fundamental basis of the work of *de Stijl,* whether in painting, architecture or sculpture, furniture or typography: in form the rectangle; in color the 'primary' hues. red, blue and yellow." By 1920 hlondrian had published his manifesto on Neoplasticism in Paris. His painting had evolved from the conventional 19th-century Dutch pictorial style to a form of absolute nonrepresentationalism. His compositions are characterized by precise measurement of rectangular spaces on a white canvas ground, with the introduction of an occasional rectangular lozenge of absolutely pure colour. His most complex picture was his unfinished "Broadway Boogie-Woogie." on which he was working at the time of his death in New Uork. Various members of this particular group had a great influence upon architecture, and at one time affected the Bauhaus trend in Germany.

3. Purism.—From 1916 to 1925 the teacher-painter Amédée Ozenfant (1886–) and the architect Charles Edouard Jeanneret (1887–), known as Le Corbusier, created a functional classicism known as Purism. This group was not unlike *de Stijl* in that it insisted upon precision, a clean line and the impersonal quality of machine design and engineering. As for the painting, it was more or less an admonition to the more rococo effects of Cubism and any of the playful variations that may have entered painting by may of Dada. The pictorial vocabulary was more or less limited to bottles and other still-life forms which exhibited an endless series of rhyming profiles of shapes and patterns somehow forced into deep space. Similar to *de Stijl,* its influence upon functional architecture and modern applied design was widespread. The German painter Willi Baumeister (1889–1955) is closely related in style to the Purists.

I. Dadaism

According to Tristan Tzara and reported by Jean (Hans) Arp (1887–), the word Dada was discovered by Tzara on Feb. 8, 1916, at six o'clock in the evening at the Terrace café in Zürich, Switz. Dada was more of an influence than an actuality, although it was supposedly a serious criticism of 20th-century civilization. It took its name from the French word for hobbyhorse or plaything, and sought through terms of derision to destroy all sense of tradition in the arts and ethical codes, as well as traditions and values of conduct. Dada groups sprang up in New York, Barcelona, Cologne, Hanover, Berlin and Paris. Most of the serious artists connected with the movement used it as a means to playfulness and further experiment in combinations of mediums. One of its chief exponents was the painter Kurt Schwitters (1887–1948), who created the *Merzbild* or collages made out of the leftovers from the trash barrel, thus proving—to himself, at least—his famous statement, "Anything the artist spits is Art." Marcel Duchamp, Francis Picabia, Max Ernst (1891–) and others were associated with it for a time. Man Ray (1890–) also made significant contributions. The positive side of the movement was in the field of experiment: the negative, the despair, feigned or real, which for a time invaded the theatre, ballet, the novel and poetry, as well as painting and sculpture. Completely anarchic, it used the materials of fantasy and destruction; its ultimate aim was chaos.

J. Surrealism

The spokesmen for the Surrealist group, like those for Dada, claimed that it was not limited to a purely aesthetic point of view but was a philosophy of life. Dealing in terms of the irrational, it sought to exalt the unconscious into an active, creative role. Greatly indebted to the teachings of Sigmund Freud, Surrealism began in 1922 in Paris, but it was not until 1924 that André Breton issued its manifesto and published the first number of *La Révolution Surréaliste.* A great deal of the material written by the Surrealists in defense and definition is not clear. However, here is Breton's own definition (from *What Is Surrealism?,* translated by David Gascoyne [Faber]):

SURREALISM, n. Pure psychic automatism, by which it is intended to express, verbally, in writing, or by other means, the real process of thought. Thought's dictation, in the absence of all control exercised by the reason and outside all aesthetic and moral preoccupations.

ENCYCL., Philos. Surrealism rests in the belief in the superior reality of certain forms of association neglected heretofore; in the omnipotence of the dream and in the disinterested play of thought. It tends definitely to do away with all other psychic mechanisms and to substitute itself for them in the solution of the principal problems of life.

The movement in painting had for its best-known exponents the Spaniard Salvador Dali (1904–), Joan Miró (1893–), Uves Tanguy (1900–55), Pierre Roy (1880–1950), Jean (Hans) Arp. Andre Masson (1896–) and the Chilean Matta (Roberto Matta Echaurren) (1911–). Some of these men carried over from Dadaism certain ideas and forms. Each artist varied greatly from the others in his handling and choice of subject matter, many subscribed to the idea of associating ordinarily unassociated objects and environments in such manner as to create surprise and shock the spectator. The most obvious example is Dali's picture "The Persistence of Memory" (1931), a picture of wet, limp watches, which is conventionally painted, the realism being pushed to the point of a coloured photograph. Only the elements of space and the fluidic form of the melting timepieces provide the paranoiac shock of the dream. The Surrealists claim the Italian Giorgio de Chirico (1888–), to whom they are heavily indebted, for his use of space shock and strange juxtapositions which resulted in images of anxiety; also, the Russian Marc Chagall for his fantasy, and Paul Klee for his provocative use of automatic writing and freedorn of meandering line. None of these three artists ever actually joined the group.

Associated with Surrealism was the movement of neoromanticism, which included at one time Pavel Tchelitchew (1898–1957), Eugène Berman (1899–) and Christian Bérard (1902–49).

Again, both the neoromanticists and the Surrealists called upon Picasso and De Chirico. The chief effect of the neoromanticists is a concern of a stage-set world in which Renaissance perspective often exploits vistas of space which contain nostalgic ruins and lone figures that cast ominous shadows. It is almost a manneristic revival.

K. School of Paris

Many of the painters of the School of Paris were identified with the changing movements after the inception of Cubism and the broadly interpreted movement of Les *Fauves.* A consistent and recognizable style was achieved by De Segonzac in his richly painted landscapes and brilliant figure drawings. Maurice Utrillo (1883–1955) followed somewhat in the tradition of his gifted mother, Suzanne Valadon (1867–1938). He developed a series of pictures of Paris and its environs in all seasons and weather which are famous for their poetic content and richly textured quality. André Derain and Maurice de Vlaminck have been treated under Fauvism, above. It must be remarked that scores of gifted painters of every nationality were a part of the development of this school.

Outstanding as a personality of great talent was Amedeo Modigliani (1884–1920), an Italian by birth, who was among the first to interpret the forms of Negro sculpture in modern painting. He combined this with a superb draftsmanship––a sensitivity to line which recalls Botticelli. His elongated nudes are at once sensuous and melancholy.

Jules Pascin (1885–1930), along with Modigliani, personified the lingering tradition of Bohemia. A world traveler, born in Bulgaria, he finally became a U.S. citizen, but largely worked in Paris. He generally depicted adolescent beauty in pearllike tones of colour with a revealing and meandering line. His influence in both Paris and New York was considerable.

Chaim Soutine (1894–1944), born in Lithuania, was essentially an Expressionist whose intensity of style and colour went beyond Van Gogh. and each of his dynamic and passionate paintings was a personal characterization worked in heavily loaded pigment with a wild stroke.

Marc Chagall (1887–), Russian by birth, created an art of delightful fantasy. Often his pictures seem based upon Jewish folk legends and fairy tales. His subjects include the circus, cows, roosters, bouquets with floating figures of lovers, often placed in the streets of provincial Russian towns.

Contributions of particular interest were also made to the School of Paris by Jacques Villon (1875–), André Lhote (1885–1962), Marcel Gromaire 11892–), Marie Laurencin (1885–1956). Moïse Kisling (1891–1953), Louis Marcoussis, Jean Lurçat (1892–), Leopold Survage (1879–) and Jean Hélion (1904–).

There was a consistent interest in the growth of a school of more or less untrained painters broadly labeled Modern Primitives, who varied greatly in individual style. Camille Bombois (1883–) and Louis Vivin (1861–1936) were among the best known.

Among later painters of a controversial nature was Jean Dubuffet (1901–) of France. He combined the naïve with the brutal. He painted oversized heads, distorted, flat bodies, and low-keyed landscapes from which scratched-in figures emerge. Dubuffet used tortured surfaces, often mixing sand and other elements into the painting medium, and the general effect is uneven and splotchy. Because of the great solitude yet brutally affirmative quality of some of his figures, some writers related him to the literary movement of Existentialists.

1. Further Contributions of **Picasso.**—Pablo Picasso was the greatest single influence after the time of Cézanne; his versatility, curiosiry and inventiveness epitomized the transient quality of the modern movement.

Picasso was born in Malaga, Sp., in 1881. His father was a drawing master, and early in life Picasso became his most apt pupil. He went to Paris about 1903, and his early work, sensitive and enormously talented, reflected influences of the Impressionists and the draftsmanship of Toulouse-Lautrec and Théophile Alexandre Steinlen (1859–1923). Until he developed Cubism, he painted a series of haunting pictures of the family of Harlequin, clowns, circus troupes and generally interpreted the wandering European poor. This group of pictures became generally known as his "blue period." Then followed the "rose period," which, at times, took a more objective and classical turn. Throughout, Picasso's extraordinary draftsmanshipand command of forms carried on. Prolific and constantly changing in his interests, he was likely in a single year (in the 1920s especially) to exhibit a sudden new development of an earlier interest or manner. He turned also to the art of ancient Greece and Rome during the 1920s and developed a classic and monumental figure style of his own in his "Lovers" of 1923. In the late 1920s he made his own Surrealist experiments which, together with his work in all the other movements of the 20th century, turned out to be more successful than that of the originators of the various schools. In 1937 he produced his famous mural panel "Guernica" for the Spanish pavillion at the Paris exposition. This huge mural, done in black, gray and white, was painted as a protest against the destruction of the Basque town of Guernica by German bombers flying for Gen. Francisco Franco Bahamonde. This composition created more discussion than any single painting since the exhibition of Marcel Duchamp's "Nude Descending a Staircase." The symbolic details of Picasso's historic work are handled ruthlessly with no attempt for the academic considerations of fine painting. It was perhaps the greatest document of intellectualized pain that the modern movement had produced. Using all the knowledge and the devices at his disposal, he made a transcription of the elements of horror and catastrophe, creating a series of moving concepts which are poignant symbols, in his own unmistakable style.

After painting "Guernica," Picasso did an especially provocative series of figure compositions in which the swiftly changing expressions of the face are melted into one moving plastic image. His portraits of his secretary, Jaime Sabartés, and those of Dora Maar are typical exzmples. In various periods of his life Picasso also experimented in sculpture and ceramics and created a large and brilliant series of drawings, etchings and lithographs. (See also Picasso, Pablo.)

L. National Development

1. Italy.—Italy's first contribution to 20th-century painting was Futurism. Working independently of that movement were the artists Giorgio de Chirico and Giorgio Morandi (1890–), joined by Carlo Carra, who grouped themselves as the *scuola metafisica.* De Chirico was mesmerized by what the U.S. critic James Thrall Soby termed "the magic of the object." He painted a series of landscapes that seemed to be set in the fixation of a dream, featuring architectural subjects with an emphasis upon perspective; accompanying these motifs of antiquity often appears a lonely symbol of modern civilization, such as a toylike locomotive. The symbology of most of his subjects was of a metaphysical nature, often making use of mannequins, elaborate still-life arrangements of separate elements and dream-shock vistas. Many of these, flawlessly painted in dramatic contrasts of colour and light, almost parody certain old masters.

Carra was often close to De Chirico in feeling, as was Morandi in his work of about 1917 and the early 1920s. Morandi later took to painting simple poetic landscapes or still lifes made up of multitudes of bottles. De Chirico returned to his early love for the manner of Courbet and the persistent influence of Arnold Bocklin.

Arturo Tosi (1871–1956) must be considered a late Impressionist, related to the intimism of Bonnard, while Mario Sironi (1885–1961) painted expressively romantic pictures and Felice Casorati (1886–) developed a classic studio painting of his own. Massimo Campigli (1895–) created a unique style related to Etruscan and Pompeian mural painting. Among the artists who reacted strongly against the forced isolation during the Fascist regime was Renato Guttuso (1912–), who became a central figure in Italian painting. Others, such as Giuseppe Santomaso (1907–), Armando Pizzinato (1910–) and Afro (Basaldella) (1912–), worked in various idioms of abstraction, also helping to bring Italy back to an important place in world painting.

2. Spain.—Except for artists such as Picasso, Miró, Gris and Dali, all internationalists, Spain remained conservative and little

influenced from the outside. Of the older painters. Ignacio Zuloaga (1870–1945) produced a series of popular decorative portraits. Other well-known Spanish painters include Joaquin Sorolla y Bastida (1863–1923) and Valentin de Zubiaurre (1874–1).

3. Switzerland.——Swiss painting was affected by Impressionism and touched by the subsequent movements. Ferdinand Hodler (1853–1918), a symbolist. was the most important Swiss painter early in the 20th century. Paul Klee. though of Swiss nationality, spent most of his life in Germany. Cuno Amiet (1868–) was an important painter working in a more traditional idiom. After World War II Swiss painters turned to a rather international style of abstraction.

4. Belgium.— In 1837 Cézanne exhibited with the "XX Group" in Brussels. The Belgians in their recognition of many of the advanccd painters in other countries at that time were to set a precedent for many galleries devoted to the exhibition of modern art. Théo van Rysselberghe brought French Neoimpressionism into Belgium. The most important figure for many years was James Ensor (see above). In the following generation the artists of the group of Laethem-Saint-Martin were significant, and among them Constant Permeke (1886–1952) made with his rough-hewn peasant figures the most valid contribution. Others in that group were Gustave de Smet (1877–1943) and Frits van den Berghe (1883–1939). Paul Delvaux (1897–) and René Magritte (1898–) belonged to the Surreaiist group and both of them made use of shock value; especially in regard to the nude figure.

5. The **Netherlands.**—At the turn of the century the symbolists Jan Toorop (1858–1928) and J. Thorn Prikker (1868–1932) were producing the most original work in the Setherlands. In the 1920s leadership was taken over by the de *Stijl* group of Piet Mondrian (*see* above) and Theo van Dcesburg. The Expressionism of Leo Gestel (1881–1941) and Jan Sluyters (1881–1957) was of primary national importance. By mid-20th century the stark realism—nith a symbolic social flavour—of Charley Toorop (1890–) and Pyke Koch (1901–) and the heavily textured abstractions of Karel Appel (1921–) seemed outstanding.

6. Scandinavian Countries.— The School of Paris and the advanced movements of Germany made themselves felt in Scandinavia. partly through exhibitions and through the influence of a few important individual painters such as the Norwegian Edvard Munch, the greatest of their artists: Per Krohg (1889–), also a Norwegian; and the Swedish portraitist Ernst Josephson (1852–1906). Per Krohg was naturaliy influenced by Munch, but should be considered more a member of the School of Paris whose work ivas modified by certain national characteristics.

Although the contribution of the Scandinavian countries was relatively small in the field of painting. their influence was widely felt in crafts, the decorative arts and architecture. as well as in sculpture. Undoubtedly most important among the younger Scandinavian artists was Rolf Nesch (1893–). Born in Germany and a student of Kirchner. Nesch made his home in Norway in 1933. By means of his experimental technique and his lyrical fantasy Nesch enriched the pictorial surface.

7. U.S.S.R.—The chief innovations in Russian painting were in the various movements that developed around Constructivism (see above). Many leading Russian artists worked successfully in the theatre and ballet. The Diaghilev Ballet Russe, famous for its sets and costumes, attracted the leading artists of Europe as well as such well-known Russian painters as Leon Bakst and Alexander Benois. Other painters who contributed to the stage were Nikolai Roerich (1874–1947), Ivan Bilibine, Matislav and Rostislav. Running a gamut from romantic realism to decorative individualism were the following. some of whom were influenced by the School of Paris: Gregor Chiltian, Alexandre Jacovlev (1887–1938), Nathalie Gontcharova, Alexis Gritchenko. Schoukaeff. Zenaide Serebriakova, Vladimir Polunin (1880–1957) and Nadia Benois. Much of the art of the U.S.S.R. after the experimental period of the 1920s was largely illustrative, devoted to extolling the virtues of various aspects of the proletarian state.

8. Great **Britain.**—Walter Sickert (1860–1942), student of Whistler and admirer of Degas. combined realistic subject matter with Impressionist form. Another exponent of Impressionism was Phillip Wilson Steer (1860–1942). Augustus John (1878–1961) painted portraits which vigorously characterize such famous persons as George Bernard Shaw and James Joyce.

Postimpressionist painting was introduced to Great Britain by an important exhibition held at the Grafton galleries in 1910. It became the standard of criticism for Roger Fry (1866–1934) and Clive Bell 11881--), who established a new and significant basis for art criticism. concerned with the pictorial form itself,

The Contemporary Art society was formed in 1910 to bridge the gap between artist and public. Duncan Grant (1887–) became important among the Postimpressionists and Matthew Smith (1879–), in contact with Matisse at one time, developed his own vigorous Fauvism. Early abstract art made its inroads in England with Wyndham Lewis' (1884–1957) short-lived Vorticism.

During the 1930s there was the beginning of an important revival in the visual arts in Great Britain, which was greatly encouraged by critics such as Herbert Read and by the programs in art education sponsored by the government's British council.

Paul Sash (1889–1946), official artist of both wars; turned to a magic realism with Surrealist overtones. Sir Stanley Spencer (1891–1959) approached religious subjects with an often eerie magic realism. Victor Pasmore (1900–) developed from his earlier realism to the totally abstract style of highly sensitive collages. Henry Moore (1898–). though essentially a sculptor, had an important influence on painting. His use of organic forms seems to encompass an evolutionary sequence that moves from fossils. prehistoric monuments and indeed a personal archaeology to forms of the present times. His shelter drawings, made during World War II. remain among the most poignant visual records of the war. John Piper (1903–). an abstractionist before the mar who was commissioned to record the bomb damage in London, in his post-World War II work dramatized old buildings in a neo-romantic fashion. Graham Sutherland (1903--). recognized by many as England's leading painter at mid-20th century, achieved a fusion of romanticism and Surrealism. He transformed thornbushes. insects and other hostile-seeming organic forms into powerful and frightening totemic images. His "Crucifixion" in Northampton is considered one of the most important religious paintings of the 20th century. Attention should be called to Francis Bacon (1410–), Keith Vaughan (1912–), John Minton (1918–1957), John Craxton (1920–) and Michael Ayrton (1921–) among the younger generation. Bacon went beyond Sutherland. Recognizing the importance of the shock value of Surrealism, he became obsessed with horror and tragedy and sometimes seemed to comment ironically on a world of utter cruelty and ugliness.

Completely different from the painters mentioned and outside the main current of English painting was Ben Nicholson (1894–1, who renounced romantic statements and like Mondrian explored the realm of pure forni in a search for an absolute simplicity of statement. His geometric abstractions indicated an extraordinary sensitivity to formal relationships.

9. United States.— The first wave of modern art struck the United States in 1913 when the famous Armory show brought to the U.S. artist and public for the first time in any volume the work of al! the leading experimental painters of Europe and those of the immediate past. Duchamp's "Nude Descending a Staircase" became a source of nation- vide controversy. Actually the foundations for modern painting in the U.S. were laid in 1908 by a new group of painters with great gifts known as "The Eight." One of this group. Arthur B. Davies (1862–1928), largely responsible for the Armory show, painted canvases of idyllic and romantic mood. Maurice Prendergast (1859–1924) did scenes with a Postimpressionist patchwork of colour and was far ahead of his U.S. contemporaries in his visual statements. Ernest Lawson (1873–1939) also painted Postimpressionist landscapes. The other members of this important group, Robert Henri (1865–1929) and his followers John Sloan (1871–1951), George B. Luks (1867–1933), Everett Shinn (1876–1953) and William Glackens (1870–1938), were concerned with developing a vigorous style for the depiction of the urban environment not unrelated to reportage writing. They were

popularly dubbed the "Ash Can school."

During the 1920s and 1930s painters such as George Bellows (1882–1925), William Gropper (1897–) and Reginald Marsh (1898–1954) continued in this tradition, while others, such as Edward Hopper (1882–) and Charles Burchfield (1893–), interpreted the U.S. scene more romantically.

In the same period there were a number of U.S. painters of extraordinary talent, who, largely under the leadership of the photographer and art dealer Alfred Stieglitz (1864–1946), presented unique formulations based on highly personal fusions of Expressionism and Cubism. Foremost among them were John Marin (1870–1953) with his vital water colours of city and ocean and Max Weber (1881–1961) with his deeply felt distortions, often religious in subject matter. Of great importance were the lyrical abstractions of Arthur G. Dove (1880–1946), the bold expressions of the New England coast by Marsden Hartley (1877–1943), the semi-Cubist precisions of Charles Demuth (1883–1935), and Georgia O'Keeffe's immaculate flower pieces and landscapes. Feininger, who returned to the U.S. in 1937, continued painting his poetic landscapes and seascapes with prismatic light. Abraham Rattner's (1895–) brilliantly coloured canvases were more closely akin to French painting, especially to Rouault. Stuart Davis (1894–) evolved a bold abstraction of colour and shape based on synthetic Cubism but adhering to the U.S. scene. Ben Shahn (1898–) developed a unique personal form of flat colour planes and piercing lines for his canvases advocating social justice. Charles Sheeler (1883–) painted the U.S. industrial landscape with a precision of vision which shows the often close relationship of realism and abstraction, and Ivan Le Lorraine Albright (1897–) using a similar sharp focus vision placed familiar objects in unfamiliar relationships with an extraordinary clarity of detail giving a strong emotional effect.

During the same period, there was also—after the depression of the 1930s—a group of homespun regionalists led by Thomas Hart Benton (1889–), John Steuart Curry (1897–1946) and Grant Wood (1892–1942). Their style, however, and especially that of their many followers, led to a narrow provincialism.

In 1935 under the administration of Pres. Franklin D. Roosevelt, two government art projects were established—the Treasury Relief Art project and the Federal Art project of the Works Progress administration. The latter gave great impetus to the development of U.S. art generally through art centres which conducted exhibitions and teaching programs. A major contribution was the "Index to American Design," which recorded in painting and photography the significant variations of indigenous arts and crafts in the United States. This also provided a measure of security for artists and made important post-World War II developments possible.

Mark Tobey (1890–), working in the Pacific northwest, became widely recognized after World War II for his calligraphic abstractions, his automatic white writing, much indebted to Japanese calligraphy. Morris Graves (1910–) was in turn influenced by Tobey and painted birds in soft colours—mystic symbols of his inner world.

New York city became an important artistic centre of western art after World War II when abstraction of various kinds grew to be the most vital strain in American painting. Arshile Gorky (1904–48), himself related at times to Picasso and Miró, evolved a symbolism of soft organic forms in which the fantastic is fused with the biomorphic. Willem de Kooning (1904–), recognized as one of the leading U.S. painters in the 1950s, was greatly concerned with the painting process itself, evolving at times a frightening human imagery. Jackson Pollock (1912–56) created most controversial paintings by trickling his paint on the canvas to produce a rhythmic labyrinth of linear colour streams. Mark Rothko (1903–) offered large canvases covered with vast expanses of hazy contrasting colour. William Baziotes (1912–) looked to amoebic forms for his inspiration and Adolph Gottlieb (1903–) found his stimulus in ancient pictographs. All of these artists, while deriving in certain aspects from European trends, evolved an abstract and evocative art based primarily on the extreme subjectivity of their own feelings and emotions. Others such as Rico Lebrun (1900–) in Los Angeles, Hyman Bloom (1913–) in Boston and Leon Golub (1922–) in Chicago found by means of personal introspection, poignant, often enigmatic images of death, decay and suffering, which nevertheless are direct in their communicative and purifying power.

10. Mexico and Latin America.—Around 1910, during the social revolution in Mexico, Diego Rivera (1886–1957) and other Mexican artists returned from Paris. Although saturated with the current French tradition, they turned to the historic arts of ancient Mexico and created a new background which developed into a national idiom. Rivera headed the newly formed syndicate of painters which undertook a large official project to decorate the walls of public buildings. He created a monumental series of wall decorations, easel paintings, drawings and prints representing him in various parts of the world.

Perhaps the greatest individual genius of the Mexican movement was José Clemente Orozco (1883–1949), muralist, easel painter and lithographer. His drawings and paintings of war, revolution and scenes from the life of the people became widely known, and many of these themes were transcribed into fresco. His frescoes in Mexico and the Cnited States combine a monumentality of concept and execution with Expressionist force. In the service of his social and political ideas, his frescoes have an incomparable persuasive power of form and content. When compared with the harmonious and human proportions of the figures in Renaissance frescoes, the figures in his murals look gigantically distorted and dissonant. A similar expressive grandeur in concept is found in the frescoes of David Alfaro Siqueiros (1898–). Both absorbed the message of Aztec art. The Mexican mural painters proved most successful in finding a functional relationship of art to society. Other well-known Mexican painters were Dr. Atl (Gerardo Murillo), painter, draftsman and writer (1877–), Federico Cantu (1908–), Jean Charlot (1898–), Miguel Covarrubias (1904–57), Carlos Mérida (1893–) and Roberto Montenegro (1885–). Among the younger generation, Rufino Tamayo (1899–), related more closely to international art, is most important.

From 1930 on there was increased interest in the development of contemporary painting, sculpture and architecture in the Latin-American countries. Several important exhibitions were held in the United States, some of them as part of the state department cultural interchange. The work of various artists such as the Argentinian Emilio Pettovrutti (1895–) and the Brazilian Cândido Portinari (1903–1962) were circulated in special exhibitions throughout the United States. The experimental work of the Chilean painter Matta (Echaurren), as well as that of the Cuban Wilfredo Lam (1902–), gained widespread attention.

(D. BEA.; P. H. S.)

11. Canada.—In Canada, the modern movement in art dates from James Wilson Morrice (1865–1924). Although Morrice lived for years abroad, his later figure and landscape paintings, which have much in common with the subtle colour equations of Matisse, inspired many young Canadian artists to greater experiment A more regionalist approach was that of Tom Thomson (1877–1917), who made direct renderings of the wilder aspects of Canadian nature. His artist friends, among whom were J. E. H. MacDonald (1873–1932), A. Y. Jackson (1882–) and Lawren Harris (1885–), formed with others the Group of Seven in 1920. The boldly patterned landscapes of these men attracted many followers; later, however, Canadian art became more varied and subjective in reference.

To landscapes of the forest, Emily Carr (1871–1945) brought a new freedom of expression; David Milne (1882–1953) combined logic and lyricism in his treatment of nature; equally individual are Goodridge Roberts (1904–), Jean Paul Lemieux (1904–) and Jacques de Tonnancour (1917–). The influence of the School of Paris can be traced in the works of Alfred Pellan (1906–) and many other French-Canadian artists, although in reaction to this a completely unshackled type of painting called *automatisme* developed in French Canada after 1945. It began aith Paul Emile Borduas (1905–1960) and influenced Jean Paul Riopelle. (1923–).

Each section of Canada has developed active and original paint-

ers: for example. in Vancouver J. L. Shadbolt (1909–), in Toronto Harold Town (1924–) and in New Brunswick the romantic realist Alex Colville (1920–). (D. W. BN.)

See FRESCO PAINTING; OIL PAINTING, TECHNIQUE OF; WATER-COLOUR PAINTING; etc. See also Index references under "Painting" in vol. 24.

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PAINTINGS, CONSERVATION OF. Paintings that have been saved from damage and decay are probably few in proportion to those that have been painted. The range of kinds within that number is very wide. There are pictures on the walls of tombs painted with gum and pigment over plastered stone; pictures on the whitewashed clay of cave temples in the desert; others on silk or linen that have been buried for centuries: altar-pieces on wood laid with grounds of gold leaf; drawings, representations on parchment and paper; paint on stone, metal, glass and ivory. The paint in all of them is composed of coloured dust held together by wax, glue, egg, gum, oil or resin. When the construction of a painting is considered, the survival of so many of these works done over thousands of years is evidently the consequence of careful conservation.

During ancient times little was known of the causes of decay in picture materials, and it was impossible to foresee the threat of conditions which later would injure them: heating systems. smoke-filled air, prolonged dampness, mold, insects, rough handling and transportation by rail, by automobile, by aircraft and by ship. Besides these regular hazards there have been the recurrent risks of calamity—fire, storm, flood and bombardment during wars. In earlier days, pictures were likely to be made for a particular place and to stay in that place. After a long time decay took hold of them. They became steadily weaker and their appearance changed slowly, imperceptibly. If they were left alone, the harm went unnoticed. It seems evident from the surviving records that until the 17th or 18th centuries paintings were not expected to be kept indefinitely. Pliny, writing in the first century of the Christian era, mourns the passing of the great art of painting which had existed in Greece four centuries before his day, but the loss of the works themselves he seems to have taken as a matter of course. With changing times and changing styles it can be supposed that paintings were expected to decay and to become forgotten with a forgotten past. The art of ancient Greece and Rome probably had a low evaluation during the centuries that intervened until the Renaissance brought back an interest in it, and it took another span of centuries before the paintings in a Gothic style had recovered any general esteem.

Development of Conservation.— The 19th century was eclectic in its evaluation of pictures. All styles of painting came in for their share of approval, and steady and progressive concern over matters of conservation probably came about as the result of this eclectic taste. It became apparent that things once discarded and neglected were later retrieved and held to be objects of value and importance. In consequence, most objects of art acquired a position of respect, and the means of preserving them were given serious consideration. Until about 1850 the care of paintings was assumed to be the proper responsibility of artists and painters, and they had carried out this work evidently as a secondary part of their occupation. By the middle of the 19th century, however, the artist's knowledge of the technology of paint and paintings had somewhat declined. Painters were being trained primarily in the problems of representation. They had less panel building to do than had the painters of a few centuries before. They no longer were required to mix their own paints and had lost touch with the manufacture of colour, medium and varnish coatings. These preparations were available to them in shops. They were less well-equipped to deal with the mechanics of conservation. Their work in this field was also clouded by a lack of comprehension of its essential purpose. Evidence shows that many artist-restorers considered it their duty to rework a picture so that it looked new instead of old.

By the end of the 19th century when old pictures had come to be highly valued and when critical historical studies of them had advanced, efforts were made to improve methods of preserving them. Sporadic but definite improvement was made, and probably the first clear sign of the general development of practice in this field was furnished in 1930 when the International Museums office, a dependency of the League of Nations, sponsored in Rome a conference on the examination and conservation of works of art. In the proceedings of that conference it was evident that many agencies had made contributions to the field. The sciences, with such facilities as radiography, filtered ultraviolet light, infrared photography, spectroscopy and spectrophotometry, together with chemical and microchemical analysis, had provided means for identification of materials and for a marked expansion of techniques for determining the condition of paintings. The 1930 conference showed that application of scientific investigation to preservation of materials in paintings had been made, and certain principles to safeguard the conservation and particular character of a work were endorsed.

The causes of damage and decay in paintings can be arranged, for the sake of convenience, into two groups: those which are from natural causes and those which are from handling, moving, treatment or accident. The natural agents of deterioration are familiar. They are light and dark, extreme dampness and extreme dryness, heat and cold, mold and insects and dust and grime. The imposed agents are also easy to review — jolts and vibration, direct violence, fluids that are spilled and splattered on surfaces, careless scrubbing or other causes of abrasion, and fire.

Construction of Paintings. — Agents of damage may strike at different parts in the construction of a painting. These parts may be different in number and widely different in kind. Some paintings have only two: a support such as paper, fabric, stone, plaster, wood, ivory or metal, and a paint layer, pigment in a medium. In some instances the latter component of a picture has no medium at all. Charcoal marked over paper or stone can produce a picture, but this generally has been called a drawing and is distinct from paint. The substance which carries the picture, usually called the support, may be one of a large number of materials. Western paintings, those of Europe and the Americas, have been done on a wide variety of supports. In ancient times both wood and fabric are known to have been used. Glass, metal, parchment and paper were added later. A few pictures have been made on stone and on leather. Ivory came in as the common support for miniatures, and from 1800 synthetic boards, usually of wood fibre, became common. These are the supports for movable paintings. In the far east a smaller number has prevailed; most of the movable works there are on paper or fabric. Paintings on a wall have naturally been adapted to the wall material, and this, broadly, has been some kind of plaster, dried clay, gypsum or the lime plaster which gave rise to fresco painting.

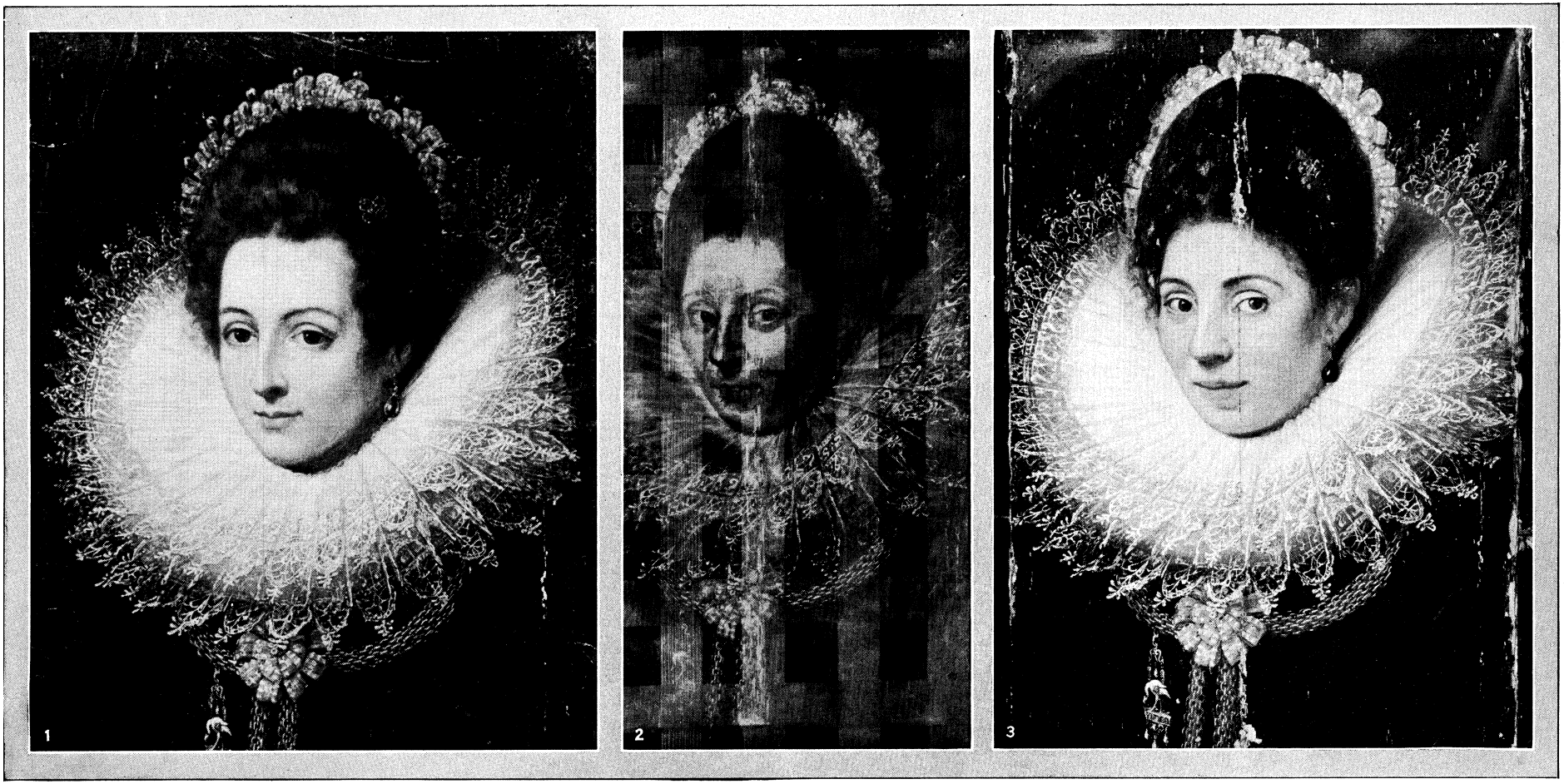
A review of these parts of the construction of paintings is necessary for a survey of the problems of conservation. The paint proper, that part of the whole work which carries the pictorial design, is usually made up of two components mixed together at some time before the paint is put on. These are colourant and medium, or, by other terms, pigment and binder. The pigment of paint is powder. For the most part it is inorganic, but a few organic dyes have been used, precipitated on an inorganic base such as aluminum silicate. The finely ground powder is mixed with an adhesive which will yield a workable paint and will dry in such a way as to hold the colour particles in a firm layer. The paint may contain little binding medium and leave the grains of pigment chalky in the film, or it may contain little pigment and make a film rich in medium and translucent. The latter is a glaze. The defects of paint that have to be dealt with in procedures for conservation are greatly influenced by this matter of structure. Lean or chalky paint is apt to lose pigment by general wear and has frequently been changed in tone and in general character by the application of varnishes which have soaked into it. Rich paint tends to react more to moisture or solvents and is more apt to crack and flake.

Between paint and support in the usual pictures of the west is another coating called ground, a uniform layer which serves to smooth the support, provide a convenient and highly reflecting tone on which the painter can work, and a substance that will take the paint evenly and firmly. In a mechanical sense, the ground is a paint but, since its purpose is not pictorial and since pictures can be made without it, the distinction according to use is a reasonable one. Movable paintings of the far east rarely have a ground. The illuminations in European manuscripts and the water-colour paintings done with a gum medium directly on paper also go without it. The powder or granular material of a ground may be pigment. Usually it is a so-called inert substance, not classed among pigments; chalk and gypsum are common. White lead is the pigment usually found in the ground.

Since the 16th century, it has been the practice to put a layer of varnish over oil paint. Varnish also has been used on tempera paintings, those executed with an aqueous medium and often with a background of gold leaf. This varnish or surface coating is an important component in many pictures and one that is often critical in their deterioration and conservation. Although it was not consistently used on tempera paintings and is not certain to have been a regular coating before the 17th or 18th century, it has an ancient history. Its story is connected with medicine and probably the resins used along with oils in early European painting were more commonly employed by physicians in the preparation of ointment. They are mentioned, however, in treatises on the art of painting that originate as early as the 8th century A.D. Broadly, there are two types of resin. One is, in fact, a fossil, the buried excretion of trees long extinct. The most familiar of these is amber; the other common one is copal. These were not soluble in spirits and had to be fused in an oil at high temperature. The spirit-soluble resins which made possible the manufacture of spirit varnishes are softer than the fossils and are taken from living trees. The common names among them are mastic, dammar and sandarac. All natural resins have somewhat the same defects. They follow a slow but persistent course of chemical and physical change, becoming more brittle, more dark and more cloudy as time goes on.

Air Conditioning. — If paintings could be kept away from dirt, from changes in the moisture of the air, from mold and worms and from handling and accidents, they would deteriorate very little even over long periods of time. Beyond a doubt, prevention of deterioration is the most valuable means of conservation and to a large extent it is possible to establish sound, preventive conditions in the housing of pictures. Air conditioning can he maintained day and night at a fixed level of relative humidity. Air can be washed and filtered and, in consequence, carry little or no dust or damaging gas. A few collections of important works have such housing but they are very few. In some collections special storage with stable conditions of atmosphere is used for certain objects that are in a fragile state. The requirements in conditioning of the air are not quite the same for all kinds of objects, but for paintings a mean can be fixed which is acceptable. A low relative humidity is desirable to prevent the risk of mold and to delay chemical and photochemical reactions. It is good for paper and for fabric. Pictures on wood and vellum, however, are subjected to a great deal of strain if the supports under them shrink or twist in a dry air. A relative humidity of approximately 55% will avoid risks of both kinds; and stability, a fixed, continuous, night-and-day level, is far more important than the exact position in per cent. Temperature is important only as it affects relative humidity.

Where pictures cannot be given air-conditioned housing or special storage, a great deal of advantage has been found in tight framing with glass. Such a frame has its disadvantages and is inconvenient to the observer because of reflections. It is, however, a great advantage in preventing extreme and rapid changes of relative humidity in the air immediately surrounding the picture. A deep frame is required and one that is mechanically firm and well-fitted. The glass needs to be sealed into the rabbet. The picture stands back of the glass at least one-quarter inch and at the back of the picture is another seal of a firm and dampproof material. Such a frame has a further advantage of keeping



BY COURTESY OF (1, 3) THE METROPOLITAN MUSEUM OF ART, NEW YORK, (2) THE FOGG MUSEUM OF ART, HARVARD UNIVERSITY

DETECTION OF FRAUD IN PAINTING BY THE X-RAY

1. "Portrait of a lady," supposed to have been painted by Franz Pourbus the Younger (1570-1622). Flemish. This was the state of the painting, with the face completely repainted, before the X-ray test was made
2. Shadowgraph, X-ray view of "Portrait of a lady," by Franz Pourbus the Younger, showing a different face. The X-ray reveals an inside view, showing the strokes of the under-painting or preparatory workmanship, which are covered by repaint
3. "Portrait of a lady" by Franz Paurbus the Younger, after the painting was cleaned, showing the same face as seen in the X-ray

PAINTINGS, CONSERVATION OF

BY COURTESY OF (1, 1A) FOGG MUSEUM OF ART. HARVARD UNIVERSITY. PHOTOGRAPH, (3) COLLECTION ARCHIVES PHOTOGRAPHIQUES

EXAMPLES OF REPAIR PROBLEMS IN THE CONSERVATION OF PAINTINGS

1, 1a. Detail showing the head of the Virgin in an Italian altarpiece of the 15th century, attributed to Antoniazzo Romano. In 1 the paint is covered with grime and a discoloured film material which tends to increase the risk of cleavage. In 1a these discolorations have been removed and the larger losses in the paint have been compensated by inpainting. 2. An example of loss in a painting on canvas. The photograph was taken after relining and after ground and paint losses had been filled with a luting material having a composition like that treated by a transfer from the original support to another. The "Holy Family" illustrated here is said to be the first picture so transferred. The work was done by Picault in Paris in 1750. 4. Relining is necessary in cases of torn canvas such as that shown. 5. Wear or abrasion of paint is evident in this detail. The dark spots are the upper level of threads in a canvas support. 6. Cleavage with buckling of the paint and losses from flaking are evident in a painting on canvas. Wax relining will correct cleavage of this kind

out dust and any concentration of those gases—hydrogen sulfide or sulfur dioxide—which might do harm to painting materials. Mold, which is also a threat to the conservation and the appearance of pictures, can be prevented in a sealed space. The common molds, spores of which are carried in the air, will grow at a relative humidity above 65% and in enough oxygen for their survival. In a sealed frame, when the relative humidity could become excessive, a toxic material, as paradichlorobenzene, inside the sealed area will prevent mold plants from developing.

REPAIR

Conservators of works of art have been much more busy with repair than with prevention of damage, and before the second quarter of the 20th century, the practice of repairing pictures usually went by the name restoration. The restorer was a painter or a gilder who had learned something about routine procedures and was usually capable in the necessary manipulations. He rarely had a thorough technological knowledge of materials or a wide range of special techniques. Under his care the old and damaged work was made firm according to the best advice at hand, usually that of a competent cabinetmaker, and when this was done the painter went over it with the definite and unquestioned aim of making it look as well as he could. That was restoration, a term signifying an effort to do the impossible. The practice it represented, however sincere the motives behind it, brought about some distortion in the appearance of pictures and may have caused a small amount of actual damage.

Any procedure in the repair of a painting begins with recognition of two main kinds of defect: flaws in the structure and disfigurements in the design.

Structural Flaws.—A structural flaw or defect may be partial loss of material in any of the component parts of a picture—corners or edges broken away from panels, pieces torn or cut from paper or fabric, parts of ground and paint that have come loose from the support and fallen out. Breaks, tears, cracks, splits and checks are other kinds of structural defect. Another is known as cleavage—the separation of layers in a painting along a plane parallel to the picture. Usually this is more marked in paintings on wood than on any other kind of support. The shrinking and swelling of wood as the air becomes drier or damper tend toward a shearing action of the support and a separation from the ground. Distortion of the support is another kind of structural defect; this includes warping of panels, bulging or wrinkling of canvases and wrinkling or cockling of paper or vellum. Paintings on other kinds of support—plaster, stone, metal or leather—are subject to similar defects.

Disfigurement.—All defects are accompanied by disfigurement, but the second main type of defect involves disfigurement alone without any basic structural flaw. The more serious of these disfigurements is change of tone in the pigment or other colourant of the pictorial design—fading or darkening. Those pigments known as lake colours, made from dyes that are precipitated on a base, are apt to fade in strong light. The colour most used among the dyes is crimson and it may have come from the madder root, from cochineal, from the resin called dragon's blood, or other sources. Darkening often occurs in drawings or gouache paintings (thin water colour with admixed white) in which white lead was used. Even small quantities of hydrogen sulfide in the air will turn this black where it is not sealed by a rich binding medium or by a surface coating.

Less damaging than chemical changes of tone are those disfigurements caused by accretions. The main kinds are obvious and there is no limit to the number of accidents or of applications that can cause them. Most common is grime—dust from the air, splatters of mud or of food, smoke deposits and fly specks. The other main kind of accretion has been deliberately put on and is usually a varnish of soft resin, more rarely an oil, or an overpainting. It is not uncommon to find pictures with repeated surface coatings that have been laid over each other until they form a heavy layer. They are not permanent. In time the resins change, evidently in consequence of oxidation, turn from a translucent straw colour to a dull brown, become extremely brittle and are shot through with fine cracks. Painting done over a picture at a time later than its origin is not unusual in works a century or more old and on panel or canvas.

Examination of Condition.—The means of treatment for repair of defects in paintings do not fall into regular categories and cannot be rightly represented by a series of recipes. Work of this kind is highly technical and all determinations of method or decisions about the use of materials need to be made on the grounds of knowledge that is the product of special training and experience. It was only during the 20th century that such training became regularly and systematically developed and that a body of knowledge in any measure adequate for the practice of the conservator was formed.

With the development of knowledge related to the conservation of paintings, the tools that need to be commanded by the conservator became numerous and complex. The extent of deterioration in original paint and subordinate parts of pictures can be appraised with the aid of laboratory science. Probably the instruments which are most discussed in this connection are not those which have the greatest and most regular utility. X-rays, ultra-violet rays and photography by infra-red radiation are all useful and may at times provide surprising revelations. They are not to be ignored, but they cannot take the place of the more direct evidence available through microscopy and microchemistry.

With training and experience a conservator can learn most about the condition of a picture by observation—general observation with the naked eye, followed by increased magnification up to 30 times. A binocular microscope rigged for examination of paint in a well-illuminated field is the standard instrument for procuring such magnification. This cannot distinguish the essential identity of materials, particularly pigments, and in doubtful cases discrimination between original and later work in a picture may require such identification. This can be done, and is regularly done in the laboratory, by microchemical analysis. The samples needed are microscopic and their loss from a painting is not visible to the eye. With samples of this size, spot tests can be made. These can fix, beyond a reasonable doubt. the identity of most of the pigments which would be critical in fixing the date of a particular paint layer. An early date cannot be confirmed by this means. Practically, there were no pigments used prior to 1900 that were not available in some way after that date. Many pigments, however, are known to have been invented, even patented, at definite times. Most of these originated after 1700 and it is likely that one of them will turn up in the overpainting of a picture that has an earlier date of origin.

Relining **of** Canvas.—For the repair of damaged paintings, a few standard manipulations were developed prior to the 20th century and, with a few modjfications, remained in practice. Probably the most common is known as relining, the procedure of attaching a new or secondary canvas at the back of a canvas support when that fabric has become too weak to serve its purpose or when the ground or paint has become loosened from it. Usually relining involves removal of a former relining. Until the 19th century the common choice as an adhesive for the attachment of the new canvas was a glue or glue mixture. The shortcomings in this had become evident and, in the Netherlands. a method of relining with wax as the main ingredient of the adhesive mixture was demonstrated as satisfactory. Wax got away from the swelling and shrinking of the adhesive film in changes of humidity and greatly reduced the tendency toward development of mold in the picture support. In addition, it served effectively, if well-applied. to reattach loosened ground or paint and permit it to be set down if it had buckled from cleavage.

Procedure in relining begins actually at the surface of the picture. The paint needs to be protected and held firmly before work on the support can be safely undertaken. If the surface coating is very brittle and is putting a strain on the paint, it may have to be removed at the start. If there are tears. the edges will have to be aligned. Occasional fabrics need a preliminary stretching to smooth them. At some stage in the process, the face of the painting is covered with paper (long-fibre and without any

sizing), usually put over the varnish with a starch paste; attachment must be uniform. The painting is taken from its stretcher. If it has been relined before, the old relining canvas is removed and then all of the old relining adhesive that remains stuck on the back of the original canvas. There is likely to be a thick and obdurate crust of this adhesive. The new relining canvas, washed linen of even, heavy thread, is stretched on a provisional stretcher of wood to leave a clear working space at least six inches beyond each edge of the original support. When both canvases are made ready, the picture is placed face down on the smooth and covered worktable and the relining canvas on its stretcher is placed over it. The wax adhesive is put on usually at the back of the new linen and in a melted state. It is then worked over with special irons, at a temperature just above the melting point of the wax, until the fabrics are thoroughly impregnated and held together, and until all cleavage and crevices, through to the surface of the paint, have been filled and reattached, After this is satisfactorily done, the facing may be removed and the support placed properly on its permanent stretcher.

Although the adhesive used for relining is commonly referred to as wax, it contains, as a rule. other ingredients. A few experimental relinings with pure wax have been reported but for most purposes this is too hard and it lacks stickiness and flexibility. Addition of a natural resin or balsam improves its working properties and such additions may run to 40% of the total volume. Lower proportions seem to be satisfactory. Tests were made by H. J. Plenderleith and Stanley Cursiter on many of these mixtures. Pure beeswax, for example. would hold a breaking load between two canvases of j.4 lb. per square inch. Beeswax taken as a proportion of 75% and with addition of 19% resin and 6% gum elemi would hold 20.6 lb. per square inch in a relining system. Beeswax. 80%, with 20% gum elemi. is found to be still unbroken as an adhesive film at a load above 25 lb. per square inch. The melting point of the mixtures is somewhat lower than that of pure beeswax and lies between 59° and 61° C.

Transfer. — Another established repair operation was originated, so far as the records can be followed, in the mid-18th century. This is called transfer or transference. In every instance it is a difficult and possibly hazardous kind of treatment, although if it is well-carried out, it does not contain any baffling sleight-of-hand performance. The result of a transfer is the removal of the paint. with or without the ground layer beneath, from one support to another. It is necessary only in those cases in which there exists a large amount of cleavage that threatens to bring about flaking and loss. and in cases where the cleavage cannot be reached or reattached either from the face of the painting or from the back through the support. Consequently, transfer is commonly done with paintings on a heavy, thick support — wood, plaster or the clay wall of the orient. There is no fixed procedure for this operation. but certain regular principles apply. The paint is first given a temporary support at its face in addition to that at the back. Paper and fabric are the common materials of the temporary support. The adhesive for them has to be one that can be removed without injury to the paint and without disturbing the attachment of the paint to the new permanent support. After the temporary facing is applied and is satisfactorily in place, the work is turned face down and the old support is removed. On the painting, still in this inverted position, a new support is built or attached. Finally, the facing, or provisional support at the front of the paint, is taken off.

A condition that usually requires transfer as a means of conservation of a painting is found in a work on panel with a heavy gesso ground which has lost its integrity as a firm layer and has become powdery. Movement of the wooden support loosens the powdery mass and the paint with part of the ground is ready to fall out if jarred or subjected to repeated vibration. The gesso is made of gypsum or chalk mixed with glue. Dampness and mold weaken or destroy the glue. If there is no access to this layer from the front, it must be reach'ed from the back. Paint on pictures of this kind may be impervious to moisture. It can be made resistant by a thin coating of spirit-soluble resin or plastic and a first paper of the facing is often applied with such an adhesive. Outer layers of the facing can then be attached with starch paste or weak glue. The work is then put face down. The panel is cut off from the back and the deteriorated part of the ground is removed. At this point, transfers in the 18th century were completed by attachment of a canvas with glue. In time this took on a distortion that was a disfigurement to a work done originally on a panel, and by the late 19th century the drawbacks of the panel-to-canvas transfer had become apparent. Thereafter. the favoured procedure was to apply a new panel. This also had its drawbacks, particularly if the new wood was attached with glue. By 1930 methods were introduced for building a composite panel at the reverse of the ground and for this strips of light wood were set together with a mixture of wax, resin and inert filling material which could be handled like putty when warm.

Treatment of Cleavage and Distortion. — Cleavage, if it is not extensive and if the pockets can be reached, is usually treated by reattachment. An adhesive is infused into the pocket or, in some instances, the paint is lifted and the adhesive is applied directly by brushing. Sealing of a panel at the reverse reduces the activity of wood in changes of humidity and tends to cut down a chief cause of cleavage. The experienced conservator who has followed the results of treatment for repair over a number of years can notice that reattachment of cleavage in paint is likely to be deceptive. The loose and buckled crusts of ground and paint layers may be somewhat softened and flattened by the work. They may be stuck down in places, but while panels, in particular, are subject to changing conditions in the air, there is always a chance that they will become loosened again. Relining, if carefully done, is the most satisfactory solution to this problem. On panel supports reattachment is less satisfactory.

Distortion in supports is a problem largely of paper and of panels. Fabrics or canvases supporting most paintings are carried on a stretcher and relining is an adequate correction of any distortion in them. Paper can usually be flattened if the paint will stand a moderate amount of dampness. Exposure in a humid chamber containing fungicide to prevent the start of mold, followed by drying under pressure, will often smooth out ordinary wrinkles if there is no continuing cause. A heavy film of glue around the edges, used for mounting, is a frequent cause. In some instances, paintings or drawings on paper will stand immersion in water, provided there is adequate control and proper equipment for handling.

Attempts to flatten panel supports have led to definite structural damage of a worse kind than the warp. This is particularly noticed in cases where fixed crosspieces have been attached to hold the wood in line. The cradle was a device introduced as a means to correct distortion without cramping the wood in its normal reaction to the moisture of the air. In construction the cradle has wood strips firmly fixed to the reverse of a panel in the direction of the grain. On the underside of these strips next to the old wood are notches into which are slid movable cross members.

Probably most panel paintings carry or have carried a cradle. In many instances it has done no damage but in others it has caused multiple warping, cracking of the panel and cleavage in the ground. The causes are complex but, in general, lie with the tendency of wood to recover a warp which is the result of the natural forces of contraction. Over a long period of time these forces overcome the slip of the cradle and pull the cross members tight. The wood breaks against the constriction that results.

Treatment of Discoloration. — There is no remedy for faded pigment in paint but the commonest discoloration, the darkening of white lead, can be corrected. Chemically, this change is from the white hydrated carbonate of the metal to the dark sulfide. Treatment of the sulfide with a solution of hydrogen peroxide will convert it to a white sulfate of lead without change in the general appearance of the paint. This is usually done on drawings in which the white is used for the light modeling tones against a tinted paper. To prevent the medium from being softened, the hydrogen peroxide is diluted with alcohol or ether to speed drying of water and reduce its effect on an aqueous

adhesive used as binder for the pigment.

A few water-colour sketches and most drawings have the paper support as part of the design. In these. stains, general darkening or development of the small brown spots known as foxing, all occurring in the support itself, are a disfigurement to the picture. If the paper is normally strong and if the material of the drawing or painting will stand treatment, a procedure for bleaching is safe and practicable. Many methods and combinations of methods have been used. A representative one is the following: The paper is detached, if mounted. Three baths are used for bleaching. The first is water, 2,700 ml., with a 5% solution of sodium hypochlorite, 150 ml., and concentrated hydrochloric acid, 15 ml. The bath, when ready, should not change the colour of litmus paper; it is practically neutral and so compounded as to release free chlorine. The second bath is a very dilute hydrochloric acid, 0.5 ml. of the concentrated acid in 2,700 ml. of water. The third bath has 2 ml. of concentrated ammonium hydroxide in 9,000 ml. of water. This should give an alkaline response with litmus paper to make certain that it can neutralize any remaining acid. The paper is left in the first or bleaching solution a matter of seconds or minutes until stains are almost removed. It is then put in the bath of weak acid. When the bleaching is completed, the paper is transferred to the weak ammonia solution and left about ten minutes. After that it is thoroughly rinsed in clear water. The techniques of handling paper in a bath have to be varied for different conditions. Usually the sheet is carried on plate glass. After it is thoroughly washed, drying is done under observation and with slight pressure to prevent distortion.

Removal of Accretions.— By far the greater part of disfigurement to pictures comes from accretion of materials that were not originally used by the artist. Removal of these is a common necessity in the conservation of paintings but, owing to the wide variety of the accretions themselves and to the extreme variations in the material, structure and condition of paint, no single procedure or even set of procedures can be called standard. Dust, smoke and grime, if adhered to paint, may be taken up on an absorbent material such as loose cotton fibre dampened with fluid. Selection of the fluid for this purpose depends upon the determined solubility of the paint. In some instances a water mixture with a surface-active agent such as sulfonated alcohol is safe. Combinations of water and wax in an emulsion are frequently usable, and a wide range of organic solvents is available. Solvents generally are used to take off accretions of varnish. If the material of these is a soft resin, it is soluble slowly in coal-tar hydrocarbons such as xylene or toluene, is more quickly dissolved by chloro- compounds such as chloroform and ethylene dichloride and, more quickly still, in the cellosolve group, the alcohols and the ketones.

The number of organic solvents available can be numbered in scores and the possible combinations are infinite. There is no rule for a safe solvent that will also be effective. Petroleum naphtha is harmless to either tempera or oil paint unless it has been infused with wax. It can, of course, dissolve waxes. In themselves, fully dried and seasoned oil and tempera paints are not disturbed by the ordinary solvents. (These do not include substances of a basic or alkaline nature which would act as reagents—ammonium hydroxide or morpholine, for example.) The difficulty with solvents in the removal of accretions is the risk that a resin has been mixed with an oil paint or that any paint may have become chalky at some previous time and have been saturated with the resin of a surface coating until the paint proper has the solubility of the resin.

Compensation and Recoating.— It is not important and it may not be desirable to make a damaged picture look as if it had no defects. It is generally regarded as necessary, however, to treat the badly damaged areas of a painting in such a way that they will not unduly disfigure the work. Holes, flaked iosses and other blemishes are usually filled with paint, toned suitably to the surrounding area but with no intrusion upon the original paint. Since each case, in which such inpainting or compensation of loss is needed, has its own problem. this part of the work of conservation is, in effect, a part of the practice of design. The aim is not deception but appropriate reduction of accidental and damaging contrasts.

Most paintings which have had old and discoloured surface coatings removed and losses compensated with appropriate inpainting must have a coating put over them as a protection from dust and grime and as a partial seal from dampness and injurious gases in the air. Complete air-tight protection in a frame might make this final coating unnecessary. Without that protection even further application of a resinous film is better than exposure of the paint. If the varnish is kept thin it can be given a superficial layer of hard wax after thorough drying. This makes a combined layer that is more impervious to damp and more inert than is the varnish alone. In addition, the wax can be removed, if it collects dust, by solution in a petroleum naphtha, a solvent which will not disturb the thin varnish layer beneath. Because of that, removal of the wax carries no risk of abrading the paint. Beeswax alone is too soft to serve as a satisfactory outer coating. It is usually combined with ceresin and with carnauba, the hard wax that comes from the leaf of a Brazilian palm.

This mixture can be smoothly applied and polished. After 1925 many conservators used synthetic plastic materials instead of the natural resins in surface coatings. The longest experience up to mid-century was with polymerized vinyl acetate. This and the polymers of acrylic acid furnish coating materials that are clear and colourless, soluble in suitable organic solvents, and are not subject to oxidation or auto-oxidation as are the natural resins. They are highly permeable to moisture, but a superficial coating of wax overcomes this defect.

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PAINTS, CHEMISTRY OF. A paint is a fluid composition which contains suspended colouring substances and which on application in a thin layer changes to an opaque, solid film. In principle the formulation of paints has changed little from ancient times. The Egyptians used lime, ochres, lampblacks and some manufactured substances as pigments in combination with gums, pitches, egg yolks and egg whites and waxes for binders. Although the earliest uses were chiefly decorative, other functions have assumed equal or greater importance. These are protection

against weathering and corrosion, maintenance of hygienic conditions and control of illumination. The manufacture of paint, once a secret art, now utilizes all the resources of synthetic chemistry, the techniques of physical measurement and the devices of engineering.

Classification. — Because of wide diversification of function and type, the compositions designated as paint are now more appropriately described as protective and decorative coatings. The term paint, however, continues to be used generically. In its primary sense, paint is a finish composed chiefly of pigments and linseed oil with only a smali amount of volatile solvent. Enamels are finishes formulated with varnishes which dry to a smooth, hard film and in surface appearance may be flat, semigloss or high gloss. Lacquers, not usually considered paints, contain cellulose ethers or esters and are characterized by rapid drying; these are to be distinguished from the lacquers of the far east. Baking or stoving finishes are formulated for heat treatment after application.

The manufacture of paints is conducted in the separate operations of vehicle preparation, pigment production, mixing and dispersion and testing.

Vehicles. — The vehicle of a paint is the liquid in which the finely divided, insoluble pigment is suspended. The properties of a finished paint are determined by the kinds of vehicles and pigments and by the ratios in which these two major components are combined. Although linseed oil is by far the most used, especially for exterior paints, a large variety of other substances is used in formulating paint vehicles: vegetable oils (*e.g.,* perilla, tung), natural resins (*e.g.,* gum and wood rosin, damar, copal), synthetic resins (*e.g.,* alkyd, phenol-formaldehyde, urea-formaldehyde types), cellulose derivatives (e g., cellulose nitrate, ethyl cellulose) and colloidal protein solutions. In most compositions a mixture of volatile solvents is present to thin the paint to a consistency suitable for application. Drying of the paint film takes place by evaporation of the solvent and by other changes of a complex colloidal nature. Where unsaturated oils (*e.g.,* linseed) are present, oxidation ensues. Synthetic resin compositions form insoluble films by oxidation or polymerization, or both, of the resinous components. In baking finishes, polymerization of thermosetting resins predominates. Lacquers, on the other hand, form a film chiefly by solvent evaporation. In practice, however, most paints contain combinations of oils and resins; and lacquers are formulated with resins and plasticizers to obtain optimum properties of resistance, adhesion and flexibility. Another class of paints depends on water-soluble film-forming substances (*e.g.,* casein, solubilized oils). Various reagents are added to the vehicle in small relative quantities for specific purposes. Driers or siccatives are catalysts which promote the oxidation of the oils; cobalt, manganese, lead and zinc combine with fatty or naphthenic acids to form oil-soluble compounds (soaps) which are widely used for this purpose. Aluminum soaps are used as thickening agents. Surface-active compounds are employed to assist in dispersing the pigment and to prevent the dispersed particles from forming clusters or flocculates (see VARNISHES. CHEMISTRY OF).

Pigments. — In a white paint the dispersed pigment particles refract and reflect a high percentage of the light striking the paint film. The ability of a white paint to obscure a dark background is termed its covering or hiding power and is determined by the difference in the refractive indexes of the vehicle and pigment. the state of subdivision of the pigment particles and the relative proportions of pigment and vehicle. When the refractive index difference between the pigment and vehicle is large, the paint exhibits high covering power; as the difference becomes smaller, the paint approaches transparency. As an example, when calcium sulphate with a refractive index (n) of 1.57 is ground in linseed oil (n=1 48), the resulting dispersion is translucent. When titanium dioxide (n= 2.72) is ground into the same oil, a paint of exceptional hiding power is obtained.

Coloured paints differ from white paint in that the incident light is selectively. absorbed; the reflected light gives the hue characteristic of the pigment. Black paint absorbs substantially all of the incident light. The quantitative measurement of the colour of pigments and paints was considerably advanced by the introduction, in 1935, of a recording spectrophotometer which automatically records the percentage of reflected light (reflectance) in relation to the wave length of light falling on the surface of a coloured paint film.

The pigment particles in a paint film are in a state of fine subdivision. The primary particles, as distinguished from aggregates formed as a consequence of manufacture. are usually near or below the limit of resolution of the microscope. Precise information on particle sizes was not available until two methods of measurement were developed: (1) direct particle-size counts from photographs of pigment dispersions taken with the electron microscope and (2) surface-ares measurements by adsorption of known quantities of a gas (*e.g.*, nitrogen, butane) on the pigment surfaces. These methods, quite different in principle, provide data in good agreement. All commercial pigments consist of particles which vary in size. A useful method of designation is the average or mean diameter calculated from the surface area of the powder. The unit is the micron (1μ=0.001 mm. or 0.0004 in.). Particle diameters of representative pigments, calculated on the assumption that the particles are cubes, are as follows: carbon black 0.01 to 0.06; lampblack 0.1; iron blue 0.06-0.08; titanium dioxide 0.2-0.3; ultramarine 0.3-0.6. The large surface of pigment particles is easily visualized when stated in area for a given weight: thus dry carbon black has a surface area ranging approximately from 10 ac. to 25 ac. per pound. White paints show a maximum obscuring effect when the particle size of the dispersed pigment is between 0.15μ and 0.4μ. Many organic coloured pigments have such extremely fine particles that the paint films containing them are transparent. This effect is utilized in making metallized novelty finishes by incorporating, for example, flake aluminum powder in a transparent coloured paint; the resulting finish has a brilliantly coloured metallic lustre.

The pigment content of paint varies widely. Gloss paint and enamels contain relatively low concentrations of pigment; flat or matte-finish paints and primers are highly loaded with pigments. A typical white enamel, for example, contains two pounds to four pounds of titanium dioxide per gallon, but a white priming paint carries eight pounds to ten pounds of pigments and extenders per gallon. In the dry paint film, the volume of pigment for different classes of white and lightly tinted paints may be generalized approximately as follows: high-gloss enamels 20%-30%; gloss and semigloss paints 30%-50%; flat paints and primers 50%-75%.

Steps in the manufacture of pigments cannot be generalized, although the unit operations are common to chemical engineering practice. For many wet-process pigments, the reagents are added to a vat with agitation; and the precipitate after settling is washed by drawing off the supernatant water. adding fresh wash water and repeating this process several times. The washed slurry is then concentrated in a filter press, and the press cakes are dried in an oven. The dried pigment is in the form of coarse lumps which are pulverized in a hammer mill. Calcination is required as a step in the manufacture of some pigments. The sequence of unit operations is designed to reduce handling to a minimum; so that efficient production is ensured. Continuous processes have been devised for the manufacture of white pigments which are produced'in large quantities. In 1946 the manufacture of coloured pigments by continuous processing methods was initiated.

White lead has been used in paints since the 4th century B.C. Chemically it is basic lead carbonate, approximating in composition $2PbCO_3.Pb(OH)_2$. For exterior use, basic carbonate white lead provides a durable paint, but the pigment darkens by reaction with sulphides present in smoky atmospheres. Much of the white lead sold is in the form of a dispersion of linseed oil which is thinned with additional oil and solvents prior to application. Basic lead sulphate, introduced in 1855, corresponds approximately to the formula $2PbSO_4.PbO$. Known also as sublimed white lead, it has properties similar to those of basic carbonate

white lead; but it is usually mixed with other pigments. The manufacture and application of lead paints are attended with the hazard of lead poisoning; and although many efforts have been made to supplant white lead with other pigments, it is still widely used. The lead pigments enter into reactions with the components of vegetable oils to form soaps which improve the properties of the paint.

Zinc oxide, ZnO, came into use about 1840 in Europe. It is also known as zinc white and Chinese white. Zinc oxide produces paints of intermediate opacity. Because of the reactivity of the pigment with paint vehicles, which confers greater hardness to the paint film, it is frequently used in combination with other pigments. A common mixture contains 65% white lead and 35% zinc oxide.

Lithopone is a composite pigment prepared by coprecipitation of zinc sulphide and barium sulphate in approximately equimolecular proportions. After drying, the precipitate is calcined. Normal lithopone contains 28%-30% zinc sulphide and 70%-72% barium sulphate by weight. The opacity of the pigment is caused by the zinc sulphide which has a refractive index of 2.37, highest of the zinc pigments. Some varieties of lithopone of enhanced hiding power contain an increased proportion of zinc sulphide or are mixed with titanium dioxide. Lithopone finds wide use in the manufacture of white and tinted interior paints and to a lesser extent in that of exterior paints since its properties make it adaptable to formulation with a variety of vehicles.

Titanium-dioxide pigments, introduced on a small scale to the paint industry in 1918, are now widely used. Titanium dioxide, TiO_2, is produced in two crystalline forms: anatase and rutile which have the highest refractive indexes of materials used in paint. Rutile ($n = 2.72$) has a covering power 25%-35% greater than the anatase modification ($n = 2.jj$). The' commercial pigment is prepared from ilmenite, $FeTiO_3$, by a complicated series of reactions including digestion of the ground ore with sulphuric acid, hydrolysis, separation of the iron compounds and calcination. The pigment is a fine white powder. Because of its brightness and high covering power, titanium dioxide is extensively used in admixture with barium sulphate, calcium sulphate or magnesium silicate to form composite pigments. The titanium-dioxide content is usually 30% by weight. Titanium dioxide is nonpoisonous and inert chemically, thus allowing considerable latitude in formulation and use.

Antimony oxide, Sb_2O_3, is used in enamels, usually in combination with other pigments, and in flameproofing paints and coatings.

Extender **Pigments.**—Pigments in this group are characterized by low refractive indexes ($n = 1.45$-1.70), and although white substances they confer virtually no opacity to an oil-paint film. Extender pigments are used to modify properties of oil paints, contributing, for example, to improved brushing properties and superior storage qualities. They are also essential components of priming and sealing paints, of flat or lustreless finishes and of casein-type paints. Many different materials find use as extender pigments. Barium sulphate, $BaSO_4$, occurs naturally as heavy spar or barytes; in precipitated form it is known as blanc *fixe* and permanent white. Gloss white is a coprecipitate of aluminum hydroxide (aluminum hydrate) and barium sulphate. Calcium carbonate, $CaCO_3$, is widely used, both in the natural forms of whiting, chalk and limestone and in precipitated varieties. Several clays (China clay, bentonite), silica, diatomaceous earth, talc, gypsum, mica, etc., have special uses.

Lead-chromate pigments range in hue from primrose to deep orange and form the most important single class of yellow pigments. Chemically they are all derived from lead chromate, $PbCrO_4$, by treating lead acetate or nitrate with sodium dichromate. Variations in colour are obtained by chemical control to alter the proportions of lead sulphate, normal lead chromate and basic lead sulphate. The lightest hues may contain 40% lead sulphate with 60% lead chromate. The proportion of lead sulphate decreases through the lemon and light varieties to medium chrome yellow which contains 93%-98% lead chromate. Chrome orange is basic lead chromate. The darkest oranges are composed of 60% lead chromate and 40% lead oxide, PbO. Molybdate orange, formed of mixed crystals of lead chromate and lead molybdate, $PbMoO_4$, is a brilliant orange-red pigment. The lead chromates have good strength and hiding power but darken on exposure to light and air.

Red lead, Pb_3O_4, is produced by heating litharge, PbO, in a reverberatory furnace at 480° C.-500° C. The commercial red lead pigments contain from 2% to 15% litharge. Red lead combines chemically with components of linseed oil to form tough, elastic, strongly adherent films. Because it imparts corrosion-resistant properties to paints, it has long been used as a priming paint for steel and iron surfaces.

Zinc yellow, a complex salt of zinc and potassium chromates, finds large use in corrosion-inhibiting paints. Cadmium yellow, CdS, is manufactured in a range of colours. The cadmium lithopones are coprecipitation products of cadmium sulphate, $CdSO_4$, and barium sulphide, BaS, manufactured by a process analogous to that of lithopone. The addition of elementary selenium to the barium sulphide results in a series of pigments ranging from light red to maroon in colour. The cadmium colours are resistant to light and heat but are decomposed by dilute acids.

Iron oxides range in colour from yellow and red to brown and black. Naturally occurring minerals are processed for the ochres, siennas and umbers of commerce. Synthetic varieties are preferred, however, because of greater uniformity and freedom from gritty, siliceous material which makes dispersion difficult. The synthetic iron-oxide pigments are made from ferrous sulphate by precipitation of the hydroxide and subsequent oxidation and calcination. Chemically the red pigment is anhydrous Fe_2O_3, and the yellow is the hydrated ferric oxide. The iron-oxide pigments find many uses in paints, both as tinting and body colours, and in metal primers (see OCHRES). The most brilliant red pigments are insoluble azo compounds. Para red, one of the oldest organic red pigments used in the paint industry, is made by coupling diazotized paranitroaniline with 2-naphthol (betanaphthol). Toluidine toner is a brilliant red of excellent light fastness; it is made by coupling diazotized 3-nitro-4-methylaniline with beta-naphthol. Lithol toner is less resistant to light than toluidine toner but is capable of considerable variation in hue; it is formed by coupling diazotized 2-naphthylamine-1-sulphonic acid (Tobias acid) with betanaphthol. Several other insoluble azo compounds and lake colours are used to a limited extent in paints.

Iron blue is a generic term for a series of complex blue pigments derived from the ferric ferrocyanides. Formerly they were designated by a number of names indicating, to some extent, the historical origins or types of different products. Prussian, milori, Chinese, Turnbull, steel, celestial, bronze, potash, soda, lacquer and toning are some of the designations now obsolescent. The pigment is usually made by precipitating ferrous ferrocyanide from solutions of ferrous sulphate and sodium ferrocyanide in the presence of ammonium salts and oxidizing the precipitate with sodium dichromate or sodium chlorate. The process is controlled to give two main classes: one with a green undertone and the other with a red undertone or shade. Iron-blue pigments have high tinctorial strength and fastness to light and are stable to acids, but they are decomposed by alkalis. Ultramarine blue is made by heating a mixture of sulphur, sodium carbonate, clay and charcoal. The reaction mixture is extracted with water to remove soluble salts and then ground. Ultramarine is a light-fast, bright blue pigment of relatively low tinctorial strength and hiding power; it is stable to alkalis but sensitive to acids (see ULTRAMARINE). Phthalocyanine blue, introduced in 1935, is a brilliant blue pigment of complex structure. It is prepared by treating phthalonitrile with copper; the resulting product is purified by dissolving in concentrated sulphuric acid and diluting the acid solution with a large volume of water. The phthalocyanine pigments are stable to heat, chemical reagents and light.

Chrome greens are mixtures in varying proportions of iron blue and chrome yellow. Although the pigments are sometimes made by mixing the two dry pigments, the usual practice is to precipitate chrome yellow on a water suspension of iron blue. The light greens may contain as little as 3% and the dark greens as high

as 50% blue. The large differences in specific gravity and particle size of the component pigments may result in an uneven distribution of the blue and yellow pigment particles in the dried paint film. This separation of the pigment components is known as floating or flooding and shows as fine streaks or spots on close inspection of the dried paint film or as an over-all difference in hue of the dried film in comparison with the paint in bulk. Chrome-green pigments are extensively used in paints because of their brilliance, satisfactory lightfastness and hiding power.

Chlorinated copper phthalocyanine is a brilliant green with properties similar to those of phthalocyanine blue to which it is related chemically. Chromium-oxide green, Cr_2O_3, is made by roasting sodium dichromate in a reducing atmosphere; the resulting pigment has exceptional lightfastness, thermal stability and infra-red reflectance. Hydrated chromium oxide (Guignet's green, viridian) is made by heating sodium dichromate with boric acid and hydrolysis of the reaction product.

Carbon blacks consisting of elementary carbon in finely divided form, are the chief black pigments. The largest production derives from the incomplete combustion of natural gas. In manufacturing the pigment, long rows of burners are arranged to impinge smoky flames on channel irons. Because of this circumstance, the pigment is also called gas or channel black in distinction to other forms of black pigments produced from oil, vegetable and animal residues. The particle sizes of carbon blacks are the lowest of all commercial pigments. Carbon blacks have a brown tone, but in paint films provide a jet-black surface of low reflectance. Lampblacks are made by the incomplete combustion of mineral oil, are classified separately from the gas blacks and have a blue tone. The largest use of lampblacks is for tinting or toning purposes. Bone blacks, sometimes called ivory blacks, are produced by the charring of animal bones and contain 10%–12% carbon in a matrix of calcium phosphate. They find use in tints and in combination with metal powders. Black iron oxide, a ferroferric oxide, is manufactured by a process essentially the same as that used in making the red iron oxide; in addition, the ore, magnetite, yields a natural black pigment containing approximately 95% Fe_3O_4. Several other black pigments find a limited use in paints. Graphite is used in corrosion-resistant paints. Vegetable black, made from charred wood pulp, has been largely supplanted by carbon black For inexpensive paints, mineral blacks, processed from black clays and shales, are used sometimes in combination with carbon black.

Metallic Pigments. — Finely divided metallic powders are used as paint pigments. Aluminum in flake form, coated with stearic acid, has the property of leafing to form a coherent metallic layer which markedly reduces the permeability of the dried paint film. Such paints are used for both wood and metal surfaces. Copper and copper alloys, lead, tin, nickel and silver are also used in flake form. Zinc dust contains particles more nearly spherical in shape and is used in metal-priming paints.

Mixing and Dispersion. — The dispersion of pigments in vehicles is accomplished by mixing the ingredients in suitable proportions to form a paste. This operation is usually conducted in a mixer with rotating blades or paddles. The pigment-oil paste so formed consists of aggregates of the pigment particles imperfectly dispersed throughout the vehicle, and the composition is hrought to requisite fineness by grinding on a roll mill, ball or pebble mill, stone mill or variations on these machines.

The roll mill consists of a series of hardened steel rolls driven at differential speeds at clearances less, usually, than 0.001 in. The rolls are hollow to allow cooling with circulating water. The mills most commonly used have three rolls, but mills with five rolls have found favour in some establishments. Roll mills are made in several sizes ranging from laboratory models to large production units. One of the two larger sizes has rolls 12 in. in diameter and 30 in. long, whereas the other has rolls 16 in. in diameter and 40 in. long. In operation, the pigment-oil mixture is introduced at the first two rolls where it is subjected to the shearing action of the roll surfaces; the mixture adheres to the second roll and passes on to the third roll and in the case of the three-roll mill is removed by a scraper blade. A five-roll mill subjects the mixture to two additional shearing interfaces. The uniroll or single-roll mill differs from the multiroll mill in that the shearing of the pigment-vehicle mixture takes place against a stationary pressure bar. Ball and pebble mills have been widely adopted for the grinding of paints. These mills consist of a horizontally placed drum, partially filled with steel-alloy or porcelain balls or with flint pebbles; in operation the cylinder rotates, and the cascading balls subject the pigment-vehicle mixture to attrition between contacting ball surfaces and to a turbulent mixing action in the free spaces between balls. For production of paints, the mills are usually four to six feet in diameter. Stone mills are the oldest instruments for the dispersion of paints. In these mills one circular stone revolves against a similar stationary stone. The pigment-oil paste, introduced at the centre of the top stone, is carried between the stones, which subject it to a shearing action, to the periphery where the dispersed composition is removed by a scraper. The stones are commonly 20 in.-36 in. in diameter. The grinding surfaces of the stones are cut to provide grooves and channels which transport the paint. The stone mill is still extensively used despite the comparative slowness of operation and low production rate.

Subjection of the paint paste to grinding accomplishes a reduction in size of the pigment aggregates and wets the individual pigment particles with the liquid vehicle. A method of dispersion which avoids grinding a dry pigment powder with vehicle is variously known as pulping and flushing and consists in mixing filter-press cakes of a pigment directly with an oil. The pigment is preferentially wetted by the oil, and the water present in the pigment cakes is displaced. This process has had long use in manufacturing white lead in oil, and it has been applied also to colours, particularly those which are difficult to disperse. The paint as discharged from the mill is sometimes ready for packaging, but for many products the paste as ground is a stock or base paint which is thinned further with solvents and tinted with colour-in-oil dispersions.

Applications. — Most paints are applied by brushing. In assembly-line production, however, more rapid methods are used. These include spraying, dipping and roller coating. Automobile finishes were originally derived from carriage enamels, formulated with slow-drying varnishes; and since many coats were applied, usually by brushing, the process of finishing required several weeks. In 1925, low-cost solvents became available through the development of fermentation processes for their manufacture on a large scale, and the spray-gun application of fast-drying nitrocellulose lacquers became feasible. Automobile bodies could be finished in hours instead of weeks. After this initial introduction of lacquers in automobile manufacturing, numerous improvements in formulation were made; and the great variety of synthetic resins which became available at the same time made possible, also, the formulation of suitable baking enamels. Both lacquers and synthetic resin finishes are now used in finishing automobiles (see AUTOMOBILE). Military paints form a class of products which have to meet unusual and exacting requirements. For protective concealment of men and matériel it is necessary to simulate the terrain against visual detection and infra-red photography. In World War II paints were designed to match the visual and infra-red reflectance of different surfaces such as sand, loam, foliage, etc. These paints, formulated to allow thinning with either gasoline or water, dried quickly to a lustreless surface. For night-fighter planes, a black enamel of exceptional gloss was used to render the detection of the plane in a searchlight beam extremely difficult. When necessary to change the character of the paint frequently in order to meet new conditions, single-mission paints were applied; the dried paint was impermanent and could be removed by scrubbing prior to application of paint of another colour (see CAMOUFLAGE). Luminescent paints found numerous applications during World War II to confer visibility to signs, markers, obstructions, etc., under blackout conditions. There are two main types of luminescence: fluorescence, in which light is emitted only when exposed to some source such as ultra-violet light, and phosphorescence, in which light continues to be emitted from the material after the exciting source

is removed. Many substances are fluorescent under ultra-violet light. Typical phosphorescent pigments are specially treated sulphides of zinc, strontium, calcium and cadmium or mixtures of these compounds. The particle size is large in comparison with paint pigments, for maximum phosphorescence is obtained from coarse crystals. Various hues may be observed, ranging from red to greenish-blue in the initial stage of phosphorescence, but as the intensity of the emitted light diminishes, the hue differences vanish. To a dark-adapted eye, some phosphorescent paints remain visible for as long as 24 hr.

Testing.—The durability of a paint film is a matter of concern to the manufacturer and consumer alike. In weathering of a house paint, several kinds of failures are to be found such as peeling, checking, wrinkling and chalking. Repainting may require the removal of all old paint if adhesion is poor or if the surface is marred by irregularities. Chalking, a progressive powdering of the paint film from the surface, is considered a desirable form of weathering by some authorities since the paint film is kept clean and bright by exposure of fresh pigment and the surface is frequently in acceptable condition for repainting. The quality of finished paints is controlled by laboratory and field tests. Paints are compared with standards for consistency, drying rate, hardness, colour, lightfastness, adhesion, covering power and resistance to weathering. For this purpose special laboratory tests have been devised and standardized for industry-wide use. Fading, for example, is measured by exposure of painted panels to radiation from a carbon arc or mercury-vapour lamp; weathering is simulated in an automatic testing machine which sprays water onto the panels and intermittently exposes them to an intense arc light. Although laboratory instruments provide an accelerated test in which data are obtained quickly, outdoor exposure tests are also conducted in order to observe performance under conditions approximating those of actual use. In this way paint durability can be correlated with composition and the experimental findings utilized in the development of superior products.

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PAISIELLO (or **PAESIELLO), GIOVANNI** (1741–1816), Italian composer, was born at Taranto on May 9, 1741. The beauty of his voice attracted so much attention that in 1754 he was removed from the Jesuit college at Tarento to the Conservatorio di S. Onofrio at Naples, where he studied under Francesco Durante, and in time rose to the position of assistant master. For the theatre of the conservatorio, which he left in 1763, he wrote some intermezzi, one of which attracted so much notice that he was invited to write two operas, *La Pupilla* and *Il Mondo al Rovescio,* for Bologna, and a third, *Il Marchese di Tulipano,* for Rome. His reputation was then established, and he settled for some years at Naples, where, notwithstanding the popularity of Niccolò Piccini, Domenico Cimarosa and Pietro Guglielmi, he produced a series of highly successful operas, one of which, *L'Idolo cinese,* made a deep impression upon the Neapolitan public. In 1772 he began to write church music and composed a requiem for Gennara Borbone. In the same year he married Cecilia Pallini, with whom he lived in continued happiness.

In 1776 Paisiello was invited by the empress Catherine II to St. Petersburg, where he remained for eight years, producing, among other charming works, his masterpiece, *Il Barbiere di Siviglia (The Barber of Seville).* It soon attained a European reputation.

The fate of this delightful opera marked an epoch in the history of Italian art. For with it the gentle suavity cultivated by the masters of the 18th century died out to make room for the dazzling brilliancy of a later period. When, in 1816, Gioacchino Rossini set the same libretto to music, under the title of *Almaviva,* it was hissed from the stage. But it made its way, nevertheless, and under its changed title, *Il Barbiere,* became known as Rossini's greatest work while Paisiello's opera was consigned to oblivion. This is a strange instance of poetical vengeance, for Paisiello himself had many years previously endeavoured to eclipse the fame of Giovanni Pergolesi by resetting the libretto of his famous intermezzo, *La Serva padrona.*

Paisiello left Russia in 1784 and, after producing *Il Re Teodoro* at Vienna, entered the service of Ferdinand IV at Naples. He composed many of his best operas there, including *Nina* and *La Molinara.*

After many vicissitudes, resulting from political and dynastic changes, he was invited to Paris (1802) by Napoleon, whose favour he had won five years previously by a march composed for the funeral of Gen. Louis Hoche. Napoleon treated him munificently while cruelly neglecting his two contemporaries Maria Cherubini and Étienne Méhul.

Paisiello conducted the music of the court in the Tuileries with a stipend of 10,000 francs and 4,800 for lodging. But he failed to conciliate the Parisian public, who had received his opera *Proserpine* so coldly that, in 1803, he requested and with difficulty obtained permission to return to Italy.

On his arrival at Naples, Paisiello was reinstated in his former appointment by Joseph Bonaparte and Joachim Murat. But he had taxed his genius beyond its strength, and he was unable to meet the demands now made upon it for new ideas. His prospects were precarious. The power of the Bonaparte family was tottering to its fall, and Paisiello's fortunes fell with it.

The death of his wife in 1815 tried him severely. His health failed rapidly, and his constitutional jealousy of the popularity of his contemporaries was a source of worry and vexation. He died on June 5, 1816, at Naples.

Paisiello's operas, of which he is known to have composed 94, abound with melodies, the graceful beauty of which was warmly appreciated. Perhaps the best known of these airs was the famous "Nel cor piu" from *La Molinara,* immortalized by Ludwig van Beethoven's delightful variations. His church music was very voluminous, comprising 8 masses and many smaller works. He also produced 51 instrumental compositions and many detached pieces. Manuscript scores of many of his operas were presented to the library of the British Museum by Domenico Dragonetti.

The library of the Gerolamini at Naples was presented with an interesting manuscript compilation recording Paisiello's opinions on contemporary composers. It presents him as a somewhat severe critic, especially of the work of Pergolesi.

PAISLEY, a large, royal and parliamentary burgh of Renfremshire, Scot., on the White Cart water, 3 mi. from its junction with the Clyde, 7 mi. W.S.W. of Glasgow by road. Paisley is the county town of Renfrewshire. Pop. (1961) 95,753. Area 9.7 sq mi. In 1791 the river, which bisects the town and is crossed by several bridges, was made navigable for vessels of 50 tons. Later it was further deepened and made navigable for vessels drawing 15 ft. The old town contains most of the principal warehouses and mills; the new town, begun toward the end of the 18th century, occupies much of the ground that once belonged to the abbey. To the munificence of its citizens the town owes many of its finest public buildings, among them the town hall, the free library and museum (with a collection of Paisley shawls), the Coats observatory, the John Neilson institution and the fine Thomas Coats memorial church. Of the 14 public parks, covering 1,572 ac., the biggest is Barshaw park (144 ac.). Paisley was created a parliamentary burgh in 1833. In the abbey precincts are statues to the poet Robert Tannahill (1774–1810) and Alexander Wilson (1766–1813), the U.S. ornithologist, both of whom were born in Paisley. John Wilson ("Christopher North") was also born there.

The abbey was founded in 1163 as a Cluniac monastery by Walter Fitzalan, first high steward of Scotland, the ancestor of the Scottish royal family of Stuart, and dedicated to the Virgin, St. James, St. Milburga of Much Wenlock in Shropshire (whence came the first monks) and St. Mirinus (St. Mirren), the patron saint of Paisley, who is supposed to have been a contemporary of St. Columba. The monastery became an abbey in the 13th century: was destroyed by the English under Aymer de Valence, earl of Pembroke, in 1307, and rebuilt in the latter half of the 14th

century, the Stuart kings endowing it lavishly. In 1553 Lord Claud Hamilton, then a boy of about ten, was made abbot, and the abbacy and monastery were erected into a temporal lordship in his favour in 1587. The abbey lands, after passing from his son the earl of Abercorn to the earl of Angus and then to Lord Dundonald, were purchased in 1764 by the 8th earl of Abercorn, who let the ground for building purposes.

The abbey church originally consisted of a nave, choir without aisles, and transepts. The nave and tower were restored, and careful work was done on the choir. The nave is used as the parish church. Robert III was interred before the high altar of the choir in 1406. Over his grave a monument to the memory of the royal house of Stuart was placed by Queen Victoria (1888). In the south transept is St. Mirren's chapel (founded in 1499), with the tombs of abbot John Hamilton and of the children of the 1st lord Paisley, and an effigy, possibly of Marjory, daughter of Robert Bruce, who married Walter the Steward and was killed while hunting at Knock hill between Renfrew and Paisley (1316). Her son became Robert II.

The village originally grew up round the abbey and the town of Paisley has been an important manufacturing centre since the beginning of the 18th century, but the earlier linen, lawn and silk-gauze industries have become extinct, and the famous Paisley shawls (imitation cashmere) are now objects of art. The manufacture of linen thread gave way in 1812 to that of cotton thread, and Paisley became the greatest thread-manufacturing centre in the world. Paisley is also famous for its tobacco, starch and corn flour, marmalade and jam. Other industries include bleaching, dyeing. calico printing, weaving, engineering, tanning, iron and brass founding, timber yards and the making of machinery and chemicals, besides some shipbuilding.

About 2 mi. S.E. of Paisley stand the ruins of Crookston castle, dating probably from the 13th century and associated with Mary, queen of Scots, and Lord Darnley. Elderslie, 1 mi. S.W., is the traditional birthplace of William Wallace.

PAITA, a port of northern Peru, in the department of Piura. Population (1958) 7,900. Paita has one of the best natural harbours on the coast and is the port of the departmental capital, Piura, with which it is connected by rail (58 mi.). The town, built on a sandy hillside, is desolate in appearance. Though free from yellow fever, sanitary conditions in Paita were so bad that much of the town was rebuilt, water and sewer systems repaired and the port permanently improved. The principal buildings include customhouse, post, telegraph and cable offices, a cottonseed-oil mill and a few branch export and import houses which control trade. Cotton constitutes three-fourths of the total exports; other items include cattle, kidskins, tobacco and Panama hats. After World War II more movement was added to the port by various fishing companies operating in the northern zone of Peru, Paita being the official point of exportation. (See PIURA.) Paita was a prosperous port in colonial times.

PAIUTE. This tribal designation is applied to two distinct divisions of Shoshonean Indians in the Great Basin, western United States. The true or southern Paiute are close relatives of the Ute and inhabit southwestern Utah, northwestern Arizona and southern Nevada. They are virtually indistinguishable from the Chemehuevi of southeastern California. The northern Paiute or Paviotso are separated from the southern by the Shoshone, inhabit northwestern Nevada and southeastern Oregon and are close relatives of the Mono of California and Bannock of Idaho. Their mode of life is an adaptation of a nonagricultural population of meagre culture to an arid environment.

PAJOU, AUGUSTIN (1730–1809), French sculptor, who became official sculptor to Louis XVI, was born in Paris, Sept. 19, 1730, and died there, May 8, 1809. A pupil of J. B. Lemoyne, he won the Prix de Rome in 1748. He was elected to the Academy in 1760. Like his master's, Pajou's main work consists of portrait busts probably the most famous of which is the bust of his former patron, Mme. du Barry (Louvre).

Also a decorator on a larger scale. he directed the decoration of the Versailles opera, and when Bernard Poyet reconstructed the Fontaine des Innocents (by Pierre Lescot, 1547–49) Pajou provided several figures for it. (AA. B.)

PAKHOI, former treaty port in Kwangtung province, south China (21° 29′ N., 109° 7′ E.), situated on a small peninsula at the head of the Gulf of Tongking.

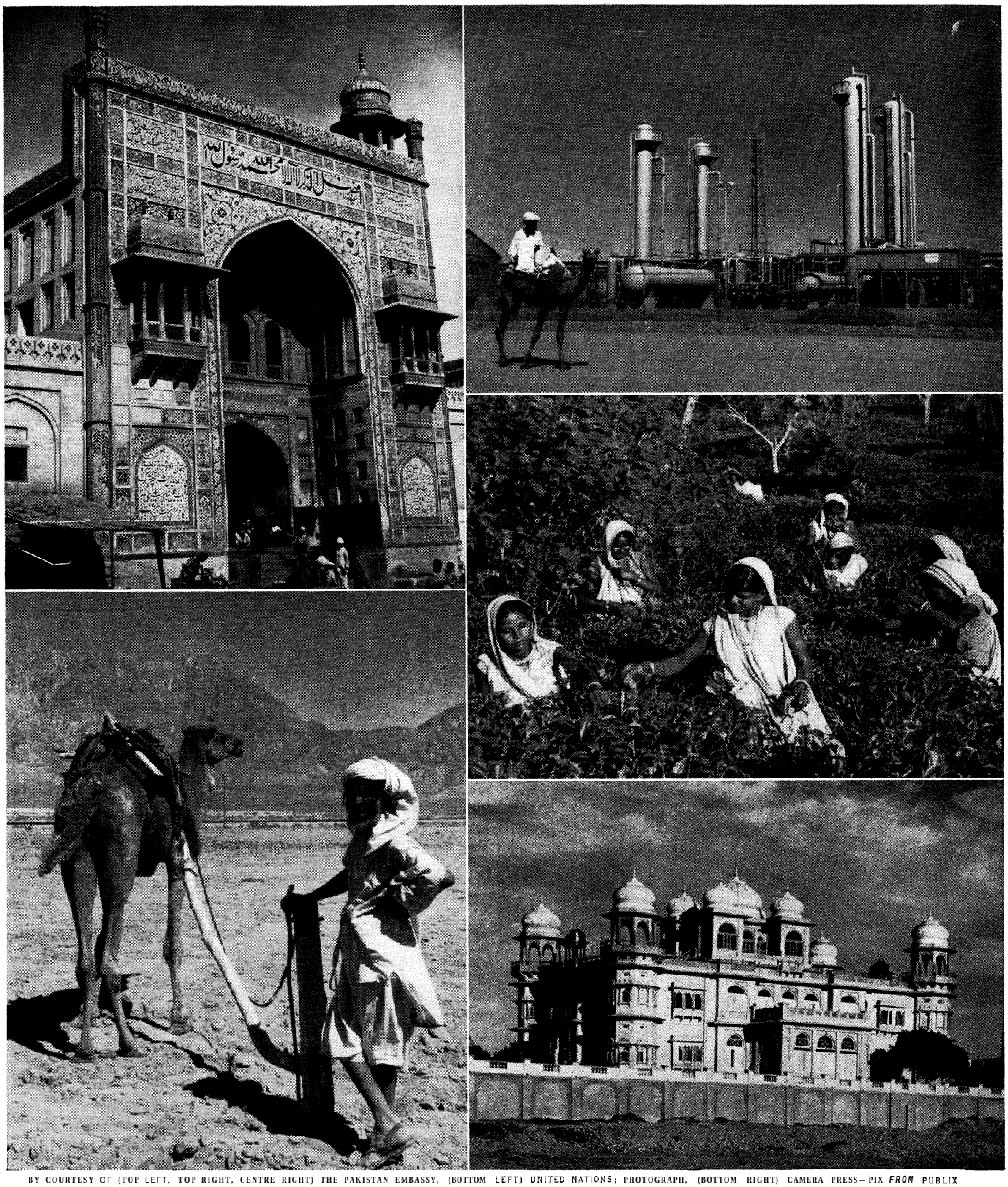
The harbour is easily accessible from the open sea, but has only one tide in 24 hours. The port was opened to foreign trade by the Chefoo convention in 1877. and in the succeeding period a considerable traffic to and from Yunnan. Rweichow and Kwangsi converged on Pakhoi, and was carried by coolies and transport animals across the mountains which separate the port from the Si Kiang valley in the interior. Thus it developed as a side door through which traffic could pass free from the trade exactions imposed along the Red river and Si Riang routes into Yunnan. In 1889, however, Mengtze was opened as a treaty port, followed by Wuchow in 1897 and Kuang-Chou-Wan (French) as a free port in 1898. With the relaxation of trade restrictions, the Red river and Si Kiang were established as the natural trade routes into Yunnan. Consequently the commercial importance of Pakhoi declined and its trade sphere became limited to its somewhat poor and sandy neighbourhood, between the coast and the mountains behind. The population in 1953 was estimated at 50,000.

PAKINGTON, the name of a famous English Worcestershire family. Sir John Pakington (d. 1560) was a successful lawyer and a favourite at court, and Henry VIII enriched him with estates, including that of Westwood in Worcestershire. His grandnephew and heir, Sir John Pakington (1549–1625), was another prominent courtier, Queen Elizabeth's "lusty Pakington," famous for his magnificence of living. His son John (1600–24) was created a baronet in 1620. His son, Sir John, the 2nd baronet (1620–80), played an active part on the royalist side in the Great Rebellion and was taken prisoner at Worcester in 1651; Lady Dorothy, his wife (d. 1679), daughter of Pakington's former guardian, the lord keeper Thomas Coventry, was long credited with the authorship of *The Whole* Duty *of Man* (1658), which later was attributed to Richard Allestree (*q.v.*). The 4th baronet, also Sir John (1671–1727), has been held by some to be the original of Steele and Addison's creation, Sir Roger de Coverley.

The baronetcy became extinct with the death of Sir John Pakington, the 8th baronet, in Jan. 1830, but it was revived in 1846 for his maternal nephew and heir, John Somerset Pakington (1799–1880), whose name was originally Russell. He was secretary of state for war (1852 and 1867–68) and first lord of the admiralty (1858–59 and 1866–67). In 1874 he was created Baron Hampton.

PAKISTAN. A federal Islamic republic and member of the Commonwealth of Nations, formed from those parts of the Indian subcontinent with a predominantly Moslem population. Geographically Pakistan falls into two sections separated by about 1,000 mi. of the territory of the republic of India. (1) West Pakistan (area, excluding Kashmir. 310,403 sq.mi.; pop., 1961 census, 42,880,378) comprises the Baluchistan, Sind and western Punjab regions of the subcontinent, and the districts and agencies of the northwest frontier. (2) East Pakistan (area, 55,126 sq mi ; pop., 1961 census, 50,840,235) consists of eastern Bengal, with the addition of Sylhet district, which before partition was in Assam. West Pakistan and East Pakistan each constitute a province under a governor. West Pakistan (capital, Lahore) is divided into 10 commissioner's divisions, and the federal territory of Karachi; East Pakistan (capital, Dacca) has 3 divisions.

Origin and Foundation.—A major problem in Indian constitutional reform was that of reconciling the claims of the Moslem league, representing the powerful Moslem community, and the Indian National Congress, representing the large Hindu majority with a few Moslem adherents. Both communities desired full self-government for India, and before the provincial elections of 1937 the league, under Mohammed Ali Jinnah, favoured cooperation with the Congress. But the latter, winning large majorities in 6 of the 11 provinces, preferred to form single-party governments (strictly controlled by the central party machine) and to endeavour to absorb the Moslem masses into its own organization, claiming to be a noncommunal body representing India as a whole and presumptive successor to British rule. These

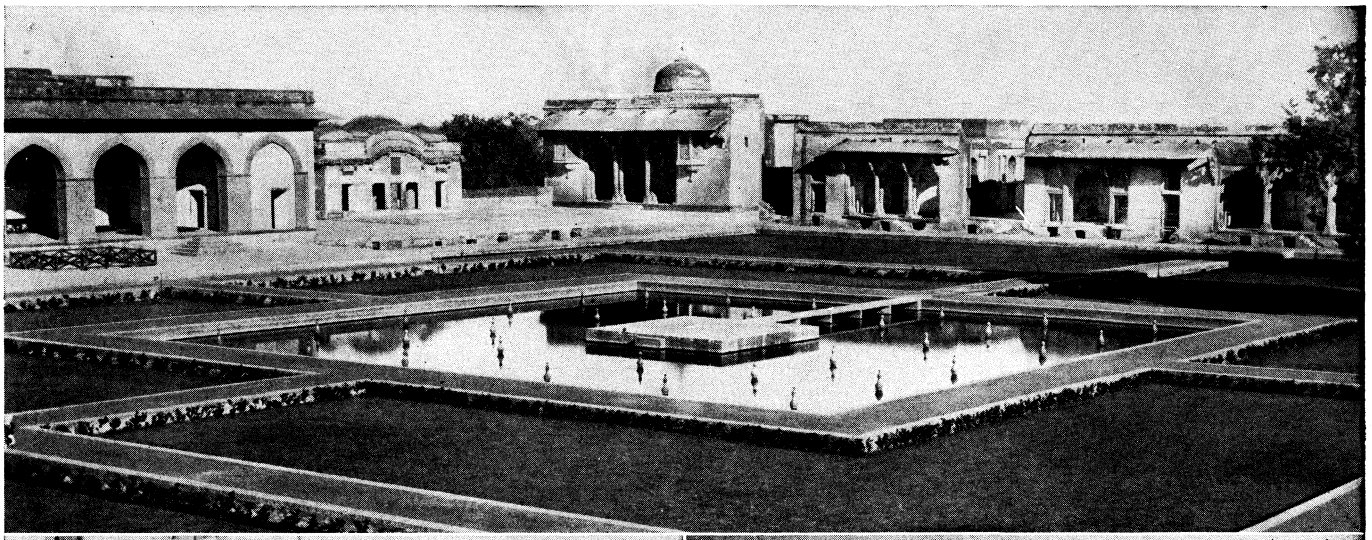


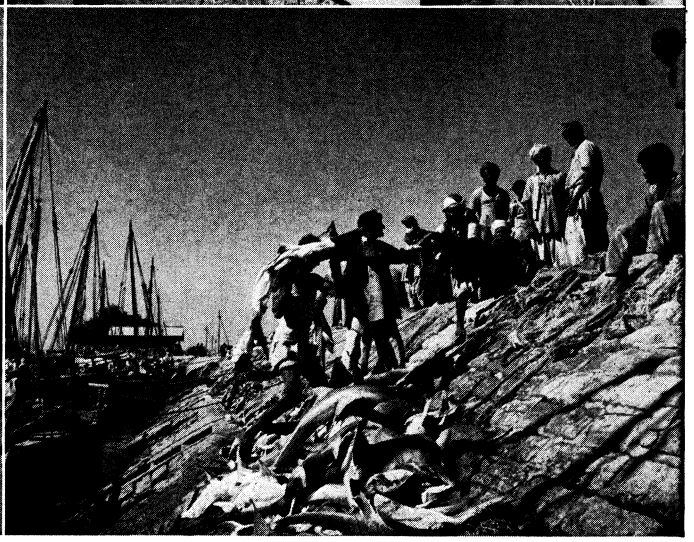
BY COURTESY OF (TOP LEFT, TOP RIGHT, CENTRE RIGHT) THE PAKISTAN EMBASSY, (BOTTOM LEFT) UNITED NATIONS; PHOTOGRAPH, (BOTTOM RIGHT) CAMERA PRESS—PIX *FROM* PUBLIX

URBAN AND RURAL PAKISTAN

Top left: Gateway of the mosque of Wazir Khan, Lahore, built in 1634
Top right: Gas pipeline terminal station in West Pakistan
Centre right: Women picking tea leaves in Shamshair Nagar tea garden
Bottom left: Baluchistan farmer and his camel. Camels serve as both farm animals and pack animals
Bottom right: Mohatta palace, Karachi, seat of the Pakistan ministry of foreign affairs and commonwealth relations

PAKISTAN





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PAKISTAN AND ITS PEOPLE

Top: The old fort at Lahore, West Pakistan, built in the 17th century and occupied by the British until 1923

Centre left: A classroom scene at the government school, Lyari (Karachi)

Centre right: Girls of Baltistan wearing heavy ornaments and ornamented caps

Bottom left: The railroad station at Chittagong. East Pakistan

Bottom right: Pakistani fishermen unloading their catch

events completely antagonized the league, whose later electoral successes justified its claim to be the only body qualified to represent Moslem opinion. In 1940 the league adopted a policy of partition which crystallized into a demand for an independent Moslem state, comprising the four northwestern provinces of India and Bengal and Assam, under the name of "Pakistan." This name had been coined in 1933 by C. Rahmat Ali for the northwestern Moslem areas, and was taken from *P*unjab, Afghan (*i.e.*, Pathan, for North-West Frontier province), Kashrnir and Baluchistan.

After the failure of British proposals aiming at Indian self-government made through Sir Stafford Cripps in 1942, the policies of the Indian parties continued to diverge. Congress under the influence of Mohandas Karamchand Gandhi (*q.v.*) concentrated on forcing an immediate transfer of full power to an Indian interim government, which would afterward settle communal differences. Jinnah, however, was determined to secure the Moslem position before the British relinquished power. A British cabinet mission (1946) failed to secure agreement and pronounced against partition, but proposed the election of an Indian constituent assembly and an elastic plan enabling the Moslem groups of provinces to frame separate constitutions within a union of India possessing minimal powers. Such an assembly was actually elected but was boycotted by the league, and an interim government composed of both parties was disunited and ineffective.

In Feb. 1947 the British government announced that it would transfer power to Indian hands by June 1948. This time limit induced a spirit of mutual compromise, and the mediation of Viscount (later Earl) Mountbatten of Burma as viceroy succeeded in securing a basis of agreement. For the sake of peace and immediate independence, Gandhi and the Congress were prepared to accept the necessity of India's partition, provided that non-Moslem majority areas should not be included in Pakistan against their ill. This proviso meant partitioning the Punjab and Bengal and, in the result, the exclusion from Pakistan of East Punjab, West Bengal (including Calcutta) and most of Assam. The British government approved a plan of immediate action which was accepted by the Indian parties and announced on June 3. It was possible to pass an Indian independence bill at once creating two new dominions of India and Pakistan from Aug. 15, 1947.

Jinnah was appointed governor general of Pakistan. The dominion capital was established at Karachi, a city with about 1,000,000 inhabitants, and a government was formed with Liaquat Ali Khan as prime minister. A constituent assembly was set up to frame a constitution and meanwhile act as the legislature. The Independence act provided an initial constitutional basis by equating the powers of the new dominions with those of the existing ones, and otherwise keeping alive the Government of India act, 1935, with necessary adaptations and until other provision was made. The lapse of British agreements with the Indian states made possible their accession to one of the new dominions, and Pakisian received the accession of the few contiguous Moslem states except Kashmir. These included Bahawalpur and Khairpur, large states that until 1955 enjoyed something like provincial status; the four Baluchistan states; and five northwest frontier states. A special initial difficulty confronting Pakistan was that it had to create the departments and organization of a central government in place of the existing machinery of government in New Delhi.

Initial Problems.—*Refugees.*—Through Gandhi's influence the partition of Bengal was effected peaceably. But in the Punjab the partition of the important but scattered Sikh community caused an outbreak of communal violence, which despite the efforts of both governments spread rapidly and was followed by migrations of refugees in each direction. By the end of 1948 the migratory movement reached the proportions of about 6,599,000 Moslems entering Pakistan and 5,563,000 non-Moslems moving to India; the net increase of 1,000,000 in West Pakistan's population consisted mostly of peasants, whose resettlement was a serious problem, and a considerable influx continued.

Kashmir.—In the autumn of 1947 the Punjab disturbances spread to the neighbouring state of Kashmir, where the maharaja was a Hindu but three-quarters of the population was Moslem. A rebellion broke out and was supported by northwest frontier tribesmen. The maharaja, Sir Hari Singh. thereupon asked to accede to India, which accepted the accession, subject to the holding of a free plebiscite when normal conditions were restored. and sent troops to protect the capital. These steps aroused strong feeling in Pakistan, which had expected to receive the state's accession in view of its population and geographical and economic connections. Fighting in Kashmir continued, and in Jan. 1948 India and Pakistan both appealed to the United Nations Security council. A cease-fire, as from Jan. 1, 3949, and a demarcation line between the combatants were arranged; but though both governments agreed in principle to a plebiscite, no agreement was reached on the preparatory steps for holding it, and in 1956 the Indian prime minister withdrew his support and proposed instead that Kashmir should be partitioned on the basis of the cease-fire line. This proposal was immediately rejected by Pakistan. which decided to refer the dispute once more to the Security council. Relations between the two countries became further strained when Jawaharlal Nehru claimed Indian suzerainty over Chitral, which had been incorporated into West Pakistan, and over the principalities of Hunza, Nagar and Punial in the Pakistan-held area of Kashmir.

Frontier Regions.—Another problem was the control of the Pathan tribes inhabiting the barren regions between the North-West Frontier province and the Afghan frontier, in order to prevent raids into the province. The Pakistan government won their confidence by withdrawing all regular forces from tribal territory, while retaining the irregular levies recruited from the tribesmen, and continuing (and gradually expanding) the support of tribal economy by subsidies and the promotion of agriculture and other means of employment. The tribes freely consented to become a part of Pakistan, and were controlled by the central government through the governor of the province. There was, however, in 1948 a dangerous Pathan separatist movement in the North-West Frontier province. The central government dealt successfully with this, but in 1956, after the incorporation of the North-West Frontier province in West Pakistan, Khan Abdul Ghaffar Khan led an agitation against this unification of the western province and demanded the reinstatement of a separate Pushto province within the boundaries of Pakistan, but with its own provincial government. He was arrested in 1956 by the West Pakistan government, of which his elder brother Khan Sahib was chief minister. This movement was quite separate from the demand by Afghanistan, supported by Marshal N. Bulganin, the Russian premier, on his visit to Afghanistan, for a Pathan state to be called Pakhtoonistan which would be independent of Pakistan.

Later History.—In overcoming its initial difficulties Pakistan's principal asset was the spirit of its people. The enthusiasm which had created a new nation was turned to the constructive tasks of securing its stability and progress. On Sept. 11, 1948, the country suffered a severe loss in the death of Jinnah. He was succeeded as governor general by Khwaja Nazimuddin of East Bengal. The peculiar position of that province presented a difficult problem; separated by 1,000 mi. from the rest of Pakistan, it contained more than half the total population in less than one-sixth of the area, and had cultural and close econoinic ties, and a common language, with Indian West Bengal; at the same time the relations between the two Bengals were exposed to special stresses because of the large communal minorities in each of them.

Relations With India.—Pakistan co-operated in efforts to mitigate the consequences of partition, which had broken up the economic unity of the subcontinent and interrupted normal trade channels. In May 1948 an agreement was made for the exchange of essential commodities, under which Pakistan supplied India with specified quantities of raw jute, cotton and grain against coal and cotton textiles.

But successful co-operation depended on neighbourly relations, and these were strained by the ill feeling over the refugee problem and the Kashmir dispute. In the winter of 1949–50 they suffered a further setback. When the pound sterling was devalued (Sept. 18, 1949), the Indian rupee was devalued to the same extent. But Pakistan, which exported only primary products and needed imports of capital goods for development, decided for economic reasons against devaluation. This led to trade difficulties and dis-

putes with India which were especially damaging to the two Bengals. Deliveries of Indian coal and of Pakistan jute to the Calcutta mills were suspended, and public feeling on both sides became dangerously inflamed. In the spring of 1950 communal riots and alarmist propaganda led to migrations of about 1,500,000 Hindus into West Bengal and 1,000,000 Moslems into East Pakistan. These movements were checked and confidence was gradually restored through the joint intervention of Jawaharlal Nehru and Liaquat Ali Khan, who signed a comprehensive agreement on April 8 for vigorous action to protect minorities. Trading relations were not fully restored till Feb. 1951, when India accepted the new value of the Pakistan rupee. By July 1955 Pakistan's decision of 1949 had served its purpose of stimulating industrial development; at the same time world prices of primary products had fallen and it was desired to facilitate their export. The Pakistan rupee was therefore devalued (July 31) from 2s. 2*d*. to 1s. 6d. sterling, the same as the Indian rate.

Another cause of intermittent disputes after 1948 had been the vital problem of the use of the six Punjab rivers for irrigation. The eastern rivers, Sutlej, Ravi and Beas, served both countries, but India needed more water for additional irrigation. In 1952 experts of the International Bank for Reconstruction and Development joined with Indian and Pakistani engineers in a study of the whole problem, including the possibilities of co-operative development, but no settlement was reached. In 1954 the bank proposed a plan for reserving the eastern rivers to India's use after a transitional period to enable Pakistan to obtain supplies by completing link canals from the western rivers, and negotiations were continued. In 1955 and 1956 temporary agreements were reached by the representatives of the two countries establishing the amounts to be withdrawn by India from the three eastern rivers for its canal system.

Economic Crisis of 1953.--On Oct. 16, 1951, Liaquat Ali Khan was murdered by a fanatic. In this emergency Khwaja Nazimuddin took up the premiership and Ghulam Mohammed, minister of finance, became governor general. In 1950 and 1951 Pakistan's basic economy benefited greatly from the rise in commodity prices, but in 1952 the position was reversed as a result of falling prices for jute and cotton exports, coupled with a shortage of food which had to be met by imports of wheat. The combined result was that the balance of payments during 1952 was converted from a previous surplus of Rs. 520,000,000 to a deficit of Rs. 870,000,000 and the gold and sterling reserves fell from Rs. 1,481,000,000 to Rs. 606,000,000. In March 1953 it was announced that, because of scanty rainfall and shortage of canal water in the previous autumn, a second wheat deficit was anticipated, and that 1,250,000 tons would have to be obtained by foreign loans or aid. Public confidence in the government was shaken, and the governor general decided that a change was necessary. In April Mohammed Ali, ambassador to the United States and an East Bengali, became prime minister and formed a strong government which was able to surmount the immediate crisis and gradually restored the financial position to one of equilibrium. The United States made a generous response to a request for aid. Congress approved a bill covering the supply of 1,000,000 tons of wheat, of which more than 600,000 tons (enough to meet the eventual need) were received as a gift in 1953–54. Canada and Australia also gave aid, and the British government made a loan of £10,000,000 for purchase of capital goods toward increasing food production.

External Relations.—The foreign portfolio was in the able hands of Mohammed Zafrullah Khan until 1954 when he became a judge of the International Court of Justice. One natural objective of foreign policy was the fostering of friendly relations with other Moslem countries, but this did not conflict with helpful cooperation in the Commonwealth of Nations. Pakistan also participated actively in the United Nations, and was elected a member of the Security council for the two years ending Dec. 1953. Mohammed Ali was anxious to promote a settlement of disputes with India, and in 1953 had meetings with Nehru at Karachi and Delhi; each prime minister received a cordial welcome in the capital of the other, and though little was decided the atmosphere was temporarily improved. Mohammed Ali continued the cultivation of friendships with middle eastern countries and also broke new ground in co-operating with the western powers. In April 1954 an agreement was signed with Turkey for closer collaboration in the political and economic field and for strengthening peace and security. An agreement with the United States was signed in May for obtaining aid in military equipment (thus easing the economic burden of defense) and special assurances of its purely defensive scope were given to India. Pakistan was also a party to the Southeast Asia Defense treaty, and in March 1956 the council of SEATO, comprising the foreign ministers of the eight member countries, met at Karachi. In Sept. 1955 Pakistan (followed shortly afterward by Iran) had joined Turkey. Iraq and Britain as a signatory of the Middle East Defense treaty, generally known as the Baghdad pact.

Industrial Development.--On its separation from India, Pakistan's economy was wholly agricultural. It was more than self-sufficient in food (until 1952), and produced in East Bengal most of the world's supply of raw jute and in West Pakistan raw cotton including long- and medium-staple varieties. It had little coal or oil but large potential resources of hydroelectric power. There was a good port at Karachi and another half-developed at Chittagong. Pakistan's strength lay in the value of its jute and cotton, which constituted the bulk of its exports, and its weakness in its dependence on these commodities and its almost total lack of manufacturing capacity. The government's economic policy (announced in April 1948) therefore included the development of large-scale industries for processing the country's own raw materials and producing consumer goods for the home market. In 1950, in connection with the Colombo plan, the government drew up a development program for the six years beginning July 1951. This was under constant review in the light of requirements and resources, but its general scope may be gauged from its original form, which was estimated to cost Rs. 2,600,000,000 divided between agriculture (32%), transport (20%), industry (19%), fuel and power (18%) and supplementation of provincial provision for social welfare (11%). Good progress was made in executing the program. By 1954 three hydroelectric projects and some well-equipped jute and paper mills were completed; the number of cotton mills had risen from 17 to 62; the capacity of Chittagong port was doubled. Fuel resources were increased by the discovery of natural gas at Sui in Baluchistan, and a strong company was floated for its transmission to industrial centres. The Kotri barrage on the Indus was opened in March 1955. This marked the completion of Pakistan's great irrigation project designed to bring water to 2,750,000 ac. in the lower Sind area.

The development program was financed partly by aid from the United States and commonwealth countries but largely by internal loans, revenue expenditure and budget surpluses. The government encouraged the use of private capital in industry by numerous fiscal concessions, and in 1952 established an industrial development corporation which participated in new undertakings where large investment was required. The revenue budget showed surpluses each year as follows: 1948–49, Rs. 20,600,000; 1949–50, Rs. 32,600,000; 1950–51, Rs. 29,700,000; 1951–52, Rs. 8,100,000; 1952–53, Rs. 5,600,000; 1953–54, Rs. 10,100,000. In 1954–55 there was a deficit of Rs. 25,100,000 estimated, mainly due to relief in flood-devastated areas.

Constitutional Questions.—The work of the constituent assembly on a federal constitution suffered repeated delays. There were difficulties in finding a satisfactory balance of parliamentary representation between East Bengal with its larger population and West Pakistan with its several units, and there were differences of opinion as to the relative powers of the federal centre and units, the functions of the head of the state and the best method of synthesizing Islamic and secular principles. Meanwhile the assembly adopted interim measures for elections of reformed provincial assemblies by adult' suffrage. Those held in Punjab province and the North-West Frontier province (1951) and Sind (1953) gave the Moslem league large majorities, but in the East Bengal elections (March 1954), because of the unpopularity of the outgoing ministry and a desire for greater provincial autonomy, the league suffered an overwhelming defeat by a united front of non-

league Moslems and other groups. The new ministry soon proved unable to prevent disturbances. which threatened the industries and security of the province. It was dismissed after an outbreak of grave rioting in May, and Maj. Gen. Iskander Mirza was appointed governor with full powers to restore order. In June 1955 parliamentary government was restored. but was again temporarily 'suspended in May 1956 on the recommendation of the governor.

In Sept. 1954 the constituent assembly made ostensible progress on the federal constitution. but it was fundamentally disunited and had forfeited public confidence. Based on elections of 1946, it was no longer representative, and the Moslem league which dominated it was discredited and split into factions. A crisis developed in October. The governor general dissolved the assembly, and a nonparty cabinet under Mohammed Ali was formed with the addition of two nonleague political leaders. Khan Sahib from the North-West Frontier province and H. S. Suhrawardy from East Bengal. This government prepared plans for a new constitution. including the consolidation of West Pakistan into a single political unit parallel with East Pakistan. The country welcomed the governor general's action. but it was challenged in the courts. In May 1955, however, the federal court advised that the assembly was legally dissolved and that a new one should be elected to frame a constitution and exercise legislative powers including that of validating some important laws, the enactment of which by the old assembly had been defective.

The new assembly. elected by the provincial legislatures with parity of representation between West and East Pakistan, met in July. The Moslem league: though the largest party, had no working majority. In Aug. 1955 the prime minister. Mohammed Ali, resigned and was succeeded by Chaudhri Mohamad Ali, previously finance minister. who formed a coalition government including Fazlul Huq of the East Pakistan united front. In September the governor general Ghulam Mohammed resigned because of ill-health and was succeeded by Iskander Mirza. In the first nine months of its existence the assembly gave its sanction to two measures of great importance. On Sept. 30. 1955, the province of West Pakistan was established as a single unit, and on Feb. 29, 1956, it adopted the Constitution bill under which Pakistan became a federal Islamic republic. On March 2 the assembly decided that the republic should remain within the British Commonwealth, and on March 5 it appointed Iskander Mirza, the governor general. as provisional president of the republic. The republic was declared on March 23. H. S. Suhrawardy succeeded Chaudhri Mohamad Ali as prime minister in Sept. 1956. (J. C. W.)

Opposition to the single administrative unit system of the constitution developed in West Pakistan where leaders wanted their province broken up into four or more smaller provinces with the same kind of local autonomy enjoyed by East Pakistan. This led President Mirza to suspend the West Pakistan constitution and to rule directly from March 21 to July 1, 1957. Meanwhile in East Pakistan there was a split in Suhrawardy's Awami league over the problem of regional autonomy and foreign relations. After a further refusal of Suhrawardy to break up West Pakistan, the Republican party withdrew its support and the prime minister resigned on Oct. 11 to be succeeded by Ismail Ibrahim Chundrigar. He was forced to resign two months later when the Republicans again broke away. On Dec. 16. 1957, Malik Firoz Khan Noon formed a cabinet with a Republican majority.

The central government remained reasonably stable during 1958, but in both West and East Pakistan a series of crises in the first half of the year gave proof of an alarming lack of political stability.

On Oct. 7, 1958, President Mirza, faced with fresh cabinet crises, abrogated the constitution, dismissed the central and provincial cabinets and assemblies, abolished all political parties and imposed martial law on the country under the administration of Gen. Mohammed Ayub Khan, commander in chief of the army. The army took charge but did not rule directly; the machinery of administration was placed under the control of experienced civil officials, while effective authority was retained by army officials. Drastic action was taken against corruption, black market dealings. hoarding of foodstuffs and profiteering in foreign imports.

On Oct. 27 President Mirza relinquished his post in favour of General Ayub. The new president announced that martial law would continue until abuses had been removed, major reforms had been effected and a neu constitution. with separation of powers between the executive and the legislature, had been worked out. (X.)

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PAKKHTO: *see* PUSHTU.

PAKOKKU, a district in the Magwe division of Burma. lying west of the Irrawaddy river and southwest of Mandalay. with the line of the Chin hills as a general boundary on the west. It has an area of 5,356 sq.mi. and a population (1941) of 359,671. The part of the district along the Irrawaddy and Chindwin rivers is alluvial. Beyond this, however, the country rises gradually to the low Shinmadaung and Tangyi ridges. where it is very arid. Westward there is a rapid drop to the well-watered valley of the Yaw river, then a rise over broken. dry country before the valley of the Myit-tha river is reached. The principal products are peanuts. millet. sesamum and sugar produced from toddy palms in the riverain districts, which also grow rice. grain. peas and beans. Tobacco and vegetables are also produced in some quantity, and maize is grown largely for the sake of the husk. which is used for native cheroot wrappers. under the name of *yawpet*. The Yenangyaung oil fields. which produce quantities of petroleum. are in the south of the district, and iron used to be worked in a small way. There are large areas of reserved forests in the west of the district where a good deal of teak is worked out. The cutch—a yellow dye obtained from a small tree in the drier parts of the Yaw country—is particularly esteemed. The heat in May and June is very great, rising considerably above 100° F. in the shade.

The great majority of the population is Burmese. but in the Yaw valley there is a peculiar race called Taungthas, who claim to be quite distinct from both Burmese and Chins.

The headquarters town, Pakokku, stands on the right bank of the Irawaddy, and grew into importance after the British occupation. The population in 1953 was 30.943. It is the emporium of the trade of the Chindwin and Yaw river valleys.

Pakokku Hill Tracts, formerly a district in the Magwe division to the west of the Pakokku district. now form the Kanpetlet subdivision of the Chin Hills district. It included 3,100 sq.mi. of the forest mountains of the Arakan Yomas, inhabited by 27,357 people (1931), mainly Chins and allied hill tribes. It included one of the highest peaks of the Xrakan Yomas, Mt. Victoria (10,018 it.). Headquarters village was Kanpetlet. The district was annexed in 1929 to that oi the Chin Hills. which had been its next northern neighbour and which with this addition included in 1941 an administered area of 10,377 sq.mi. and a population of 186,405. Its headquarters town is Falam.

The whole district consists of a succession of forested mountain ridges.

PALACE: see CASTLE; GOVERNMENTAL ARCHITECTURE.

PALACIO VALDES, ARMANDO (1853–1938), Spanish novelist and critic. His early writings. pungent essays remarkable for independent judgment and refined humour. were printed in the *Revista Europea*. His first novel. El *Señorito Octavio* (1881), showed an uncommon power of observation. In *Marta* y *María* (1883), a portrayal of the struggle between religious vocation and earthly passion, somewhat in the manner of Valera, Palacio Valdés achieved a very popular triumph which placed him in the first rank of contemporary Spanish novelists. He followed this up by *El Idilio* de *un enfermo* (1884), a most interesting fragment of autobiography and by *José* (1885), a realistic picture of the manners and customs of seafaring folk, containing passages of animated description barely inferior to the finest penned by Pereda himself.

The emotional imagination of the writer expressed itself anew in the charming story *Riverita* (1886), one of whose attractive characters develops into the heroine of *Maximina* (1887); and from *Maximina,* in its turn. is taken the novice who figures as a professed nun among the personages of *La Hermana San Sulpicio* (1889). in which the love passages between Zeferino Sanjurjo and Gloria Bermudez are set off with elaborate, romantic descriptions of Seville. *El Cuarto poder* (1888) is, as its name implies. concerned with the details, not always edifying, of journalistic life. *La Espuma* (1891) and *La Fe* (1892) were enthusiastically praised in foreign countries. but in Spain their reception was cold. Subsequently Palacio Valdés returned. to his earlier and better manner in *Los Majos de Cádiz* (1896), in *La Alegría del Capitán Ribot* (1899) and in *La Aldea Perdida* (1903). In these novels, and still more in *Tristán, ó el pesimismo* (1906), he frees himself from the reproach of undue submission to French influences. His later works. *Papeles del Doctor Ange'lico* (1911), *La Novela de un Novelista* (1921) and *La Hija de Natalia* (1924) preserve much of the charm, if not the freshness, of his earlier novels; in any case Palacio Valdes takes a prominent place in modern Spanish literature as a keen observer and analyst of emotion.

See A. Cruz Rueda, *Armando Palacio Valdts, estudio biográfico* (1925). (J. F.-K.)

PALACKY, FRANTISEK (1798–1876), the founder of modern Czech historiography and a leading figure in the political life of 19th-century Bohemia. was born at Hodslavice, Moravia, on June 14, 1798. Of Protestant upbringing. he was educzted mainly in Slovakia where he came into contact with the resurgence of national feeling that had begun to influence Czech and Slovak intellectuals. His early writings were concerned with aesthetics. In 1823 he settled in Prague where he was enabled by noble patronage and by his marriage to the daughter of a well-to-do lawyer to devote himself to his scholarly and patriotic interests. In 1827 he became editor of the journal of the Bohemian museum in which he published articles on aesthetics (on Kantian idealistic lines) and on the Czech language (advocating a moderate traditionalism against attempts to make far-reaching changes).

In 1832 he began his magnum opus, a history of the Czech nation in Bohemia and Moravia, to 1526. The first volume, written in German, appeared in 1836; the later volumes were written in Czech. It was published as *Geschichte von Bohmen,* 5 vol. (1836–67), and *Dtjiny ndrodu českého* (1848–76). The work shows a clear conception of the nature of, Czech history, which Palacky held to consist in "the constant contact and conflict between the Slavs on the one hand and Rome and the Germans on the other." Thus the Hussite period became the central episode of Czech history, epitomizing the national and the religious struggle.

As a politician. Palacky supported the Austro-Slavonic conception of a federal Austria, composed of nationalities with equal rights. He defended this conception in his letter to the Frankfurt *Vorparlament* of 1848 ("If the Austrian state did not exist we should have to create it in the interests of Europe and of humanity"), as chairman of the Prague Slavonic congress in the same year and at the diet of Kromeriz (Kremsier). After the failure of the 1848 revolutionary movements Palacky retired from active politics until 1861 when he became a deputy in the *Reichsrat.* In his *Idea státu rakouského* ("Idea of the Austrian State." 1865; German trans., 1869) he propounded a federalism based not on nationalities but on the historic provinces of the Habsburg empire ("We were before Austria, we shall still exist when she has disappeared"). His influence on Czech political thought and historiography was immense. The liberal nationalism of T. G. Masaryk and his generation owed much to Palacky.

Palacky died in Prague. May 26, 1876.

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PALAEO-ASIATIC LANGUAGES. The languages described as "Palaeo-Asiatic" are spoken in the extreme north-east of Siberia; Yukaghir, Chukchee, Koryak, Kamchatkan, and Gilyak. They contain features characteristic of many American languages. The phonetic system is rich and is marked by a scheme of vocalic harmony by which the three classes of vowels, weak, strong, and neutral, are duly regulated. In ordinary conversation the women do not use the pronunciation of the men. The grammatical processes are numerous. Koryak has a dual and the relation between subject and predicate is conceived differently in transitive and intransitive verbs. Prefixes and suffixes are numerous, number, location, size being thus indicated. The numbers are derived from manual concepts; five being a hand and zo being a man. Higher numbers are composed with the word for man, and numbers higher than 400 are called "limit of knowledge." Chukchee and Roryak have borrowed some words from Russian but possess the power to form new words for new ideas. Kamchatkan has been much modified by Russian.

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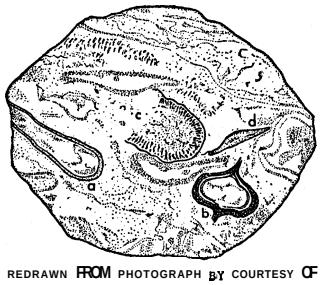
PALAEOBOTANY or **PLANT PALAEONTOLOGY** is concerned with the plants of the geologic past. The documents on which the history of the plant kingdom is founded are plant fossils, the debris of vegetation preserved in the rocks: leaves, twigs, seeds, fruits, flowers, spores and pieces of wood representing trunks, branches and roots. These fossils record the presence of aquatic plants upon the earth as far back as the Proterozoic era (*see* GEOLOGY), about 1,500,000,000 years ago; land plants are known first from Silurian rocks laid down during the Palaeozoic era. While these earliest records are incomplete, there is sufficient evidence to show that the oldest known plants were small and simple as compared with modern trees. The evolutionary development of plants to their present high level of organization is a phase of palaeobotany most closely related to the science of botany, as is the consideration of their structures. The stratigraphic occurrence of fossil plants falls in the field of geology; if the time of appearance, dominance and extinction of a plant, or of a group of plants (a flora), can be associated with rocks of known age, the geologist is thereafter able to correlate other rocks containing the same plants and to establish their age as approximately the same. Fossil plants may also supply the geologist with reliable evidence regarding ancient climate and topography; by comparison with related living forms, whose temperature and moisture requirements may readily be determined, and whose topographic occurrence is also a matter of observation, the plants of the past may be judged to have lived in similar environments. With the combined viewpoint of the botanist and geologist, plant fossils may indicate the lines of evolution and relationship of the principal groups, the dates when they lived, and the nature of the lands which they occupied.

History of **Palaeobotany.**—As in the case of animal remains, fossil plants have long attracted the attention of man. The ancients generally subscribed to the idea of spontaneous production of fossils from inorganic matter; this involved the operation of stone-making spirits or cosmic forces, and was an accepted doctrine as late as the 17th century; even in the 20th century the people of a small village in Shantung, China, believe that imprints of leaves on thin layers of shale in near-by hills represent the early efforts of gods of art and writing. Some appreciation of the organic nature of fossils was shown by the Pythagorean school and by Aristotle, but there was no general understanding of their significance in the record of earth history until many centuries later. In the 13th century, Albertus Magnus made the first written mention of a fossil plant. In a commentary on Genesis in about the year 1534, Martin Luther suggested that fossil wood might be expected to occur near mines, from which timbers had been washed by the deluge. Actually it was the extensive mining of coal following the destruction of forests in western Europe which first uncovered the abundant record of Carboniferous plants, and provided a basis several centuries later for a scientific interpretation of fossil plants. But the diluvial theory flourished long after the day of Luther, with its Christian compromise that although plant fossils were of organic origin, they represented the remains of vegetation washed away during the Noachian flood. The idea that fossils represent the accumulation of plants and animals over long periods of geologic time gained impetus after the discovery by William Smith (England) in 1798 that certain

fossil shells always occurred in a given rock layer, while other beds above and below contained other shells. The founder of the science of palaeobotany was Adolphe T. Brongniart (France) who during the 19th century established a sound classification for fossil plants, and formulated several of the principles which govern their study. Other pioneers were H. Witham (England) who made the first anatomical study of petrified plants; H. R. Goeppert (Germany) whose voluminous works cover a wide range of interests; Oswald Heer (Switzerland) whose studies include a seven-volume discussion of arctic floras; J. W. Dawson (Canada) and Leo Lesquereux (United States) who founded palaeobotany in North America. In later years A. C. Seward (England), A. G. Nathorst (Sweden), F. H. Knowlton and E. W. Berry (United States) have made extensive contributions. Since about 1800 it has gradually been realized that plants in older rocks are relatively simple in organization, and that they show a progressive trend toward complex structure in successively younger layers. With this understanding of the significance of time in the history of life, palaeobotany has become a science in which the disorganized and mystical interpretations of earlier centuries have given way to a developmental point of view based upon comparisons with the morphology, distribution and behaviour of living plants.

Modes of Preservation.—Most of the plants which lived in past ages have been subjected to decay and disintegration, and no trace of them remains; but under certain favourable conditions their more resistant structures may be preserved, commonly as dissociated organs. Rapid burial in fine-grained sediments or volcanic ash greatly facilitates the formation of impressions of leaves and seeds, or an occasional flower. If they imprint their margins and nervation on the sediments which bury them, these impressions will remain after the sediments have been compacted into solid rock even though all the original plant tissues have then disappeared (Pl. II, figs. 4, 5, 7, 8). If the hard structures of logs, roots or fruits are decayed or dissolved away, or burned where lava engulfs a forest, the surrounding rock may form a mould which shows the external characters of the bark or other surface features; if such a mould is later filled by sediments or mineral deposits, a cast of the original stem or fruit is formed which shows the outward appearance and shape but includes no other evidence of the original structure (Pl. II, fig. 3).

Circulation of ground water may add minerals carried in solution, commonly silica and calcium carbonate, to buried plant tissues (permineralization), or may completely dissolve them with a gradual substitution of inorganic substances (replacement) so that all the details of cell structure remain. Stems, roots and less commonly cones and seeds are preserved in this manner (Pl. II, figs. 1, 2; Pl. IV, figs. 1, 2). Petrified wood which has been permineralized or replaced by silica is said to be silicified. Concretionary masses known as coal balls (fig. 1), of common occurrence in older coal seams in Europe and North America, contain well-preserved plant fragments which have been petrified by solutions of calcium and magnesium carbonates. Deeply buried plants may be subjected to pressure and heat until their volatile constituents are distilled away leaving a residual film of carbon in the case of leaves, or carbonized logs in the case of stems.



REDRAWN FROM PHOTOGRAPH BY COURTESY OF C. A. ARNOLD

FIG. 1. — SECTION OF COAL BALL From Conemaugh series, Ind., showing: (a) *Stigmaria* root; (b) *Lepidocarpon* seed; (c) petiole of Medullosa; (d) cross section of undetermined leaf (x 3)

A third method of preservation is involved in certain rare situations where bacterial action is inhibited and plants are preserved in essentially their original state. At Rancho LaBrea and other California localities, great numbers of cones (Pl. V, fig. 14), seeds, leaves and wood fragments, together with the bones of mammals and birds, have been enclosed in asphalt which has seeped out and impregnated the sands and clays in which they were buried. In the frozen muck of boreal regions, plant remains have been placed in natural cold storage for thousands of years without decay. The wood of some trees, of which *Sequoia* is a common example, contains substances such as tannin which protects it from bacterial action, and the only apparent change after burial for millions of years may be a slight crushing of the woody tissues. The dried and hardened resin of gum-bearing trees, especially conifers, may be preserved as amber in coal beds or other carbonaceous deposits. Amber from Oligocene sediments along the Baltic coast of Germany contains many flowers and other plant fragments, as well as insects, which became entrapped when the gum was soft. The original substance of these organisms has ordinarily disappeared, but the details of their form are retained as moulds. Pollen grains are of common occurrence in peat and carbonaceous shale, where resistant outer shells or exines are preserved in an essentially unaltered state.

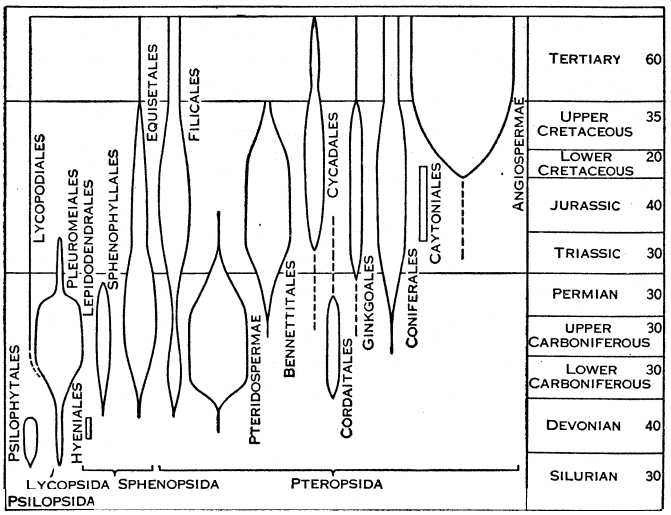
Conditions which favour the preservation of plants may be found in valleys, lake basins and estuaries where sediments are accumulating. Volcanic ash is an especially favourable medium for impression of plant remains, and for rapidly enclosing logs and fruits which may later be petrified by the action of associated ground and magmatic waters. Since accumulation of sediments and ash is most permanent at low elevations where erosion is least active, it follows that the fossil record is limited largely to forests of the lowlands; trees of the highlands are ordinarily represented only by fragments which have been transported long distances, or by pollen and winged seeds which are readily transported by wind. The tissues of herbs are less substantial than those of trees and shrubs, and even though they may have been numerous in the vegetation of the past, these smaller plants are seldom represented in fossil floras. Plants which are rare have less opportunity to enter the fossil record than abundant forms whose leaves, fruits and stems may be deposited in large numbers. We may conclude that the plants making up the fossil record are largely of common lowland types which have woody structures and substantial leaves. Our knowledge of forests of the highlands is relatively incomplete, as is the record of herbs and of structures such as flowers which are too delicate often to be preserved.

Time-Space Relations — Use of fossils as indicators of the age of rocks in which they occur is based upon observations made in many parts of the world that a given sedimentary layer or formation contains certain characteristic types of life (index fossils), and that the fossils in lower and higher formations are of different kinds. The basic concept that there has been a trend from simple structures in ancient organisms to progressively more complex structures in those of later age has already been mentioned; as we come up through the rock layers from the beginnings of life, plants and animals of increasing complexity enter the fossil record. Thus in its simplest form, a general determination of age may be based upon the presence or absence of certain major groups. The following diagram shows that angiosperms, an advanced type, were not known at a period older than the Cretaceous, while the more primitive pteridosperms became extinct during the Jurassic. No rocks have been found to contain members of both these plant groups; thus the age of a formation containing angiosperms is known to be Cretaceous or younger, while rocks with pteridosperms are Jurassic or older. Certain groups such as *Algae* have only slight value in age determination since they have survived long ages with relatively little change.

Closer age determinations must depend upon occurrence of genera or species, for their span of life in earth history is shorter than that of the larger plant groups. Plants which have evolved rapidly and lived for only a short segment of geologic time before they became extinct constitute the best index fossils. The pteridosperms of the Carboniferous period are among the most valuable horizon markers, since in addition to living through a brief time range many of their species were abundant and broadly distributed geographically.

Presence of index fossils in rocks of unknown age, together with certain geologic criteria, makes possible their correlation in age with those in regions where the age of the rocks is well

known. Plants of the Carboniferous period show a marked similarity in Europe, Asia and North America, providing a basis for age correlations across these continents. A much younger flora referred to the Miocene, containing redwood (Sequoia), oak (Quercus) and other living genera of tree, was found across Eurasia from Japan to western Europe, and in western North America; a closely similar flora is known in arctic regions from



northern Siberia to Spitzbergen, Greenland and Alaska. Originally correlated with the Miocene of Switzerland because of similarity in composition, this northern flora (Arcto-Tertiary) is now known to be of an older, Eocene age from its geologic relations and associated faunas. The discrepancy in age from Miocene to Eocene represents the time required for migration of the redwood-oak flora southward from high to middle latitudes under the influence of cooling climate. Such similar floras, occurring in different areas at different times, are said to be homotaxial rather than synchronous. The redwood-oak floras of Greenland and Switzerland, or of Alaska and Oregon, may readily be correlated within the limits of the Tertiary period, which includes both the Eocene and Miocene epochs and covers a span of some 60,000,000 years; but such wide differences in latitude must be considered to indicate a considerable difference in age, for at any one time in the past, as today, the plants of Greenland and Alaska differed greatly from those of Switzerland and Oregon. While it is doubtless true that at some past times climatic zones may have been less distinct than at present, there is no basis for supposing that at any time in earth history has the influence of latitude on land climate and vegetation been negligible. Marine faunas and to some extent the animals of the land may be somewhat less affected by climatic zones, since many of them are not fixed in position like land plants, and can migrate as individuals. But any correlation of terrestrial floras must take into consideration the factor of latitude. The cosmopolitan flora of the Jurassic was contemporaneous from Greenland to Antarctica only within the time limits of this period, some 40,000,000 years in duration. There is no basis for supposing that the vegetation of England was identical at any one epoch of the Jurassic with that of the poles, for conditions responsible for the growth of plants could never have been uniform over so wide a range in latitude. Having in mind the interrelations of time and space in the history of vegetation, correlations of similar plants may be made in approximate latitudes; or differences in age may be established if homotaxial floras occur at different latitudes.

Classification of Fossil Plants.— Grouping of plants which lived in past ages has followed a great number of plans, of which one of the earliest and most fanciful was the segregation of five classes based upon their type of preservation. In current practice, the classification proposed by botanists who have studied the vegetative and reproductive structures of living and fossil plants is followed. Starting with the simplest, we advance through intermediate types to the groups which show the greatest complexity in structure and efficiency in function. There are many minor differences of opinion among systematists, and the classification which is most appropriate for the often incomplete fossil record is adopted here. Where common names are regularly used, they are included in the right-hand column.

Thallophyta	
Algae	
Cyanophyceae	Blue-green Algae
Chlorophyceae	Green Algae
Rhodophyceae	Red Algae
Phaeophyceae	Brown Algae
Charophyta	Stoneworts
Fungi	
Schizomycetes	Bacteria
Phycomycetes	Algal Fungi
Bryophyta	
Hepaticae	Liverworts
Musci	Mosses
Tracheophyta	
Psilopsida	
Psilophytales	
Psilotales	
Lycopsida	
Lepidodendrales	Scale Trees
Pleuromeiales	
Lycopodiales	Club Mosses
Sphenopsida	
Hyeniales	
Sphenophyllales	
Equisetales	Horsetails
Pteropsida	
Filicineae	Ferns
Coenopteridales	
Ophioglossales	
Marattiales	
Filicales	
Gymnospermae	
Pteridospermae	Seed Ferns
Cordaitales	
Bennettitales, Cycadales	Cycadophyta
Ginkgoales	
Coniferales	Conifers
Caytoniales	
Angiospermae	Flowering Plants
Monocotyledonae	
Dicotyledonae	

Thallophyta is an old phylum name applied to relatively simple plants which are sometimes considered to fall in several major groups or phyla. Although somewhat inexact, it may appropriately be used in this discussion, since all the plants included in it are of minor importance in the fossil record and rarely include the reproductive structures on which the classification of corresponding living plants is based. Details of classification of the phylum Bryophyta are not here included, since mosses and liverworts are among the most rare plants in the fossil record. In placing all higher plants in the phylum Tracheophyta we are following the classification developed by A. J. Eames, one which appears to bring out fundamental resemblances and differences between major groups more fully than the older separation into Pteridophyta and Spermatophyta. In the major divisions or subphyla of the Tracheophyta, ferns are separated from such diverse groups as the club mosses and horsetails, and are placed with the seed ferns and other seed-bearing plants in the subphylum Pteropsida. This plan of classification, far better adapted to the major groups of plants making up the fossil record than are the older classifications. will be further discussed in the consideration of the floras of the Palaeozoic era.

In handling the smaller categories of classification, problems arise because of the dissociated occurrence of most plant organs; for example, it is unusual to find leaves or fruiting structures attached to stems. It is therefore convenient to constitute form-genera each including a different part of what may be the same plant or a group of related plants. In a common Palaeozoic genus of Lycopsida, the stems are placed in the form-genus *Lepidodendron* (scale tree), the detached leaves in *Lepidophyllum* (scale leaf), and the cones in Lepidostrobus (scale cone); the root-bearing parts which are indistinguishable from those of an allied

genus *Sigillaria* are grouped with those of the latter genus in the form-genus *Stigmaria*. In some cases genera have been independently described for separate organs which are later found in association. A Carboniferous stem described as *Medullosa* is now known to have borne fronds called *Alethopteris;* some of the three-ribbed fruits known as *Trigonocarpus* have been found attached to *Alethopteris;* so it is apparent that all three of these names refer to different parts of the same plant. Form names may also be appropriately applied to plants whose characters show only a family resemblance. *Laurophyllum* is the generic name assigned to leaves which appear to belong to the laurel family (Lauraceae), but which do not show distinctive characters of any particular genus.

The Plant Record Through Geologic Time.—Geologic time is divided into eras of which the oldest, known as the Archaeozoic, shows no direct evidence of the existence of life. The fossil record of the four subsequent eras, covering an estimated 1,500,000,000 years, shows increasing complexity in the character of plant life. We shall consider the vegetation of these eras in their sequence from the dawn of life down to the present.

PLANTS OF THE PROTEROZOIC ERA

There is no evidence of land plants during this early era of earth history. In fact even the existence of plants in the sea has been questioned by many competent students. However in recent years evidence has been accumulating to show that primitive plants were abundant in some parts of the Proterozoic seas, and that certain beds of limestone and dolomite are largely made up of the calcareous structures which they secreted as supports for their plant bodies.

Thallophyta.—Algae fall in this group of thallose and filamentose plants. Algal reefs in the Belt series of Montana, first studied by C. D. Walcott, have received detailed consideration by C. L. and M. A. Fenton, who describe several species of the genus *Collenia* which they consider to represent blue-green algae (Cyanophyceae) or red algae (Rhodophyceae). Colonies made up of great numbers of these microscopic plants have built up masses and columns of calcium carbonate with concentric laminations, but the actual structures of the plants themselves have not been preserved. Similar reefs have been reported in rocks of this age as far north as Yukon Territory and southward to Grand Canyon National park in Arizona; they also occur in the iron-bearing deposits of the Lake Superior and Hudson bay regions. Layers of graphite and black slate in Proterozoic formations of the Lake Superior district and elsewhere may be considered to represent accumulations of ancient plants or animals, though no details of any structures of such organisms have been preserved. The only other indications of Proterozoic plants are minute bodies interpreted as bacteria from the iron ore of Michigan; their resemblance to the living *Chlamydothrix* has been suggested. It is significant that no plants with a higher degree of organization than these simple Fungi and the calcareous Algae have ever been found in the Proterozoic rocks representing this early chapter of earth history.

PLANTS OF THE PALAEOZOIC ERA

In this great division of geological time plants became established on the land and most of the major groups became differentiated. These groups will be considered in systematic order, and the floristics (distribution and relative abundance) of the more important types will be discussed with their ecology at the end of this section.

Thallophyta.—*Algae.*—As a class these are difficult fossils to study. The plant body is soft in most cases, and the reproductive structures, which are most useful in determining their systematic position, are rarely preserved. In many instances fossil algae have been named and described from material which may represent the tracks of worms or other animals in the mud, or the rill-marks produced on the ocean bottom by water currents. *Cryptozoon* from the Cambrian of New York, and in rocks of younger age, has been described as an alga on the basis of its concentrically laminated structure, which is suggestive of *Collenia.* Its organic nature has been questioned because of the absence of any evidence of a cellular framework, but its mode of occurrence and general resemblance to living seaweeds indicate that most of the specimens referred to *Cryptozoön* are of organic origin. There are a number of well-defined types of algae not known to occur in rocks older than the Palaeozoic. *Marpolia,* from the Cambrian of British Columbia, shows several cellular filaments united in a sheath, like the living *Schizothrix. Archaeothrix oscillatoriformis* from the Middle Devonian chert of Aberdeenshire is another blue-green alga consisting of cellular filaments so like those of some living Cyanophyceae that there is no doubt of its systematic position in that family. A deposit of bituminous shale known as Kuckersite from the Ordovician of Estonia is made up of countless millions of minute bodies resembling the living *Gloeocapsa;* the name *Gloeocapsonzorpha* has been applied to these cell-aggregates.

Several fossil algae of the Palaeozoic appear to be referable to a more advanced-type, the green algae (Chlorophyceae). An Ordovician genus, *Dimorphosiphon,* is remarkably like the living genus *Codium* but differs in having a secretion of lime on its surface; in this respect it seems related to *Halimeda,* a reef-forming, calcareous seaweed in the tropical seas of today. In the Ordovician limestone of the Girvan district in Scotland is another related alga named *Girvanella;* this tangled mass of minute tubes may be a blue-green rather than a green alga. The family name Protophyceae has been suggested for those ancient fossils which seem to be algae but are not readily assignable to a definite systematic position. Certain bituminous shales and cannel coals of the Carboniferous and Permian are made up largely of *Pila* and *Reinschia. A* similar living genus, *Botryococcus,* stores up oil in its cells, and a like origin may be suggested for the combustible deposits containing *Pila* and *Reinschia.*

The red algae of Rhodophyceae include many of the more important reef-building algae of today. The most characteristic genus, *Lithothamnium,* has a world-wide distribution, and is known to have lived as far back as the Cretaceous. It had an allied representative in the Carboniferous seas of northern England known as *Solenopora garwoodi,* which with related forms built layers of limestone in seas widely distributed over the earth from the Ordovician down to the Jurassic period. Red algae are in general difficult to determine from these calcareous reefs. and it is possible that many other Rhodophyceae are present in Palaeozoic limestones.

The *Charophyta* or stoneworts represent a highly specialized group which are sometimes considered as separate from the Algae. A well-known living example is *Chara* which lives in fresh or brackish water where its lime-encrusted stem and branches may accumulate to form marl. A similar plant named *Algites* has been recorded from a Devonian swamp. Here also were living some of the oldest known land plants, the Psilophytales, considered below.

Fungi.—*The* pre-Devonian period of the Fungi is largely limited to infrequent records of bacteria, which are so poorly preserved as to have little scientific value. But in the later rocks of the Palaeozoic there are many examples of other fungi which lived as parasites in the tissues of trees and shrubs. These fall largely in the group known as Phycomycetes as shown by their nonseptate hyphae. While some of the parasitic types of fungi doubtless had harmful effects on their hosts, as do their modern descendants, there appear to have been others which had established a symbiotic relationship. There are several later Palaeozoic records of the roots of trees in which the distribution of fungal hyphae suggests such a beneficial parasitism.

Thallophyta of Uncertain Systematic Position.—In Silurian and Devonian rocks from Europe and North America, there is a large-stemmed plant, *Nematophyton,* which appears to represent one of the Algae. The stem reaches a diameter of two feet, which is larger than that of any living alga. It has a structure which is typically algal; loosely packed tubes without cross-partitions make up the bulk of the stem, following a sinuous course along its axis; their smooth walls lack the pits and bands which characterize the conducting cells of vascular plants. Associated with these relatively thick tubes are narrower tubes resem-

bling the filaments of fungi. In one specimen in which the outer surface is preserved, there is a narrow zone where the tubes turn outward and meet the surface at right angles. No roots, branches or reproductive organs are known. Occurrence of *Nematophyton* in a peat deposit confirms the suggestion that it was a land plant. In the absence of any structures which would support so large a stem upright, we may suppose that it sprawled upon the ground in swampy situations. Other simply organized plants which may have shared this terrestrial habitat are *Parka* and *Foerstia. Parka* is represented by circular impressions on whose surface occur groups of spores with resistant walls like those of plants now growing in contact with the air. *Foerstia* is represented only by the tips of branches containing cutinized spores in groups of four (tetrads) which likewise resemble those of land plants. All of these little-understood plants occur in rocks laid down during the Silurian or Devonian periods, at a time when the land habit was being developed by plants and animals. When known from more complete material they may be found to represent the first plants which left the relatively sheltered environment of seas and lakes, and established themselves on the more diversified shores of the continents.

Bryophyta.—Mosses and liverworts are found widely over the world at the present day; they are terrestrial in habit, commonly living in moist situations. If, as seems probable, their ancestors in past ages were likewise small and lacking in woody tissues, it is not surprising that they have so infrequently entered the fossil record. On structural grounds they must be considered a simple and probably primitive type of plant. It has been suggested that the problematical *Nematophyton, Parkia* and *Foerstiu* may represent a stage of development intermediate between the Thallophyta and Bryophyta.

Fossil liverworts from the Upper Carboniferous of England have been referred by J. Walton to the genus *Hepaticites*. These are small plants, in some species branching dichotomously and with parallel rows of leaves. Ancient equivalents of the mosses from the Upper Carboniferous of France are assigned to *Muscites*. The principal value of these rare and incomplete fossil members of the Bryophyta is that they demonstrate the existence during the Palaeozoic era of an ancestral group of plants which affords, as Seward has stated, "an impressive instance of the persistence through a long succession of ages, of a delicate organism undisturbed by the influences which transformed again and again the character of the world's vegetation." (Seward, *Plant Life Through the Ages,* by permission of the Cambridge University Press.)

Tracheophyta.—This phylum, including plants with vascular tissues, is divided into four major divisions or subphyla, all of which make their first appearance during the Palaeozoic and become numerous and highly diversified before its close. The vascular tissues of the stem comprise: (1) phloem, made up of sieve tubes and other cells through which food is transferred from one part of the plant to the other; and (2) xylem, made up of elongated cells (tracheids), or groups of cells fused end to end (tracheae) to form vessels, which conduct water and mineral nutrients. The cells of the xylem, including fibre cells, become thickened (lignified) by addition of lignin, giving them added strength and hardness. Without the mechanical support of such tissues it would not be possible for land plants to rise as trees for tens or even hundreds of feet above the ground.

PSILOPSIDA.—Included here are the Psilophytales, the most primitive vascular plants and the first to establish themselves on the land. This order appears to be ancestral to the living Psilotales, represented by two simple genera of the tropics and southern hemisphere. It is noteworthy that there is no intermediate record from the Middle Devonian, at which time the Psilophytales became extinct, down to the present; so it may be supposed that since Devonian times the ancestors of the modern Psilotales must have been small and few in number.

The Psilophytales are defined as simple plants with dichotomously branching stems bearing terminal sporangia and lacking true roots and leaves. Their resemblance to the living *Psilotum* was first noted by Dawson when he described *Psilophyton* from the Devonian of Canada in 1859. The most significant occurrence of this order was made known by R. Kidston and W. H. Lang in 1917 when they described the middle Devonian flora from the Rhynie Chert of Scotland. The genus *Rhynia* (fig. 2, B; Pl. II, figs. 1, 2) had a horizontal rhizome from which rose cylindrical, sparsely-branching shoots 8–20 in. in height with sporangia at their tips. The internal structure of the shoots shows the simplest type of vascular tissue (Pl. II, fig. 1), a protostele made up of a single strand of xylem (wood) enclosed in a sheath of phloem (bast), with a broad zone of surrounding cortex and an epidermis made up of a single layer of cutinized cells; there are a few simple stomata on the epidermis. *Hornea* was a similar plant, differing in its swollen base which lacks vascular tissues, and in having columellate sporangia resembling those of certain Bryophyta. *Asteroxylon* (fig. 2, A) had longer shoots clothed with leaflike scales, becoming naked at their tips where some of them bear sporangia. The cross section of the stem shows a stellate protostele with small vascular strands extending up to but not into the bases of the scales; in true leaves there is a vascular connection from the wood into the nerves.

AFTER KIDSTON AND LANG BY COURTESY OF THE ROYAL SOCIETY OF EDINBURGH

FIG. 2.—TYPES OF LAND PLANT FROM THE DEVONIAN OF SCOTLAND. A. ASTEROXYLON, B. RHYNIA

Greater complexity of reproductive structures is apparent in *Zosterophyllum,* a widely distributed Lower Devonian genus, and in *Bucheria,* which occurs in beds of the same age in Wyoming, in which genera the sporangia are borne in terminal spikes. These plants and the genera above mentioned show many resemblances to the Algae and the Bryophyta. But in spite of their simplicity, there are advances over these lower plants which place the Psilophytales at a higher level of development. The Psilopsida may be considered ancestral to the other groups of Tracheophyta which like them were becoming established on the land during the Palaeozoic era.

LYCOPSIDA.—This group includes among its fossil members some of the largest and most abundant trees of the later Palaeozoic forests. Surviving examples such as *Lycopodium* and *Selaginella* are small and inconspicuous, and largely confined to low latitudes. In their vegetative characters certain members of this subphylum, both fossil and modern, show sufficient resemblance to the spiny types of Psilopsida to suggest that the latter bear an ancestral relationship. An important difference is the position of the sporangia at the end of the axis in the Psilopsida, while in the Lycopsida they are situated on the upper side of the leaves or at the leaf bases. Two primitive genera of Lycopsida appear to stand in an intermediate position with the Psilopsida. *Drepanophycus,* known from the Lower Devonian of Canada, northwestern Europe, China and Australia, has the vegetative appearance of *Psilophyton,* but is a typical lycopsid in having sporangia attached on the upper side of the spines near their bases, as shown by R. Krausel and H. Weyland. In 1935 Lang and Cookson described a second genus, *Baragwanathia,* from the Upper Silurian of Australia, which also shows a combination of lycopsid and psilopsid characters. The stems of this plant are similar to those of *Asteroxylon* in their structure, but with a direct connection by leaf traces between the woody axis and the foliar organs, making them true leaves. Sporangia occur along the upper end of the stem among and possibly attached to the leaves, instead of on naked tips as in *Asteroxylon* and related psilopsids.

Another ancient genus of the Lycopsida is *Protolepidodendron* (Pl. I) from the Middle Devonian of Europe and Australia. While it shows a resemblance to modern *Lycopodium,* it differs from this and most other Lycopsida in having its leaves forked near the tip; this may represent a tendency toward the dichotomy which characterizes the Psilopsida and other primitive groups.

The trunk of Archaeosigillaria, a second widely distributed Devonian genus, shows vertically placed leaf scars near the base like Sigillaria, and spiral scars above like Lepidodendron.

Lepidodendron, the scale tree, ranged from Upper Devonian to Middle Permian, and its stems are among the most abundant fossils of the Carboniferous. Its slender trunk reached a height of more than 100 ft. while above the crown of forking branches rose for a further 20 ft. At the base were rootlike divisions of the trunk, dichotomously branched and spreading, which bore roots; these basal appendages, known as Stigmaria (fig. 1, a), may extend from the trunks down into sandstone or shale underlying the coal seam, giving evidence that the coal was formed in the actual place of growth of the trees from whose remains it was accumulated. Covering the smaller branches of the crown were spirally placed, lance-shaped leaves a few inches to nearly three feet in length; they were shed when the part of the plant bearing them reached a certain age, leaving a diamond-shaped scar on the leaf base (Pl. II, fig. 3). The stem is made up of a slender cylinder of primary wood with or without pith inside, surrounded in most species by a broader cylinder of secondary wood with no indication of growth rings. Unlike the stems of conifers and angiosperms, in which this woody portion makes up 80–90% of the cross section, the stele of Lepidodendron made up only 9–14%. It would have been impossible for such tall trees to be supported by so slender a core of wood alone; the development of a thick periderm made up of fibrous tissue in the outer part of the stem gave it the necessary mechanical strength. The cones (Lepidostrobus and other cone genera) were like those of *Selaginella* only much larger; most of them produced two types of spores (heterospory), with the sporophylls bearing megasporangia at the base of the cones; sporangia of both types were borne on the upper surface of the sporophylls. Vast numbers of spores were produced, as indicated by the fact that some coals of Carboniferous age consist largely of the compressed spores of *Lepidodendron* and its closely related but less branched associate, *Sigillaria*. Other distinguishing characters of Sigillaria are its longer leaves with once-forked veins, and the vertical arrangement of the leaf scars which are rounded or hexagonal in shape.

Lepidocarpon.—Certain isolated cones and sporophylls have been found with attached megasporangia containing only one large megaspore (fig. 1, b). At maturity an integument formed by an outgrowth from the sides of the sporophyll stalk enclosed the megasporangium except for a narrow opening along the top which may have served as a micropyle. The sporophyll appears to have broken away from the parent plant before fertilization took place, or possibly even before microspores were deposited on the sporangium, unlike a true seed in which an embryo is usually developed before the seed is liberated.

Miadesmia.—This genus represents the fructification of an herbaceous lycopsid in which the seed habit is even more fully developed. Here the integument is prolonged in the form of a sheath beyond the top of the sporangium, with the micropyle a rounded pore at the top. Like *Lepidocarpon* this seed differs from those of all other groups in having the entire sporophyll shed with it.

Lycopodites and *Selaginellites*.—In addition to *Miadesmia* there are several other lycopsids which appear to have had an herbaceous habit like that of living club mosses. Such plants are much less common than the tree types and less completely preserved.

SPHENOPSIDA.—Members of this subphylum are characterized by jointed stems with whorls of leaves and in some cases cones attached at the nodes. Most abundant during the Palaeozoic were the calamites which resemble the modern horsetail, Equisetum, in general appearance but were tall trees instead of herbs. Other extinct types of this group show relationship to the ancestral Psilopsida and will be first considered.

Hyeniales.—The oldest known articulate plant is *Calamophyton* from the Middle Devonian of Germany. Shrublike in habit, it bore slender, dichotomous leaves on the nodes of its stem and branches which were less regularly jointed than in later forms. Sporangia were borne in pairs on fertile branchlets which were grouped into a loose terminal cone; these branchlets appear to correspond to the sporangiophores of more advanced types of Sphenopsida. The terminal position of the sporangia on branchlets suggests a relationship to the Psilopsida. Hyenia was generally similar in appearance to *Calamophyton*, but shows no evidence of a jointed stem, and had leaves more deeply cleft. In both these genera the leaves and fertile branchlets are homologous, and it has been suggested by Eames that the same relationship holds for the Equisetales in which these structures have developed greater outward dissimilarity.

Sphenophyllales.—*Sphenophyllum* (Pl. II, fig. 4), a genus common in the Carboniferous, ranges from the Upper Devonian through the Permian. The plant grew in the form of a slender shrub which may have supported its branches by scrambling over other plants. The stems are jointed with whorls of small wedge-shaped leaves, which are often deeply dissected. The leaves of one whorl lie immediately above those of the whorl below and are usually in multiples of three. This arrangement is related to the structure of the stele which is triangular in section and has a central column of xylem with no pith; at the nodes two vascular strands pass out from each corner to supply the leaves. The stems and roots have a considerable amount of secondary vascular tissue. The slender, terminal cones are built up of whorls of leaflike bracts, and are relatively complex as compared with other members of the Sphenopsida. Sporophylls are divided into an adaxial and abaxial lobe, the latter usually sterile but in some species fertile. Commonly homosporous, certain cones (*Bowmanites*) show heterospory.

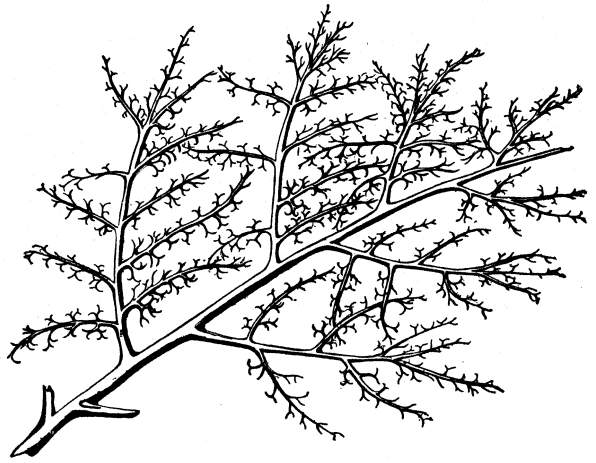
Equisetales.—This was the most abundant order of the Sphenopsida during the Palaeozoic era, and the only division which has survived down to the present. The oldest known genera, Asterocalamites and Pseudobornia, are recorded from the Upper Devonian; these were small trees with jointed stems and whorls of large, forked leaves. They show a lack of alternation of the ribs along the stem from node to node which characterizes later members of the order. The cones resemble those of Equisetum in being without bracts.

Calamites.—During the Carboniferous the trees referred to this stem genus reached a height of more than 100 ft. and a diameter of 2–3 ft. They rose from rhizomes of treelike proportions. The stems show prominent ribs alternating in position from joint to joint; these ribs, representing the position of strands of woody tissue, are conspicuous in fossil specimens, but were covered in life by a smooth bark which is rarely preserved. Calamites differed from Equisetum in size, though it is possible that some of the specimens considered to be branches may represent herbaceous individuals. They also differed from living forms in the development of secondary wood and of a thick periderm for support but were similar in having a hollow central cavity. Jointed branches from the nodes bore whorls of linear leaves distinct at their bases (*Asterophyllites*), or leaves more broadly rounded and fused into a sheath around the stem (Annularia, Pl. II, fig. 8). The cones show a considerable range in form and structure, indicating that several distinct types of plants may be included in Calamites. *Calamostachys* was a terminal cone with whorls of sporangiophores similar to those of Equisetum but with alternating whorls of sterile bracts. Two types of spores (heterospory) are found in some species, but the difference in size is less marked than in most of the lycopsids. Heterospory and the growth of secondary wood suggest development in the direction of the Gymnospermae. Bodies which have been interpreted as seeds have even been reported on whorls of Annularia from the Carboniferous of Missouri, but since they lack internal structure the development of the seed habit by any of the Sphenopsida may not be considered as established.

PTEROPSIDA.—In placing the ferns and the seed plants in the same subphylum, recognition is given to fundamental resemblances of leaf and stem which seem more significant than the presence or absence of seeds. Development of seeds by certain Palaeozoic scale trees and possibly by one of the horsetails and the abundant occurrence of seeds in association and contact with leaves of the Pteridospermae, all point to the unimportance of the seed habit as a basis for major grouping. As further pointed out by Eames,

whose system of classification is followed here, ferns are more closely related to Gymnospermae and Angiospermae than to the "fern-allies" of the old classifications, the scale trees (Lepidophyta) and the horsetails (Arthrophyta). Spore-bearing ferns are here designated as Filicineae, a class of the *Pteropsida,* along with Gymnospermae and Angiospermae. Seed-bearing ferns are designated as Pteridospermae, the most ancient and primitive order of the Gymnospermae.

Filicineae.—In this class are placed plants with relatively large, complex fronds, connected by large leaf traces with a simple stem



FROM KRAUSEL UND WEYLAND, "DEVONFLORA" (SENCKENBERGISCHE NATURFORSCHENDE GESELLSCHAFT)

FIG. 3.— ANEUROPHYTON, ONE OF THE MOST ANCIENT FRONDS KNOWN. FROM THE MIDDLE DEVONIAN OF GERMANY

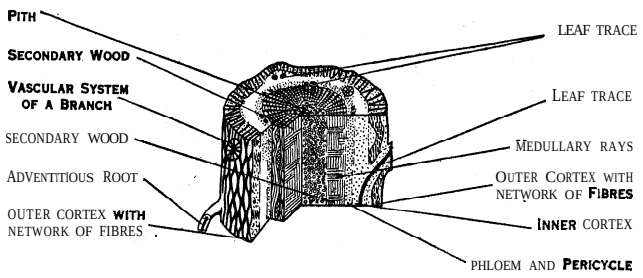
which rarely produces secondary wood; sporangia are commonly borne on the margins or under surface of the leaf, and have a dehiscent mechanism known as an annulus. Heterospory is limited to two living families, and is not certainly known among Palaeozoic ferns. Many of these older members of the Filicineae are preserved as stems; they were dichotomously branched with their upper ends serving as leaves. Most of these foliar organs did not have wide blades; sporangia characteristic of the ferns were borne on the fronds singly or in terminal clusters. The general appearance of these ancient ferns must have been wholly different from most modern members of the Filicineae.

Coenopteridales (*Primofilices*).—This order was established by Seward to include extinct ferns with characters now found to occur in several living families. *Iridopteris,* described by C. A. Arnold from the Middle Devonian of New York, is a stem with definite psilopsid resemblances but with other characters which seem to establish it as the oldest known fern. Nothing is known of its leaves and fructifications. *Asteropteris* from the Upper Devonian appears to have been herbaceous; it is represented by petrified stems with whorls of leaves, and seems more nearly related to the Ophioglossales than to any other living ferns. Ferns appear to have been more numerous in the Lower Carboniferous than at any other time in the Palaeozoic. They are largely represented by stems, and such leaves as are known do not have as broad blades as modern types. Another difference is the position of the sporangia which hung from the tips of frond branches. The best known genus. Psaronius, was an Upper Carboniferous tree-fern whose stem resembles that of the Marattiaceae, a primitive family now living in the tropics. Unlike modern ferns its fronds were commonly borne in two to four vertical rows. Some fronds attached to *Psaronius,* such as the common form-genus *Pecopteris,* branched in one plane as in living ferns, but Palaeozoic ferns more commonly branched in several planes, giving them a bushy aspect. Fertile fronds such as Asterotheca bore sporangia in circular clusters or sori like those of some modern ferns. The number of spores produced was large, as in the more primitive living ferns. Stem and frond genera of several other types have been described as resembling Osmundaceae, Schizeaceae and Gleicheniaceae, but no well-defined representatives of these iamilies appear in the fossil record before the Mesozoic era. Few Palaeozoic ferns are sufficiently well known to indicate that they are the direct ancestors of modern ferns, but certain of the living Ophioglassaceae and Marattiaceae may represent their lineal descendants.

Gymnospermae.—Five orders are represented in Palaeozoic rocks, of which the Pteridospermae, Cordaitales and Bennettitales are now extinct, the Ginkgoales are represented by only a single living genus and species, and the Coniferales alone make up an important part of modern vegetation. There is some reason to believe that certain of these groups may represent categories higher than orders.

Pteridospermae.—The seed ferns were among the most abundant plants of later Palaeozoic time, and continued in reduced numbers into the middle of the Jurassic period of the Mesozoic era. Their stems show resemblance both to ferns and cycads, and their occurrence in the Devonian as the first seed-bearing plants adds confirmation of their ancestral relationship to the Bennettitales and Cycadales. Fronds of seed ferns are abundant in rocks of Carboniferous age, and were interpreted as true ferns until 1903 when seeds were found attached to Sphenopteris. Since then most of the form-genera of fernlike leaves in Palaeozoic rocks have been found to bear seeds. Several common types, notably *Pecopteris,* appear to represent the foliage both of seed ferns and true ferns, and their systematic position can be established only when reproductive bodies are attached to them. When detached it may be impossible to distinguish the flattened type of pteridosperm seeds from those of the Cordaitales, but radiospermic seeds all seem referable to the Pteridospermae. The wood of Pteridospermae differs from that of the Filicineae in its secondary thickening.

One of the oldest pteridosperms is *Aneurophyton* from the Middle Devonian of Germany and New York. Its stem shows a cylinder of secondary wood surrounding a three-angled core of primary xylem. Its leaves represent the most primitive type of frond (fig. 3), triply branched with the smallest branches bearing short forked appendages, and with no development of leaf blades. Aneurophyton shows a general resemblance to Eospermatopteris (Pl. I, fig. 1), described by W. Goldring from the Middle Devonian of New York. The stems of *Eospermatopteris* occur largely as casts with little structure preserved; the bases of the stumps are bulbous, narrowing upward to trunks with an estimated height of 30–40 ft. and a maximum diameter of 2–3 ft. Like Aneurophyton the fronds are compoundly tripinnate with slender, bilobed pinnules, and larger specimens indicate a total length of 6–9 ft. Seeds were borne in pairs probably near the tip of the frond and resemble those of Lyginopteris as described below. Smaller bodies are interpreted as part of the male fructification. *Sphenopteridium* and *Sphenopteris* show the beginning of a leaf blade in the broadening of the pinnules on their fronds, and Archaeopteris, one of the most widespread Upper Devonian plants, has fronds with rows

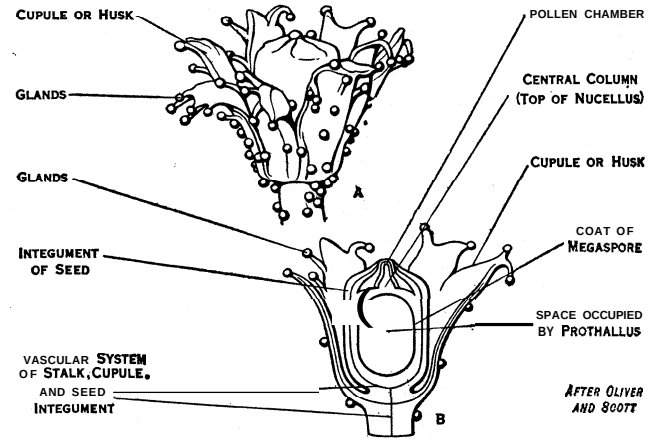


AFTER W. C. WILLIAMSON, IN "TRANSACTIONS OF THE ROYAL SOCIETY"

FIG. 4.—DIAGRAMMATIC RECONSTRUCTION OF THE STEM OF LYGINOPTERIS

of wedge-shaped pinnules resembling those of the living fern *Adiantum. Lyginopteris oldhamia* the most completely known pteridosperm is of Upper Carboniferous age and is of common occurrence in the coal-measures around Oldham and other parts of Lancashire. It is found petrified in the coal balls and also as impressions in the shales forming the roofs of the seams. The frond by an equal forking of the leaf-stalk is divided into two equal divisions. The stem (fig. 4) varies from 2 mm. to 4 cm. in diam-

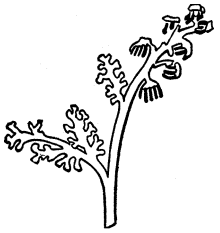
eter. There is a pith forming the core of the stem surrounded by a ring of scattered vascular strands which are connected with the leaf supply system. In older stems the ring of strands is surrounded by a considerable quantity of secondary wood and bast. The outer cortex contained long anastomosing bands of fibres which formed a reticulum just below the epidermis. In *Heterangium,* a closely allied genus, the centre of the stem is occupied by a solid core of primary xylem and the strands of the leaf-trace system were incorporated in the outer part of the primary xylem. F. W. Oliver and D. H. Scott in 1903 were able to identify a petrified seed found in a coal bail, as the seed of *Lyginopteris* by the presence on its husk of glandular spines exactly like those on the frond and stems of *Lyginopteris.* The seed, *Lagenostoma lomaxi* (fig. 5, *A* and B), is enclosed in a lobed husk or cupule; it is barrel shaped and its integument is furnished with a vascular system. One part of the nucellus (sporangium wall) is modified to form a complicated pollen chamber or cavity in which the pollen became lodged. In structure the seed is similar to those of the living cycads or ginkgo but the pollen-chamber is rather more complicated than any of these iiving plants. Kidston described some tassels of microsporangia (fig. 6) attached to small pieces of fronds which bore leaflets of the same shape as those of *Lyginopteris* and there is no doubt that they represent the pollen producing organs of this plant. In most seed-bearing plants the microsporangia are borne on highly modified structures, stamens, which are quite unlike leaves in appearance; but in many pteridosperms the fronds which bear the microsporangia are like the sterile foliage fronds and in this respect the pteridosperms are primitive.



BY COURTESY OF THE COUNCIL Of THE ROYAL SOCIETY AND Of PROF. OLIVER

FIG. 5.—SEED AND HUSK OF LYGINOPTERIS

A. Reconstruction of the seed in its husk. B. Seed and husk cut longitudinally



FROM SCOTT, 'STUDIES IN FOSSIL BOTANY' (A & C BLACK)

FIG 6. — CROSSOTHECA HOENINGHAUSI

Male fructification of *Lyginopteris*

The *Medulloseae,* another important group of pteridosperms, of Carboniferous and Permian age had fernlike foliage belonging to the form-genera *Neuropteris* and *Alethopteris* (Pl. II, figs. 5, 7). The stems, *Medullosa* (fig. 1, c), which are known to belong to the group are peculiarly complicated in structure; in place of the usual single vascular column they had several. Each vascular column was in structure like that of *Heterangium* and the stem could be briefly described as a polystelic *Heterangium.* The spirally arranged leaf stalks are of large size and contain a large number of small collateral vascular strands. Seeds have been found attached to fronds of *Neuropteris* (fig. 7, B) and *Alethopteris. Trigonocarpus* is a genus of seeds which were borne on some species of *Alethopteris;* it resembles the seeds of living cycads in having a testa consisting of both soft and stony layers (Pl. II, fig. 6). The micropyle was of very considerable length. The pollen-producing organs of these plants (fig. 7, A and C) are still imperfectly known. *Potoniea* (fig. 7, C) very probably represents the pollen-bearing flower of a *Neuropteris.* The structures with toothed margins were originally cup-shaped with microsporangia placed on the inner surface of the cup. *Linopteris* an allied frond-genus had similar microsporangiate fructifications. Another fructification *Wltittleseya* had large cups more than an inch deep and large pollen grains have been isolated from them.

Several genera of seed ferns based on fronds, such as *Gigantopteris, Taeniopteris* (in part), *Glossopteris, Gangamopteris* and *Gondwanidium* add significant data regarding late Palaeozoic climate and distribution, and will be considered below in the section on floristics and ecology.

Cordaitales.—Unlike the pteridosperms, the Cordaitales have little in common with the ferns and may be regarded as typical gymnosperms. *Cordaites,* which lived during the Carboniferous and Permian, was a lofty tree unbranched except near the summit (fig. 8). The stem resembles that of conifers, especially *Araucaria,* except that the pith is much larger; but like most other Palaeozoic woods from the northern hemisphere no evidence of seasonal periodicity is indicated by growth rings.

The wood of some genera has features in common with pteridosperms. The vascular supply to the leaf is represented by two of the primary strands surrounding the pith, which at higher levels pass outward and on reaching the base of the leaf fork repeatedly and link up with the numerous veins of the leaf blade. This double vascular connection with the axis is also found in *Ginkgo* (maidenhair tree) and in the pteridosperms. The leaves of *Cordaites* (Pl. III, fig. 1) are large, linear or spatulate in shape, and traversed by numerous parallel veins. In their structure the leaves of some species show close resemblance to the cycads. Seeds occur in cones, but were borne on short branches rather than on cone-scales as in the conifers. Pollen grains were contained in microsporangia attached to long, slender stems rising from between small, crowded scale leaves.

Several types of gymnospermous wood from Devonian and Carboniferous beds may be referable to the Cordaitales, although in absence of associated leaves and fruiting organs their relationship is at present uncertain. *Callixylon* and *Dadoxylon,* of doubtful taxonomic status, are stem genera which show a striking resemblance to the living conifer, *Araucaria,* as do such definitely cordaitalean genera as *Cordaites* and *Pitys.* We may conclude that relationships in stem and leaf structure between the Cordaitales and the Pteridospermae, Cycadales, Ginkgoales and Coniferales, indicate that these orders all have descended from a common

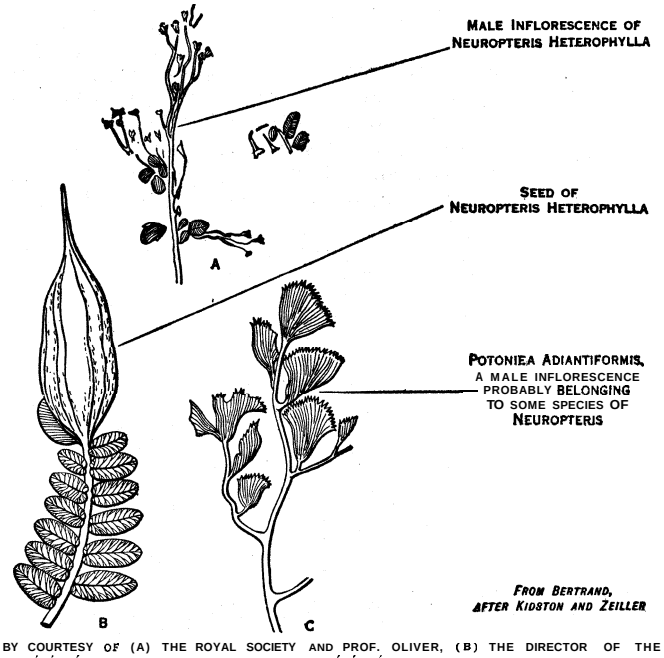


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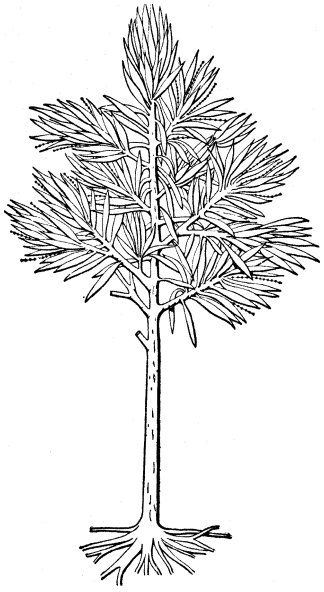
FIG. 7.—PTERIDOSPERM FRUCTIFICATIONS

ancestral stock. There is no certain evidence of the persistence of Cordaites and its allies after the end of the Permian period, although the occurrence of large leaves of similar appearance as late as Jurassic time suggests such survival. The living coniferous family, Araucariaceae, whose first certain appearance is recorded in the Triassic, and which may be represented by the genus Araucarites from the Permian of France, may trace its ancestry to the Cordaitales.

Ginkgoales.—Several leaf genera from the Devonian, such as *Psygmophyllum* and *Ginkgophyllum,* have been doubtfully referred to this order, but nothing is known of their stems or fructifications. The wedge-shaped leaves of *Psygmophyllum* also are found in Carboniferous and Permian rocks, where their variation in form suggests that they may belong to several groups of plants. The genus Saportaea from the Lower Permian of West Virginia and north China is represented by leaves which closely resemble those of living *Ginkgo.* In the flora from China. T. G. Halle also recognizes leaves of Baiera, and *Rhipidopteris,* two common Mesozoic genera. These leaves. may well represent the late Palaeozoic ancestors of the Ginkgoales which became abundant during the Mesozoic era, but in absence of other than foliar structures the presence of this order in Palaeozoic time is not fully established.



AFTER GRAND EURY IN SCOTT, "STUDIES OF FOSSIL BOTANY" (A & C BLACK)

FIG. 8.—RESTORATION OF A CORDAITES TREE, SHOWING ROOTS, TRUNK AND BRANCHES BEARING LONG LANCEOLATE LEAVES AND FRUCTIFICATIONS

Bennettitales.—These ancient cycadlike plants are represented in later Palaeozoic rocks by fronds belonging to several genera which continued into the Mesozoic. during which era the order had its widest development. *Pterophyllum* appears in the Upper Carboniferous of Europe, becoming more widespread in rocks of later age. Dioonites is first recorded from the Permian of north China. *Sphenozamites* occurs in beds of that age in France. While little is known of these plants, their presence over a wide area at the end of the Palaeozoic era indicates that the *Bennettitales* had a long antecedent history before their period of first abundance, the Triassic.

Coniferales.—There are relatively few representatives of this now abundant order of gymnosperms until near the end of the Palaeozoic era. Stems with typical araucarian structure in their secondary wood suggest that the remote ancestors of the Araucariaceae may have been in existence as early as Middle Devonian time. However these seem more on the line of cordaitean or seed fern stocks, and no true conifers are known from rocks older than Upper Carboniferous.

Walchia.—This genus appeared during the Upper Carboniferous, and was most common during the Lower Permian, after which it became extinct. It was a tree with foliage shoots resembling *Araucaria excelsa* (Pl. III, fig. 4), and had male and female cones, the latter differing in mode of seed attachment and in other details from living conifers, and resembling cordaites. *Lecrosia* had needle-shaped leaves and oval cones with winged seeds. *Ullmannia* and *Voltzia* are two of the common Permian genera, and the latter continued to live through the Triassic period of the following era. A possibly related form, Palaeotaxites, is represented by leafy twigs with attached fruits which resemble those of the modern *Juniperus.* Genera confined to the southern hemisphere are *Paranocladus* and *Walkomia.*

Voltzia.—This genus is an example of an ancient and generalized type which shows resemblances to at least two major lines of living conifers. In its habit, in the form and spiral arrangement of its leaves, and in the structure of its wood, Voltzia shows a resemblance to the Araucariaceae, a family widely distributed in both hemispheres during the Mesozoic era and now limited to southern latitudes; its cone-scales (Pl. III, fig. 2) suggest relationship to certain of the Pinaceae (tribe Abietineae), plants well represented during the later Mesozoic, and now most abundant in north temperate regions. In the occurrence of three seeds on its cone-scales. *Voltzia* differs from all living conifers.

Floristics and Ecology of Palaeozoic Land Floras.—Any accurate understanding of the distribution, relative abundance and environments of these ancient floras is made difficult by the incompleteness of the fossil record and by the fact that few Palaeozoic types have survived to the present for comparison. However the vegetation of the past gives us more reliable information than any other body of evidence for reconstructing past topography and climate, and is also useful in determining the general distribution of the continents and oceans. It is therefore desirable to go as far as the evidence permits in interpreting the physical indications of Palaeozoic plants.

Development of *the* Land *Habit.*—This is a subject which has long engaged the interest of botanists, and several possible types of plants have been suggested as those most likely to have made the transfer from a water to a land environment. We shall consider briefly the evidence offered by fossil plants. The simplest known land plants are *Rhynia* and Hornea, psilopsids of the Middle Devonian Rhynie Chert. Their naked branching stems tipped by simple sporangia differ from those of certain filanientous algae only in having a vascular strand in the stem; stomata on the epidermis and cutinized spores; there is little of the differentiation of body parts which characterizes all higher plants. Resemblance is apparent to Focrstia whose branching tips bore sporangia containing resistant spores; no other parts of this algalike plant are known. It or some other unknown filamentous alga may have established itself along the shore where recurrent changes in water level caused by tidal and other factors brought it into frequent contact with the atmosphere. Although it is not to be mentioned as an ancestral type, a living kelp known as the sea palm (Postelsia) suggests the sort of habit which might favour establishment upon the land; growing along the shore, this erect stout-stemmed seaweed is regularly exposed to the air at low tide. In such an environment, intermediate between sea and land, and from some unrecorded algal stock, we may suppose that the first land plants developed their conducting and supporting stem tissues, their stomata and other structures required by a terrestrial habitat.

The date of this major event in plant history could not have been as late as Middle Devonian, when *Rhynia* and *Hornea* lived. For in later Silurian time there are records of the primitive lycopsid *Baragwanathia* in Australia; another lycopsid, *Drepanophycus,* is known from the Lower Devonian of Canada, Europe, China and Australia. If the psilopsids of the Rhynie Chert represent the ancestral stock from which all higher vascular plants arose, there is implied a long antecedent history during which these relatively advanced, though still primitive, lycopsids branched off and developed such structures as leaves: and stalked sporangia, and for their wide migration over four continents. The date of origin of their ancestors, the psilopsids. must have extended into earlier Silurian or even pre-Silurian time. It is apparent that the earliest chapter in the history of land vegetation has not yet been uncovered.

Devonian Floras.—The Psilopsida are the most numerous and widely distributed plants in earlier Devonian time. Their relatively undifferentiated plant body is consistent both with their ancestral status and with their serniaquatic environments: many of them are judged to have been swamp plants because of their occurrence in carbonaceous (peat) deposits; the association of *Psilophyton* and *Bucheria* with the remains of primitive fishes in Wyoming suggests a brackish-wster habitat. The psilopsids had disappeared by the close of the Middle Devonian. and in their place are found larger plants with root systems. stronger stems and improved means of dispersing their spores or seeds (Pl. I. fig. 1). The Cpper Devonian record, like that of most of geologic time, is

made up largely of lowland types, for plants growing along shores and valley bottoms are in the best situation to contribute their parts to sedimentary deposits. Club mosses, horsetails, *Sphenophyllum,* ferns and seed ferns all are represented; although they are for the most part smaller than their Carboniferous descendants and less adequately preserved, they provide a preview of the vegetation so widely developed along shores and valleys later in the era. Collections from Bear Island, at the south end of the Spitzbergen archipelago, come nearer to constituting a flora than those from any comparable area. Lycopsida represented are *Leptdodendron, Protolepidodendron* and *Cyclostigma;* Sphenopsida include *Pseudobornia* and *Sphenophyllum;* Pteropsida include *Archaeopteris, Cephalopteris* and *Sphenopteridium,* all of which are considered to be seed ferns, and *Psygmophyllum* which has a doubtful taxonomic status. *Archaeopteria* and *Sphenopteridium* have been recorded from Ellesmere Land, at lat. 80° N. Devonian reef corals within the Arctic circle confirm the suggestion of these northern plants that mild climate extended into polar regions during at least part of Upper Devonian time. It seems probable that currents of warm water may have been largely responsible for the northward extension of mild climate at this and later periods of earth history.

Carboniferous Floras.— In most parts of the world, conditions for preservation of plants were less auspicious in Lower than in Upper Carboniferous time for there were still widespread epicontinental seas in whose basins limestone was being deposited. Fossil plants have been found in Lower Carboniferous rocks of North America, Europe and Australia; true ferns were numerous, and new genera of club mosses and horsetails made their appearance; many of the seed ferns are represented by stems rather than fronds.

One of the largest floras of this age is recorded from the island of Spitzbergen and shows a close relationship to the Upper Devonian vegetation of Bear Island. *Adiantites, Cardiopteris* and *Sphenopteris* are new genera of seed ferns to appear; the size of their fronds and of associated stems indicates an environment favourable for plant growth.

During the Upper Carboniferous and particularly during its Westphalian stage an abundance of land plants together with ideal conditions for their preservation resulted in one of the most complete records of past vegetation in all earth history. Extensive mining of coal, with which most of the plant-bearing deposits are interbedded, has greatly facilitated the collection of these Upper Carboniferous fossils.

Plate I, fig. 2, shows the aspect of a Carboniferous swamp as reconstructed from fossils found in Illinois. Lycopsids (*Lepidodendron, Sigillaria)* are the largest and most abundant trees, with sphenopsids *(Calanzites, Sphenophyllum*) also numerous. The understory of this forest included the latter genus, which appears to have had a climbing habit in part, and an abundance of Pteridospermae (*Alethopteris, Neuropteris);* some of the latter reached the size of small trees. True ferns (Filicineae) were represented in subordinate numbers by the fronds of *Pecopteris.* One of the most abundant orders of gymnosperms, the Cordaitales, is not so regularly represented in this swamp forest; it is considered to have lived on higher ground, from which its coarse leaves *(Cordaites)* were commonly washed or blown into the basins and mingled with the remains of plants growing there. Many of the seed ferns are also thought to have lived as trees above swamp level. Similar forests are known to have ranged over wide areas from the eastern United States to Europe and Asia Minor. The flora described by Halle from Shansi province, China, is somewhat younger but includes many of the same genera as mentioned below.

Evidence of a frequently shifting position of the shore over wide areas of Eurasia and North America is afforded by the varying types of Carboniferous sediments. Fluctuations of level resulting from crustal instability had their effects upon the vegetation growing along swampy shores and estuaries, bringing marked changes in floral composition especially among the pteridosperms. Their comparatively rapid modification from time to time under the influence of crustal movements is shown by the different species found in the sequence of plant-bearing beds, and affords a basis for local and intercontinental correlations. The general aspect of the vegetation of this age leads to the conclusion that the climate was mild and humid, for most modern plants with similar stem and leaf development are found in regions with no frost and with ample rainfall.

From several localities in the western United States, plant fossils have been collected which indicate other types of forests and different environments. The dominant members of the Garnett flora of Kansas are a conifer, *Walchia,* and a seed fern, *Taeniopteris,* both of which reach their greatest abundance during the succeeding Permian period though they have also been recorded from the Upper Carboniferous of Europe. Associated with them are *Annularia,* several typically Carboniferous seed ferns, and *Cordaites.* This flora is considered to have lived in the relatively dry uplands, and its marked dissimilarity to the lowland swamp vegetation of the Carboniferous is a measure of this wide difference in environment. From sandy and shaley beds in Oregon another upland flora has been shown to include *Calamites,* conifers and cordaitaleans, together with fronds of seed ferns. The smaller size of most of these Oregon plants, and the absence of typical swamp types of seed ferns and lycopsids are in marked contrast to the Upper Carboniferous floras from the lowlands of the eastern United States and Europe. Remains of *Lepidodendron* and *Calamites* from Colorado are suggestive of a lo land forest which may have lived, as do certain modern club mosses and horsetails, under semiarid conditions less favourable to the growth of the seed ferns, few of which have been found with them. It seems clear that while most of the known forests of the Carboniferous lived on moist warm lowlands bordering inland seas, there were other less favourable environments in the western United States, and doubtless elsewhere, occupied by a less luxuriant type of vegetation.

Permian Floras.— Many of the plants of latest Carboniferous (Stephanian) time resemble those of the final period of the Palaeozoic era, and are commonly grouped with them under the transitional name Permo-Carboniferous. Because of their wide distribution and probable origin in the northern hemisphere, these late Palaeozoic plants are termed the Arcto-Carboniferous flora. The common types of horsetails and club mosses continue to be represented. *Odontopteris, Callipteris, Callipteridium, Supaia* and *Taeniopteris* (Pl. III, figs. 3, 6) begin to displace the typical Carboniferous types of seed ferns. The appearance of fronds of cycadophytes, and the conifers *Walchia, Lebachia* and *Voltzia* give a Mesozoic aspect to the Arcto-Carboniferous flora. It is significant that these northern conifers are not recorded south of the equator, where typically southern genera such as *Paranocladus* and *Walkomia* are .dominant. Similar regional diversity may be noted among other groups of plants, and it is apparent that two major floras may be distinguished. This division of vegetation from north to south is in striking contrast to the world-wide occurrence of similar plants in earlier Carboniferous and Devonian time. It came about at a time when major physical events of earth history were taking place, the uplift of some continents, the warping down of others, and the building of mountain ranges. These events of the late Palaeozoic appear to have brought about important climatic changes: gradual reduction of temperature and rainfall greatly modified the genial climate of Carboniferous time especially in the southern hemisphere where the luxuriant forests of the Carboniferous swamps began to give way to types of plants better suited to the new environments.

The Permian flora of the southern hemisphere including peninsular India is termed the Antarcto-Carboniferous or Glossopteris flora. The latter name comes from one of its most characteristic genera of seed ferns, *Glossopteris* (Pl. III, fig. 7), which had a simple, tongue-shaped frond much thicker than those of typical northern genera. The name Gondwanaland has been applied to the southern land masses, but need not be considered to indicate a continuous continental mass during late Palaeozoic and early Mesozoic time. A common horsetail is *Schizoneura,* readily distinguishable from the northern *Calamites* by its more stocky habit and its larger leaves forming a sheath around the stem. With a

single exception to be described below, none of these genera are recorded in the Palaeozoic rocks of the northern continents. Certain of the northern plants are represented to the south, such as *Sigillaria, Lepidodendron, Sphenophyllum* and *Psaronius,* and heavy leaves resembling *Cordaites.* Stems of gymnosperms probably assignable to *Cordaites* show well defined growth rings. In this respect, and in their shorter stems and thicker leaves, plants of the Antarcto-Carboniferous flora differ from those of earlier floras, and are commonly interpreted as representing a response to an environment relatively unfavourable to plant life. Discovery of *Glossopteris* 300 mi. from the south pole by the second Scott expedition suggests the possibility that this plant and its associates may have had their origin on Antarctica and ranged north into Australia, Africa, India and South America.

The most northern Permian extension of the Antarcto-Carboniferous flora is recorded in Siberia, where several typical southern genera occur with Arcto-Carboniferous forms; in addition there are a number of Mesozoic types of' Bennettitales, Ginkgoales and Coniferales. Represented in this Kusnezk flora is a thick-leafed seed fern, *Supaia,* which has been found in various other parts of the world, and is common in a Lower Permian flora from Arizona. This American flora contains a combination of Siberian and Arcto-Carboniferous elements, differing from floras of Permian age in the eastern United States and Europe in the reduced size of its stems and fronds, and in other characters which suggest a relatively arid climate. In other parts of North America and in Europe the Arcto-Carboniferous flora is made up largely of Carboniferous types, some of which (*Calamites, Sphenophyllum, Lepidodendron, Sigillaria, Psaronius, Alethopteris, Neuropteris* and most of the seed ferns) disappear by the end of the era, with others *(Pecopteris, Cladophlebis, Neuropteridium, Taeniopteris* among the seed ferns, and certain members of the Bennettitales, Ginkgoales and Coniferales) continuing on into the Mesozoic. The Permo-Carboniferous flora from Shansi, China, is Arcto-Carboniferous in composition; it includes such distinctive genera as *Lobatannularia* and *Gigantopteris* (now also known from North America), and a considerable number of Mesozoic types, the seed ferns *Cladophlebis* and *Neuropteridium, Baiera* and other ginkgoids, and cycadophtes. This Chinese flora differs materially from the Kusnezk flora of Siberia, partly as a result of age differences, but probably also due to migration barriers and unlike environments.

The closing days of the Palaeozoic witnessed the disappearance of most of the older plants, and the introduction of many new types. Continental uplift was draining the swampy lowlands; climatic changes involving greater extremes of temperature and precipitation were becoming more pronounced; other factors not fully understood may also have contributed to this major modification of vegetation. An outstanding feature was the development of floral provinces, with the Antarcto-Carboniferous flora in the southern hemisphere and India, the Arcto-Carboniferous flora in much of the northern hemisphere and with a mixture of the two in Siberia.

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PLANTS OF THE MESOZOIC ERA

At the beginning of the Mesozoic era the prevalence of desert conditions over a wide area in North America and in the old world was highly unfavourable to the further development or the continued existence of many members of the rich Permo-Carboniferous flora. By far the greater number of the Palaeozoic species failed to survive; a few new forms were evolved, and some plants such as *Schizoneura* and *Glossopteris* were immigrants from Gondwanaland. A comparison of late Palaeozoic and early Mesozoic floras reveals a sharp contrast which furnishes an interesting illustration of the interdependence of organic and inorganic evolution, of the effect of changing geographical conditions on the evolution of the plant world. One of the more important aims of the student of evolution is to discover connecting links in the plant world particularly at epochs of widespread. crustal disturbances. Attention has already been called to the presence in late Permian floras of genera that are characteristic of Mesozoic floras: types, which became prominent in the latter part of the Triassic period and persisted through the several stages of the Jurassic period, were already in existence, though in a subordinate position, before the close of the Permian period. The greatest contrast between the two eras is the marked difference in the general facies of the vegetation consequent on the disappearance of most of the commoner members of the older forests; but there is also a considerable difference which is due to the relative abundance in the Mesozoic floras of plants of more modern aspect, plants that are closely akin to living species as contrasted with the more archaic and much less familiar types in the Palaeozoic floras.

Thallophyta.—Reefs made up of calcareous seaweeds are of common occurrence in the dolomites of the Tyrolese Alps and in other regions where the marine record of the Triassic period has been preserved. These seaweeds are green algae (Chlorophyceae) of a type now abundant in tropical seas. *Diplopora,* one of the common genera, had a stalk several centimetres long with clusters of small branches. Its distribution northward to Siberia suggests either that this Triassic seaweed was less tropical than its modern descendants, or that warm currents in the seas extended its environment far to the north. A reef-building family of the red algae (Rhodophyceae), the Corallinaceae, is represented in marine deposits of Cretaceous age by the genus *Lithothamnium,* a genus still living. The oldest well-defined stoneworts *(Chara)* of the family Characeae, often considered a group intermediate between Algae and Bryophyta, are also known from the Cretaceous. The diatoms (Diatomaceae) first appear during the Jurassic period. Bryophyta are too meagrely represented to require discussion here.

Tracheophyta.—Plants with vascular tissues continue to make up most of the fossil record as during the later half of the Palaeozoic.

Lycopsida.—The order Lepidodendrales which included the largest and most abundant trees of the Palaeozoic forests lost its dominant position at the close of the Palaeozoic when *Lepidodendron* and *Sigillaria* became extinct. *A* genus surviving into the Upper Triassic (Rhaetic) of Sweden, Greenland and Arizona is *Lycostrobus,* represented by cones and spores which resemble those of *Lepidodendron.* The Arizona cone has oval seedlike bodies near its base. *Pleuromeia* is a widespread Triassic form which shows resemblance to *Sigillaria* in the leaf scars on its stem, but it is placed in a distinct order, the Pleuromeiales, because of its seedlike reproductive organs; it was a short unbranched shrub with needlelike leaves, and with numerous rootlets growing from its swollen base as in modern *Isoetes. Nathorstiana* from the Cretaceous of Germany, a small plant with tuberous stems, has also been considered to represent a possible ancestor of *Isoetes. Lycopodites* and *Selaginellites* both occur in Mesozoic rocks, and may be considered ancestors of the common modern herbaceous lycopsids, *Lycopodium* and *Selaginella.*

Sphenopsida.—Unlike the scale trees, horsetails continue as abundant members of Mesozoic floras. though they are reduced in size. *Schizoneura,* which first appeared in the Antarcto-Carboniferous flora of Permo-Carboniferous time, was widespread throughout the world in the early Triassic; both it and the somewhat younger *Neocalamites* appear to be descendants of the Palaeozoic calamites. Another common Mesozoic genus was *Equisetites* which resembled the living *Equisetum* in many ways but was larger.

Pteropsida.—Members of this subphylum take over complete dominance in the Mesozoic era, which is often termed the age of cycads because of the abundance of the cycadean orders Bennettitales and Cycadales. Ferns, ginkgoids and conifers are also numerous, and by the end of the era the Angiospermae become

well established.

Filicineae.—A comparison of the rich fern vegetation of the Upper Triassic floras with the comparatively small number of true ferns in the Carboniferous vegetation raises a question which has not been fully answered: whence came the more modern types of ferns which characterize Mesozoic floras? Few Palaeozoic ferns apart from the Marattiaceae can be linked with Triassic forms, and the evidence they afford of direct relationship to Mesozoic ferns is not convincing. The latter include representatives of most of the common living families. Among these a palmately branching frond is referred to *Laccopteris,* of the now Malayan family Matoniaceae; this genus is recorded from many Eurasian localities, Greenland, Arizona, Mexico and Honduras, and continues into the Cretaceous. Somewhat similar fronds are referred to Clathropteris (Pl. IV, fig. 7), whose finer nervation is net-veined and resembles the leaves of certain angiosperms. The Marattiaceae is represented by Danaeopsis of the Triassic and *Marattiopsis* of the Jurassic. Large-fronded and widely distributed genera such as Cladophlebis and *Lonchopteris* fall in the Osmundaceae, along with the stem form-genus Osmundites. *Schizaeopsis* of the Lower Cretaceous represents the Schizaeaceae, and Acrostichites appears assignable to the Polypodiaceae. *Coniopteris*, a wide-ranging tree fern of the Jurassic, had fronds resembling the Palaeozoic genera *Sphenopteris* and *Pecopteris.* A Cretaceous tree fern, *Tempskya,* had a compound stem covered with fibrous roots, suggestive of the Palaeozoic Psaronius.

Gymnospermae.—Two typically Palaeozoic orders of this class, the Pteridospermae and probably the Cordaitales, persist in small numbers into the Mesozoic, but their places as important members of the forests are taken by the cycadophytes and the conifers.

Pteridospermae.—During the Triassic period plants with leaves resembling the southern genus *Glossopteris* became widely distributed over the world, with their last known occurrence in the Rhaetic of Greenland. Callipteridium is another Palaeozoic genus which persisted into the Triassic but is known only from Africa and Madagascar. Thinnfeldia, considered to be a derivative of the Permian genus *Supaia,* is world-wide in distribution and continued into the Cretaceous, but it is probable that some of the younger fronds so identified are ferns rather than seed ferns. *Neuropteridium,* which is related to Gondwanidium of the Antarcto-Carboniferous flora, is recorded as late as Upper Triassic, but at this level may represent a true fern.

Cordaitales.—There is some question of the occurrence of members of this order beyond the Permian, though typical cordaitean wood assigned to the stem form-genus Dadoxylon has been found as late as Upper Triassic, and leaves known as Pelourdea (*Yuccites*) may be related to Cordaites.

Bennettitales.—Rare in later Palaeozoic and early Triassic time, fronds representing cycadean plants become common at the end of that period. Although the cone structure and mode of attachment in the Bennettitales (the extinct order) shows marked differences from the Cycadales (the order still living), it is impossible to distinguish the fronds of the two orders. R e shall therefore use the general term cycadophytes for all detached fronds, and apply the order names only when other structures are represented.

The most primitive genus of the Bennettitales is Wielandiella from the Cpper Triassic. Its shrubby stem was dichotomously forked and bore small leaves; between the forking branches were budlike shoots bearing sterile and fertile scales; the latter formed a circle of small male organs (stamens) around the base of the shoot, with several stalked female organs (ovules) surrounded by sterile scales above. This type of reproductive structure, which may be termed either a bisporangiate strobilus or a bisexual flower, shows a marked difference from those of modern Cycadales, in which the female and male elements are borne terminally in separate cones,—monosporangiate strobili or unisexual flowers. It differs from a true flower in having the ovule naked, while in such a similar structure as the flower of a buttercup (*Ranunculus*) the ovules are enclosed. *Williamsoniella,* a Jurassic genus with similar stem and reproductive structures, is known to have borne scattered leaves of the form-genus Taenoipteris.

A more advanced genus of the Bennettitales, appearing in the Triassic and becoming widespread in the Jurassic, is Williamsonia. It resembled living cycads in general habit, a simple stem covered with leaf-bases and with a crown of leaves at the summit. But the reproductive structures were of the bennettitalean type, and borne on the ends of short branches along the stem. Associated leaves indicate that the fronds of Williamsonia were those assigned to the form genera Zamites, Otozamites and *Ptilophyllum.* Cycadeoidea, a genus which reached its greatest abundance in the Lower Cretaceous, also had the general habit of modern cycads, a short thick stem enclosed in leaf bases and a fluffy mass of scales resembling the ramentum of ferns; along the axis of the stem were short lateral branches bearing flowers which were largely enclosed in the armor of leaf bases and scales; most of the flowers were bisexual, aligning this genus with the Bennettitales; another difference between it and the living Cycadales is its relatively small seeds.

Among the common form-generic names assigned to cycadophyte fronds are *Pterophyllum, Nilssonia, Sphenozamites, Otozamites* (Pl. IV. fig. 3) and Pseudoctenis, most of which had wide distribution during the Triassic period; *Ptilophyllum* is added to several of the above genera in widespread Jurassic floras, and is also recorded in rocks of Cretaceous age along with certain genera suggesting relationships to modern cycads, Zamites, *Zamiophyllum* and Pseudocycas. Leaves of a number of these form-genera have been found in attachment with the stems of Bennettitales, but none of them is certainly known to be referable to the Cycadales.

Cycadales.—No stems have been found with terminal monosporangiate cones which would establish the presence of members of this order in the Mesozoic, nor have any complete cones been discovered. The same may be said for the Cenozoic record of the Cycadales, and it is possible that absence of their cones from both groups of rocks may be due to factors of preservation; unlike the cones of Bennettitales, the more advanced types of which were enclosed in a thick mat of leaf bases and scales and were persistent on the stem up to the time it was buried and preserved in the fossil record, the cones of living cycads tend to fall apart while still attached at the end of the stem, and are deciduous after a few years; any opportunity for Cycadales of the past to have been preserved in association with the parent stems would appear to have been greatly limited, and the chances for preservation of complete cones may also have been low. The discovery of specimens which appear to represent detached cone scales is highly significant, although these are not sufficiently well preserved to provide indisputable evidence of their exact nature and relationships. *Dioonitocarpidium* from the Upper Triassic of Germany is interpreted as a fertile leaf or megasporophyll; its axis bears two rows of small leaflets, and at the base two oval bodies interpreted as seeds. *Cycadospadix* represents a somewhat similar structure of Triassic and Jurassic age. Both these fertile leaves show a resemblance to the megasporophylls of the living Cycas, whose strobili are less compactly organized and presumably more primitive than those of other living Cycadales. As above indicated there are Cretaceous fronds, Pseudocycas, which closely resemble the sterile leaves of Cycas. These and certain stems whfch appear to lack the armour of leaf bases and the axial cones characteristic of the Bennettitales may possibly represent the vegetative structures of Cycadales. Perhaps the strongest indication for the Mesozoic occurrence of the Cycadales comes by implication from the Cenozoic record of these plants; immediate ancestors of many of the living genera were well differentiated and widely distributed at the beginning of this era, which can only be interpreted as indicating a long pre-Cenozoic history for the Cycadales.

. From this discussion it is clear that there is little basis for establishing connecting links between the Bennettitales and the Cycadales. It may be surmized that they both arose from a remote, perhaps Palaeozoic ancestor, and that they lived side-by-side until the end of the Mesozoic era. At that time the more abundant and in many ways more specialized Bennettitales became extinct, leaving the Cycadales as the surviving order of cycadophytes.

Ginkgoales.—This order shows many relationships to the Cordaitales, and with that extinct order appears to occupy an intermediate position between the Coniferales and the more primitive groups of seed-bearing plants. Scantily represented during the Palaeozoic, Ginkgoales had their first abundance in Upper Triassic floras. The genus Baiera is represented by large wedge-shaped leaves cut into deep lobes, without a petiole in the more typical species. *Czekanowskia,* with more deeply dissected or branched leaves, is another Palaeozoic genus which lived during the Triassic. A new genus, Ginkgoites, appeared in the later half of the period, and its name implies resemblance to the sole surviving member of the order, Ginkgo, the maidenhair tree, apparently a native of China and now widely cultivated in temperate regions. Ginkgo first appeared during the Jurassic (Pl. IV, fig. 4), and has survived down to the present. Fossil leaves of the Ginkgoales, including the typical Palaeozoic genus Saportaea, resemble the leaves of living Ginkgo in their cuticle. Little is known of the stems and reproductive structure of the extinct members of the order, though the discovery of male organs in the Jurassic of Siberia confirms the close relationship between *Ginkgoites* and Ginkgo as suggested by their leaves. The wood may not in all cases be readily distinguishable from that of the conifers.

Coniferales.—During the Mesozoic era representatives of this order were abundant and widely distributed, and they have continued to hold an important place in world vegetation down to the present time. The Palaeozoic genus *Voltzia,* already described as a generalized conifer possibly representing the ancestral stock of both the Araucariaceae and the Abietineae, persisted into late Triassic time. *Araucarites* (Pl. IV, fig. 6), a form-genus indicating relationship to the family Araucariaceae, ranges through the whole of the Mesozoic, grading into the genus Araucaria at the end of the era. In his study of remarkably preserved cones from Triassic (or possibly Cretaceous) beds of Argentina, G. R. Wieland assigns a new generic name, *Proaraucaria* (Pl. IV, figs. 1, 2), to material previously called *Araucarites.* Leafy twigs, branches and large trunks with araurcarian type of wood occur with these cones. Other smaller cones associated with *Proaraucaria* are named *Pararaucaria,* and appear to combine the characters of Araucaria and *Pinus;* there are several additional types of Mesozoic cones in other parts of the world which suggest relationships intermediate between the pines and araucarias. Wood from the Upper Triassic of Arizona is referred to the form-genus *Araucarioxylon;* among all the giant logs in the Petrified Forest National Monument, not a single araucarian cone has been discovered. At this and many other localities scattered throughout the world occur leafy shoots or cone-scales of another possibly araucarian type which is called Podozamites; certain cycadean characters suggest that it may represent a generalized type related both to conifers and cycads. *Rhexoxylon* from the Triassic of South Africa is represented by a stem which appears to be coniferous but which shows an arrangement of its woody tissues similar to that of certain climbing angiosperms living in the tropics. Representatives of the Podocarpaceae have been reported from many parts of the world, but the only well-defined Mesozoic records are from the southern hemisphere to which this family is now largely restricted. Although plants from the Jurassic have been referred to the form-genus Sequoites, suggesting resemblance to the *Sequoia* or redwood, no well-defined members of this genus have been recognized in rocks older than Cretaceous. Leafy twigs and cones are well represented in Lower Cretaceous deposits of North America, together with *Pinus* (pine), Picea (spruce), *Taxus* (yew), Torreya and other genera, and the appearance of modern types of conifers is reported in many other regions during Cretaceous time.

Caytoniales.—This order has been established by H. H. Thomas to include plants whose relationships are with both gymnosperms and angiosperms. The female shoots, described by him as species of *Gristhorpia* and Caytonia, consist of an axis bearing two rows of short branches each of which carries an apical case containing seeds which is compared with the carpel (pistil) of a flowering plant. These "carpels" differ from those of modern angiosperms in being modified leaflets, and not formed from complete leaves. The male shoots, referred to the genus *Antholithus,* are of similar form and their branches bear clusters of four-lobed stamens containing winged pollen-grains. The fruits, first described from the Jurassic rocks of Yorkshire, England, contain closely packed seeds; on the surface of the wall near the attachment of the fruit to its stalk is a stigmatic lip for reception of the pollen. Other similar plant remains have been found in the late Triassic of Greenland and in the Jurassic of Sardinia. Leaves of the genus *Sagenopteris* are regularly found in association with these reproductive organs, and since they have an epidermal structure identical with that of Cayfonia and Gristhorpia they are considered to represent the foliage of the Caytoniales. Nothing is known of their stems. Thomas has suggested that their general aspect and the structure of their seeds may indicate that the Caytoniales have been derived from Palaeozoic pteridosperms. Until additional information is at hand regarding them, we can go no farther than to consider the Caytoniales as probably a branch of the ancestral stock which gave rise to the Angiospermae. They appear to have become extinct in early Cretaceous time.

Angiospermae.—Several problematical specimens have been found in older Mesozoic rocks which suggest the leaves, seeds and wood of angiosperms. These together with the Caytoniales and the Bennettitales, both of which orders show a tendency to develop structures approaching the flower, represent the only evidence for the pre-Cretaceous existence of the now dominant Angiospermae. The abundance of angiosperms in some of the older Cretaceous floras and the rapidity with which they wandered over the world during the earlier stages of the Cretaceous period suggest that they must have been evolved long before they came to occupy the premier position in the vegetable kingdom. The primitive types of angiosperms probably differed widely in habit from those with which we are now familiar. *Sagenopteris* may be a pioneer of the present ruling dynasty, which having passed slowly through the earlier stages of evolution reached its full vigour in the early days of the Cretaceous period.

From the rocks of western Greenland comes the earliest record of angiosperm leaves. *Magnolia,* Diospyros (persimmon), Sassafras, Quercus (oak), *Platanus* (plane tree) and other broad-leafed trees were living in the far north with older types of ferns, cycads and gymnosperms during these early days of the Cretaceous. Farther south at middle latitudes the forests of this time were made up wholly of these older types, but in beds of somewhat younger age from Portugal, England and Virginia are found the remains of leaves and stems of true flowering plants. By late Cretaceous time angiosperms had become established widely over the earth, including a sufficiently large number of common living families to give a decidedly modern aspect to the vegetation. In addition to *Magnolia* and Liriodendron, members of the primitive tree family, the Magnoliaceae, there were representatives of other primitive families such as Anonaceae (Anona), Cercidiphyllaceae (*Cercidiphyllum*), Dilleniaceae (Dillenites), Lauraceae (*Cinnamomum, Laurus,* Sassafras). Cretaceous floras also include some of the more specialized families such as Caprifoliaceae (*Viburnum*) (Pl. IV, fig. 5), Ebenaceae (Diospyros), Juglandaceae (*Juglans*), Rhamnaceae (*Rhamnus*), together with many of intermediate position including Betulaceae (*Alnus, Betula*), Fagaceae (*Castanea, Fagus, Quercus*), Moraceae (Ficus, *Artocarpus*), Ulmaceae (*Ulmus*). It is apparent that family differentiation had been largely accomplished during Mesozoic time, and that many modern genera were already distinct. Most botanists believe that herbs are less primitive than trees and shrubs, but their general absence from the Cretaceous and later rocks can not be considered confirmatory evidence since their habit and structure make entrance into the fossil record of any age unlikely. All palaeobotanical evidence supports the idea that Monocotyledonae have long been a separate line from the Dicotyledonae, since such diverse families as Alismaceae (*Alismacites*), Gramineae (*Grammaephloios*), Liliaceae (Smilax), and Palmaceae (*Sabal*) are recorded in rocks of Cretaceous age

Floristics and Ecology of Mesozoic Land Floras.—*Triassic* Floras.—At the beginning of the period environments favouring the growth of forests appear to have been limited in ex-

tent. Land-laid sediments in Eurasia and North America include saline deposits, and show other evidences of an arid climate during most of the period. Certain plants which survived the closing events of the Palaeozoic; such as *Pleuromeia* and *Schizoneura,* are of smaller stature than their lycopsid and sphenopsid allies of the Arcto-Carboniferous flora. These and a few surviving seed ferns and conifers, together with new types of ferns, horsetails and cycadophytes, made up the rather xerophytic population as the Mesozoic era began.

By contrast. the vegetation in later Triassic time is characterized by a greater variety of plants distributed over many parts of the world. These appear to have lived in valleys and swamps under relatively favourable climatic conditions. The immense trunks of araucarians in the Petrified Forest of Arizona indicate a forest comparable in density of growth with those of today in Queensland, Australia, and elsewhere in the southern hemisphere; thick growth rings of the fossil logs indicate an adequate supply of moisture and a relatively short season of drought or cold. Associated ferns are of types now living in moist tropical regions: and numerous large horsetails also suggest locally humid habitats. L. H. Daugherty has reconstructed an environment like that to be found in the savannas at low latitudes today, where dense forests fringe the streams and valley swamps; such a setting is in marked contrast to the variable climate of Arizona today. where sparse vegetation is a reflection of aridity and seasonal cold. Many of the same types of late Triassic plants are found in the eastern United States and Europe. In the latest Triassic or Rhaetic floras of Europe, ferns of now-tropical types, cycadophytes, conifers and members of the Ginkgoales become numerous and diversified. Related types are also found in as widely distant localities as Greenland and Indo China, though at the latter locality there is indication of an intermediate relationship with floras of the southern hemisphere. During the Mesozoic, as in Permo-Carhoniferous time, there were marked differences in character between the floras on opposite sides of the equator.

Jurassic Floras.—The Jurassic period is generally considered to have witnessed the most widespread uniformity in living conditions of any time in earth history. The degree of this uniformity has probably been overemphasized; in the course of a period lasting some 40,000,000 years migrations between lands as distant as Greenland and England may have brought certain plants from one area to the other, and similar extensions in range doubtless occurred to other areas in the northern hemisphere. But the picture of a world-wide cosmopolitan flora during the Jurassic does not meet the evidence presented by the fossil conifers of the southern hemisphere. which have been found by R. Florin to differ as much from those to the north as they did in Permo-Carboniferous time, and as they do today. Fuller acquaintance with plants of the past may be expected to bring about certain changes in our major concepts, and in this case it is not surprising that marked differences in vegetation should be demonstrable over such wide distances in latitude.

In both hemispheres cycadophytes become a dominant part of the vegetation during Jurassic time, with more specialized Bennettitales apparently more numerous than the Cycadales. The habitat of these plants is difficult to reconstruct. since the Bennettitales are now extinct, and the Cycadales live both in dry and in humid situations; it may be supposed that they were most common in regions of mild temperature. which brings up certain questions of past climate when it is realized that stems and fronds have been found as far south as Antarctica (Graham Land. lat. 63° S.), and fronds from northern Alaska and Siberia (Yew Siberian Islands, lat. 75° N.). There seems to be little question that broad submergence of the continents during Middle Mesozoic time resulted in more general circulation of ocean currents and winds than is found in the world today. and that the effects of latitude were reduced. It may also be possible that some cycadophytes developed an ability to live under lower temperature conditions than others. as is the case with certain living conifers and angiosperms. Such changes in climate and tolerance appear more readily explainable than the assumption that the continents themselves have moved widely over the surface of the earth.

Abundance of ferns related to living types of the tropics confirms the indication of a frostless environment in many parts of the Jurassic world; the rarity of most of these in floras from high latitudes is in accord with the suggestion that the climate at high latitudes was less mild. The last of the seed ferns, characterized by thick leaves, are recorded at this time. All known lycopods were of small size. and the horsetails, while larger than any now living, had much shorter stems than those of the Palaeozoic.

Several genera of the Ginkgoales reach their greatest abundance and widest distribution in the Middle Jurassic. The Coniferales were also numerous and widespread. especially *Araucarites* which is the only conifer whose distribution in both the northern and southern hemispheres seems accurately established. Living members of the Araucariaceae are confined to southern latitudes, as are most of the Podocarpaceae. It is significant that podocarps are widely recorded at southern localities during the Mesozoic, but are not certainly known to have lived north of the equator (except in peninsular India which was on the south side of the Tethys sea). The absence to the south of representatives of such typically northern families as Taxodiaceae, Cupressaceae and Pinaceae further emphasizes the provincial character of the coniferous elements of Mesozoic floras in the two hemispheres.

Summarizing our knowledge of the general aspect of vegetation during Triassic and Jurassic time, there is evidence of widespread forests of humid lowland type in which large-leafed ferns were conspicuous, with conifers and ginkgoids making up the common trees, and with horsetails of moderate size. The upland forests appear to have been largely coniferous, with araucarians the most numerous type in the northern hemisphere, and with podocarps in the southern. Cycadophytes may have been largely restricted to the more open savannas. though they were doubtless mingled with ferns in the understory of the lowland forests. A rich flora from the Triassic of Virginia, including horsetails, ferns, cycadophytes, ginkgoids and conifers, is associated with coal deposits and appears to represent the vegetation in and adjacent to a swamp.

Cretaceous Floras.—At middle latitudes there is no sharp break between the later Jurassic and the earlier Cretaceous floras. In Greenland, however, the record of angiosperms at the beginning of the period brings a new and distinctive element. The diversity of these earliest known flowering plants strongly implies a long antecedent history. of which only obscure fragments have been found in older rocks. A tendency toward the development of structures comparable in complexity with the angiosperm flower has been noted in such earlier groups as the Bennettitales and the Caytoniales. We may suppose that during the earlier periods of the Mesozoic, the actual ancestors of the Cretaceous angiosperms may have been living in upland habitats which were not suited to the preservation of their remains. The appearance of highly diversified insects in the Jurassic doubtless accentuated the rate of evolution of angiosperms, since it added the possibility of insect pollination to the earlier and less effective method of pollination by wind. With the mountain-making and continental uplifts at the end of the Jurassic, the environments of the older plants were modified, and flowering plants were in a position to migrate down from the uplands and enter into successful competition with them. Their first record in Greenland suggests a northern origin for the angiosperms, and during later stages of the early Cretaceous they appeared at more southerly latitudes in North America and Europe. By late Cretaceous time they had crossed the equator and were displacing the Mesozoic ferns, cycadophytes and ginkgoids over most of the earth. With the conifers evolving many of their living genera during the closing days of the era, angiosperms also were becoming differentiated into their principal existing families and many of their living genera. Their complete invasion of the lowlands seems to have been finally achieved during late Cretaceous time, and the stage was set for the development of modern vegetation in the era which followed.

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PLANTS OF THE CENOZOIC ERA

No new major groups of plants have appeared since the first record of the angiosperms in early Cretaceous time. At the dawn of Cenozoic time the earth was covered with plants of modern aspect, but their distribution differed greatly from that of our day. Following a brief résumé of the plant groups represented, the major migrations of Cenozoic time which have brought the vegetation of the world to the regions where we now find it will be discussed. With reference to the time divisions of the Cenozoic era, in the Tertiary period shall be included the four epochs (Eocene, Oligocene, Miocene, Pliocene) preceding the ice age, or Pleistocene epoch; this latter is assigned to the Quaternary period and continues without floristic break down to our day (Recent epoch).

Thallophyta and Bryophyta.—Blue-green algae (Cyanophyceae) appear to have played a major role in the accumulation of oil shales such as the 2,000-ft. deposits in the Green river basin of the central northern Rocky mountains in the United States. Lime-secreting types of green (Chlorophyceae) and red (Rhodophyceae) algae closely similar to those of today contributed to the building of marine limestones in many parts of the world. Brown algae (Phaeophyceae) are seldom recorded in the fossil record because of their lack of hard parts. Characeae (stoneworts) continue down to the present as one of the most persistent types of plants, forming beds of fresh-water limestone. Diatoms (Diatomaceae) were abundant especially during the Miocene, forming thick layers of shale (diatomite) from their siliceous shells; they are considered to have been an important source material for petroleum in California and elsewhere in later geologic time. Various types of fungi are encountered on leaves and in wood, with a few records of the woody bracket fungus (Fomes). Bryophytes, never common in the fossil record, are represented by an occasional liverwort (Hepaticae) of modern appearance, and by various types of mosses (Musci) especially in deposits of the Pleistocene.

Tracheophyta.—The once-abundant Lycopsida and Sphenopsida make up an even less important part of Cenozoic vegetation than during the Mesozoic era. They are most numerous and diversified in tropical regions at the present time, ranging also into high latitudes. Stems of horsetails (*Equisetum*) are common Cenozoic fossils, but remains of the club moss (*Lycopodium*) are rarely found. Pteropsida continue as the dominant subphylum, with ferns (Filicineae) making up a subordinate class. Most of the larger types of ferns disappeared by the close of the Mesozoic, and while stems and fronds of tree ferns (Cyatheaceae) are occasionally encountered in Cenozoic floras, smaller and more fragile types of leaves make up most of the fern record. The Polypodiaceae, now the most abundant and widely distributed family, is represented by Acrostichum, *Adiantum, Asplenium, Dryopteris, Onoclea, Polypodium,* Pteris and *Woodwardia;* their relative scarcity in the fossil record may be interpreted as resulting from their herbaceous habit and thin fronds rather than actual rarity in the forests of the Cenozoic; the fact that the fronds are not regularly shed by abscission as in most conifers and dicotyledonous angiosperms makes their burial in sedimentary deposits more infrequent. One of the common Mesozoic families, the Schizeaceae, is represented by *Lygodium,* a now largely tropical genus whose Cenozoic occurrence is also with plants of tropical types. Osmunda of the family Osmundaceae was widely distributed as it is today, but other genera of this abundant Mesozoic family had largely disappeared. Several prominent families of the preceding era, such as the Marattiaceae, Gleicheniaceae, Matoniaceae and Dipteridaceae, are rarely represented in Cenozoic floras, and are today limited to the tropics.

Gymnospermae.—With Pteridospermae, Cordaitales, Bennettitales, and Caytoniales extinct, and with Cycadales and Ginkgoales greatly reduced in numbers, the Coniferales comprise the only abundant order of gymnosperms during the Cenozoic era. Fronds of several modern genera of the Cycadales, Cycas (Japan), Dioon (Alaska), Encephalartos (Greece) and Zamia (Europe, North America, Puerto Rico) are of occasional occurrence in Cenozoic rocks, but this order may be said to have constituted an unimportant element of vegetation then as it does today. The only genus of the Ginkgoales surviving into the Cenozoic was Ginkgo; its leaves are widely distributed from Spitzbergen and Alaska into middle northern latitudes where it lingered on into the Pliocene and has continued to the present in China though perhaps no longer in the wild state. All of the modern families of the Coniferales and most of the modern genera were differentiated at the opening of the era. The Taxodiaceae (Cryptomeria, Gyptostrobus, *Sequoia,* Taxodium), Taxaceae (*Taxus,* Torreya), Pinaceae (Abies, Picea, *Pinus, Pseudotsuga,* Tsuga) and Cupressaceae (*Chamaecyparis, Cupressus, Juniperus, Libocedrus,* Thuya) are the common families of the northern hemisphere, with the Araucariaceae (*Agathis,* Araucaria) and the Podocarpaceae (*Dacrydium, Podocarpus*) characteristic of the southern.

An order of the Gymnospermae not previously mentioned is the Gnetales, whose living members show vascular anatomy resembling that of the Angiospermae in having true vessels; in certain characters of the reproductive structures a further relationship to the angiosperms is suggested. Twigs and pollen grains of *Ephedra* have been collected from several Cenozoic horizons, with other doubtful material from the Cretaceous. The history of the Gnetales is so meagrely recorded that there is little palaeontologic evidence for supporting the opinion of certain botanists that this order holds a position intermediate between the Gymnospermae and Angiospermae.

Angiospermae.—This class is represented by 264 existing families, of which Magnoliaceae (magnolias) and Ranunculaceae (buttercups) appear to be the most primitive now living; the latter are herbaceous, and in common with other plants of similar habit are rarely if ever represented in the fossil record. All of the common temperate families of trees and shrubs are represented in the Cenozoic record, as well as many of the tropical families of woody plants. As indicated in our discussion of Mesozoic floras, Magnolia is one of the first angiosperms to appear, and was widely distributed by the end of the era. It is a common Eocene genus, along with others listed from the Cretaceous, and with new genera of primitive types (Dillenia and Tetracera of the Dilleniaceae, Anonasprrmum [Pl. V, fig. 3] of the Anonaceae, and many new members of the laurel family, Lauraceae). There are also many more specialized genera such as Eopuntia (Cactaceae), *Inga,* Lonchocarpus, Sophora (Leguminosae), Ficus (Moraceae), Meliosma (Sabiaceae), *Cordia* (Boraginaceae), and various members of the Euphorbiaceae. Representatives of such typically north temperate families as Aceraceae, Betulaceae, Fagaceae, Juglandaceae and Salicaceae became more widespread during Miocene time. Several families which may have had their origin in the northern hemisphere, but which show most of their Tertiary and modern distribution in low and southern latitudes are the Monimiaceae (*Laurelia*), Myrtaceae (Eucalyptus, *Myrcia*), Proteaceae (Knightia, Lomatia), Rubiaceae (*Coprosma*), and Winteraceae (Drimys). Monocotyledons, never as abundant in the fossil rrcord as dicotyledons, were also present during the Tertiarv period, with members of the grass family, Gramineae, first becoming numerous in the fossil record of the Miocene.

Floristics and Ecology of Cenozoic Floras.—The outstanding feature of the vegetation of this latest era is its modern aspect. Many older Cenozoic plants are assignable to living genera, and before the middle of the era close relationships to living species are apparent. These relationships make it possible to recognize well-defined zones of vegetation during the Cenozoic, especially in the northern hemisphere where the fossil record is more complete than in the southern Similar zones were doubtless in existence at some earlier times in earth history, but this is the only era in which the distribution and habitats of past vegetation can be so fully reconstructed.

Cretaceous uplifts temporarily removed many of the barriers to land migration and numerous family and generic resemblances may be noted not only between Cretaceous floras of northern continents; but with those of the southern hemisphere. During early Tertiary time the Tethys sea of the old world and the Caribbean Mediterranean of the new world once again set up barriers to north-south migrations, and since then vegetation in the northern and southern hemispheres has shown marked differences. World-wide moderation in temperature during early Tertiary time is indicated by major plant migrations away from the equator. The subtropical forests which migrated northward into Eurasia and southward into Airica and Australia may be termed the Palaeotropical-Tertiary flora; they differed in many respects irom those which invaded middle latitudes of North and South America, which are termed the Keotropical-Tertiary flora. Temperate forests which became established in high northern latitudes have long been assigned to the Arcto-Tertiary flora, and those which occupied a corresponding position to the south may be termed the Antarcto-Tertiary flora. The distribution and composition of these four floras during the Cenozoic era throw light on the climate and topography of much of the earth in the immediate past, and help to explain many problems of modern vegetation.

Palaeotropical-Tertiary Flora.— The largest and best-known unit of this flora has been described by E. M. Reid and M. E. J. Chandler from abundant fruits and seeds collected in the London Clay. Growing in this forest at lat. 50° N. were trees whose modern equivalents live in the tropical rain-forest of the Indo-Malayan region. One of the most significant of these mas *Nipa* (Pl. V, fig. 2), a tropical palm now limited to tidal flats of the Indian ocean and adjacent shores; its occurrence at many localities southeastward across Eurasia is considered to mark the shores of the Tethys sea along which the London Clay and other floras of Eocene age migrated trom Indo-Malaysia into the Ukraine and western Europe. Among these are the floras from the Paris basin and from Huppaye and Gelinden in Belgium which show a general resemblance to the London Clay flora. Palms, figs, laurels and other common members of these floras show their closest resemblance to living plants of the old world.

Progressive uplift of the Alps, Caucasus and Himalayas, and the gradual withdrawal of the Tethys sea were among the factors bringing new living conditions, especially wider extremes in temperature, to middle latitudes in Eurasia in post-Eocene time. Many members of the Palaeotropical-Tertiary flora lingered on as late as the Pliocene in western Europe, where inland seas continued over reduced areas. To the eastward such typical members oi the Eocene floras as figs and laurels were restricted southward to Indo-China and Burma during later Tertiary time. In the middle latitude belt across Eurasia there appeared increasing numbers of temperate species from the Arcto-Tertiary flora, whose migration southward will be more fully discussed below.

The Palaeotropical-Tertiary flora in lower latitudes shows some resemblances to that of the European Eocene. Along the southern shore of the Tethys sea in Egypt, seeds of nipa palm have been collected along with figs, laurels, legumes and other northern types. B. Sahni has described a flora including *Nipa* and other palms from the Eocene Deccan Traps on the south shore of Tethys in peninsular India. Wood and leaves of the Dipterocarpaceae, a tropical family now confined to Airica and Asia and most abundant in India and the Philippines, are iound in the East Indies and also in Burma. The family Proteaceae had a few representatives such as *Lomatia* in middle northern latitudes, but is largely restricted southward in the forests of the Tertiary, as it is today. Similar past distribution characterized the Myrtaceae, whose centres of distribution are now in Australia and tropical America but which may have been represented by the now southern genus *Eucalyptus* in Europe during the Tertiary and Cretaceous periods. Little recent work has been done in the East Indies and Australia, and the older Tertiary vegetation of Africa is almost completely unknown. Leaves figured by Goeppert (1854) from the Eocene of Java are strongly suggestive of laurels, legumes, figs and persimmon. The most reliable records from Australia and New Zealand are those summarized by R. Florin for the conifers; the occurrence of *Agathis, Dacrydium*, *Phyllocladus* and *Podocarpus* in the Eocene of New Zealand, of these genera and *Callitris* in the Miocene of Australia at lat. 35° S., and of *Podocarpus* and *Widdringtonia* in the Tertiary of South Africa, suggests generally distributed warm temperate to subtropical conditions over middle southern latitudes. These genera all have their centres of distribution in the southern hemisphere today, and are considered to have had a southern origin. A small flora of Pliocene age has been described from Uganda, in equatorial Africa, all of whose members resemble species now living on this continent at low latitudes.

Neotropical-Tertiary Flora.— This forest spread north into middle latitudes in North America during Eocene time. Fossil leaves are of relatively large size, with texture, nervation and shapes resembling the foliage of trees and shrubs of many tropical families; fruits and wood confirm these relationships, although mood is comparatively rare as might be expected by reference to modern forests of the tropics where fungi, termites and other organisms rapidly destroy the trunks of fallen trees. The more common families of the Palaeotropical-Terti ry are well represented in America, but many of the genera and most of the species are of new world types. Palms, figs, legumes, laurels (Pl. V, fig. 1) and euphorbs are numerous. *Nipa* has not been recorded but several other palms are well represented. No record has been iound of the Dipterocarpaceae, a family now confined to the old world, and Proteaceae and Myrtaceae are nowhere common.

The Wilcox flora of the southeastern United States gives us a rather complete picture of the vegetation which lived along the deltas and swampy shores of the Mississippi embayment during Eocene time. Angiosperms predominated, with a few ierns, cycads and conifers. The immediate ancestors of some of these plants lived in this region during preceding Cretaceous time when the climate appears to have been more temperate, but most of them came northward irom northern South America and the West Indies in response to the same moderating. climatic influences that brought the London Clay flora from Indo-Malaysia to England. Similarity of Eocene molluscs from Colombia to the southern United States supports the idea that a uniformly mild climate characterized this region as far north as latitude 37°. What is known of the Eocene vegetation of northern South America also indicates climatic uniformity along the Antillean route of migration to the Mississippi embaymcnt. It has been suggested that the migration route followed by the plants to the west shore of the embayment in Texas may have been northward through Central America and Mexico.

Warm humid conditions persisted in the southeastern United States until Oligocene time, but in the Miocene epoch there is evidence of a reversal in direction of migration. The Calvert flora of this age in Virginia is made up largely of typically temperate Arcto-Tertiary trees such as pine, oak and elm, with a small representation of plants suggesting warmer conditions. Miocene and Pliocene vegetation in Florida is essentially like that found there today, with comparatively few relicts of the Neotropical-Tertiary flora surviving.

Northwestward in New Mexico and Colorado the Raton flora, somewhat older than the Wilcox, is also largely composed of angiosperms. Although nearly one-half of these fall into genera which range today into lower latitudes, the general aspect of the Raton flora is more temperate than the Wilcox. Northward along the Rocky mountains and on their eastern border, the Denver and Fort Union floras indicate progressively more temperate climates consistent with their latitudes. Like the Eocene floras from higher middle latitudes in the interior of Europe, they include many angiosperms of typically northern types mhich are characteristic of the Arcto-Tertiary flora, and such northrrn coniicrs as *Sequoia*. Still farther north in Saskatchewan, the Upper Ravenscrag and other Eocene floras are predominantly temperate in aspect, with only a few warm temperate genera. Cooler and dryer living conditions are shown by the Green river flora from the Middle Eocene of the Rocky mountain interior. Here evaporation products (such as gypsum) are conspicuous at certain horizons, while at others the leaves of angiosperms indicate a warm temperate climate probably with a marked dry season. Pollen described by R. P. Wodehouse is referable to many upland genera. From the Pacific coast eastward into the Columbia plateau, a coastal type of iorest indicates that the mild climate along the shore extended inland with no such topographic barriers as the Cascades and Sierra Nevada of today. The Goshen flora of western Oregon, the Chalk bluffs flora of central California, and many others are made up largely of plants whose modern equivalents are iound living in a climate with higher rainfall and less frost than now prevails in the. western United States. To the north in Alberta and on Kupreanof Island in southeastern Alaska, several subtropical to warm temperate trees are present in reduced numbers in floras made up largely of temperate plants, which may be more properly considered with the Arcto-Tertiary flora. The trend toward cooling climates in post-Eocene time is first shown by the gradual withdrawal of the Neotropical-Tertiary flora from the continental interior coastward. Only a few warm temperate trees map be noted in such Oligocene and Miocene floras as the Florissant (Colorado), Latah (eastern Washington), Bridge creek and Mascall (eastern Oregon) which are predominantly Arcto-Tertiary in origin and composition. In the belt of marine climate adjacent to the Pacific shore, they are more numerous; the Oligocene Weaverville flora of California is typically warm temperate in aspect, with large-leafed angiosperms such as *Tetracera* and *Calyptranthes*, and the conifer *Taxodium*. By the end of the Miocene even the hardy avocado (*Persea*) is restricted to central California, where it has survived into the Pliocene. *Umbellularia* is the only western American survivor of the Lauraceae, a family characteristic of both the Neo- and Palaeotropical floras. Living palms do not now range north of the Colorado desert in southern California, and members of other typical Neotropical families such as the Euphorbiaceae and Leguminosae are today represented in western North America only by herbs or shrubs rather than by trees as in the Eocene. While there are some plants living in the old world tropics mhich show a general resemblance to the Neotropical-Tertiary flora of western North America, the great majority of the modern descendants of this flora are to be found in Mexico and Central America.

The Keotropical-Tertiary flora of low and southern latitudes is not as well known as that of the United States. Judging from the available fossil material from the equatorial zone in Panama. Colombia, Venezuela and Ecuador. the vegetation there has been tropical from Eocene time down to the present with none of the marked changes

which resulted from climatic trends at higher latitudes. Resemblance of the Eocene flora of Venezuela to the Wilcox of the United States suggests that northern South America may have been a centre from which forests migrated over the Antillean land bridge. No floras of this age are known from Brazil, but a southward movement of vegetation under the influence of moderating climate is shown in Eocene floras of Patagonia and central Chile at lat. 37° to 45° S. They are made up largely of angiosperms as in the case of the corresponding Keotropical-Tertiary flora at middle latitudes in the northern hemisphere, with Lauraceae a common family. Certain families now more characteristic of the southern hemisphere assume importance, such as Apocynaceae, Bignoniaceae, Myrtaceae and Rubiaceae. The more abundant conifers, *Araucaria* and Podocarpus, are likewise largely southern in their modern distribution. In fact these Eocene floras are as typically South American in composition as the modern vegetation. They appear to have lived under climatic conditions involving no frost and heavy rainfall. Coupled with the world-wide amelioration in climate, other factors responsible for this southward extension of subtropical conditions may have been the broad marine transgression from the east, and absence of the Andes (shown by the similarity of floras in Patagonia and Chile on opposite sides of their present axis). With gradual post-Eocene cooling, most of the members of the Neotropical-Tertiary flora have moved northward 5° to 15° to their present ranges in South America. Peruvian floras of Oligocene and Miocene age appear to have extended across the present Andean axis into Brazil, where the somewhat younger Bahia flora is tropical in aspect. The Pliocene Potosi flora from high altitudes in Bolivia includes plants whose living relatives occupy lower regions with higher rainfall and temperature; E. W. Berry concludes that this part oi the Andes has been uplifted 5,000 ft. or more in post-Pliocene time. Lowland Miocene floras in Ecuador, Colombia, Venezuela and Trinidad resemble the moclern forests of the upper Amazon basin, and may be readily distinruished from floras of this age in Costa Rica and southern Mexico. This confirms an assumption based on faunal evidence that the land connections which characterized the Cretaceous and earlier Tertiary had been broken before Miocene time.

Summary of Tropical-Tertiary Floral Evidence. — Ameliorating climate at the outset of the Tertiary period resulted in an extension of subtropical vegetation to lat. 49° N. on the western shore of North America, and to lat. 50° N. on the equally favoured coast of western Europe. Inland these floras did not extend so far north, as is consistent with their more continental climates. Such distribution seems to establish the northern continents and ocean basins in essentially their present positions during the Tertiary period, and serves as a strong argument against continental drift in later geologic time. Similar distributional relations in earlier periods may also be considered to indicate the permanence of ocean basins and continental platforms through that portion of earth history in which land plants have lived. Families common to the old world (Palaeotropical-Tertiary) flora and that of the new world (Xeotropical-Tertiary) sungest a common origin for much of the vegetation of the northern hemisphere during Cretaceous time or earlier; generic and specific differences serve to distinguish the Eocene floras of middle latitudes on the two continents and these diiterences are still apparent in modern Palaeotropical and Xeotropical floras.

Lowered temperature and rainfall at the close of the Eocene epoch resulted in a gradual movement of vegetation southward, although subtropical and warm temperate trees and shrubs lingered on into Miocene and Pliocene time along the westward shores of the continents, especially in Europe. Unlike the north-south ranges in North and Central America which permitted migration to more favourable latitudes, the transverse Alps served as a barrier to southward movement into Africa, as did the Tethys-Mediterranean sea.

Migrations of vegetation southward from the equator carried the Tropical-Tertiary floras into middle southern latitudes of South America and Australia during the Eocene, from where they gradually withdrew as climatic conditions became more rigorous. A considerable part of these southern hemisphere forests, both in the old and new worlds, appears to have developed south of the equator; differences with floras of corresponding age north of the equator are especially apparent when the conifers are compared, perhaps because they are better known and more accurately determined than most Tertiary angiosperms from the southern hemisphere. Increments have been progressively added to the forests of the equatorial belt by movements of vegetation from middle to lower latitudes in post-Eocene time, which may account in part for the high degree of diversity now to be found in forests of the tropics.

Arcto-Tertiary Flora. — The northward extension of forests dominated by angiosperms during Eocene time had its parallel during the Devonian period in the occupation of ferns, and in the Jurassic occurrence of ferns, cycadophytes, ginkgoids and conifers, at high northern and southern latitudes. In all three cases wide submergence tended to equalize water and air temperatures, and it is considered probable that polar icecaps completely disappeared. Many students of past climates believe that increases in solar radiation may have brought a rise in temperature throughout the world. We have seen that the Tropical-Tertiary flora extended into middle latitudes in Eocene time, especially along the windward shores of the continents. A corresponding movement of temperate vegetation brought diversified forests into Greenland, Spitzhergen, central Siberia and Alaska, and to southern Chile, Seymour Island in Antarctica, and the Kerguelen archipelago. These latter are assigned to the Antarcto-Tertiary flora. At still higher northern latitudes on New Siberia Islands, in northern Siberia and Canada, in Banks Land, Bathurst Islands, Ellesmere Land, and to Grinnell Land at lat. 83° N., Eocene floras of cold-temperate character include pine, spruce, sedges, poplar, willow and birch. The occurrence of *Sequoia* with these typically northern plants is difficult to explain, for the living coast redwood, S. *sempervirens*, is limited to regions of mild temperature; however the Sierra redwood, S. gigantea, occurs at an altitude of 8,000 ft. in the mountains of central California where winter temperature goes to −12° F. and snowfall is heavy; it seems probable that an ecotype of the redwood may have been suited to life within 7° of the north pole under the mild climatic regime of the Eocene, and that it may have had the deciduous habit of modern Taxodiirnz and certain other conifers.

Like the Tropical-Tertiary floras of the Eocene, the Arcto-Tertiary ranged iarther north on the windward sides of the continents than in their interiors. Alder (*Alnus*), birch (*Betula*), beech (*Fagus*), hornbeam (*Carpinus*), elm (*Ulmus*), maple (*Acer*, Pl. V, fig. 10), oak (*Quercus*), and katsura (*Cercidiphyllum*) are among the most common angiosperms; among the gymnosperms, Sequoia, *Taxodium* (bald cypress, Pl. V, fig. 7) and *Ginkgo* are characteristic. There is no basis for differentiating what A. Kryshtofovitch has called the Turgayan flora of northeastern Asia from other Eocene floras in the Greenland region and in Alaska. During the Oligocene epoch which followed, these temperate forests appear to have largely disappeared from high latitudes, and to have migrated southward over some 12° of latitude. Bridge creek flora from the John Day basin of eastern Oregon includes species of *Sequoia* (Pl. V, fig. 5), and Quercus (*Lithocarpus*) which have similar living relatives in western North America (Pl. VI, fig. 2); species of *Ostrya* (Pl. V, fig. 4) and *Fagus* whose living equivalents are now restricted to the eastern United States (PI. VI, fig. 3); and species of *Cercidiphyllum* and *Ulmus* whose most nearly relattd equivalents live in eastern Asia. These and other common genera of the Arcto-Tertiary flora are represented in the Oligocene floras of France, Germany, Austria, Croatia, Manchuria, Korea. southeastern Siberia, Sakhalin, British Columbia and Colorado, and it is clear that regional differentiation such as characterizes the forests of the northern hemisphere today had not yet been attained. Many of the mountain ranges which now serve as climatic and migrational barriers were not then in existence, and both temperature and rainfall must have been more uniformly distributed than in the world of today.

By Miocene time the Arcto-Tertiary flora had ranged south into China and Japan, into Spain, Switzerland and southern Russia, and into central California and Nevada. Extensive mountain-making anti volcanism during this and the following epoch produced a topographic setting and its resultant climate unfavourable to the survival of many tree genera. With a change from rainfall uniformly distributed areally and seasonally to large areas of rain shadow and summer-dry climate, vegetation began to show greater regional differentiation. The Shanwang flora from the Miocene of northeastern China contains several genera such as *Broussonetia, Eriobotrya, Firmiana, Hovenia, Kalopanax* and Pueraria which have not been recorded from Miocene floras in Europe and North America, and which are limited to Asia in their modern distribution. The Mascall flora of Oregon and other Miocene floras from western North America include several species of black oak (Pl. V, fig. 11), a division of the genus *Quercus* which has not been found in fossil floras from Eurasia and is not represented on that continent today. Many Pliocene floras show smaller numbers of tree species, and the size of their leaves is much reduced in the case of aspen (Pl. V, fig. 8), oak (Pl. V, fig. 6), and other trees. Such genera as Ginkgo, *Glyptostrobus, Cercidiphyllum* and *Zelkova* (Pl. V, fig. 15) were rare or absent in North America. where none of them is known to have survived the Tertiary period; in Europe most of these now-Asiatic genera lived later, hut none oi them lasted beyond the end of the Pliocene. In North America such deciduous genera as *Fagus, Carpinus,* Castnnea, *Carya* and *Ulmus* disappeared from the west during the Pliocene and have survived on this continent only in the east where a summer-wet climate has persisted. The redwood became restricted to the immediate borders of the Pacific where it lives today in a marine-controlled environment. It became extinct in Eurasia before the end of the Pliocene epoch. The Lower Pliocene flora of the Dutch-Prussian border, which includes many well-preserved seeds (Pl. V, figs. 9, 12), still showed a strong Asiatic alliance; but by the end of the epoch the vegetation of this age from western Europe was essentially like that of today.

The changing climate of later Tertiary time placed grasslands in a favourable position for competition with forests in the interiors of the northern continents. Fossil grasses are not of common occurrence, presumably because of conditions unsuited to their preservation. Occasional remains of the Gramineae have been found in rocks of Cretaceous age and younger, but it is not until the Miocene epoch that grasses are known to have become abundant. The silicified remains of their seeds have been described by M. K. Elias from a wide area in the high plains of North America. The abundance of grazing types of mammals indicates the extent of grasslands over a still more extensive region of this and other northern continents. Few other plant remains are found associated with them, but occasional leaves, fruit

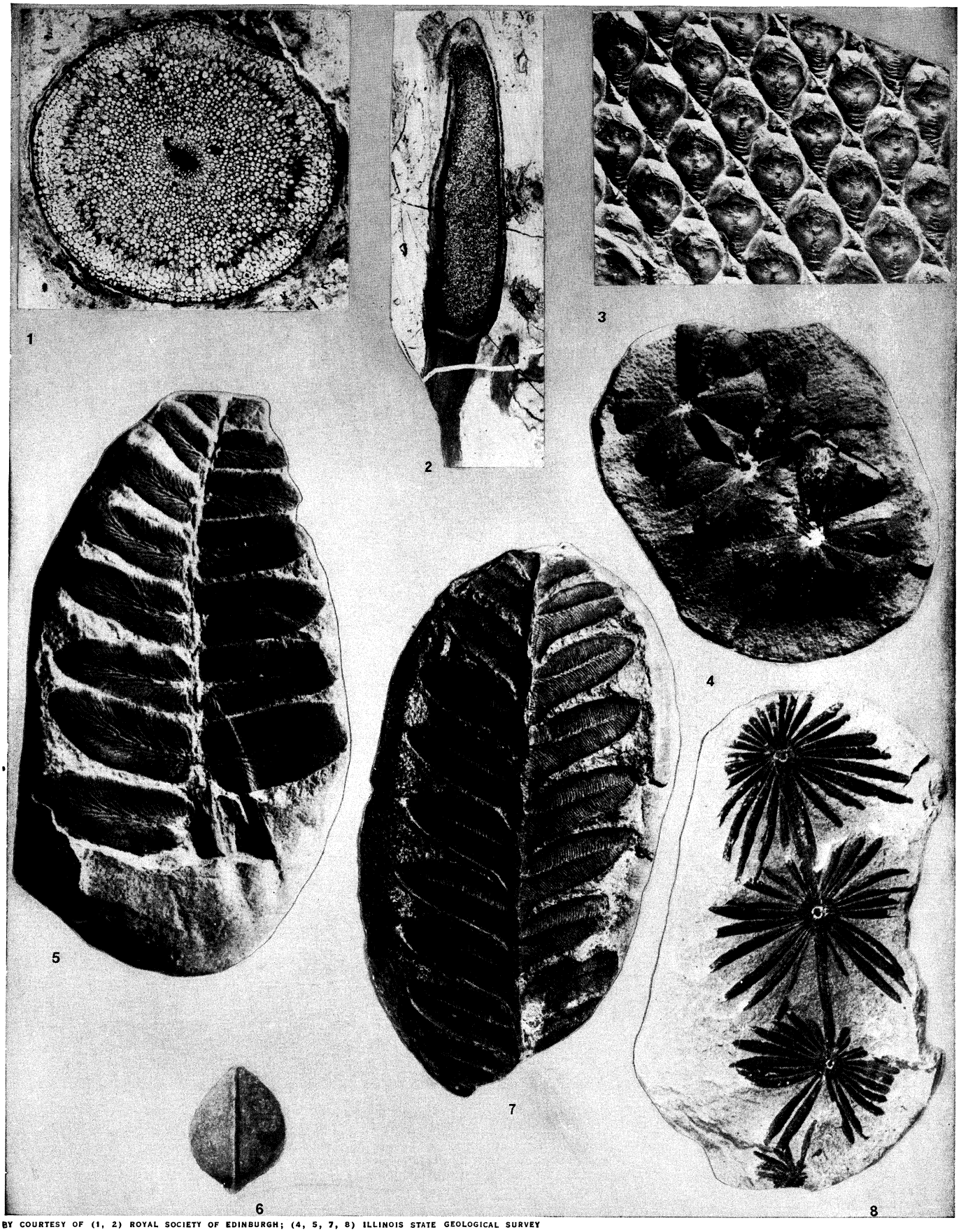
BY COURTESY OF (1) NEW YORK STATE MUSEUM; PHOTOGRAPH (2) CHICAGO NATURAL HISTORY MUSEUM

RESTORATIONS OF PALAEOZOIC FLORAS

1. Restoration of plant life of the Devonian period. In foreground casts of base of *Eospermatopteris* trunks; in background trees of Eospermatopteris (bearing fronds) and Protolepidodendron (with bare, forked stems.)

2. Restoration of plant life of the Carboniferous period. At left trunks and cone-bearing branches of lepidodendrids; trees with whorled branches at right are calamites; sphenophylls and seed ferns growing on the forest floor

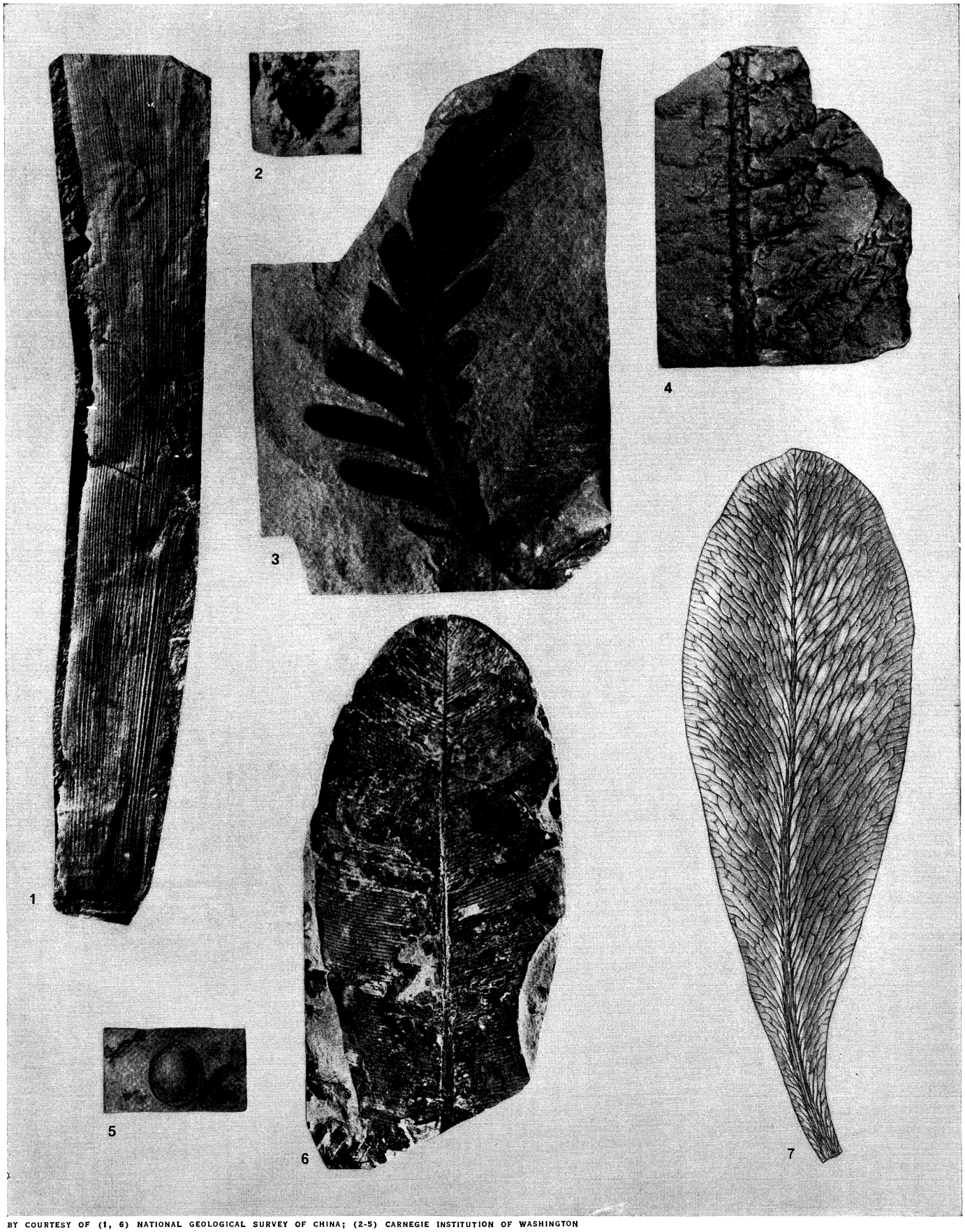
PALAEOBOTANY



BY COURTESY OF (1, 2) ROYAL SOCIETY OF EDINBURGH; (4, 5, 7, 8) ILLINOIS STATE GEOLOGICAL SURVEY

PLANT FOSSILS OF THE PALAEOZOIC ERA

1. *Rhynia* major, cross section of stem (after Kidston & Lang) (x 12). 2. *Rhynia* major, sporangium in longitudinal section (after Kidston & Lang) (x 4½). (1 and 2 are specimens from Rhynie Chert, Middle Devonian of Scotland.) 3. *Lepidodendron* sp., cast of stem. 4. Sphenophyllum *emarginatum*, leafy stem (x ⅔). 5. *Neuropteris vermicularis*, portion of leaf (x 5/4). 6. Trigonocarpus sp., seed. 7. *Alethopteris serlii*, portion of leaf. 8. Annularia *stellata*, leafy stem. (3 through 8 are specimens from Alleghany series, Upper Carboniferous, of Illinois.)

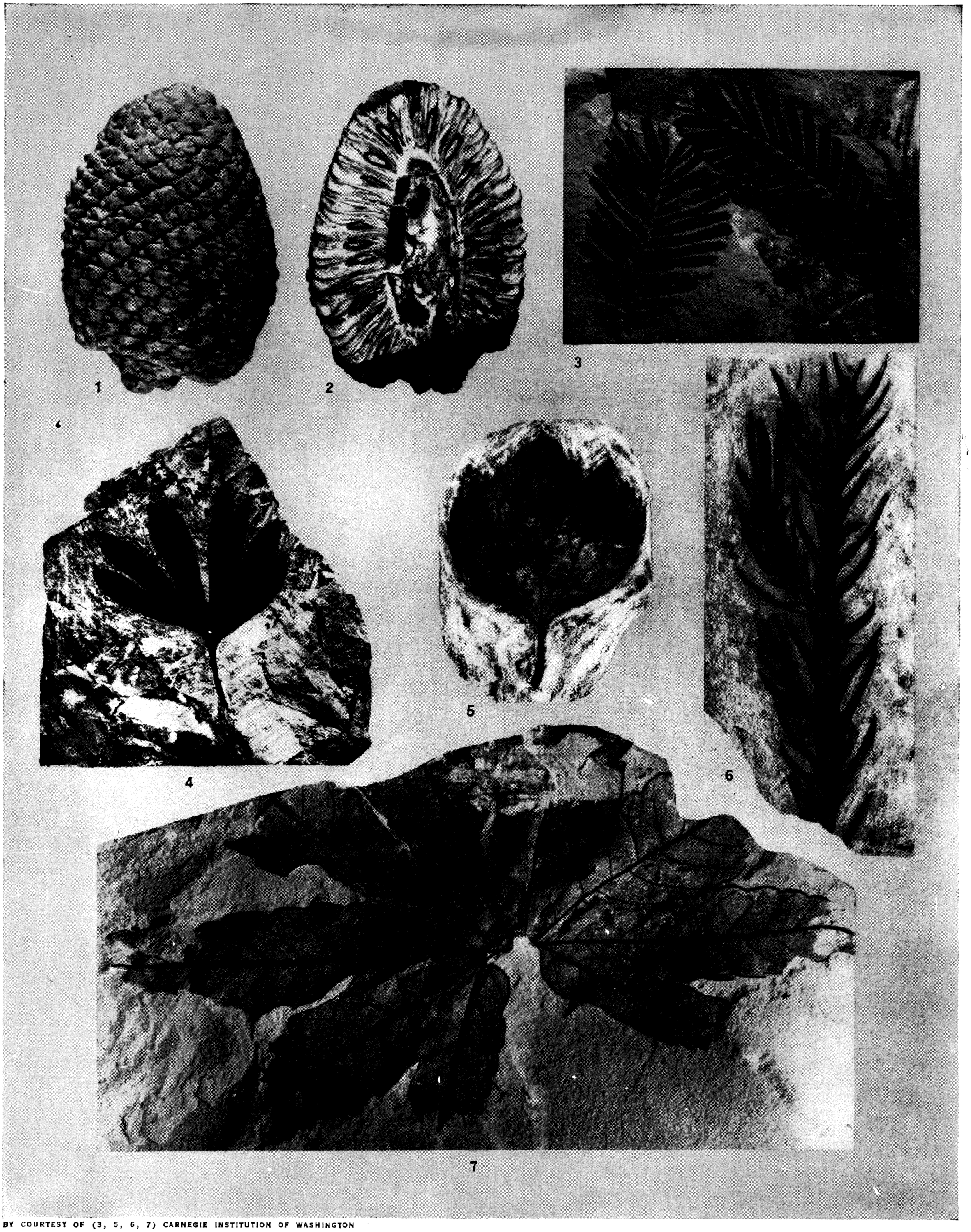


BY COURTESY OF (1, 6) NATIONAL GEOLOGICAL SURVEY OF CHINA; (2-5) CARNEGIE INSTITUTION OF WASHINGTON

PLANT FOSSILS OF THE PERMO-CARBONIFEROUS

1. Cordaites sp., leaf. (Specimen from Yuehmenkou series of Shansi, China.)
2. *Voltzia* sp., cone-scale
3. *Supaia compacta*, leaf
4. *Walchia* dawsoni, branchlet
5. *Cordaites* sp., leaf. (2 thru 5 are specimens from Hermit Shale of Arizona.)
6. *Taeniopteris* norinii, leaf. (Specimen from Upper Shihhotse series of Shansi, China.)
7. *Glossopteris conspicua*, leaf (reconstruction). (Specimen irom Damuda series of India.)

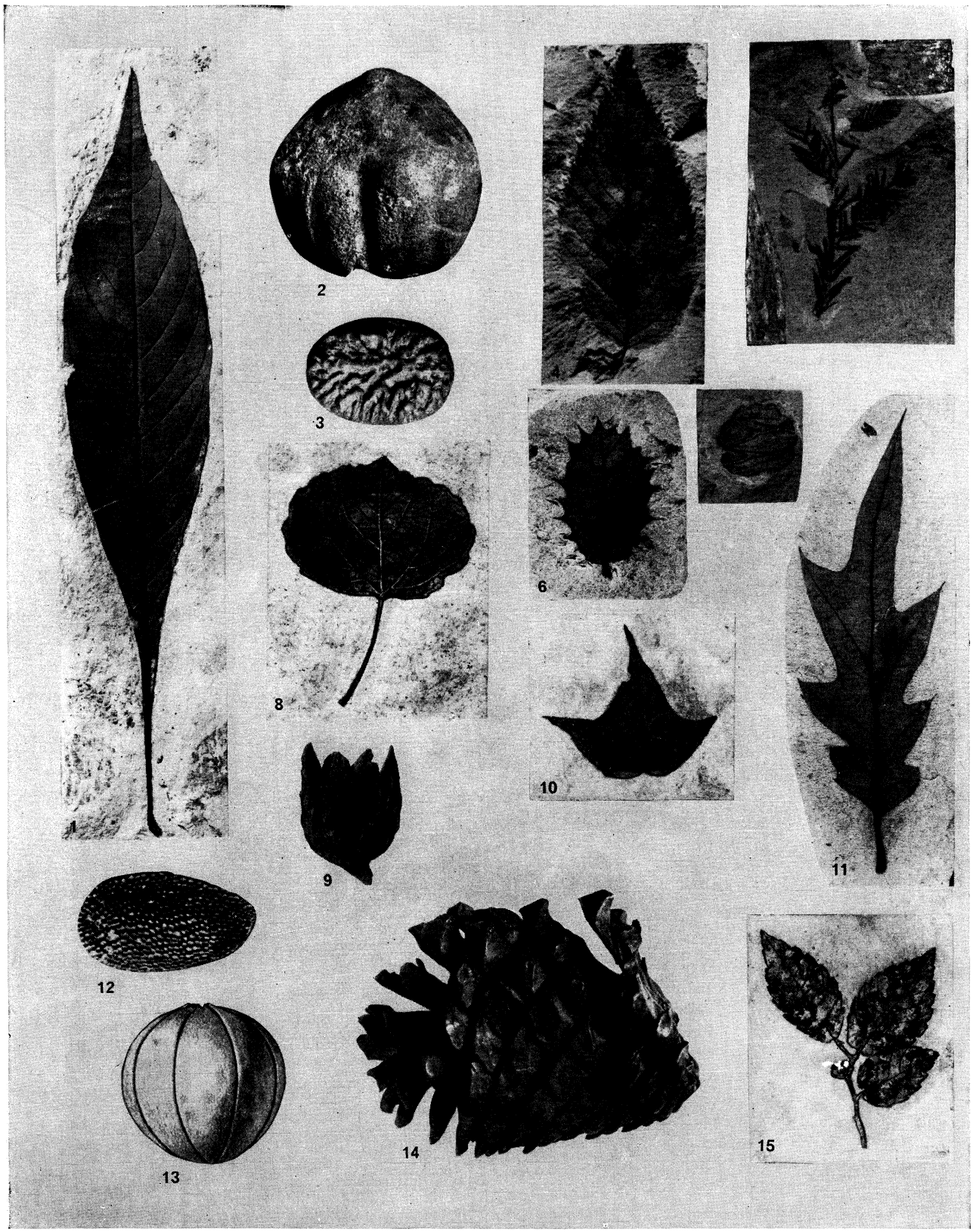
PALAEOBOTANY



BY COURTESY OF (3, 5, 6, 7) CARNEGIE INSTITUTION OF WASHINGTON

PLANT FOSSILS OF THE MESOZOIC ERA

1. Proaraucaria *mirabilis,* cone. 2. Proaraucaria *mirabilis,* cone in longitudinal section. (1 and 2 are specimens from Triassic[?] of Argentina.) 3. *Otozamites powelli,* fronds. 4. Ginkgo sp., leaf. (Specimen from Jurassic of Oregon.) 5. Viburnum *marginatum,* leaf. 6. *Araucarites longifolia,* branchlet. (5 and 6 are specimens from Lance [Upper Cretaceous] of Wyoming.) 7. *Clathropteris walkeri,* frond. (3 and 7 are specimens from Late Triassic of Arizona)



BY COURTESY OF (1, 4-8, 10, 11, 13-15) CARNEGIE INSTITUTION OF WASHINGTON; (2, 3) TRUSTEES OF THE BRITISH MUSEUM (NATURAL HISTORY); (9, 12) THE INSTITUTE OF GEOLOGICAL EXPLORATION OF THE NETHERLANDS FROM E. M. REID, "THE PLIOCENE FLORA OF THE DUTCH-PRUSSIAN BORDER"

PLANT FOSSILS OF THE CENOZOIC ERA

1. *Laurophyllum merrilli*, leaf (x ¾). (Specimen from Early Tertiary of Oregon.) 2. Nipa *burtini*, seed. 3. Anonaspermum *ovale*, internal cast of seed (x 3). (2 and 3 are specimens from Early Tertiary of England.) 4. *Ostrya oregoniana*, leaf. 5. Sequoia *langsdorfii*, branchlets (x ⅔). 6. Quercus dayana, leaf. 7. *Taxodium dubium*, cone. (4 through 7 are specimens from Middle Tertiary of Oregon.) 8. *Populus pliotremuloides*, leaf. (Specimen from Late Tertiary of Oregon.) 9. *Fagus* decurrens, involucre (x 2). (Specimen from Late Tertiary of Holland.) 10. Acer *florinii*, leaf. (Specimen from Middle Tertiary of Shantung, China.) 11. Quercus pseudolyrata, leaf. (Specimen from Middle Tertiary of Oregon.) 12. *Actinidia faveolata*, seed (x 12). (Specimen from Late Tertiary of Holland.) 13. Arctostaphylos *glauca*, fruit (x 3). 14. *Pinus* muricata, cone. (13 and 14 are specimens from Pleistocene of California.) 15. Zelkova *ungeri*, twig with leaves and fruit. (Specimen irom Middle Tertiary of Shantung, China.)

BY COURTESY OF CARNEGIE INSTITUTION OF WASHINGTON

MODERN FORESTS RESEMBLING CENOZOIC FLORAS

1. Subtropical forest in Panamá. 2. Redwood forest in California. 3. Broad-leafed deciduous forest in Kentucky. 4. Valley of the John Day river, Oregon

and stems indicate that trees such as *Celtis* (hackberry), *Platanus* and *Populus* lived on the stream borders and in other favoured situations in the high plains of interior North America. In central Asia, in Kansu and Sinkiang provinces. China, stems and leaves believed to represent grass are associated with leaves of poplar, willow and other stream-border plants.

Madro-Tertiary Flora.— Another result of the more rigorous climate following the Eocene epoch was the appearance in the western United States of a small-leafed, arid type of vegetation from the south. Its exact time and place of origin have not been established by fossil evidence, but its relations mith living plants suggest that it became differentiated in early Tertiary time on the arid uplands of Mexico, and that it later migrated northward along mountain ranges. Its representation in the Green river flora of Eocene age is indicated by the occurrence of a nut pine, a cactus and small-leafed legumes. The Oligocene flora from Florissant, Colorado also includes plants which may have had their origin in the Sierra Madre. The Tehachapi flora irom the Miocene of southern California is made up predominantly of Madro-Tertiary species, which are likewise well represented in Pliocene floras extending across Nevada into Oregon, and in central Colorado. Small-leafed oaks (Pl. V, fig. 6) are characteristic members of the Madro-Tertiary flora, together with *Ceanothus, Arctostaphylos* and other chaparral plants. A small flora of Oligocene age from Turkestan is made up of steppe plants which suggest that an old world flora corresponding to the Madro-Tertiary may have developed in Asia and ranged northward.

Antarcto-Tertiary Flora.— While there is a wide divergence of opinion regarding the place of origin of vegetation which occupied high and middle latitudes of the southern hemisphere in later geologic time, there seems to be little question that much of it has had a separate development there during the Tertiary period, and that it became established in high southern latitudes during Upper Cretaceous time. Evidence of a broader extent of Antarctica has been presented in our discussion of Permo-Carboniferous and Jurassic floras. Northward connections from this polar continent to South America, to Australia and New Zealand, and probably to Africa, seem also to have been in existence at the beginning of the Tertiary period, and to have provided routes for migration between the southern continents.

The Eocene flora of Seymour Island, Antarctica, in lat. 64° S. contains three genera of coniiers, *Acmopyle, Araucaria* and *Podocarpus,* all of which are now southern in distribution; the angiosperms are also of southern types, *Drimys, Knightia, Laurelia, Lomatia* and *Nothofagus.* To the north on the southern tip of South America (Strait of Magellan in Chile and Tierra del Fuego in Argentina), an early Tertiary flora includes the coniiers *Araucaria* and *Podocarpus,* and the angiosperms *Nothofagus* (most abundant), *Knightia, Laurelia* and others not generically determined. All of these plants ranged northward to lat. 45° S. during older Tertiary time, and several of them occur in ecotonal relationship with the Neotropical-Tertiary flora at lat. 41° S. in Patagonia, here considered to be of Eocene age. Their present centres of distribution are at still lower latitudes in the southern continents other than Africa.

A small flora including *Araucaria, Podocarpus,* and fragmentary angiosperm leaves of which the best-preserved resembles *Coprosnza,* has been recorded irom the Kerguelen Islands at lat. 4g° S. below Africa and Australia, in beds of older Tertiary age. Little is known of the temperate vegetation of South Airica. Most of the Tertiary floras of Australia and New Zealand are in need of revision, and only preliminary comments can be made here. An Eocene flora from New South Wales (lat. 35° S.) includes laurels, *Magnolia, Eucalyptus,* legumes, *Pittosporum* and other subtropical genera. together with such typically temperate forms as *Nothofagus* and *Knightia;* most of the Miocene plants are typically temperate, including *Nothofagus, Araucaria, Lonzatia, Coprosnza;* the majority of these plants are characteristic of the southern hemisphere, and many of their living equivalents are Australian. A significant flora of later Tertiary age has been described by Oliver from South Island, New Zealand (lat. 45° S.). Along with *Podocavpus* are numerous angiosperms, some of which (*Nothofagus, Knightia, Laurelia*) appear to have had their origin to the south, while others are of Malayan origin and doubtless entered this region during the southward extension of the Palaeotropical-Tertiary flora.

The discontinuous distribution which now characterizes so many genera in the southern hemisphere seems to have resulted irom the breaking of land bridges between Antarctica and continents to the north during Tertiary time, and to climatic changes which made the higher latitudes uninhabitable for trees. Resultant migrations brought Antarcto-Tertiary conifers and angiosperms northward from Antarctica into middle latitudes of South America, Australia and New Zealand, and to a lesser extent into Africa during Tertiary time, and certain genera have spread into still lower latitudes along mountain ranges to become mingled mith the descendants of the Tropical-Tertiary floras. There has been some intermingling with vegetation north of the equator, where similar migrations mere shifting the Arcto-Tertiary flora southmard, but the iorests of the southern hemisphere have continued largely distinct from those of the northern down to the present day.

Pleistocene Floras.— The vegetation of this epoch, which with the Recent makes up the Quaternary period, grades imperceptibly into that of today. Fossil plants preserved in river and glacial clays, and in peat and asphalt deposits, seem in most cases to represent species now living. But their distribution may show marked discrepancies with that of today because of the relatively rapid changes in climate which characterize the Pleistocene. The southward extension of continental glaciers in the northern hemisphere brought arctic birch and willow into England during colder and moister stages. The occurrence of white spruce *(Picea glauca)* in Louisiana, more than 800 miles south of its present southern limit, is indicative of corresponding glacial climate in North America. On the Pacific coast, where glaciers are not known to have come down out of the mountains to the coastal plain, the redwood appears to have lived in the regions it now occupies; but it also ranged down into southern California, where the present warm, dry climate is unsuited to it. Fossil cones of Monterey pine (*Pinus radiata*), Bishop pine *(P. muricata,* Pl. *V,* fig. 14), and other northern species also indicate a cooler and more humid climate than is now found there. Manzanita (*Arctostaphylos glauca,* Pl. *V,* fig. 13) and other shrubs lived. in the adjacent hills. During an interglacial stage of the Pleistocene, Monterey pine ranged north along the Pacific coast beyond its present limits. In the North American interior, *Asimina triloba, Robinia pseudoacacia,* and other species with more southerly modern ranges occur with northern trees in an interglacial deposit in Ontario, Canada. A similar flora in western Austria includes a *Rhododendron* and other species now living under milder conditions. Remains of *Libocedrus* and *Podocarpus* in Pleistocene deposits of the Falkland Islands indicate a milder climate at southern latitudes during part of this epoch than that of today, for trees no longer live there. Alternations of cold with mild climate brought the final elimination of many plants from middle latitudes, especially in Europe where the Alps served as a barrier to north-south or south-north migrations. Pollen records in post-glacial peat deposits indicate several fluctuations in precipitation and temperature during past millenia. Vegetation of today is doubtless responding to climatic changes, but its migrations are ordinarily too slow to be perceptible.

Summary of Cenozoic Floral History.— During the era in which we live, there has been a world-wide movement of iorests from higher to lower latitudes under compulsion of climatic change. The sequence of fossil floras in the John Day basin of eastern Oregon provides one of the most complete known records of plant migrations. It is now a region of low rainfall and of wide temperature extremes, with willow, cherry, hackberry and other small trees largely limited to the river borders (Pl. VI, fig. 4). But in Middle Tertiary time this region was inhabited by redwoods like those now living on the humid coast of northern California (Pl. VI, fig. 2). Their leaves and petrified stems are found preserved in the rocks showing as a light-coloured outcrop near the centre of the picture of the John Day valley (PI. VI, fig. 4), underlying flows of Columbia lava which poured out across this region during the Miocene epoch. With these redwoods grew beech, hornbeam and other deciduous hardwoods now restricted in North America to its eastern half where a summer-wet climate prevails (Pl. VI, fig. 3); certain trees of the Oligocene and Miocene forests of the John Day basin have their nearest living equivalents in northeastern Asia. During a still earlier stage of Cenozoic history, a subtropical forest occupied this part of Oregon (Pl. VI, fig. 4). Its presence is recorded by large, thick, fossil leaves of trees and vines now living in the humid, frostless environment of Central America. In the course of the 60,000,000 years represented by these fossil floras, the John Day basin has been covered successively by the Neotropical-Tertiary flora, the Arcto-Tertiary flora, and modern steppe vegetation. During the ages since the Eocene, the Neotropical-Tertiary flora has retreated southmard, with the Arcto-Tertiary flora moving in from Alaska and British Columbia to take over the area it occupied. Subsequent uplift of the Cascades has cut off most of the rainfall from eastern Oregon, and the moderating influence of the ocean on its temperature is no longer felt in the interior of the continent. The redwood and many of its moisture-requiring associates have been confined to the Pacific shores, while other trees which flourish during rainy summers and shed their leaves during the winter have survived in the eastern part of North America, and in eastern Asia.

In other parts of the world, similar changes in plant distribution have been taking place; forests have been forced equatorward by temperature reduction, or have given map to grasslands and deserts in regions of lessened rainfall. Vegetation of today is the product of all of the floras of the past. It has been modified through the ages by changing environments which have shifted iorests widely across the earth. During these journeys some elements have become extinct, others have developed into more specialized types, while a few have survived with little change to show us the nature of yesterday.

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PALAEOCENE: *see* EOCENE AND PALAEOCENE.

PALAEOGRAPHY, the name given to the science of ancient handwriting acquired from a study of surviving examples. The word is sometimes erroneously used where epigraphy would be better (for inscriptions, *q.v.*, on stone or metal).

It is difficult, indeed, to define the boundary between the two sciences; many of the ancient inscriptions of the far east, Cambodia, India, Ceylon, etc., may quite legitimately be dealt with as part of the study of palaeography, although they are usually treated by epigraphists as purely confined to their realm of activity. The different implements used from the beginning in the making of marks or outline characters, whereby man made a permanent record of his thoughts and experiences, have had their influence on the classification of writings as adopted by later scholars.

In the present article only Greek and Latin palaeography will be discussed. *See* EGYPT and HIEROGLYPHS for the Egyptian records. (X.)

GREEK

A history of Greek handwriting must be incomplete owing to the fragmentary nature of the evidence. If we rule out the inscriptions on stone or metal, which belong to the science of epigraphy, we are practically dependent for the period preceding the 4th or 5th century of the Christian era on the papyri from Egypt (*see* PAPYROLOGY) the earliest of which take back our knowledge only to the end of the 4th century B.C. This limitation is less serious than it might appear, since the few mss. not of Egyptian origin which have survived from this period, like the parchments from Avroman (E. H. Minns, *Journ. of Hell. Stud.*, xxxv., 22 *seq.*) or Dura (*New Pal. Soc.*, ii., 156), the Herculaneum papyri, and a few documents found in Egypt but written elsewhere, reveal a surprising uniformity of style in the various portions of the Greek world; but some differences can be discerned, and it is probable that, had we more material, distinct local styles could be traced.

Further, at any given period several types of hand may exist together. There was a marked difference between the hand used for literary works (generally called "uncials" but, in the papyrus period, better styled "book-hand") and that of documents ("cursive") and within each of these classes several distinct styles were employed side by side; and the various types are not equally well represented in the surviving papyri.

The development of any hand is largely influenced by the materials used. To this general rule the Greek script is no exception. Whatever may have been the period at which the use of papyrus or leather as a writing material began in Greece (and papyrus was employed in the 5th century B.C.), it is highly probable that for some time after the introduction of the alphabet the characters were incised with a sharp tool on stone or metal far oftener than they were written with a pen. In cutting a hard surface it is easier to form angles than curves; in writing the reverse is the case; hence the development of writing was from the angular letters ("capitals") inherited from the epigraphic style to rounded ones ("uncials"). But only certain letters were affected by this development, in particular E (uncial ϵ), Σ (c), Ω (ω), and to a less extent A (α).

The Ptolemaic Period.—The earliest Greek papyrus yet discovered is probably that containing the *Persae* of Timotheus, which dates from the second half of the 4th century B.C. and its script has a curiously archaic appearance. E, Σ, and Ω have the capital form, and apart from these test letters the general effect is one of stiffness and angularity. More striking is the hand of the earliest dated papyrus, a contract of 311 B.C. Written with more ease and elegance, it shows little trace of any development towards a truly cursive style; the letters are not linked, and though the uncial c is used throughout, E and Ω have the capital forms. A similar impression is made by the few other papyri, chiefly literary, dating from about 300 B.C.; E may be slightly rounded, Ω approach the uncial form, and the angular Σ occurs as a letter only in the Timotheus papyrus, though it survived longer as a numeral (=200), but the hands hardly suggest that for at least a century and a half the art of writing on papyrus had been well established. Yet before the middle of the 3rd century B.C. we find both a practised book-hand and a developed and often remarkably handsome cursive.

These facts may be due to accident, the few early papyri happening to represent an archaic style which had survived along with a more advanced one; but it is likely that there was a rapid development at this period, due partly to the opening of Egypt, with its supplies of papyri, and still more to the establishment of the great Alexandrian library, which systematically copied literary and scientific works, and to the multifarious activities of Hellenistic bureaucracy. Henceforward the two types of script were sufficiently distinct (though each influenced the other) to require separate treatment. Some literary papyri, like the roll containing Aristotle's *Constitution of Athens*, were written in cursive hands, and, conversely, the book-hand was occasionally used for documents. Since the scribes did not date literary rolls such papyri are useful in tracing the development of the book-hand.

The documents of the mid 3rd century B.C. show a great variety of cursive hands. We have none from the chancelleries of the Hellenistic monarchs, but some letters, notably those of Apollonius, the finance minister of Ptolemy II., to his agent, Zeno, and those of the Palestinian sheikh, Toubias, are in a type of script which cannot be very unlike the Chancery hand of the time, and show the Ptolemaic cursive at its best. These hands have a noble spaciousness and strength, and though the individual letters are by no means uniform in size there is a real unity of style, the general impression being one of breadth and uprightness. H, with the cross-stroke high, Π, M, with the middle strokes reduced to a very shallow curve, sometimes approaching a horizontal line, ϒ, and T, with its cross-bar extending much further to the left than to the right of the up-stroke, Γ and N, whose last stroke is prolonged upwards above the line, often curving backwards, are all broad; ϵ, c, θ, and β, which sometimes takes the form of two almost perpendicular strokes joined only at the top, are usually small; ω is rather flat, its second loop reduced to a practically straight line. Partly by the broad flat tops of the larger letters, partly by the insertion of a stroke connecting those (like H, ϒ) which are not naturally adapted to linking, the scribes produced the effect of a horizontal line along the top of the writing, from which the letters seem to hang. This feature is indeed a general characteristic of the more formal Ptolemaic script, but it is specially marked in the 3rd century B.C.

Besides these hands of Chancery type, there are numerous less elaborate examples of cursive, varying according to the writer's skill and degree of education, and many of them strikingly easy and handsome. In some cursiveness is carried very far, the linking of letters reaching the point of illegibility, and the characters sloping to the right. A is reduced to a mere acute angle (∠), T has the cross-stroke only on the left, ω becomes an almost straight line, H acquires a shape somewhat like h, and the last stroke of N is extended far upwards and at times flattened out till it is little more than a diagonal stroke to the right. The attempt to secure a horizontal line along the top is here abandoned. This style was not due to inexpertness, but to the desire for speed, being used specially in accounts and drafts, and was generally the work of practised writers. How well established the cursive hand had now become is shown by some wax tablets of this period in University college, London (*Ancient Egypt*, 1927, part 3), the writing on which, despite the difference of material, closely resembles the hands of papyri.

Documents of the late 3rd and early 2nd centuries B.C. show,

perhaps partly by the accident of survival (we have nothing analogous to the Apollonius letters), a loss of breadth and spaciousness. In the more formal types the letters stand rather stiffly upright, often nithout the linking strokes, and are more uniform in size; in the more cursive they are apt to be packed closely together. These features are more marked in the hands of the 2nd century. The less cursive often shon an approximation to the book-hand, the letters growing rounder and less angular than in the 3rd century; in the more cursive linking was carried further, both by the insertion of coupling strokes and by the writing of several letters continuously without raising the pen, so that before the end of the century an almost current hand was evolved. A characteristic letter, which survived into the early Roman period, is T, with its cross stroke made in two portions (Ϯ). In the 1st century the hand tended, so far as can be inferred from the surviving examples, to disintegrate; we can recognize the signs which portend a change of style, irregularity, want of direction, and the loss of the feeling for style. A fortunate accident has preserved two Greek parchments nritten in Parthia, one dated 88 B.C., in a practically unligatured hand, the other, 22/21 B.c., in a very cursive script of Ptolemaic type; and though each has un-Egyptian features the general character indicates *a* uniformity of style in the Hellenistic norld.

The development of the Ptolemaic book-hand is difficult to trace, as there are few examples, mostly not datable on external grounds. Only for the 3rd century B.C. have we a secure basis. The hands of that period have an angular appearance; there is little uniformity in the size of individual letters, and though sometimes, notably in the Petrie papyrus containing the *Phaedo* of Plato, a style of considerable delicacy is attained, the book-hand in general shows less mastery than the contemporary cursive. In the 2nd century the letters grew rounder and more uniform in size, but in the 1st century there is perceptible, here as in the cursive hand, a certain disintegration. Probably at no time did the Ptolemaic book-hand acquire such unity of stylistic effect as the cursive.

The Roman Period.—Papyri of the Roman period are far more numerous and show greater variety. The cursive of the 1st century has a rather broken appearance, part of one character being often made separately from the rest and linbed to the next letter. A form characteristic of the 1st and 2nd centuries and surviving after that only as a fraction sign (=$\frac{1}{8}$) is η in the shape 3. By the end of the 1st century there had been developed several excellent types of cursive, which, though differing considerably both in the forms of individual letters and in general appearance, bear afamily likeness to one another. Qualities which are specially noticeable are roundness in the shape of letters, continuity of formation, the pen being carried on from character to character, and regularity, the letters not differing strikingly in size and projecting strokes above or below the line being avoided. Sometimes, especially in tax-receipts and in stereotyped formulae, cursiveness is carried to an extreme. In a letter of the prefect, dated in 209, we have a fine example of the Chancery hand, with tall and laterally compressed letters, o very narrow and α and ω often written high in the line. This style, from at least the latter part of the 2nd century, exercised considerable influence on the local hands, many of which show the same characteristics less pronounced; and its effects may be traced into the early part of the 4th century. Hands of the 3rd century uninfluenced by it show a falling off from the perfection of the 2nd century; stylistic uncertainty and a growing coarseness of execution mark a period of decline and transition.

Several different types of book-hand were used in the Roman period. Particularly handsome is a round, upright hand seen, *e.g.*, in a British Museum papyrus containing Odyssey III. The cross-stroke of ϵ is high, M deeply curved and A has the form α. Uniformity of size is well attained, and few strokes project, and these but slightly, above or below the line. Another type, well called by Schubart the "severe" style, has a more angular appearance and not infrequently slopes to the right; though handsome, it has not the sumptuous appearance of the former. There are various classes of a less pretentious style, in which convenience rather than beauty was the first consideration and no pains were taken to avoid irregularities in the shape arid alignment of the letters. Lastly may be mentioned a hand which is of great interest as being the ancestor of the type called (from its later occurrence in vellum codices of the Bible) the biblical hand. This, which can be traced back to at least the late 2nd century, has a square, rather heavy appearance; the letters, of uniform size, stand upright, and thick and thin strokes are well distinguished. In the 3rd century the book-hand, like the cursive, appears to have deteriorated in regularity and stylistic accomplishment.

In the charred rolls found at Herculaneum and dating from about the beginning of our era we have specimens of Greek literary hands from outside Egypt; and a comparison with the Egyptian papyri reveals great similarity in style and shows that conclusions drawn from the hands of Egypt may, with caution, be applied to the development of writing in the Greek world generally.

The Byzantine Period.—The cursive hand of the 4th century shows some uncertainty of character. Side by side with the style founded on the Chancery hand, regular in formation and with tall and narrow letters, which characterized the period of Diocletian, and lasted well into the century, we find many other types mostly marked by a certain looseness and irregularity. A general progress towards a florid and sprawling hand is easily recognizable, but a consistent and deliberate style was hardly evolved before the 5th century, from which unfortunately few dated documents have survived. Byzantine cursive tends to an exuberant hand, in which the long strokes are excessively extended and individual letters often much enlarged. But not a few hands of the jth and 6th centuries are truly handsome and show considerable technical accomplishment. Both an upright and a sloping type occur and there are many less ornamental hands, but there gradually emerged towards the 7th century tn-o general types, one (specially used in letters and contracts) a current hand, sloping to the right, with long strokes in such characters as τ, p, ξ, η (which has the h shape), ι, and κ, and with much linking of letters, and another (frequent in accounts), which shows, at least in essence, most of the forms of the later minuscule. (See below.) This is often upright, though a slope to the right is quite common, and sometimes, especially in one or two documents of the early Arab period, it has an almost calligraphic effect.

In the Byzantine period the book-hand, which in earlier times had more than once approximated to the contemporary cursive, diverged widely from it.

VELLUM AND PAPER MSS.

The change from papyrus to vellum involved no such modification in the forms of letters as followed that from metal to papyrus. The justification for considering the two materials separately is that after the general adoption of vellum the Egyptian evidence is first supplemented and later superseded by that of mss. from elsewhere, and that during this period the hand most used was one not previously employed for literary purposes.

The Uncial Hand.—The prevailing type of book-hand during what in papyrology is called the Byzantine period, *i.e.*, roughly from A.D. 300 to 650, is known as the biblical hand. It went back to at least the end of the 2nd century and had had originally no special connection with Christian literature. In mss., whether vellum or paper, of the 4th century found in Egypt we meet other forms of script, particularly a sloping, rather inelegant hand derived from the literary hand of the 3rd century, which persisted to at least the 5th century; but the three great early codices of the Bible are all written in uncials of the biblical type. In the Vaticanus, placed in the 4th century, the characteristics of the hand are least strongly marked; the letters have the forms characteristic of the type but without the heavy appearance of later mss., and the

general impression is one of greater roundness. In the Sinaiticus, which is not much later, the letters are larger and more heavily made; and in the Alexandrinus (5th century?) a later development is seen, with emphatic distinction of thick and thin strokes. By the 6th century, alike in vellum and in papyrus rnss., the heaviness had become very marked, though the hand still retained, in its best examples, a handsome appearance; but after this it steadily deteriorated, becoming ever more mechanical and artificial. The thick strokes grew heavier; the cross strokes of T and Θ and the base of A were furnished with drooping spars. The hand, which is often singularly ugly, passed through various modifications, now sloping, now upright, though it is not certain that these variations mere really successive rather than concurrent. A different type of uncials, derived from the Chancery hand and seen in two papyrus examples of the Festal letters despatched annually by the Patriarchs of Alexandria, was occasionally used, the best known example being the Codex Marchalianus (6th or 7th century?). A combination of this hand with the other type is also known.

The Minuscule Hand.—The uncial hand lingered on, mainly for liturgical rnss., where a large and easily legible script was serviceable, as late as the 12th century, but in ordinary use it had long been superseded by a new type of hand, the minuscule, which originated in the 8th century, as an adaptation to literary purposes of the second of the types of Byzantine cursive mentioned above. A first attempt at a calligraphic use of this hand, seen in one or two mss. of the 8th or early 9th century (*e.g.*, *Specimina Cod. Graec. Vatican.* No. 5), in which it slopes to the right and has a narrow, angular appearance, did not find favour, but by the end of the 9th century a more ornamental type, from which modern Greek script is descended, was already established. It has been suggested (T. W. Allen, *Journ. Hell. Stud.* xl., *1–12*) that it was evolved in the monastery of the Studium at Constantinople. In its earliest examples it is upright and exact but lacks flexibility; accents are small, breathings square in formation, and in general only such ligatures are used as involve no change in the shape of letters. The single forms have a general resemblance (with considerable differences in detail) both to the minuscule cursive of late papyri, and to those used in modern Greek type; uncial forms were avoided.

In the course of the 10th century the hand, without losing its beauty and exactness, gained in freedom. Its finest period was from the 9th to the 12th century, after which it rapidly declined. The development was marked by a tendency (1) to the intrusion, in growing quantity, of uncial forms, which good scribes could fit into the line without disturbing the unity of style but which, in less expert hands, had a disintegrating effect; (2) to the disproportionate enlargement of single letters, especially at the beginnings and ends of lines; (3) to ligatures, often very fantastic, which quite changed the forms of letters; (4) to the enlargement of accents, breathings at the same time acquiring the modern rounded form. But from the first there were several styles, varying from the formal, regular hands characteristic of service books to the informal style, marked by numerous abbreviations, used in mss. intended only for a scholar's private use. The more formal hands were exceedingly conservative, and there are few classes of script more difficult to date than the Greek minuscule of this class. In the 10th, 11th and 12th centuries a sloping hand, less dignified than the upright, formal type, but often very handsome, was specially used for mss. of the classics.

Hands of the 11th century are marked in general (though there are exceptions) by a certain grace and delicacy, exact but easy; those of the 12th by a broad, bold sweep and an increasing freedom, which readily admits uncial forms, ligatures and enlarged letters but has not lost the sense of style and decorative effect. In the 13th and still more the 14th centuries there mas a steady decline; the less formal hands lost their beauty and exactness, becoming ever more disorderly and chaotic in their effect, while the formal style imitated the precision of an earlier period without attaining its freedom and naturalness, and often appears singularly lifeless. In the 15th century, especially in the West, where Greek scribes were in request to produce mss. of the classical authors, there was a revival, and several mss. of this period, though markedly inferior to those of the 11th and 12th centuries, are by no means without beauty.

ACCENTS, PUNCTUATION, DIVISION OF WORDS

In the book-hand of early papyri neither accents nor breathings were employed. Their use was established by the beginning of the Roman period, but was sporadic in papyri, where they were used as an aid to understanding, and therefore more frequently in poetry than in prose, and in lyrical oftener than in other verse. In the cursive of papyri they are practically unknown, as are marks of punctuation. Punctuation was effected in early papyri, literary and documentary, by spaces, reinforced in the book-hand by the paragraphus, a horizontal stroke under the beginning of the line. The coronis, a more elaborate form of this, marked the beginning of lyrics or the principal sections of a longer work. Punctuation marks, the comma, the high, low and middle points, were established in the book-hand by the Roman period; in early Ptolemaic papyri a double point (:) is found.

In vellum and paper mss. punctuation marks and accents were regularly used from at least the 8th century, though with some differences from modern practice. At no period down to the invention of printing did Greek scribes consistentiy separate words. The book-hand of papyri aimed at an unbroken succession of letters, except for distinction of sections; in cursive hands, especially where abbreviations were numerous, some tendency to separate words may be recognized, but in reality it was phrases or groups of letters rather than words which were divided. In the later minuscule word-division is much commoner but never became systematic, accents and breathings serving of themselves to indicate the proper division.

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LATIN

Attention should be drawn at the outset to certain fundamental definitions and principles of the science. The original characters of an alphabet are modified by the material and the implements used. When stone and chisel are discarded for papyrus and reed-pen, the hand encounters less resistance and moves more rapidly. This leads to changes in the size and position of the letters, and then to the joining of letters, and, consequently, to altered shapes. We are thus confronted at an early date with quite distinct types.

The majuscule style of writing, based on two parallel lines, ADLP. is opposed to the minuscule, based on a system of four fines, with letters of unequal height, adlp. Another classification, according to the care taken in forming the letters, distinguishes between the set book-hand and the cursive script. The difference in this case is determined by the subject matter of the text; the writing used for books *(scriptura libraria)* is in all periods quite distinct from that used for letters and documents *(epistolaris, diplomatica)*. While the set book-hand, in majuscule or minuscule, shows a tendency to stabilize the forms of letters, the cursive, often carelessly written, is continually changing in the course of years and according to the preferences of the writers.

This being granted, a summary survey of the morphological history of the Latin alphabet shows the zenith of its modifications at once, for its history is divided into two very unequal periods, the first dominated by majuscule and the second by minuscule writing.

I. MAJUSCULE WRITING

Capital Writing. — The Latin alphabet first appears in the epigraphic type of majuscule writing, known as capitals. These characters form the main stem from which developed all the branches of Latin writing. On the oldest monuments (the *inscriptiones bello Hannibalico antiquiores* of the *Corpus Inscriptionum Latinarum*), it is far from showing the orderly regularity of the later period. Side by side with upright and square characters are angular and sloping forms, sometimes very distorted, which seem to indicate the existence of an early cursive writing from which they would have been borrowed. Certain literary texts clearly allude to such a hand (Van Hoesen, *Roman Cursive Writing*, pp. 1–2). Later, the characters of the cursive type were progressively eliminated from formal inscriptions, and capital writing reached its perfection in the Augustan age.

Epigraphists divide the numerous inscriptions of this period into two quite distinct classes: *tituli,* or formal inscriptions engraved on stone in elegant and regular capitals, and *acta,* or legal texts, documents, etc., generally engraved on bronze in cramped and careless capitals. Palaeography inherits both these types. Reproduced by scribes on papyrus or parchment, the elegant characters of the inscriptions become the square capitals **of** the manuscripts, and the *actuaria,* as the writing of the *acta* is called, becomes the rustic capital.

Of the many books written in square capitals, the *éditions de luxe* of ancient times, only a few fragments have survived, the most famous being pages from manuscripts of Virgil (Chatelain, *Pal. des classiques latins,* pl. LXI.–II., LXXV.; *Oxyrhynchus Papyri,* viii., 1,098). The finest examples of rustic capitals, the use of which is attested by papyri of the first century (Zangemeister and Wattenbach, *Exempla,* pl. I.–II.), are to be found in manuscripts of Virgil (Ehrle, *Fragm. Virgiliana,* 1899; *Pal. Soc.,* pl. 113–117; *Archivio paleogr. ital.,* i., 98) and Terence *(Pal. Soc.,* pl. 135). Neither of these forms of capital writing offers any difficulty in reading, except that no space is left between the words. Their dates are still uncertain, in spite of attempts to determine them by minute observation (Dziatzko, *Untersuchungen;* E. A. Lowe in the *Classical Quarterly,* vol. xix., p. 197).

The rustic capitals, more practical than the square forms, soon came into general use. This was the standard form of writing, so far as books are concerned, until the 5th century, when it was replaced by a new type, the uncial, which will be discussed below.

Early Cursive **Writing.**—While the set book-hand, in square or rustic capitals, was used for the copying of books, the writing of every-day life, letters and documents of all kinds, was in a cursive form, the oldest examples of which are provided by the graffiti on walls at Pompeii (*C.I.L.*, iv.), a series of waxen tablets, also discovered at Pompeii (C.I.L., iv., supplement), a similar series found at Verespatak in Transylvania *(C.* I. L., iii) and a number of papyri (Wessely, *Schrifttafeln* and *Studien zur Pal.,* xiv.; *Oxyrhynchus Papyri, passim;* Federici, *Esempi di corsiva antica;* etc.). From *a* study of a number of documents which exhibit transitional forms it appears that this cursive was originally simplified capital writing (Steffens, *Lat.* Pal., 2nd ed., pl. 3; Wessely, *Studien,* xiv., pl. viii., etc.). The evolution was so rapid, however, that at quite an early date the *scriptura epistolaris* of the Roman world can no longer be described as capitals. By the first century, this kind of writing began to develop the principal characteristics of two new types: the uncial and the minuscule cursive. With the coming into use of writing surfaces which were smooth, or offered little resistance, the unhampered haste of the writer altered the shape, size and position of the letters. In the earliest specimens of writing on wax, plaster or papyrus, there appears a tendency to represent several straight strokes by a single curve. The cursive writing thus foreshadows the specifically uncial forms. The same specimens show great inequality in the height of the letters; the main strokes are prolonged upwards ($\supset = b; \partial = d$) or downwards ($\curvearrowleft = q; \curvearrowright = z$). In this direction, the cursive tends to become a minuscule hand.

Uncial Writing. — Although the characteristic forms **of** the uncial type appear to have their origin in the early cursive (Thompson, *Latin Palaeography* in Sandy's *Companion,* 2nd ed., p. 771; Van Hoesen, *The Parentage* and *Birthdate of the Latin Uncial* in *Transactions and Proceedings* of the American Philological Association, xlii.), the two hands are nevertheless quite distinct. The uncial is a *libraria,* closely related to the capital writing, from which it differs only in the rounding off of the angles of certain letters, principally ą ȣ ę ɱ. It represents a compromise between the beauty and legibility of the capitals and the rapidity of the cursive, and is clearly an artificial product. It was certainly in existence by the latter part of the 4th century, for a number **of** manuscripts of that date are written in perfect uncial hands (*Exempla,* pl. XX.). It presently supplanted the capitals and appears in numerous manuscripts which have survived from the 5th, 6th and 7th centuries, when it was at its height. (A list is given in Traube, *Vorlesungen,* i., 171–261, and numerous reproductions in Zangemeister and Wattenbach's *Exempla,* and in Chatelain, *Uncialis scriptura.)* By this time it had become an imitative hand, in which there was generally no room for spontaneous development. It remained noticeably uniform over a long period. It is difficult therefore to date the manuscripts by palaeographical criteria alone. The most that can be done is to classify them by centuries, on the strength of tenuous data (Chatelain, *Unc. script., explanatio tabularum*). The earliest uncial writing is easily distinguished by its simple and monumental character from the later hands, which become progressively stiff and affected.

II. MINUSCULE CURSIVE WRITING

Early Minuscule Cursive. — "When writing has to be done frequently and rapidly," says the *Nouveau Traité de Diplomatique* (ii., 491), "majuscule writing is bound to turn imperceptibly into a connected or cursive minuscule." It would be easy to illustrate this generalisation by examples taken from ancient cursive writing, in which here and there from the 1st century onwards are found symptoms of transformation in the form of certain letters, the shape and proportions of which correspond more closely to the definition of minuscule writing than to that of majuscule. Rare and irregular at first, they gradually become more numerous and more constant and by degrees supplant the majuscule forms, so that in the history of the Roman cursive there is no precise boundary between the majuscule and minuscule periods.

The oldest example of minuscule cursive writing that has been discovered is a letter on papyrus, found in Egypt, dating from the fourth century *(Archiv für Urkundenforschung,* iii., pl. i.). This marks a highly important date in the history of Latin writing, for with only one known exception, not yet adequately explained — two fragments of imperial rescripts of the 5th century (Mommsen, *Fragmente zweier Kaiserrescripte* in the *Jahrbuch des gemeinen deutschen Rechts,* vi., 398; Preisigke in *Schriften der wissensch. Gesellsch. in Strassburg,* xxx.; *Pal. Soc.,* pl. 30)— the minuscule cursive was thenceforth the only *scriptura epistolaris* of the Roman world.

The ensuing succession of documents (*e.g.,* a certificate of A.D. 400 in Wessely, *Studien,* xiv., pl. xiii.; a letter of A.D. 444 in Wessely, *Schrifttafeln,* pl. xii., No. 19) show a continuous

improvement in this form of writing, characterised by the boldness of the strokes and by the elimination of the last lingering majuscule forms. The Ravenna deeds of the 5th and 6th centuries (Marini, *I papiri diplomatici;* Champollion-Figeac, *Chartes et Mss. sur papyrus; E.* A. Bond, *Facsimiles of Ancient Charters; Archivio paleogr. italiano,* i., pl. *1–j)* exhibit this hand at its perfection.

At this period the minuscule cursive made its appearance as a book-hand, first as marginal notes, and later for the complete books themselves. The only difference between the book-hand and that used for documents is that the principal strokes are shorter and the characters thicker. This form of the hand is usually called semi-cursive.

The National Hands. — The fall of the Empire and the establishment of the barbarians within its former boundaries did not interrupt the use of the Roman minuscule cursive hand, which was adopted by the newcomers. But for gaps of over a century in the chronological series of documents which have been preserved, it would be possible to follow the evolution of the Roman cursive into the so-called national hands, forms of minuscule writing which flourished after the barbarian invasions in Italy, France. Spain, England and Ireland, and which are still known as Lombardic, Merovingian, Visigothic, Anglo-Saxon and Irish. These names came into use at a time when the various national hands mere believed to have been invented by the peoples who used them, but their connotation is merely geographical.

Nevertheless. in spite of a close resemblance which betrays their common origin, these hands are specifically different, perhaps because the Roman cursive was developed by each nation in accordance with i t artistic tradition. *(Cf.* Schiaparelli, *Note paleografiche* in *Archivio stor. italiano,* lxxiv. 55.)

Lombardic Writing.—In Italy, after the close of the Roman and Byzantine periods, the writing is known as Lombardic, a generic term which comprises several local varieties. These may be classified under four principal types: two for the *scriptura epistolaris,* the old Italian cursive and the papal chancery hand, or *littera romana,* and two for the *libraria,* the old Italian book-hand and Lombardic in the narrow sense, sometimes known as *Beneventana* on account of the fact that it flourished in the principality of Bencvcnto.

The oldest preserved documents written in the old Italian cursive show all the essential characteristics of the Roman cursive of the 6th century (Bonelli, *Cod. pal. lombardo; Arch. pal. ital.,* i., iii., vii.). In northern Italy, this hand began in the 9th century to be influenced by a minuscule hook-hand which developed, as will be seen later, in the time of Charlemagne; under this influence it gradually disappeared, and ceased to exist in the course of the 12th century. In southern Italy, it persisted far on into the later middle ages (Russi, *Paleogr. . . . de' docum. della prov. Napolitana*).

The papal chancery hand, a variety of Lombardic peculiar to the vicinity of Rome and principally used in papal documents, is distinguished by the formation of the letters *a, e,* q, *t.* It is formal in appearance at first, but is gradually simplified, under the influence of the Carolingian minuscule, which finally prevailed in the bulls of Honorius II (1124–30). The notaries public in Rome continued to use the papal chancery hand until the beginning of the 13th century.

The old Italian book hand is simply a semicursive of the type already described as in use in the 6th century. The principal examples are derived from *scriptoria* in northern Italy, where it was displaced by the Carolingian minuscule during the 9th century.

In southern Italy this hand persisted, developing into a calligraphic form of writing, and in the 10th century took on a very artistic angular appearance (Lone, *Beneventan Script;* facsimiles in Piscicelli-Taeggi, *Paleogr. artist. di Monte Cassino*). The *Exultet* rolls provide the finest examples. In the 9th century, it was introduced in Dalmatia by the Benedictine monks and developed there, as in Apulia, on the basis of the archetype, culminating in a rounded *Beneventana* known as the Eari type (Novak, *Scriptura Beneventana,* Zagreb. 1920).

Merovingian.—The offshoot of the Roman cursive which developed in Gaul under the first dynasty of kings is called Merovingian writing. It is represented by thirty-eight royal diplomas (Lauer and Samaran, *Les diplômes originaux des Mérovingiens*), a number of private charters (Tardif, *Facsim. de charfcs et diplômes*) and the authenticating documents of relics (Prou, *Recueil de facsim.,* 1904, pl. v.).

Though less than a century intervenes between the Ravenna cursive and the oldest extant Merovingian document (A.D. 625), there is a great difference in appearance between the two writings The facile flow of the former is replaced by a cramped style, in which the natural slope to the right gives way to an upright hand, and the letters, instead of being fully outlined, are compressed to such an extent that they modify the shape of other letters. Copyists of books used a cursive similar to that found in documents, except that the strokes are thicker, the forms more regular, and the heads and tails shorter *(Album paléogr. de la Soc. de l' Ec. des Chartes,* pl. 12).

The Merovingian cursive as used in books underwent simplification in some localities, undoubtedly through the influence of the minuscule book-hand of the period. The two principal centres of this reform were Luxeuil and Corbie (Traube, *Perrona Scottorum* in *Sitzungsberichte* of the Munich Academy, 1900; Liebart, *Corbie Scriptorium* in W. M. Lindsay's *Palaeogv. Lat.,* i.).

With the appearance. early in the 8th century, of the Carolingian minuscule, the Merovingian hand ceased to be used for books. In the Carolingian chancery, where it persisted longest, it soon discarded its characteristic forms and intricate combinations of letters under the influence of the new hand Only a few archaic types with long slender heads and tails, vaguely reminiscent of the old script, survived in diplomatic writing until the 11th century.

Visigothic Writing. — In Spain, after the Visigothic conquest, the Roman cursive gradually developed special characteristics. Some documents attributed to the 7th century display a transitional hand with straggling and rather uncouth forms (Ewald and Loewe, *Exempla scripturae visigothicae,* pl. 3). The distinctive features of Visigothic writing, the most noticeable of which is certainly the q-shaped g, did not appear until later, in the book-hand. The book-hand became set at an early date. In the 8th century it appears as a sort of semi-cursive; the earliest example of certain date is ms lxxxis in the Capitular Library in Verona (Clark, *Collectanea hispanica,* 63, 129–130; Schiaparelli in *Arch. stor. ital* lxxxii., 106). From the 9th century the calligraphic forms become broader and more rounded until the 11th century, when they become slender and angular (numerous reproductions in Ewald and Loewe, *Exempla;* Burnam, *Paleogr. iberica;* Clark, *Collectanea;* Garcia Villada, *Paleogr. espanola*).

The Visigothic minuscule appears in a cursive form in documents about the middle of the 9th century,, and in the course of time grows more intricate and consequently less legible (Munoz, *Paleogr. visigoda;* Garcia Villada, *op. cit.*). It soon came into competition with the Carolingian minuscule, which supplanted it as a result of the presence in Spain of French elements such as Cluniac monks and warriors engaged in the campaign against the Moors (Hessel, *Ausbreitung der karo. Minuskel* in *Archiv fur Urkundenforschung,* vii , viii).

The Irish and Anglo-Saxon hands, which were not directly derived from the Roman minuscule cursive, will be discussed later.

III. SET MINUSCULE WRITING

One after another, the national minuscule cursive hands were superseded by a set minuscule hand which has already been mentioned Its origins may now be traced from the beginning.

Half-uncial Writing. — The early cursive was the medium in which the minuscule forms were gradually evolved from the corresponding majuscule forms Minuscule writing was thus cursive in its inception As the minuscule letters made their appearance in the cursive writing of documents, they were adopted and given calligraphic form by the copyists of literary texts, so that the set minuscule alphabet mas constituted gradually letter by letter, following the development of the minuscule cursive Just as some documents written in the early cursive show a mixture of

majuscule and minuscule forms, so certain literary papyri of the 3rd century (*Oxyrhynchus Papyri*, iv., pl. vi.. No 663; xi. pl. vi., No. 1,379), and inscriptions on stone of the 4th century (*Pal. Soc.*, pl. 127–8; *Arch. pal. ital*, v., pl. 6) yield examples of a mixed set hand, with minuscule forms side by side with capital and uncial letters. The number of minuscule forms increases steadily in texts written in the mixed hand, and especially in marginal notes, until by the end of the 5th century the majuscule forms have almost entirely disappeared in some mss.

This quasi-minuscule writing, known as the Half-uncial (*see* the many examples in Chatelain, *Semiuncial Script.*) is thus descended from a long line of mixed hands which, in a synoptic chart of Latin scripts, would appear close to the oldest *librariae*, and between them and the *epistolaris* (cursive), from which its characteristic forms were successively derived. It had a considerable influence on the continental *scriptura libraria* of the 7th and 8th centuries.

Irish and Anglo-Saxon Writing. — The half-uncial hand was introduced in Ireland along with Latin culture in the 5th century by priests and laymen from Gaul, fleeing before the barbarian invasions. It was adopted there to the exclusion of the cursive, and soon took on a distinct character. There are two well established classes of Irish writing as early as the 7th century: a large round half-uncial hand, in which certain majuscule forms frequently appear, and a pointed hand, which becomes more cursive and more genuinely minuscule. The latter developed out of the former (Keller, *Angelsächsische Palaeogr.*). One of the distinguishing marks of mss. of Irish origin is to be found in the initial letters, which are ornamented by interlacing, animal forms, or a frame of red dots. The most certain evidence, however, is provided by the system of abbreviations and by the combined square and cuneiform appearance of the minuscule at the height of its development (*cf.* Schiaparelli in *Arch. stor. ital.*, lxxiv., ii., 1–126).

These two types of Irish writing were introduced in the north of Great Britain by the monks, and were soon adopted by the Anglo-Saxons, being so exactly copied that it is sometimes difficult to determine the origin of an example. Gradually, however. the Anglo-Saxon writing developed a distinct style, and even local types (Keller, *op. cit.*; Lindsay, *Early Welsh Script*), which were superseded after the Norman conquest by the Carolingian minuscule Through St. Columba and his followers, Irish writing spread to the continent, and mss. were written in the Irish hand in the monasteries of Bobbio and St. Gall during the 7th and 8th centuries.

The Carolingian Minuscule. — In Ireland, an imported quasi-minuscule hand developed into a perfect minuscule. On the continent, where the copyists of books commonly used a cursive script, it is more difficult to trace the transition from the half-uncial to the perfect minuscule, which appeared in the time of Charlemagne and is consequently known as Carolingian. The origin of this hand is much disputed. This is due to the confusion which prevailed before the Carolingian period in the *libraria* in France. Italy and Germany as a result of the competition between the cursive and the set hands. In addition to the calligraphic uncial and half-uncial writings, which were imitative forms, little used and consequently without much vitality, and the minuscule cursive, which was the most natural hand. there were innumerable varieties of mixed writing derived from the influence of these hands on each other. In some, the uncial or half-uncial forms were preserved with little or no modification, but the influence of the cursive is shown by the freedom of the strokes; these are known as rustic, semi-cursive or cursive uncial or half-uncial hands. Conversely, the cursive was sometimes affected, in varying degrees, by the set *librariae;* the cursive of the *epistolaris* became a semi-cursive when adopted as a *libraria.* Nor is this all. Apart from these reciprocal influences affecting the movement of the hand across the page, there were morphological influences at work, letters being borrowed from one alphabet for another. This led to compromises of all sorts and of infinite variety between the uncial and half-uncial and the cursive. It will readily be understood that the origin of the Carolingian minuscule, which must be sought in this tangle of pre-Carolingian hands, involves disagreement. The new writing is admittedly much more closely related to the *epistolaris* than the primitive minuscule; this is shown by certain forms, such as the open *a* ( ), which recall the cursive, by the joining of certain letters, and by the clubbing of the tall letters *b d h l*, which resulted from a cursive *ductus*. All palaeographers agree in assigning the new hand the place shown in the following table:

Librariae					*Epistolaris*
Capitals Uncials	Half-uncial	Rustic uncial and half-uncial	Pre-Carolingian Carolingian	Semi-cursive	Minuscule cursive

Controversy turns on the question whether the Carolingian minuscule is the primitive minuscule as modified by the influence of the cursive or a cursive based on the primitive minuscule. Its place of origin is also uncertain; Rome, the Palatine school, Tours, Metz, Reims, St. Denis and Corbie have been suggested, but no agreement has been reached. (For the latest pronouncement *cf.* Steinacker in *Miscellanea Ehrle*, iv., 126 *sq.*)

In any case, the appearance of the new hand is a turning point in the history of culture. So far as Latin writing is concerned, it marks the dawn of modern times.

IV. THE RISE OF MODERN WRITING

It is impossible here to describe in detail the transformations which the Carolingian minuscule underwent at the hands of generations of clerks through the middle ages. The course of its development may be summarized in a few words. There are undeniable points of contact between architecture and palaeography, and in both it is possible to distinguish a Romanesque and a Gothic period. The creative effort which began in the post-Carolingian period culminated at the beginning of the 12th century in a calligraphy and an architecture which, though still somewhat awkward, showed unmistakable signs of power and experience, and at the end of that century and in the first half of the 13th both arts reached their climax and made their boldest flights.

The topography of later mediaeval writing has hardly been investigated at all as yet. National varieties can, of course, be distinguished. The English Gothic cursive presents certain typical forms and a number of peculiarities of outline. In Germany, efforts have been made to tabulate the distinguishing features of local hands (Steinacker, *Diplomatik und Landeskunde;* Schubert, *Eine lütticher Schriftprovinz*, etc.). The problem becomes complicated as a result of the development of international relations, and the migration of clerks from one end of Europe to the other (Hajnal, *Irrastortenet az irasbeliseg felujulasa korabol*, Budapest, 1921).

During the later centuries of the middle ages the Gothic minuscule continued to improve within the restricted circle of *de luxe* editions and ceremonial documents. In common use, it degenerated into a cursive which became more and more intricate, full of superfluous strokes and complicated by abbreviations.

In the first quarter of the 15th century an innovation took place which exercised a decisive influence on the evolution of writing in Europe. The Italian humanists were struck by the eminent legibility of the mss., written in the improved Carolingian minuscule of the 10th and 11th centuries, in which they discovered the works of ancient authors, and carefully imitated the old writing. Their example was followed by many copyists. The papal chancery adopted the new fashion for some purposes, and thus contributed to its diffusion throughout Christendom. The printers played a still more significant part in establishing this form of writing by using it, from the year 1465, as the basis for their types. The humanistic minuscule soon gave rise to a sloping cursive hand, known as the Italian, which was also taken up by printers in search of novelty and thus became the italic type.

In consequence, the Italian hand became widely used, and in

the 16th century began to compete with the Gothic cursive. In the 17th century, writing masters were divided between the two schools, and there was in addition a whole series of compromises. The Gothic characters gradually disappeared. A few survived until the middle of the 18th century, but since then, except in Germany, which has shown a persistent preference for the Gothic, the Italian has been universally used. Brought to perfection in recent times by English calligraphers, it is taught in schools everywhere under the name of English cursive.

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PALAEOLITHIC: see ARCHAEOLOGY.

PALAEOLOGUS, a Byzantine family name which first appears in history about the middle of the 11th century. Michael Palaeologus (see MICHAEL VIII), son of Andronicus I'alaeologus Comnenus, became the eighth emperor of that name in 1260, and was in turn followed by his son Andronicus II (1282–1328). Michael, the son of Andronicus, and associated with him in the empire, died in 1320, but left a son, Andronicus III (1328–41); John V or VI (1341–47, 1355–76, 1379–91), Manuel II (1391–1425) and John VII or VIII (1425–48) then followed in succession; Constantine XI or XII, the last emperor of the east (1448–53), was the younger brother of John VII. Other brothers were Demetrius. prince of the Morea until 1460, and Thomas, prince of Achaia. who died at Rome in 1465. A daughter of Thomas Zoë by name, married Ivan III of Russia. A younger branch of the Palaeologi held the principality of Monferrat from 1305 to 1533, when it became extinct.

See BYZANTINE EMPIRE and articles on the separate rulers.

PALAEONTOLOGY, the science which deals with the remains of animals and plants found buried in the rocks. For convenience it is now customary to use the term only for the study of fossil animals. and to deal with plants under the head of palaeobotany (*q.v.*). In essence however, the two form one science distinguished from zoology and botany hy the fact that the organisms with which it deals are not all of the same age. but cover, incompletely it is true. the history of life in the world from a time not long after its appearance, when organisms capable of being preserved first arose.

Preservation. — In most cases only the hard parts of animals are capable of preservation as fossils, but under especially favourable circumstances the soft parts may bc represented either by an impression upon the surrounding rock, or by stains, or even by a petrifaction which may preserve the microscopical structure of muscle and other tissues.

The preservation of any animal as a fossil depends on its burial in a sediment nhich is not subsequently destroyed by denudation. In the sea, the remains of marine animals are continually accumulating on the sea bottom. They may lie in the place where they fali or. if exposed to the action of currents, be carried for considerable distances and when the speed of the current becomes insufficient to move them, be laid down, often in association with many other objects of the same area and weight. Thus it is common to find great accumulations of fossil shells all of approximately the same size, which are not necessarily in the place where they actually lived. On the other hand shells of burrowing molluscs may be found as they were in life. The remains of animals even if of such relatively permanent structure as shells are soon destroyed if they lie for long exposed to the action of the sea, and they can only be preserved if they are deposited at a place where mud or sand is being laid down. Such districts are comparatively rare and of local occurrence. They may be found chiefly where the sea bottom off a coast is sinking. Certain special areas such as coral reeis provide exceptionally favourable conditions for the preservation of marine fossils.

On land the possibilities of preservation are much smaller. The remains of a land fauna are chiefly preserved either in the sediments which form on the bottom of lakes. or perhaps more commonly in arid areas where the general level of the land surface is rising, because of tlie distribution of dust and sand over it by wind action. Under these circumstances the skeleton of a dead animal may become covered by a pile of blown sand, and may, if it escape the action of floods and wind, remain buried for geologicnl periods. One exceptional method of preservation, more important in the case of plants than animals, is in the detritus of forests growing on a coastal plain at or below high-water mark, as do mangroves to-<In)-. If this plain be situated in a sinking area, great masses of deposits (now represented by coal fields) may be built up, and in them animals and plants will be abundantly preserved. The nature of the preservation of an individual fossil depends grcntly on its own chemical and physical composition, and on that of the surrounding sediments. The calcareous shells of molluscs and brachiopods, if buried in a mud which becomes converted into a clay, may be preserved indefinitely in their original form, because such rocks hinder the passage of water, which, when freely allowed, will either dissolve the shell completely or bring about a rearrangement, often into crystals, of the molecules of which it is composed. In some cases such clays, especially if they become impregnated with petroleum, may preserve traces of the soft parts of the animal, in the form of a carbonaceous film made from its material exactly as coal has arisen irom plant materials.

The most remarkable of such fossils are those from the Middle Cambrian of Burgess pass, British Columbia, described by C. D. Walcott. Here the external form even of slender soft processes of worms has been perfectly preserved and even something of their internal anatomy can be made out from colour differences in the carbonaceous films which represent them.

When buried in sand a shell is exposed to the action of percolating waters which if acid are capable of dissolving it. Its preservation is thereiore dependent either on the sealing down of the sand by sucli a layer of clay as will prevent the circulation of water, or on a solidification of the sand by a cementing together of the individual grains, usually by calcium carbonate, which happens sufficiently rapidly to form a solid case round the shell, which may then persist if the percolating water he completely saturated with calcium carbonate, altered only by the laying down of further calcite in its pores. In many cases. however, tlie shell itself is entirely removed in solution, and its former presence is shown by a cavity in the sandstone. which reproduces the surfaces of the shell in negative (often with complete perfection).

When buried in a calcareous mud such as that which accumulates in the lagoon behind a cord reef. a shell often remains unaltered, and in a limestone which has been formed from such a mud. may be found in its original form, or changed only by the addition of more calcite. Under exceptional circumstances the material of an animal's skeleton may be removed and replaced y silica, sometimes as opal, by iron pyrites or other minerals.

Preparation of **Fossils.**—Before it can he studied, any fossil

must be freed as completely as possible from the surrounding matrix. The technique of this operation varies in each individual case; bones and shells preserved in clays can often be entirely cleaned by washing. The chitinous skeletons of arthropods and graptolites are sometimes preserved unaltered in shales, sandstones or limestones, and can then be prepared by removing the rock nith hydrofluoric or hydrochloric acid. The resulting preparation can then in some cases be stained and mounted or cut into sections exactly as if it had formed part of a recent animal. Generally, however, the rock surrounding the fossil must be removed mechanically by needles or chisels and hammers. Where the fossil is represented by a cavity whose walls preserve a mould of its surfaces, it is necessary to make casts in plaster of Paris or more usually in wax, plasticene or glue. For small complex objects such as the skull of a fish, it is often preferable to remove the bone and rely on such casts, rather than to attempt to pick away the stone and preserve the actual bone substance. Sometimes, however, both rock and bone are too hard to be attacked by steel tools, and too similar chemically to be prepared by solution in acid. In these cases it is possible to discover the structure by a method invented by W. J. Sollas. By this technique one surface of the specimen is ground to a flat face on which the fossil is shown in section. An enlarged photograph is then made of this ground surface; or, better the surface is etched or softened with acid and a cellulose preparation is poured over it which, when hardened, is removed as a "peel" containing a thin layer of the original material. A layer of rock of a definite thickness is then removed by further grinding and another photograph is taken, and the process is repeated until the whole of the fossil is ground away; but the appearance of the sections made across it at definite distances apart is preserved in the series of photographs or peels. Each section is reproduced by being cut out of a sheet of wax of appropriate thickness and these wax plates when piled up in correct order reproduce perfectly the shape of the original fossil at any magnification required. This method, though extremely laborious, leads to results which can be attained in no other way. In some cases, it may be necessary to make a thousand sections and wax plates of a single object.

The preparation of the skeleton of a large vertebrate is usually carried out with a hammer and chisel, the rock being carved away from the bones until these are free: they can then be mounted so as to form a skeleton exactly as are the bones of a recent animal.

History.—The fossil remains of animals have long attracted attention. In a neolithic grave at Dunstable, Beds., a skeleton was found surrounded by fossil echinoderms from the chalk, and a famous silicified tree trunk acted as a pedestal in an Etruscan tomb. Fossil shells were repeatedly observed during mediaeval times and are referred to in such works as Agricola, *De Natura Fossilium*, 1558. During the 18th century many works containing illustrations of fossils mere published and some attempt was made to understand their structure and compare them with living forms. In one case a skeleton of *Megatherium* was actually set up in what was supposed to be its natural position in the museum at Madrid. The whole conception of palaeontology was, however, changed by the work of two men. The first of these was William Smith (q v), a land surveyor who in 1791 when supervising the construction of the Kennet and Avon canal, observed that each of the well-marked formations represented in the Jurassic rocks in the neighbourhood of Bath was characterized by the presence of fossils mhich could not be found in the beds above or below. Smith was able to show that it mas possible by the aid of the contained fossils to trace the formations he had recognized near Bath, across the Midlands of England to the Yorkshire coast. These observations form the basis of stratigraphical geology and showed that there had been a succession of different faunas living in the English region during geological time.

Secondly, Georges Dagobert, Baron Cuvier (*q.v.*) applied to the skeletons of fossil vertebrates the methods of study already developed for recent animals. In his great work *Rechevches sur les Ossements Fossiles*, he gave most accurate and detailed accounts of the teeth and bones of fossil mammals and reptiles, endeavouring to build up by a comparison of many specimens the complete skeleton of a number of forms and to determine their systematic position in the animal kingdom by the methods of comparative anatomy. Finally, from a study of the skeleton he attempted to infer something of the habits of the animals with which he dealt. His work was of the first importance because it showed that many fossil animals were of types that no longer exist. Previously when only extinct invertebrates had been studied, it was always possible to say that they still lived and would one day be found when the seas of the world had been completely explored. When not one but very many large extinct animals had been shown to have existed in France and elsewhere, this possibility became less plausible; even in 1824 the world had been so well exploited that it was most improbable that many large animals remained unknown to zoologists. Indeed only two completely new types have since been discovered, the great panda and the okapi.

From William Smith and Baron Cuvier two different lines of palaeontological work have arisen. Until comparatively recently invertebrate fossils have chiefly been studied by men whose interests lay in stratigraphical geology and who used them purely as time markers, just as potsherds are used by archaeologists. The type of work initiated by Cuvier has been carried on chiefly by zoologists and anatomists and has been concerned in the main with vertebrates.

GEOLOGICALPALAEONTOLOGY

The geological use of fossils as time markers rests primarily on a basis of observation of the actual occurrence of the remains of the species of animals in the rocks. Very extensive collections have shown, for example, that individuals of the genus *Productus* are never found except in rocks of Upper Devonian, Carboniferous and Permian age: that the species *Productus giganteus* can only be found in rocks whose deposition occupied a comparatively small part of Lower Carboniferous time, whilst the family Productidae lived from the Upper Ordovician to the end of the Permian. These facts are a mere matter of observation; their accuracy depends upon a correct identification of fossils, and on the extent of the collections which have been studied. The importance of stratigraphical geology for commercial purposes is so great that not only have all civilized countries been subjected to survey, but geological investigations have been conducted on an extensive scale all over the world even in such difficult regions as Spitsbergen, Patagonia, central Africa and Mongolia. Thus the extent of the evidence as to the distribution in time of the larger groups of fossil animals is very great, and we are entitled to lay great weight on the order of appearance and period of existence of such groups.

Classification of Stratified Rocks.—The divisions recognized by William Smith were marked primarily by lithological differences. The Lower Lias in the Bath district is mostly clay, the Middle Lias contains hard bands of sandstone known as marlstone, the thin Upper Lias is predominantly limestone, the base of the Inferior Oolite is merely unconsolidated sand and so on. It was in such formations readily separable from one another by inspection that Smith collected the fossils on which he founded his generalization that geological formations could be identified by the fossils which they contained.

Later workers extended this conception and used it for the division of the stratified rocks of the world into systems originally distinguished from one another by the character of their fauna. Thus R. I. Murchison separated a great series of formations as the Silurian system, because of the occurrence in them of certain fossils, trilobites and graptolites for example, which do not occur or are rare and inconspicuous in later geological time. The character of the basis on which this system was formed was made clear by the famous long-continued discussion between Murchison and Adam Sedgwick. The latter had mapped north Wales, dividing up the rocks of which it is composed into formations and grouping the whole in the Cambrian system. When after the establishment of the Silurian system by Murchison, the fossils collected by Sedgwick came to be examined, it was discovered that the whole assemblage of Sedgwick's Cambrian fossils

was that which characterized the Silurian system, and Murchison claimed that the term Cambrian was synonymous with Silurian. Thus the two conceivable methods of dividing stratified rocks into groups on the basis of their lithology and of their palaeontology were placed in opposition and the true nature of the differences had to be considered.

It is certain that every change in the character of sediments depends on a modification of the geography of the region in which they were being laid down, and that in those cases where successive rocks have an unconformable relationship to one another, there is an interval of time separating the two. It is now evident that the changes in the fauna which distinguish one formation from another are to a great extent the result of the evolution which has proceeded during the time separating the deposition of the sediments involved. Thus the evidence from stratigraphy and from palaeontology should lead to the same conclusions. But the changes in fauna, depending as they do on evolution which proceeds with time, should occur nhether or not the geography is so altered as to cause a modification in sedimentation. It should therefore be possible on palaeontological grounds to divide the rocks of a single geological formation into smaller periods not necessarily recognizable by lithological differences but displayed by a change in fauna. The first geologist to do so was Oppel, who divided the Lias into small periods which he called zones. Technically a zone consists of the sediments which were laid down during the period of existence of a particular species of animal. In practice it is usually found that they are most readily recognized not by the presence of a single species but by the coexistence of a group of forms not one of which is necessarily present in each locality where the zone occurs.

Zones.—This process of dividing rocks into small divisions has been carried to an extreme length among Jurassic and Cretaceous sediments, but has to some extent been applied to all systems. The Cambrian system, divided into groups primarily on the lithology of the sediments of that age in north Wales, has been subdivided into about 12 zones, chiefly on the evidence afforded by the range of different genera or species of trilobites. The succeeding Ordovician and Silurian systems were shown by Charles Lapworth to be divisible on the evidence of graptolites, and it has since been found that these graptolite zones can be recognized not only in the region of south Scotland, where they were established, but throughout western Europe, North America and even Australia. They are thus of world-aide significance.

Facies.—In the course of his work, Lapworth emphasized the fact that the Ordovician and Silurian rocks of south Scotland existed in two different forms—sandstones. shales and limestones, containing trilobites, the shells of brachiopods and molluscs, and corals; and very thin-bedded usually black shales often crowded with graptolites but usually yielding very few other fossils. He called these two rock types the shelly and the graptolite facies respectively. Owing to the occasional occurrence of graptolites in the shelly facies, he mas able to show that the difference between the faunas of the two types did not depend on differences of time, but could be completely accounted for by the assumption that the rocks of the shelly facies were laid down near the coast in shallow water, where trilobites and shells were living. The graptolite shales on the other hand were deposited in relatively deep water and the graptolites whose remains were found in them were pelagic animals floating freely in the sea, their skeletons after the death of the colony sinking to the bottom and becoming buried in the scanty sediments which mere there accumulating. The conception that two faunas of identical age may differ even completely on account of such a difference of facies, is a most important one, which has always to be kept in mind in discussing the geological age of any rock. Modern work on the distribution of animals on the floor of the Cattegat, the North sea, and the English channel, has shown conclusively that in very short distances, in some cases within a few hundred yards, totally different forms may be lying buried in the sea bottom; the character of the fauna being determined in part by the nature of the soil, whether gravel, sand or mud, in part by the depth of water. (See MARINE BIOLOGY.)

The fact that graptolites are unattached 'forms living floating in the surface layers of the water, explains the occurrence of their skeletons in both the shelly and graptolitic facies, and also accounts for their extraordinarily wide distribution, while the fact that they were undergoing a rapid evolution is the explanation of their value for recognizing small periods of time. The graptolite zones of the Palaeozoic, however, probably cover long periods of time in comparison with those which are recognized in Jurassic rocks. Throughout the Mesozoic, zones have been established on the basis of the ammonites. These animals are often enormously abundant as individuals and were undergoing very rapid evolution from their first appearance at the base of the Permian to their disappearance at the top of the Cretaceous. Many of them are found in sediments of all types, individuals of tlie same species may be buried in sandstones, shales or limestones, a fact which suggests that, like the graptolites, most of them at least did not dwell on the sea bottom but swam freely in mid-waters or near the surface. These habits would explain the wide geographical range which some of them are known to have covered. For example, the same or closely similar species of Mortoniceras occur in Texas, India, South Africa and Europe.

Ammonite zones may be and have been established in all marine sediments up to the top of the Cretaceous, but when we pass to Tertiary formations we enter into conditions in which no group of marine animals can be used for a world-wide division into zones. The difficulty of subdividing the Tertiary period in all probability is to be accounted for by the absence of any group of highly developed pelagic forms undergoing a rapid evolution and capable of ready preservation as fossils. A survey of the present fauna of surface waters, especially of those not entirely coastal, suggests that the most valuable groups for zonal purposes in the Tertiary would be the whales, whose size and rarity renders them unavailable; and the copepods which are! except in very special cases, incapable of preservation. Thus the subdivision of the Tertiary period, so far as rocks of marine origin are concerned, necessarily rests on bottom-living forms from shallow seas, such as the Foraminifera, Gastropoda, Lamellibranchia and Echinoidea. It is perfectly clear from the present-day distribution that species belonging to the last three groups have in general a restricted geographical distribution, and that they are very sensitive to changes of facies. The fundamental nature of the shortcomings which such materials possess when used as time markers is vividly illustrated by the uncertainty which still exists as to the ages of the Tertiary deposits of Australia and South America. Indeed the Foraminifera, unsatisfactory as they theoretically should be, seem on the whole the most suitable fossils for determining the correlation of Tertiary rocks, at any rate over such a part of the world's surface as experienced tropical or warm conditions.

Foraminifera and such other small fossils as Ostracoda have recently attained a new and special importance in stratigraphical geology, because they can be determined in the fragments fetched up from boreholes made with a jumper. The exploratory bores, made very extensively to prove oil fields, yield such material, the investigation of which has become a special branch of palaeontology—micropalaeontology—now actively pursued because of its economic importance, especially by U.S. workers.

Establishment of Zones.—The zones so far considered rest entirely on an observational basis. They have been defined by recording the observed distribution of particular species in a series of rocks whose succession can be determined by mapping. It is clear that their validity depends entirely on the certainty with which the individuals of a species can be recognized and on the extent to which collections have been made. The business of a geologist intent on establishing zones is to collect as many fossils as possible from each bed of a well-exposed series, and then in the presence of the whole material to draw the limit of his species as finely as he can: that is, to indicate by a name (to be regarded purely as a method of handling the facts) each type of organism which can be distinguished from all others by observable and constant morphological characters. Theoretically such groupings should be made without reference to the beds in which the indi-

vidual fossils have occurred, but in practice it is usually found that recognition of the more minute differences in structure is rendered much easier if the relative ages of the specimens under consideration be taken into account. This practice, universally and necessarily pursued, introduces the danger that the optimism of the student may lead him into the acceptance, as permanent and characteristic, of features which are not such in fact.

For full use to be made of the information acquired by the process suggested in the preceding paragraph, it is necessary to compare the species of fossils which have been thus recognized. with materials from other parts of the world. As very few museums possess collections from all over the world and as these will in any case be inadequate, such a comparison can only be made with fossils previously described. It is therefore a primary duty of a palaeontologist to publish detailed descriptions illustrated by accurate and clear figures of the forms he recognizes, but he may only do so after he has compared his own specimens with the whole of the published accounts of similar creatures. This process is extraordinarily laborious and tedious but is rendered far easier if there is a modern monograph of the whole group involved. After each individual fossil of the collection has been referred to a definite species, it is easy to discover whether any of them are restricted to a definite bed or series of beds, and it is then necessary to consider whether the absence of a given species at any particular horizon is due to the age of those rocks, or can be accounted for by a change of facies, which will in most cases be indicated by a change in the lithology. Life zones are intended to be founded on the period of existence of a definite species of animal, and hence should have a validity throughout the entire region in which the animal in question lived. Thus zones should not be established, although they may be tentatively put forward, until it can be shown that they are recognizable over some area which represents a fair sample of the probable space range of the species. As it is known from present-day conditions that no individual species of sedentary animal which lives in shallow seas occurs uniformly distributed over any area even so small as the English channel, it is clear that the nonoccurrence of the zone fossil at any place does not necessarily imply that deposits of its zone are absent there. Thus even in rocks not lithologically dissimilar, the same zone may contain different faunas in places only a few miles apart.

If the zonal fossil be a pelagic form whose remains only secure burial after they have sunk from the surface to the sea bottom, then within wide limits its occurrence should be independent of the nature of the sediments, and its distribution, depending as it will on currents which change from season to season, may be expected to be uniform when periods of time exceeding a few years, are considered. Thus the nonoccurrence of a pelagic zonal fossil in an area within which its remains are found, assuming that the collections are adequate, is good evidence that sediments laid down during its zone, were either not deposited or have subsequently been removed. The very detailed zoning of Jurassic rocks which has been established in England by the work of S. S. Buckman and his successors has shown that such failures of sedimentation or local unconformities are exceedingly common in shallow water deposits, and that they may be entirely unrecognizable by ordinary stratigraphical methods.

Palaeogeography.—In addition to their value as time markers, fossils may throw light on the geographical conditions under which rocks were laid down, and on the palaeogeography of the world as a whole. Certain groups of animals are now, and, so far as our knowledge extends, always have been, restricted to salt water; no echinoderm, for example, is ever found in rivers or lakes. Although a few forms (none capable of preservation as fossils) do occur in fresh water, the Coelenterata, as a group, are marine, and the occurrence of a coral is almost conclusive evidence that the rocks in which it was found were laid down under the sea. Brachiopods are equally marine, but *Lingula* and presumably some of its allies extend their range into brackish, though not into fresh water. In most cases, however a phylum may have representatives both in the sea and in fresh water, but even in these cases it will usually be found that many of its larger divisions are restricted to one or the other habitat. Thus the Mollusca have four great groups, the Solenogastres, Polyplacophora, Scaphopoda and the Cephalopoda, all of whose members are marine, while the other two, the Gastropoda and the Lamellibranchia, occur both in fresh and salt water, the former group also inhabiting the land.

The actual structure of the hard parts of an animal may indicate whether it lived on land or in water. but can never present any direct evidence on the problem of the nature of the water in which it lived. Thus the whole geological use of a fossil as an indicator of the marine or fresh-water origin of' the rocks in nhich it is found depends on the accuracy of the determination of its affinities primarily with living forms whose habitat is known, and secondarily on its association with other organisms which are shown to have been marine by independent lines of evidence. But it is possible from the structure of a shell to determine something of its conditions of life. For example, those Mollusca which live between tidemarks on the seashore have to resist the full force of wave action, and can only do so if they bury themselves in sand, lie concealed in cracks in rocks. or. like *Purpura*, have a shell so thick and massive as to stand hard blows. Forms like limpets, with their conical shell held down tightly to a fixed rock surface, escape displacement and destruction because of their shape. Lamellibranchs depend for the whole of their food supplies on suspended particles in water current which is caused to pass over their "gills" by ciliary action. Thus a lamellibranch which lives buried in sand, must maintain contact with the sea water by a double tube long enough to stand out above the floor of the sea. The former presence of this great siphon is usually shown by a gaping hole left at the posterior end when the tno valves of the shell are closed. By this means the habitat of certain forms may be discovered from their structure.

Such organisms as live in deep water are not exposed to the risk of mechanical damage by currents. Their shells need be no more massive than is necessary for the maintenance of the shape of the animal, and hence as a whole deep-sea echinoids, lamellibranchs and brachiopods are characterized by the excessive tenuity of their skeletons, sometimes so thin that the animal can scarcely support its own might in air.

Fossils and Climate.—Appeal is often made to fossils in discussions as to the temperature under nhich certain formations have been deposited. For example, it is stated that such an extensive development of corals as occurs in the Coral Rag of Mid-Jurassic age, implies that this sea nas at that time tropical This conclusion is based entirely on the fact that at the present day coral reefs are only found in the tropics or some few hundred miles on each side thereof. This rests on an observational basis and there is nothing in the structure of the coral individuals to explain it. The coral *Lophohelia*, which forms great branching colonies two feet in height, lives in the cold deep waters of the Norwegian fjords, and off the coasts of Scotland. This animal and others nhich occur nith it, differ in no consistent respects from allied tropical forms. Thus the mere occurrence of corals provides very unsubstantial evidence on which to found an interpretation of the temperature of past seas. If this doubt be present in Jurassic times then it is quite clear that abundance of corals in Palaeozoic rocks affords no evidence whatsoever as to the temperature, especially as the phylogenetic relationships between Palaeozoic and Mesozoic corals are quite uncertain. In the case of rocks of Pleistocene and late-Tertiary age in which the remains of living species are found, however, it is possible to use their evidence in following the course of temperature changes during the period of their deposition.

Most living species of marine animals have a distribution ahich is limited by temperature. Such fish as the haddock can live and breed only in waters nhose upper and lower temperature limits are strictly defined. and it is reasonable to suppose that this disability has existed from the time of their origin. Thus the discovery of such an animal as *Haliotis* (whose present northern limit is the Channel Islands) in late Tertiary rocks in England, would imply that there has since been a fall in temperature in the sea surrounding the British Isles. It is, however, clear that

such evidence must be used with caution and that it becomes more fragile the further back the species be traced.

Today, the faunas of the land. fresh waters and shallow seas are not uniformly distributed over the world. For example, each of the great land masses has a fauna? which, taken as a whole, is peculiar to it, and as the present distribution reflects the history of the individual forms, it is to be expected that similar zoogeographical regions should be recognizable at every geological period. In fact it is found from the evidence of mammals that in Oligocene times North America, Mongolia and Europe, Africa, Australia and South America formed independent provinces. Some facts of the distribution of ammonites suggest that in Cretaceous times a similar regional arrangement occurred in the seas. Because of the difficulty of being certain that the observed faunal differences in this and similar cases do not really depend on the absence of deposits of identical age, it is rarely possible to determine the limits or indeed the real existence of palaeozoogeographical regions in the sea.

It has often been stated that in past times the distinction between the climates of the tropical and temperate zones was far less pronounced than it is today. This statement is based on the fact that certain floras and faunas, the marine fauna of the Lower Carboniferous and the Rhaetic flora: for example, spread uniformly over the world, and that their remains may be found indifferently in the tropics and within the Arctic circle. It is difficult to conceive of any circumstances which could have greatly modified the existing arrangement, and the wide distribution of certain faunas may be accounted for either on a basis of inadequate discrimination of species. or on a greater adaptability of the animals concerned to temperature changes. There are, in fact; certain cases where the distribution of fossil animals can be accounted for only by the existence of such temperature belts. Thus. comparison of the fauna found in the Upper Marine series of Permian age in New South Wales, which from the occurrence of isolated glacial blocks on it is known to have been formed under conditions analogous to those now existing in the Antarctic seas, with the Permian faunas of the Himalayas. which cover the same period, shows .conclusively that we are here dealing with the results of temperature differences. The two faunas are completely dissimilar and it is most improbable that this can be accounted for by varying fncies. (D. M. S. W.)

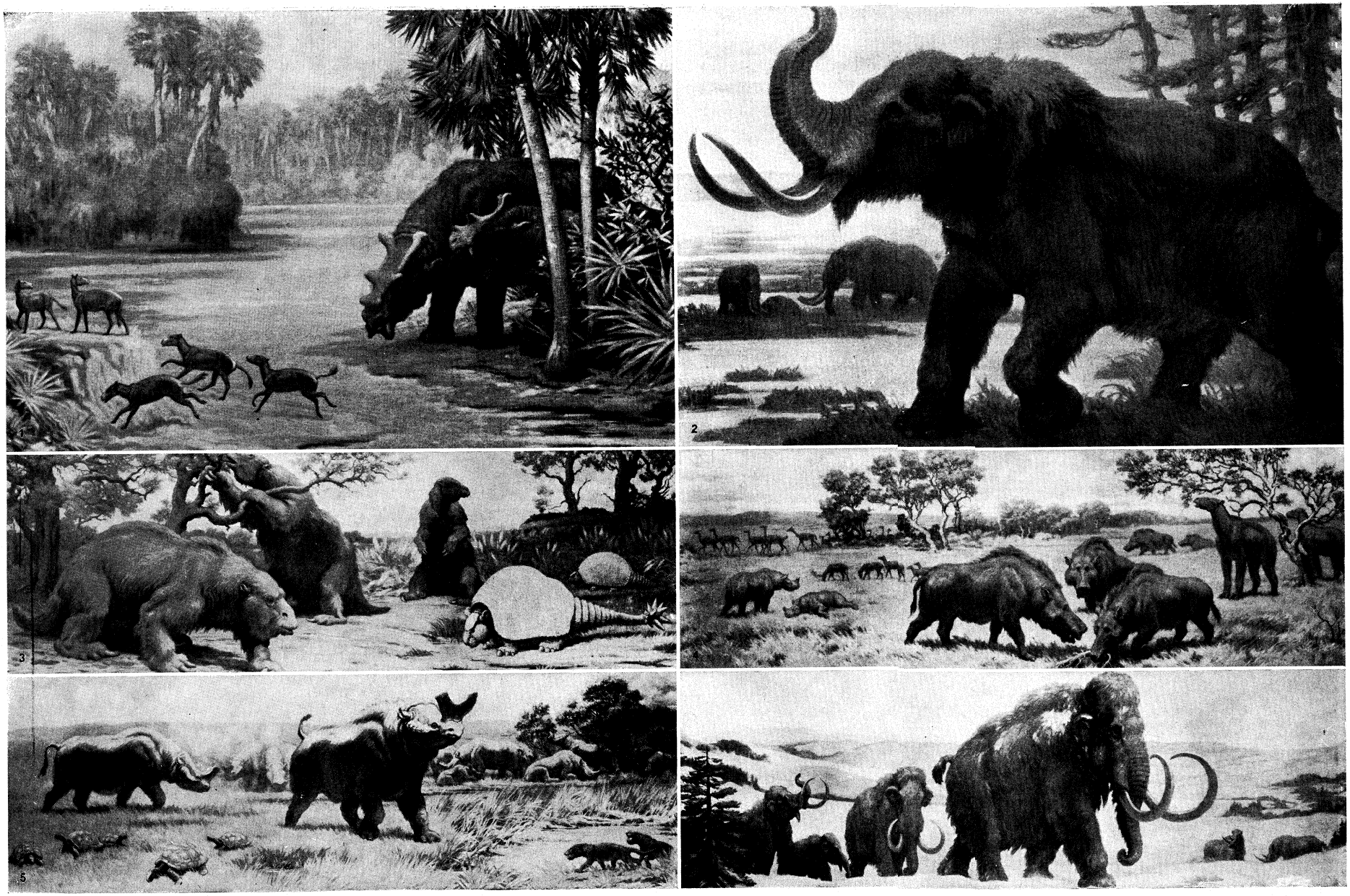
THE SUCCESSION OF FAUNAS

Of the five great eras into which geological time is customarily divided, only the last three—Palaeozoic, Mesozoic and Cenozoic — contain any appreciable record of animal life. In the earlier Archaeozoic and Proterozoic eras. covering perhaps three-yuarters of the estimated life span of the earth, there were laid down numerous series of sedimentary rocks, but in them there are almost no positive traces of living things of higher organic grade than algae. Trails and burrowlike structures possibly attributable to worms are known from some Proterozoic formations, hut other reported pre-Palaeozoic animal fossils are either of doubtful nature or of doubtful age.

Cambrian. — In the Cambrian, earliest of the Palaeozoic periods, which began perhaps 500.000,000 years ago, there appears a highly varied fauna including representatives of almost every major animal phylum. Two groups are particularly prominent — the trilobites and the brachiopods. The trilobites (*q.v.*) are exceedingly numerous and varied and make up more than half the Cambrian fauna. The brachiopods, or lamp shells (see BRACHIOPODA), although relatively unimportant today, were common in all Palaeozoic periods; and in the Camhrian constitute nearly a third of all reported genera. Other types of invertebrates were relatively rare. Of the Protozoa there are representatives of the Foraminifera, a group abundant in later periods. Of sponges (*q.v.*), there are spicules of the siliceous type. Much more common, however, are members of the Pleospongia. or archaeocyathids, a problematical Cambrian group of reef builders, considered by some to be coelenterates hut more probably a class of calcareous sponges. Proved coelenterates (*see* COELENTERATA) are rare, although there are some impressions of jellyfishes, one form which may be a sea anemone and a group (conulariids) probably allied to the hydroids. Corals, common in later times, are unknown in the Cambrian. Graptolites, small floating types of doubtful relationships, appear in the Middle Cambrian. Molluscs (see MOLLUSCA), highly important later, were relatively rare at this time. Most of the known genera were gastropods (see GASTROPODA). Snails of primitive sorts were present in the earlier Cambrian, and in the later part of the period show evolutionary advances and difierentiation. In greater numbers were the Hyolithidae, perhaps related to the modern pteropods. The Cephalopoda, (*q.v.*), highest of molluscan groups, are not surely known until late in the period when authentic nautiloids appeared. The Burgess shale of British Columbia, mentioned earlier. has preserved delicate impressions of a variety of soft-bodied Middle Cambrian animals of types not ordinarily preserved in the fossil record. There are several highly developed genera of marine annelid worms. Present there also were several groups of arthropods. In these beds are the only fossil representatives of the Onychophora (*q.v.*), primitive arthropods showing annelid characteristics, as well as members of the crustacean groups Brachiopoda (*q.v.*) and Phyllocarida and primitive genera of the marine arachnid group, the Merostomata. Of major arthropod groups, however, the myriapods and insects are unknown. Other unusual types in the shales are the only fossil chaetognaths, or arrowworms (see CHAETOGNATHA), and possible members of the peculiar living wormlike group of the Gephyrea. Before the end of the Cambrian the echinoderms (see ECHINODERMATA) had appeared in moderate numbers. However, all definitely identified forms belong to the extinct and presumably primitive classes Cystoidea and Edrioasteroidea.

In contrast to the dearth of animal remains in all pre-Cambrian rocks the Camhrian period thus exhibits an abundant and varied fauna of invertebrate animals. At first glance one gains the impression that this condition had been attained by a sudden evolutionary outhurst, but further reflection shows that this need not have been the case. A number of the groups represented in the Cambrian are soft-bodied forms known only from the Burgess shale and not likely to be preserved under ordinary conditions. The absence of shelled forms in the late pre-Cambrian is, however, more difficult of explanation. We must assume that the ancestors of the later shelled types were then soft-bodied. Various explanations have been advanced in this regard; the early absence of a shell may have been because of different chemical conditions in pre-Cambrian waters or (more probably) because of the fact that the ancestral types were free-swimming or pelagic forms whose descendants became shelled only when they assumed a henthonic mode of life (*see* MARINE BIOLOGY).

Ordovician. — In this second Palaeozoic period the variety of marine invertebrate life is greatly increased. Fossil protozoans are, however, relatively rare. Coelenterates become abundant at this time. Corals, including representatives of the subclasses Tetracoralla, Tabulata and probably the Alcyonaria appear and begin their rise to the position of importance which they were to hold throughout the Palaeozoic. The Ordovician also witnesses the origin of the stromatoporoids, reef-making organisms resembling hydrocoralline coelenterates. The graptolites (*q.v.*) attain the peak of their development at this time and are important for stratigraphic purposes. Of the molluscs, the gastropods are relatively abundant and highly varied in nature. The pelecypods (lamellibranchs) enter the picture in the form of primitive types of clams: and the cephalopods first gain importance in a great variety of nautiioids with both straight and coiled shells. Xrnong the arthropods the trilobites are at the climax of their evolutionary history: the typical crustaceans include the first of the Cirripedia (*see* BARNACLE) and the tiny shelled ostracods (see OSTRACODA); the merostomes include the first rare eurypterids (*see* EURYPTERIDA). Brachiopods continue numerous, but those with phosphatic shells are greatly exceeded in number by those with the calcareous type of shell. Among the echinoderms additional groups that are represented include the blastoids, starfishes (*q.v.*), echinoids (sea urchins. see ECHINOIDEA) and crinoids (sea lilies. *see* CRINOIDEA), the last already numerous. The Bryozoa (see



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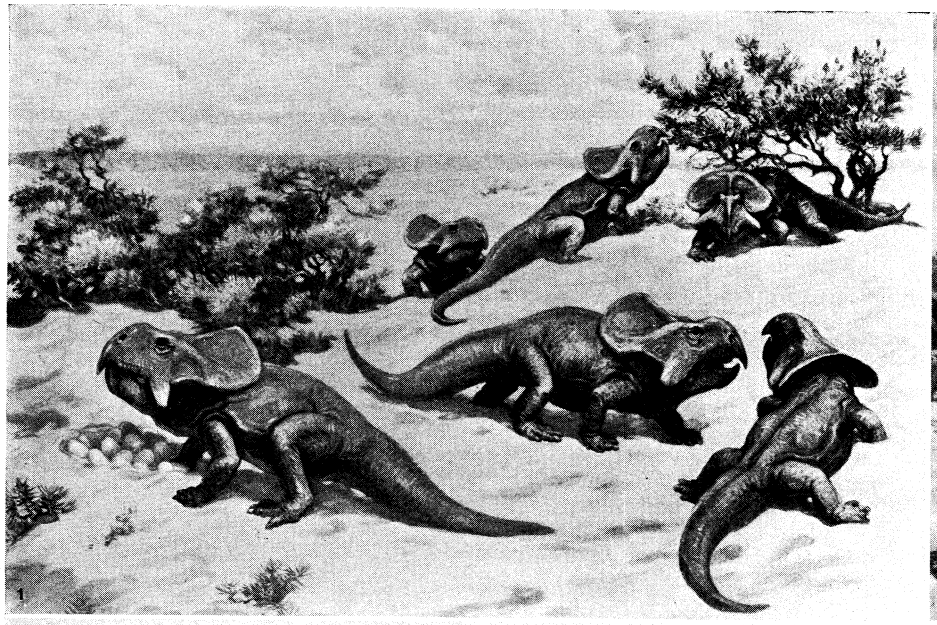
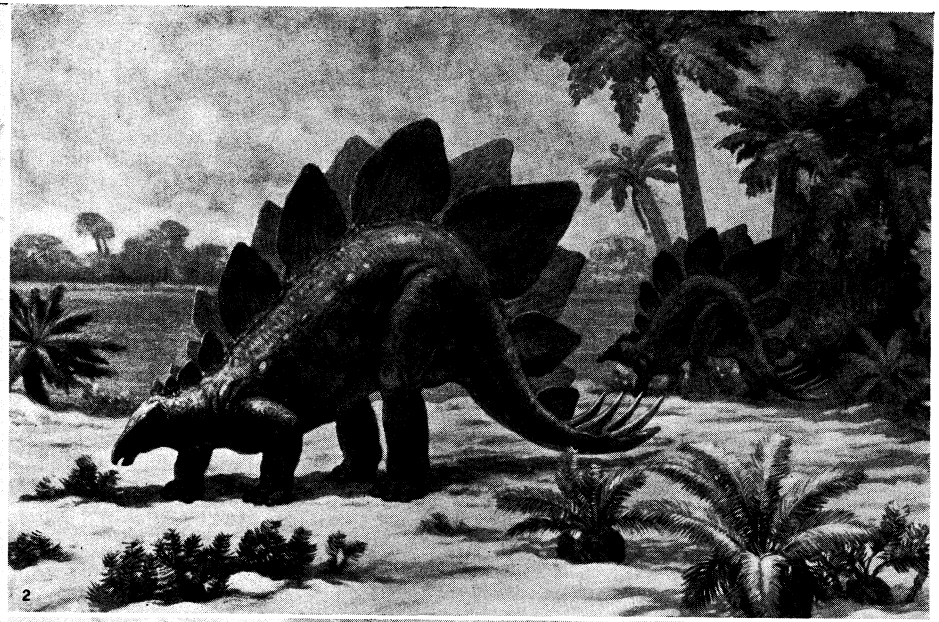
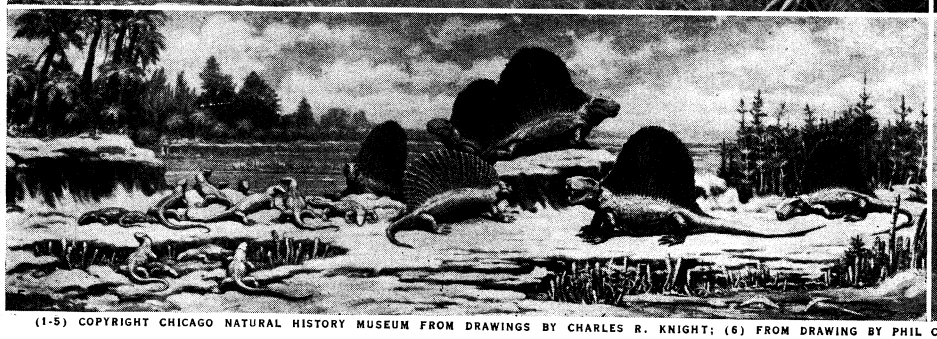
MAMMALS

1. *Orohippus* and *Uintatherium;* 1/47th natural size
2. *Mastodon;* 1/57th natural size
3. *Megatherium* and *Glyptodont;* about 1/100th natural size
4. Giant Hog, Camel, Rhinoceros and *Morop s* 1/95th natural size
5. *Brontotherium;* 1/96th natural size
6. Mammoths; 1/84th natural size







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REPTILES

1. *Protoceratops* (the egg-laying dinosaur); about 1/24th natural size
2. *Stegosaurus;* 1/65th natural size
3. *Triceratops* and *Tyrannosaurus;* 1/100th natural size
4. Flying reptiles, short-necked swimming lizard, and primitive sea-turtle; 1/100th natural size
5. Permian reptiles; 1/100th natural size
6. Scale drawing of *Apatosaurus* and a modern horse; 1/120th natural size

POLYZOA), or moss animals, appear in considerable variety during the Ordovician. The first traces of vertebrates (other, lower, chordates are unknown as fossils) are found in the shape of fragmentary bony plates in presumed estuarine deposits in the North American Ordovician. The rarity of vertebrates in the earlier Palaeozoic periods may be correlated with the generally marine nature of sediments of that age; the fishes may have originated in fresh waters.

Silurian. — This period witnesses few marked changes in the invertebrate fauna, although there are variations in the relative abundance of major groups and various evolutionary developments within these groups. The graptolites were in decline, while the corals were expanding in numbers and variety and had become important reef builders. Trilobites were still abundant and there were numerous eurypterids (water-dwelling scorpionlike types). True scorpions (*q.v.*) also appear — the first of known land animals. Of the echinoderms, the crinoids are very common, but the primitive cystoids are past the peak of their career. Late Silurian deposits of continental type yield the first adequate remains of vertebrates. Most are varied ostracoderms (*q.v.*). bony-armoured jawless relatives of the modern cyclostomes (*see* CYCLOSTOMATA); there are, however, traces of the acanthodian and arthrodiran fishes which were common in the following period.

Devonian. — In the various major groups of invertebrates the Devonian shows in most instances an increase in the variety of types present. Siliceous sponges are locally abundant, corals abundant and varied, as are the cephalopod molluscs, among which the ammonoids make their first appearance. Gastropods are highly diversified. Crinoids are still common, and the brachiopods are extremely abundant and diversified. On the other hand, both trilobites and eurypterids are much reduced in numbers before the close of the period. Among other arthropods, the Devonian shows the first of the horseshoe crabs (Xiphosura, *q.v.*) and the first myriapods.

The Devonian is often called the "Age of Fishes" because of the remarkable expansion of the primitive vertebrates during this period. The ostracoderms survived, but in diminished numbers beyond the earliest Devonian. Placoderms, including arthrodires and the spiny-finned acanthodians, were abundant. Sharks appear toward the end of the period. Higher bony fishes are present in the form of numerous crossopterygians and lungfishes and rarer representatives of the ray-finned Actinopterygii. In deposits in Greenland which lie close to the Devonian-Carboniferous boundary are remains of the first indubitable amphibians.

Carboniferous. — In America the Carboniferous is frequently divided into two periods, but we shall here follow European convention in treating this period of time as a unit. Aquatic invertebrates are more common in the dominantly marine strata of the Lower Carboniferous (Mississippian). The fauna shows considerable changes from those of the earlier Palaeozoic periods. The corals are greatly reduced in importance, as are the stromatoporoids, and the graptolites are extinct. Trilobites and eurypterids are rarities. Among the echinoderms the edrioasteroids make their last appearance, and the cystoids had been extinct since later Devonian times; but crinoids and blastoids are at the peaks of their careers. Brachiopods and lacy bryozoans are abundant. Of fishes, the ostracoderms are extinct, the placoderms nearly so. In the seas there were numerous sharks and their pavement-toothed, mollusc-eating relatives, the bradyodonts. Continental deposition was more prevalent in the later Carboniferous (Pennsylvanian). At this time there appear numerous fossil insects of various primitive types; most belong to extinct orders, but others are related to the cockroaches or (more distantly) to the dragonflies. Fresh-water invertebrates include clams, and land snails had developed. Fresh-water bony fishes were common. Crossopterygians had become rare. but the ray-finned fishes were represented by numerous primitive types. the palaeoniscoids. Amphibians were abundant and varied, including many lahyrinthodonts. often of large size. numerous smaller lepospondyls and possible frog ancestors. In the closing phases of the Carboniferous are found sparse remains of the first reptiles.

Permian. — In the early phases of this final Palaeozoic period the marine invertebrate life was similar to that of the Pennsylvanian, except for such features as the greater complexity of the ammonite cephalopods. By the close of the period, however, there had occurred major instances of extinction. Groups which made their last appearance in the Permian include the trilobites, eurypterids, one of the dominant Palaeozoic coral groups. major groups of bryozoans, the blastoids. most of the crinoids among the echinoderms and a majority of the brachiopods. The fusilinid Foraminifera were of' great importance in the Permian as horizon markers and rock formers.

Among the fishes the extinction of the acanthodians in the Permian marks the end of the placoderms. During the period occurred the extinction of most of the sharklike fishes and typical crossopterygians; primitive ray-finned bony fish continued to flourish, however. Of amphibians the Inhyrinthodonts. mostly in the rhachitomous stage'of evolution, remained abundant; but the small lepospondyls became extinct. Remarkable is a radiation of early reptiles, which continued into the early Triassic. There were various stein reptiles (cotylosaurs), but the dominant groups were those related to mammalian ancestry: the primitive pelycosaurs (mainly American) in the early part of the period. the more advanced therapsids (mainly in South Africa) in the later Permian. Various small and often inadequately known forms may include ancestors of the prominent Mesozoic orders.

Triassic.—Following the extinction or reduction of most of the prominent Palaeozoic groups, we find in the Triassic a marine invertebrate assemblage of a much more modern appearance. Instead of the brachiopods, the pelecypod and gastropod molluscs from this time on are the common shelled invertebrates. Among the corals the shell-secreting Hexacoralla, a modern group, appears in the Middle Triassic to displace the Palaeozoic coral groups as reef builders. Cephalopods are very common. but the nautiloids are henceforth relatively rare and are in great measure replaced by a characteristic ammonoid fauna and to a lesser degree by the more modern appearing belemnites. Among arthropods typical crustaceans displace the trilobites in the marine assemblage; from the Triassic onward the decapods (a group including the lobsters and crabs) become increasingly prominent. Of lower fish groups, only a single type of shark is known in typical Triassic deposits. From the Triassic onward the bony fish record is almost entirely one of actinopterygian history; the Triassic representatives include palaeoniscoids and somewhat more progressive types. The amphibians are known only from specialized and usually degenerate end forms of the Labyrinthodontia. Reptiles were abundant. In the earlier Triassic the fauna was essentially a continuation of that seen in the Permian; later in the period, however, new groups predominate. These groups include rhynchocephalians, forms antecedent to lizards, and the oldest turtles. hlarine reptiles appear in the shape of primitive ichthyosaurs and sauropterygians. The development of the Archosauria, or ruling reptiles, was well under way. for besides the development of the general ancestral stock (Thecodontia), bipedal saurischian dinosaurs appeared in the late Triassic.

Jurassic. — Jurassic sediments are predominantly marine, and the seas swarmed with an abundance of invertebrate forms. The ammonoids were at the height of their development: abundant and varied, they are of great use as stratigraphic markers. There were numerous reef-building corals of modern families. abundant pelecypod and gastropod molluscs, belemnites and varied crustaceans of modern groups. Fishes swarmed in the seas. The sharklike fishes had begun a radiation of types leading to modern sharks and rays, and there appear the first of the chimaeras. Ray-finned bony fishes had invaded the oceans in great numbers; dominant were the holosteans, intermediate between the ancient palaeoniscoids, seen here for the last time, and the modern teleosts. which first appear in the late Jurassic. Marine reptiles were present. including numerous ichthyosaurs and plesiosaurs and marine crocodiles. On land the appcarancc of such familiar groups as the Coleoptera. Hymenoptern. Lepidoptera and Diptera gives an essentially modern aspect to the insect fauna. Amphibians are represented only by rare remains of the first frogs. Crocodiles as well as turtles were common in fresh waters, and

lizards make their appearance. Dinosaurs (see DINOSAUR) were the dominant vertebrates. The saurischian dinosaurs include not only bipedal carnivores but the large amphibious types such as Brontosaurus and Diplodocus. The herbivorous ornithischian dinosaurs include not only bipeds but plated quadrupeds such as Stegosaurus. In the air there were various types of flying reptiles, the pterosaurs, and the first birds are known from two skeletons in the Bavarian lithographic stone. The mammallike reptiles were extinct, except for a few questionable forms, but had given rise to the earliest mammals, represented by small jaws and teeth in a few Jurassic localities.

Cretaceous.—By this time the marine invertebrate fauna had become essentially modern in aspect, although the genera were for the most part distinct from those living today. Clams, oysters and various gastropods were common among the molluscs; the ammonoids still flourished but tended to develop into bizarre types frequently considered to indicate racial senescence. Among the lower fishes, almost every family of modern sharks and rays had evolved before the close of the period, and teleosts of modern aspect had almost entirely replaced the older ray-finned types of bony fishes. Ichthyosaurs were rare, but plesiosaurs flourished; and marine lizards, the mosasaurs, were abundant in the late Cretaceous. Continental deposits are in the main confined to the later half of the period. Of amphibians we find urodeles as well as frogs. Lizards are numerous, and primitive snakes had appeared. Dinosaurs still abounded. The saurischians included bipeds large and small and relatively rare survivors of the amphibious quadrupeds. The ornithischians were more common; the duckbills were the common bipeds; four-footed types included broad-bodied armourcd forms and the horned dinosaurs. Giant pterosaurs are found in the Upper Cretaceous; but the birds, still possessing teeth but essentially modernized in other respects, appear to have attained a dominant position in the air. Mammals were still comparatively small and rare, but most of the archaic groups of the Jurassic had disappeared in late Cretaceous days, to be replaced by the opossumlike marsupials and the first rare placentals.

At the close of the Cretaceous there occurred the greatest mass extinction in geologic history. Among the invertebrates the disappearance of the ammonoids is the most marked feature. The plesiosaurs, ichthyosaurs and mosasaurs disappeared from the seas. On the continents we see the complete extinction of the dinosaurs, of which almost all groups were still abundant in late Cretaceous times; and the pterosaurs were wiped out as well. The causes of this major biological catastrophe are far from completely known. However, the mountain building which was taking place in the late Cretaceous tended to bring about physiographic, climatic and floral changes which must have seriously affected the life conditions of the times.

Cenozoic.—This era of "modern" life, most of which is included in the Tertiary period (with the Quaternary, including Recent times, as a short appendix), exhibits throughout a marine invertebrate fauna readily comparable with that of the present day. With few exceptions not merely the orders but the families of fossils present at the beginning of the Tertiary are among those still living. In the earliest Cenozoic, however, the genera for the most part differ from those present today; and the series of epochs into which the Cenozoic is divided—Palaeocene, Eocene. Oligocene, Miocene, Pliocene (all in the Tertiary period) and Pleistocene (of the Quaternary period) was established mainly on the increasing prevalence of modern marine genera in the successive faunas. Among the fishes the Tertiary shows a constantly increasing variety of teleosts, particularly of progressive spiny-finned members of the tribe. Other fish groups and amphibians appear to have reached essentially modern conditions by the beginning of the era. Reptiles, following the extinction of the dominant Mesozoic groups, have been reduced to a relatively inconspicuous role, although fossil crocodiles, lizards, snakes and turtles are not uncommon. By the beginning of the Tertiary the organization of the birds had reached an essentially modern level. Except for the development of large flightless types at various times, the incompletely known Tertiary history of this class is for the most part that of the establishment of the modern orders and families (see BIRD). The most striking feature of Cenozoic history is the evolution and radiation of higher mammalian groups (see MAMMALIA). Rare, small and little differentiated in the Cretaceous, the mammals, relieved from the tyranny of the dominant reptiles, developed and diversified rapidly in successive Tertiary epochs. Most Cenozoic forms belong to a series of progressive orders, usually grouped as placental mammals, in which the young are born alive and at a relatively advanced stage of development. In the Palaeocene, mammals were already abundant, varied and frequently of large size. Many, however. were members of archaic placental orders, early "experiments" doomed to speedy extinction, and only three of the existing orders were represented—Insectivora, Primates (*qq.v.*) and Carnivora. In the Eocene various other modern orders, including even and odd-toed ungulates, rodents, whales, bats, etc., appeared, although represented for the most part by primitive forms; numerous archaic types still survived. Most of the archaic orders disappeared in the Oligocene; and by the Miocene not only was the list of orders present close to that of modern times, but at least half of the modern families were represented. In the Pliocene we find that numerous modern genera were already present; in the Pleistocene, except for the presence of various large forms non extinct, the fauna was closely comparable with that of the present day.

(See MAMMALIA; ANIMALS, PHYLOGENY OF; EVOLUTION. ORGANIC; CARNIVORE.)

EVOLUTIONARY EVIDENCE

The fossil record is of the utmost importance in the study of evolution. It provides the best possible answers to two major questions: "Has evolution actually occurred?" and "By what modes has this process taken place?"

The Fact of Evolution.—That. living animals have presumably descended, with modification, from pre-existing forms was demonstrated to the satisfaction of most scientists by Charles Darwin and other workers with little or no recourse to fossil evidence. That evolutionary change is not only possible, but probable, was indicated by a study of the similarities found to varying degrees among living animals and plants and by a study of the variability which living forms may exhibit. There is, however, nothing in the study of living forms alone definitely to exclude the possibility that (as indicated by a strict interpretation of the Book of Genesis) we are part of a special, direct creation. and that! although modification of the animals thus created may occur, these modifications have been only of a minor nature, not meriting the designation of a major evolutionary process.

With the development during the 19th century of a connected palaeontological story much light was shed on this situation. It was discovered that, in the past history of the earth, there had existed hosts of animals now extinct, which differed to varying degrees from those now living. It was found, too, that these animals constituted a series of successive faunas which followed one another in time. The members of each fauna show in general the broad structural pattern characteristic of the major groups of animals still living, but difier to a variable degree from the modern representatives of these groups. It became gradually clear that the degree of difference from modern forms was in general correlated with the amount of time involved and that the successive faunas exhibit a pattern of progressive change. The older faunas differ most from animals now living; members of more recent faunas gradually come to resemble more and more closely the modern animal types.

All these facts are quite in harmony with the doctrine of evolution, but they by no means prove its truth. Indeed, such great figures in the early history of palaeontology as Cuvier and Louis Agassiz held no evolutionary beliefs and claimed that these successive faunas were the results of successive creations. Cuvier maintained that the world had undergone a series of "revolutions," each cycle corresponding in time essentially to what we now term a geological period. At the end of each cycle the existing fauna was overwhelmed by some catastrophe of nature; the creation

de *novo* of a new fauna began the next cycle. The resemblances between successive faunas were held to be because of the tendency of nature or the Deity to reproduce the earlier creations with successive modifications of each type in the direction of greater perfection.

But with increasing knowledge of fossils it became more and more difficult to adhere to a belief in a series of revolutions and creations. Thc breaks between successive faunas are actually not sharp. We frequently find faunas intermediate in nature and containing some old, some new, forms. In many instances there are series of beds which appear to extend without break from one period into another and show series of forms transitional between those of supposedly distinct creations.

Obviously, there have been no major catastrophies or violent revolutions leading to complete extinction of faunas. Changes have been continuous and seemingly gradual. There were no major times of new creation; if successive creations occurred, they must have been of almost constant occurrence. Today, the evidence for continuity of life and change in thc fossil record is so great that lack of belief in the evolutionary story is almost impossible to any competent person familiar with the facts of palaeontology.

It is difficult to interpret the general story of faunal succession, as outlined elsewhere in this article, in any fashion other than that of a progressive evolutionary story. Not only do the faunas as a whole show a steady drift toward modern conditions, but numerous lines which can be traced through successive faunas give every evidence of being evolutionary in their nature. In many instances (the horses are a familiar example) we have well-documented family histories, covering scores of millions of years, which are inexplicable in other than evolutionary fashion. In numerous other cases the story is less clear (we know, of course, but a relatively small percentage of the animals of the past), but the facts are never inconsistent with an evolutionary explanation.

Is evolution "true?" The answer to this question depends upon what is considered by the questioner as valid evidence. Obviously, no one can go back through the ages and furnish birth certificates for each of the countless generations of individuals in every animal series. But we can say this: that all the known facts of palaeontology are consistent with the theory of evolution, and impossible of rational interpretation on any other basis. Few accepted truths of any sort rest on firmer grounds.

Theories of Evolution. — Most modern students of evolution are of the neo-Darwinian school, believing that evolutionary progress has been accomplished in the main through selection of variations arising through mutation. There are, however, adherents of other general theories of evolutionary change—of the Lamarckian concept of inheritance of acquired characteristics, or of more "vitalistic" types of speculation which hold that evolution is a response to some inner urge of the organism or because of some predestined plan.

On the whole, the evolutionary record affords, as yet, little evidence to prove or disprove any one of these major theories. Most of the facts of the fossil record can be interpreted on a neo-Darwinian basis, and a majority of the palaeontologists currently interested in evolutionary problems accept this theory as a working hypothesis. However, palaeontologists in the past have been prone to subscribe to the doctrine of orthogenesis (*q.v.*), and some still do. It is held, under this theory, that much of evolution has taken the form of an "undeviating straight line" from the original ancestor to the terminal member of a phyletic series, and that this orthogenetic trend is because of some vitalistic principle working within the animals concerned—a sort of evolutionary predestination. This concept gained its hold on palaeontologists through the fact that many evolutionary lines seemed to be of this nature. The changes witnessed in the successive members of evolutionary phyla all tended, it seemed, in the same direction; the evolutionary tree appeared to be, in many cases. branchless.

Belief in this concept, however, has tended to decrease in recent decades. With increasing knowledge, it is now seen that there are actually few examples of undeviating and unbranched evolutionary lines. The horses, for example, were once thought to exemplify orthogenesis, but we now know that in both the Eocene and Miocene there were various side branches of the horse stock; and the rhinoceroses, related to the horse group, branch so wildly that they form (so to speak) not an evolutionary tree, but a bush, with a wild tangle of stems, branches and twigs. And even where there still appears to be some semblance of a single stem, the condition need call for no vitalistic explanation. If the main evolutionary line represents the direction in which change was of an adaptive nature, and hence of selective value, the single stem may be accounted for on a neo-Darwinian basis: the side branches may have begun, but were eliminated as inadaptive before they became visible in the fossil record. The single stem is a tree rigorously pruned by selection.

Closely related to the doctrine of orthogenesis is that of the irreversibility of evolution, formerly held by many palaeontologists. In its broadest, literal sense this implies that evolution, once it has taken up a given direction, never changes in its course; that structures once acquired are never lost; that structures once lost are not regained. When carried to this extreme (as has been done by many workers in the past), adherence to this doctrine leads to absurdity. The course of evolution does change. For example, reptiles and mammals, many of whose ancestors left an aquatic environment for dry land, have returned to the sea; some birds whose ancestors had become flying types have lost this power and have descended again to earth. Structures once gained are often lost; the snake has abandoned the four terrestrial limbs acquired by his ancestors; we mammals have lost the armour of scales which covered the body of our piscine ancestors.

However, Louis Dollo, the distinguished palaeontologist to whom the doctrine of irreversibility is attributed. was more modest in his beliefs. He claimed only that structures once reduced to an essentially functionless state seldom redevelop to or toward their original condition, and that when organs are lost in the course of phylogeny. they do not reappear, although some effective substitute may develop if a need for such a structure should arise. This limited thesis of irreversibility is reasonable from the point of view of genetic theory, and appears to be borne out by the known history of fossil lines. If, for example, a reptile or mammal returns to an aquatic life, it never redevelops the gills lost by its ancestors when they left the water, although they would be highly useful if present; a tail fin may redevelop in an ichthyosaur or whale, but it is not the original type of fin—rather, an effective substitute built on a different pattern.

Adaptation. — Evolution is change; changes which persist in a stock are, in general, in the direction of closer adaptation of the animal to its environment. For, unfavourable changes tend to be weeded out by selection, favourable changes lead to survival of the individual and its progeny. Most of the structures (and functions) of living animals are readily interpretable in terms of adaptative utility; others, not in themselves useful, may in the pattern of inheritance be tied in with useful structures or functions.

In the examination of the fossil record we find a constantly changing structural pattern which we attempt to interpret in terms of useful adaptation. Some of the structures seen are of a familiar sort, and their utility, is fairly obvious. Others, however, are widely different from any seen in living animals, and their function (if any) difficult to interpret; some would appear to have been definitely detrimental. It is. for example, difficult to imagine a function for the great sail, supported by long spines, which sprang from the back of certain Permian reptiles; the enormous antlers of the extinct Irish elk would seem to us to have been an almost insupportable burden. But it is not impossible that the sail of the Permian reptiles was an effective heat-regulating device: possible (although incapable of proof) that the presence of gigantic antlers may have been of advantage to their bearer in the annual fights of the deer for mates and progeny.

In many instances students of adaptation in modern animals have found it difficult to imagine that any utility could have been

found for a complex structure during the stages in its evolutionary development; it is frequently assumed that there has been a condition of "preadaptation"; structures were developed and became incorporated into the normal members of a species or group before any utility was found for them. In a limited sense this is perhaps true, for genetic theory implies that single mutations are random events, occurring without reference to need or necessity for them. But it seems highly improbable that the complex of mutations necessary for the development of a major structure should become established in the absence of any action of selection because of utility. And a consideration of palaeontological evidence indicates that many supposed cases of preadaptation are not of that nature. We may cite a specific example.

A good land animal, such as a reptile, differs basically from its fish ancestors in (1) lungs for air breathing. (2) four land-limbs and (3) a shelled amniote egg which can be laid on land. All these adaptations for land life would appear, at first sight, to be useless to a fish, and hence to have developed as preadaptations before they became useful. But the study of the fossil record combined with the evidence of living forms shows that this is not the case. It appears that in late Palaeozoic days many fishes living in fresh waters were subject to conditions of marked seasonal drought. Lungs would be extremely useful in supplementing the meagre oxygen supply in stagnant or failing waters. Limbs, even if but feebly developed, would have been of use in enabling a stranded fish to seek another pool. And although amphibians normally lay their eggs in fish fashion, in the water, many forms today (particularly those living in tropical regions where rainfall is seasonal) have more or less effective adaptations, parallelling those of the amniotes, for the development of the young without deposition of the eggs in the pond. Thus, all the major features which make land animals successful could have been, and apparently were, developed in earlier, prereptilian stages as immediately useful and adaptive structures; there was no preadaptive lag.

Emphasized particularly by the late Henry Fairfield Osborn was the principle of adaptive radiation. Given the opportunity, the descendants of a "generalized" ancestral form may spread out widely, with a striking variety of adaptive features, into a number of different environments and modes of life. On a large scale, the development of the higher, placental, mammals illustrates this principle. Their ancestors were present, in the shape of small, insect-eating forms, at the close of the Age of Reptiles. With the extinction of the dinosaurs the world lay before them, and there began a rapid adaptive radiation into types ancestral to such diverse mammals as men, bats, whales, cows and lions. On a somewhat more modest scale is the adaptive radiation of the marsupials, or pouched mammals, in Australia. The placental mammals never reached that continent in the early days of their expansion; but apparently there were present primitive opossumlike marsupials from which has descended the native mammal fauna of that continent. This adaptive radiation of marsupials produced pouched flesh eaters such as the Tasmanian "wolf," anteaters and moles resembling placental forms of other continents and a variety of herbivores such as the kangaroos, the marmotlike wombat and pouched "squirrels."

From what has just been said, it is obvious that two adaptive radiations may overlap one another and produce end forms which have similar habits and adaptive structural features but are quite unrelated having descended from ancestors remote from one another. This is the phenomenon of convergence. As an example may be cited the case of the Tasmanian "wolf" just mentioned and the true wolf of other continental areas. The two lead similar lives as terrestrial, running predators and are strikingly similar in adaptive features of the jaws, teeth, limbs, etc. They are however, quite unrelated, come from very different ancestral stocks and their dissimilar pedigrees can be determined by examining, not the superficial features readily modified in adaptive ways, but more basic, internal structural features (of the brain case, etc).

Parallelism.— To be distinguished carefully from convergence is the phenomenon of parallelism, which in recent decades has been realized to have been a very common and important feature in evolutionary history. In convergence we see the attainment of similar features by unrelated animals; in parallelism, we have a situation in which two end forms similar to one another have evolved from related ancestral types. The end forms may possess many characters which their common ancestors lacked and have acquired these characters step by step, in parallel fashion.

This type of phenomenon is readily interpretable in terms of modern genetics. Numerous examples of parallel mutations are known, for example, in different species of the common fruit fly *Drosophila*. If such parallel mutations of this sort were proof of selective value, we would witness their incorporation in the general population of the various species in which they occur, and the beginning of a process of parallel evolution such as that actually witnessed in the fossil forms.

The Tasmanian "wolf" and the true wolf, we have noted, are to be considered as convergent, for their ancestors were of quite different stocks. As an example of parallelism me may note the case of the same Tasmanian "wolf" with certain South American marsupial flesh eaters—Borhyaena, etc. Now extinct, these forms were the typical carnivores of the Tertiary period in that continent. The borhyaenids were exceedingly similar to the Tasmanian "wolf" in almost every feature: and some have argued that there must have been a Tertiary land bridge between South America and Australia to account for this fact. This is, however, improbable. The borhyaenids appear to have been a group which originated, like the Tasmanian "wolf," from opossumlike ancestors, and which adopted a flesh-eating mode of life like their Australian cousins. Given a similar basic structural pattern in the two cases and a similar change in habits, it is not unreasonable that similar adaptive changes should have occurred in these two related stocks, providing an example of true parallelism.

In such a case as this we find a parallelism in almost the entire structure of the organism. In other instances related forms may diverge in certain features but exhibit parallel advances in other regards. Thus, for example, the mammallike reptiles of the Permian and Triassic are quite diverse in many regards; but all later members of the group tended to develop a secondary palate in the mouth and tended to reduce the count of toe joints in the feet from the higher reptilian number to that characteristic of primitive mammals and man. These developments appear to have taken place independently at about the same time in several distinct, although related, groups of mammallike reptiles, and hence exemplify parallelism of a sort.

Such illustrations of partial parallelism, however, may perhaps best be considered under another term, that of phyletic drift—the general tendency for a group of animals to move in a certain evolutionary direction as regards certain of their structures, although diversifying in other ways. For example, the labyrinthodont amphibians of the Triassic varied greatly in numerous features—heads were long or short, snouts broad or narrow, etc.—but all tended to drift in common toward the development of very low skulls, feebly ossified, and with enormous openings present in the palate. Again, early land vertebrates almost uniformly retained a third median eye in the centre of the forehead. But in Triassic days the drift in land vertebrates as a whole was away from this structure; and, at about this time, the opening which housed it disappeared in group after group.

The evolution of the mammalian brain is likewise illustrative of the phenomenon of phyletic drift. The brains of modern progressive mammals—not only man and the primates, but various ungulates, carnivores, etc.—exhibit in common a variety of advanced character? not present in primitive mammals. It has been assumed that these characters were present in the common ancestors of the modern forms. But recent studies of casts of the brain cavity in a series of fossil horses by Dr. Tilly Edinger show that these advanced characters, as seen in the living horses, appeared at a fairly late date in the history of the equids and that, therefore, there mas a parallel drift in brain structure in the various higher mammal groups.

The most widespread example of phyletic drift seen in fossil

fines is the almost universal tendency toward increase in size. If we follow through any well-known evolutionary series. we find' almost invariably that it commences with forms of modest size, whose descendants tend steadily to increase in bulk with the passage of time. Indeed, the general impression we get from the fossil record is that we should today be living in a world of giant forms of life. But, actually, we are not; today, as always, there is still a host of small as well as large animals. Bulk has its advantages. It is in itself a partial protection against enemies; for warm-blooded animals, heat conservation is simpler because of the relatively small surface in proportion to bulk. But size also appears to have disadvantages; large animals appear to be able to adapt themselves less readily to changing environments. The survivors tend to be forms of smaller size which, in turn, generate new series of bulky and temporarily successful descenclnnts.

Among mammals the Pleistocene epoch just behind us represented the climax of development in size. There existed during the ice age numerous large animals, such as the various mammoths, mastodons, ground sloths, etc. Most have since become extinct. The wiping out of many of the larger animal types is most noticeable in the Americas; the reasons for this depopulation are far from clear. Also noticeable to a minor degree in the Pleistocene was the rarer opposite trend, the development of dwarf types, of which the most curious was the occurrence on Mediterranean islands of pygmy hippopotamuses and tiny elephants — one no larger than a collie. The trend toward dwarfism appears to be particularly associated with adaptation to island life.

Speed of Evolutionary Development. — The neo-Darwinian concept assumes, in general, a relatively slow evolutionary development: the gradual appearance and spread through a species of numerous small mutations which only after countless generations cumulate to produce a markedly different descendant. Until recently it seemed difficult to account for such a leisurely process of evolutionary change, for the times computed by the geologists for the various eras and periods were far too short. Recent work on the age of radioactive rocks has, however, given us a much longer sweep of time. The Cambrian period. when most of the major animal groups were already established, was approximately 500,000,000 years ago; for the time of development of the modern mammals, since the extinction of the dinosaurs, there appears now to have been about 70,000,000 years available instead of the 5,000,000 once thought to be the extent of the Cenozoic era.

To visualize the relatively slow type of evolutionary change which may have been characteristic of much of phylogenetic development there have been suggested the concepts of adaptive hillocks (Sewall Wright) or adaptive zones (G. G. Simpson). The former concept would picture the face of nature as a plain in which there rise here and there elevations: each representing a specific type of environment. Within a group of animals each form would be found occupying one of theie adaptive hillocks and in great measure the changes which each animal would undergo would be the gradual development of features adapting it more perfectly to its own small area. But these hillocks are not, in this concept, fixed; they change position gradually, much like slowly moving waves in a swelling sea. As the hillock moves, the animals must move with it and change with it. Simpson's concept of adaptive zones is an attempt to restate this picture with more emphasis on time as a dimension. We may make a graphic plot with time as (say) moving horizontally from left to right. We may substitute for the concept of hillocks the concept of bands or zones following the time axis across the field and separated by untenantable intermediate belts (the bare plain of the Wright concept). These bands may be placed essentially horizontally, in which case little or no evolutionary change is required in the animals which inhabit them. But if the band is tilted. the inhabitants of the zone must gradually change adaptively to maintain themselves within it.

It has however, been argued that not all evolution follows such a course of slon adaptive change Many have contended that part at least of the evolutionary process has consisted of major changes accomplished in a short period of time or even in one single step — "saltations." The mutations of the geneticist were originally conceived to be of this nature; but most mutations. as now known, are changes of a very modest sort. and those of larger proportions are generally markedly deleterious if not lethal. In plants, abrupt changes are positively known in certain instances, caused by the phenomenon of polyploidy — a doubling-up of the chromosomes present in ancestral generations — but it is doubtful if this phenomenon has been at all common in animals. There is thus little reason to believe, on the basis of observation of living forms. that there have been abrupt, single-step evolutionary changes in the phylogeny of animals.

When we examine the fossil record the case is far from clear. In many cases where evolutionary series are known, evolution appears quite surely to have been a gradual, orderly process. In many cases, too. where the record is imperfect and many forms are missing, there is nevertheless a sufficient time interval betn-een the known representatives of the group for gradual development to have taken place. But there are still many instances where it is reasonable to believe that rapid evolution has occurred. We may note the fact that the origin of numerous major groups is shrouded in obscurity as fossils, no matter how common their later representatives may be, nor how sure we may be of the general nature of the ancestral stocks from which these groups sprang. Further, we are often sure that the time inter\-a1 between deviation from the ancestral stock and the appearance of the new type in the fossil record must have becn short.

The lack of connecting links in such cases might he because of there having been a saltation, but in all probability the explanation lies in other directions. Presumably the population of animals making the transition was relatively small in number (a feature conducive to rapid evolutionary change); this with the fact that the time interval was short, makes the chances of finding specimens of transitional forms very poor indeed; there are many missing links that are destined to remain missing. These relatively sudden shiits, however, may have taken place by the normal mechanisms of mutation and selection — but a selection which proceeded at a very rapid rate.

To understand the reasons for this rapid selection and consequently rapid evolutionary change, we may return to the concept of adaptive hillocks or zones. As long as an animal clings to the slopes of its own hillock, it will change but little or but slowly. If, however, in the gradual shifting of these hillocks, two approach one another, it may be possible for the dwellers on one to cross the ground between them and to take up life in this new area. When the animal does this, however, it must rapidly adjust itself, structurally and functionally, to a new environment. In terms of adaptive zones, an animal may "jump" from one zone to another, passing rapidiy through the intervening area where life is impossible for it. In the old zone, changes would have been gradual; in the new one, the newly evolved type may soon settle down to a leisurely evolutionary pace; but in transition the pressure of selection would be very strong, and change in adaptive features rapid.

Evolutionary Sterility: Extinction. — Kith evolution may be compared antithetical processes also seen in geologic history — the stability of type seen in some lines over long periods of time, and the extinction of various animal groups.

While the fossil record shows most groups of animals to have continuously undergone chance, whether fast or slow, there are cases in which there has becn little modification over long periods of time. Brachiopods of the *Lingula* group are frequently cited in this connection; they appear to have persisted with relatively little change since Palaeozoic days. How we are to regard such a condition depends in great measure upon mental concepts which may have little to do with the actualities of the case. We may approve such stability as showing that the organism has reached a nearly periect adjustment to its environment; or we may frown upon such a situation as exhibiting evolutionary sterility.

In evolutionary sequences we not infrequently find that terminal members are more simplified, less complex in structure. than their ancestors. The proccss of simplification is frequently referred to as one of deeeneration, with the moral overtones (or undertones) associated with that word when applied to human beings. But nature is unaware of human moral values; survival is success, and simplification may bc as effectual an evolutionary proccss as progress by increase in complexity.

Many major animal groups evolve, hut most of the species and genera of past axes — and even many families and higher categories — have become extinct without leaving progeny. Extinction is thus the

common fate, evolutionary progress the exception.

The reasons for extinction have been oiten pondered, but with little result as far as reaching any general principles goes. In certain instances specific causes ior extinction have been reasonably claimed: disappearance of an appropriate food supply, appearance of predatory enemies, successful competition for available food by rivals with more progressive adaptations. etc. Frequently there has been a recourse to a hypothesis of "racial senility" which leads to extinction (Alpheus Hyatt and others); a spinescent condition sometimes seen in terminal members of a group is cited as a manifestation of this senescence. But a comparison between somatic tissues of the body, of, an individual animal and a species or group as a whole seems unjustified. An individual body and its specialized tissues may be young or old, but it is obvious that (unless one believes in special creation) every animal in existence at a given time in the earth's history has exactly the same number of millions of years in its pedigree as every other.

Specialization is frequently cited as a major cause of extinction. The term reiers to the presence of adaptations fitting an animal to a special type of environment; a generalized type is, on the contrary, one defined as lacking such specializations. These terms should, however, be used with caution. After all, every animal must be adapted to its environment in order to live at all; an animal lacking adaptive specializations of some sort could hardly survive. Too frequently, it would seem, we confuse cause and effect in the use of these terms. If an animal of the past has given rise to descendants, it is admired as a generalized type; ii it became estinct it mas *ipso fncto* specialized. The dinosaurs became extinct; we therefore term them specialized. The small contemporary mammals survived and flourished. Were these latter thereiore generalized? Actually, if we were living in the days of the dinosaurs anti knew nothing of later history, we would probably consider the mammals, with their nonprimitive limbs, reduced toe joints, highly modified skulls and jaws, very modified teeth, brains, etc., as among the most specialized of then existing vertebrates. Yet mammals arc very much with us today.

Geographical Distribution.—The evidence from existing animals suggests that geographical features have played a major part in the origin of new species, and the fossil evidence suggests that geographical factors may have been of importance in the evolutionary history of major animal group; as well. Our knowledge of past topography is incomplete, and many points in palaeogeography—even major ones—are in dispute. There is, however, a great body of evidence demonstrating that the distribution of marine and continental areas of the earth has varied widely in past geological times, and that the arrangement of mountains and lowlands over the globe has been continuously modified. All these changes have unquestionably been ·fective in stimulating or altering the course of evolution. Thus, for example, the later part of the Cretaceous period was notable for the elevation of great mountain ranges (including the American Rocky mountains); the climatic disturbances causcd by this mountain building are generally thought to hat-e been of major importance in the emergence of the higher plant groups (angiosperms); and the resultant changes in the flora probably played a prominent role in the extinction of the dinosaurs and the consequent rise nf the mammals. Conditions in marine waters tend to be relatively uniform as compared with those on the continents, but changes in land connections and the development of relatively isolated seas may have played an important part in the origin of many invertebrate groups. The making and breaking of continental connections have without question been of great importance in the evolution of the higher vertebrates. We have, for example, cited ahove the adaptive radiation of marsupials in the Cenozoic in Australia, and the development, although more limited, of carnivorous marsupials in South America at the same time. Both developments were because of isolation of those areas and the consequent absence of competing animals of more advanced type. Regions may be isolated by climatic zones as well as by more obvious geographical barriers.

The great family of bovids, including cattle, sheep, goats and the numerous antelopes, developed in the late Cenozoic of Eurasia. During much of this time Eurasia and North America were connected by a Siberian-Alaskan land bridge, but climatic and environmental factors made a harrier nearly as effective as a sheet of water would have been. Bovids are in the main plains dwellers in warm climates. No true antelopes reached America to survive there; the only successful migrants were a few forms which could live in cold or mountainous terrains—musk ox, bison, mountain sheep, mountain goat.

(*See* DISTRIBUTION OF ANIMALS; EVOLUTION, ORGASIC; ANIMALS, PHYLOGENY OF.)

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PALAEOSPONDYLUS. A small fishlike vertebrate fossil found in the Old Red Sandstone of Caithness, sometimes referred to as the Cyclostomata (*q.v.*) but not improbably a primitive jawed vertebrate.

PALAEOTHERIUM, a genus of primitive perissodactyls of the Upper Eocene and Lower Oligocene of Europe. The genus includes many species, ranging in size from that of a rhinoceros to that of a pig, and is typical of a large group of primitive perissodactyls nearly related to the Eocene ancestors of the horse but currently distinguished as a separate family. They are limited to the later Eocene and early Oligocene of Europe and Asia. The Palaeotheres have three toes on each foot, but the side toes are not so much reduced as in the earlier three-toed horses. The teeth are short-crowned without cement, the upper teeth with a pattern of two outer crescents and two transverse crests which are usually more oblique than in the early Equidae. The premolars are as fully molariform as in the post-Eocene Equidae. The nasals in *Palaeotherium* are somewhat retracted, suggesting the possession of a short proboscis. (W. D. M.; ***S.***)

PALAEOZOIC ERA, the middle of the five major divisions of geologic time, beginning more than 500,000,000 years ago and lasting at least 300,000,000 years. Rocks of the era are principally of sedimentary marine origin and contain the first abundant fossil record. The fossils indicate a predominance of marine invertebrate life throughout the era,; fishes appeared near the middle: and toward the end terrestrial life became prominent, consisting of amphibians. primitive reptiles and insects. The latter half witnessed the rise of land plants and the first forests, giving rise to the world's major coal deposits. The era is subdivided into seven periods: Cambrian. Ordovician. Silurian. Devonian. Mississippian, Pennsylvanian and Permian (*q.v.*); the Mississippian and Pennsylvanian are often called collectively the Carboniferous or great coal age. During the era's closing stages enormous mountain ranges were formed in various parts of the world, including the Appalachians. Hercynian Alps, the high ranges of central Asia and others bordering the Pacific ocean. The earth's most unusual glaciations took place in near-tropical latitudes of the southern hemisphere, notably in Australia, Tasmania, India, Africa, and South America. Those of India were near sea level and within 18° of the equator. At the same time widespread aridity is indicated elsewhere by great salt and gypsum deposits, particularly in western America. These pronounced physical changes extinguished most of the characteristic plant and animal species.

(R. E. JN.)

PALAEPHATUS. the author of a small extant treatise, entitled Περὶ Ἀπίστων ("On Incredible Things"). It consists of a series of rationalizing explanations of Greek legends. without any attempt at arrangement or plan, and is probably an epitome, composed in the Byzantine age of some larger work.

See edition by N. Festa, in *Mythographi graeci* (1902).

PALAESTRA, the name apparently applied by the Greeks to two kinds of places used for athletic exercises. In the one case it seems confined to the places where boys and youths received gymnastic training, in the other to a part of a gymnasium where the *athletae,* the competitors in the public games, were trained in wrestling and boxing. The boys' palaestrae were private institutions and generally bore the name of the manager or founder; thus at Athens there was a palaestra of Taureas (Plato, *Charmides*). The Romans used the terms gymnasium and palaestra indiscriminately for any place where gymnastic exercises were carried on.

PALAFOX DE MENDOZA, JUAN DE (1600–1659), Spanish bishop was born in Aragon. He was appointed in 1639 bishop of Angelopolis (Pueblo de los Angeles) in Mexico, and there sought to protect the natives from Spanish cruelty, forbidding any methods of conversion other than persuasion. In this he met with the uncompromising hostility of the Jesuits, whom in 1647 he laid under an interdict. In 1653 the Jesuits secured his translation to the little see of Osma in Old Castile.

PALAFOX Y MELZI, JOSE DE (1780–1847), duke of Saragosss. Brought up at the Spanish court. he accompanied Ferdinand to Bayonne in 1808 as a sublieutenant. Aiter a vain attempt to secure the king's escape. he fled to Spain. Proclaimed by the populace governor of Saragossa and captain general of Aragon (May 25. 1808), he declared war against the French, who had already overrun Catalonia and Navarre. He defended Saragossa for a period of 61 days. Palafox then attempted a campaign in the open country. Forced back by Napoleon's army into Saragossa. he sustained a second siege lasting three months. Palafox himself mas captured and imprisoned at Vincennes until Dec. 1813. From 1820–23 he commanded the royal guard of King Ferdinand. He took the side of the constitution in the civil troubles and was stripped of his honours and offices by the king. Queen Maria Cristina created him duke of Saragossa and from 1836 he took part in military and political affairs as captain general of Xragon and a senator. He died in Madrid, Feb. 1j. 1847.

See P. de Madrago's biographical notice in the Span. trans. of Thiers, *Hist.* des *consulates de l'empire;* C. W. C. Oman, *Peninsular War* (Oxford, 1902), vol. i; J. Ibáñez Marín, *El defensor* de *Zaragoza* in *Ateneo,* vol. v, pp. 81–89 (1908).

PALAMAS, GREGORIUS (*c.* 1296–1359), Greek mystic and chief apologist of the Hesychasts *(see* HESYCHASM), belonged to a distinguished Anatolian family, and his father held an important position at Constantinople. Palamas at an early age retired to Mt. Athos. where he became acquainted with mystical theories of the Hesychasts. In 1326 he went to Skētē near Beroea, where he spent some years in isolation in a cell specially built for him. His health having broken down. he returned to Mt. Athos. but, finding little relief, removed to Thessalonica. About this time Barlaam. the Calabrian monk, began his attacks upon the monks of Athos. Palamas championed their cause in two synods (1341 and 1351) at Constantinople, which definitively secured the victory of the Palamites. During the civil war between John Cantacuzene and the Palaeologi, Palamas was imprisoned. After Cantacuzene's victory in 1347. Palamas was released and appointed archbishop of Thessalonica; being refused admittance by the inhabitants, he retired to the island of Lemnos, but subsequently obtained his see.

See the historical works of John Cantacuzene and Nicephorus Gregoras, the *Vita Palamae* by Philotheus, and the encomium by Nilus (both patriarchs of Constantinople); also C. Krumbacher, *Geschichte der byzantinischen Litteratur* (1897).

PALAMAS, KOSTES (1859–1943), Greek poet, played an important part in the evolution of modern Greek literature. Born at Patras in the Peloponnese on Jan. 13 (old style; Jan. 26, new style), 1859, he was educated at Mesolonghi and at Athens. He was the central figure in the demotic movement of the 1880s which sought to shake off traditionalism and draw inspiration for a new literary and artistic style from the life and language of the people. and became the founder of the "new school of Athens" which condemned romantic exuberance and reverted to a purer and more restrained type of poetry. In 1886 Palamas published his first collection of poems, the *Tragoudia tes Patridos mou* ("Songs of My Country"), followed by the *Iamboi kai Anapaestoi* ("Iambs and Anapaests"; 1897), the *dsalefte Zoe* (1904; Eng. trans. by A. E. Phoutrides, *Life Immovable,* 1904), the *Dodckalogos tou Gyftou* ("The Twelve Lays of the Gipsy"; 1907) and the *Flogera tou Basilia* ("The King's Flute"; 1910). Palamas was the first poet to express the national sufferings and aspirations of the Greeks. and with his lyricism, metrical variety and robust language he remolded a great deal of Greek history, mythology and philosophy, fusing it with many western European and even eastern ideas. His play, the *Trisevgene* ("The Thrice Noble"; 1903) has lyric rather than dramatic merits. He also wrote short stories and his criticism raised the standard of modern Greek literary criticism. He died at Athens on Feb. 27. 1943.

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(CE. A. T.)

PALAMAU, a district in the Chota Nagpur division of Bihar state. India. Pop. (1961) 1,187,914. Area 4.031 sq.mi. It consists of the lower spurs of the Chota Nagpur plateau, sloping north to the valley of the Sone. About 2,000 sq.mi. are cultivated: the remainder is jungle. Rich deposits of coal. bauxite. limestone and iron are being worked and large stocks of bamboo are used in the manufacture of paper. There is a portland cement industry at Japla. The administrative headquarters are at Daltonganj (pop [1951] 1) . Palamau was under the rule of the Chero chiefs till their conquest by the Moguls in 1660. They had their capital at the village of Palamau, where the ruins of two great forts built by them may be seen.

PALAMCOTTAH, a town in the Tirunelveli district of Madras state. India. on the opposite bank of the Tambraparni river from Tinnevelly town, with which it shares a station on the Southern railway. 444 mi. S. of Madras. Pop. (1951) 40,010. It is the administrative headquarters of the district.

PALAMEDES, in Greek legend, son of Nauplius, king of Euboea, one of the heroes of the Trojan War, belonging to the post-Homeric cycle of legends. During the siege of Troy Agamemnon, Diomedes and Odysseus (who had been detected by Palamedes in an attempt to escape going to Troy by shamming madness) caused a letter containing money arid purporting to come from Priam to be concealed in his tent. They then accused Palamedes of treasonable correspondence with the enemy, and he was ordered to be stoned to death. His father exacted vengeance from the Greeks on their way home, by placing false lights on the promontory of Caphareus. The story of Palamedes was first handled in the *Cypria,* afterward by the tragedians. Palamedes was regarded as the inventor of some letters of the alphabet. lighthouses. weights and measures. several games, etc.

PALATE, the roof of the mouth in man and vertebrate animals. It consists of the anterior bony "hard palate" *(see* MOUTH) and the posterior fleshy "soft palate" (*see* THROAT). It is the partition between the mouth and nasal passages and the nasal pharynx. The name is popularly applied to the uvula or teatlike process of the soft palate. For the malformation consisting of a longitudinal fissure in the roof of the mouth, cleft palate, *see* SPEECH DISORDERS.

PALATINATE (Ger. PFALZ), originally the name given to the imperial castles where the emperor stayed on his journeys through Germany. The name is derived from the Latin *palatium,* "palace." The chief official of these castles. who also played an important part in the emperor's court of justice held there. was called the count palatine.

In later times the most important of these counts palatine was the count palatine of the Rhine, mentioned first in the 11th century. He held lands on both sides of the river and his seat was originally at Aachen and later at Heidelberg. In 1214 his lands passed to the house of Wittelsbach. Later a dispute arose between the Bavarian and the Palatinate branches over the exercise of the electoral vote but in 1356 the Golden Bull (*q.v.*) secured the privilege to the count palatine of the Rhine. The first electoral prince. Rupert I, founded the university of Heidelberg. In 1410, on the death of Rupert III, the Palatinate was divided among his four sons into: the Electoral Palatinate. the Upper Palatinate, Zweibrücken-Simmern and Mosbach. The Upper Palatinate line died out in 1448 and its possessions were divided between the Electoral Palatinate and Zweibrücken-Simmern. In 1499 the Mosbach lands also fell to the former. In 1559 Frederick of Simmern succeeded to the electoral lands and title.

When in 1619 Frederick V accepted the Bohemian crown (*see* THIRTY YEARS' WAR) he loosed a train of events which led first to his own disastrous defeat and subsequently, in 1623, to the conferment of his lands on Maximilian of Bavaria. At the peace of Westphalia Charles Louis, Frederick's son. recovered some of his possessions but the Upper Palatinate and the original title of elector palatine remained with Bavaria; a new electorate was created for Charles Louis.

In 168 j the Simmern line died out, thus giving Louis XIV of France the pretext to claim the country through his sister-in-law Liselotte of the Palatinate. During the war of succession which followed. and which was merged in the War of the Grand Alliance

(*q.v.*), the Palatinate was devastated by the French. Louis withdrew his claims under the treaty of Ryswick.

In the Palatinate the Simmern line was succeeded in turn by those of Zweibrücken-Neuburg and (1742) Sulzbach. In 1777 the elector Charles Theodore became elector of Bavaria, thus uniting the two countries.

In 1801 Napoleon took the part of the Palatinate left of the Rhine for France and divided the rest between Baden and Hesse-Darmstadt. In 1815 some of the lands left of the Rhine returned to Bavaria and the rest were divided between Hesse-Darmstadt and Baden, the latter's acquisitions including Mannheim and Heidelberg. The new Bavarian administrative division marched by no means, therefore, with the old Palatinate; indeed, but for Zweibriicken, all the old centres of government were outside it.

After both World Wars I and II the Palatinate was occupied by the French. In 1919 the ,most westerly part of the area became part of the Saar. In 1946 the Palatinate was formed into the *Land* Rhineland-Palatinate together with Rhine-Hesse and parts of the Prussian province Rhineland and of Hesse-Nassau. An attempt was made in 1956 to secure the return of the Palatinate to Bavaria, or alternatively to unite it with Baden-Württemberg, but the vote failed. *See* also Index references under "Palatinate" in the Index volume. (M. KL.)

PALATINE. In the late Roman empire certain officials attending the emperor or discharging duties at his court were called *palatini.* From the time of Constantine the Great the term was applied to the soldiers stationed in or around the capital to distinguish them from those stationed on the frontier of the empire. In the Eastern Roman empire the word was used to designate the administrators of finance and the imperial lands.

This use of the word palatine was adopted by the Frankish kings of the Merovingian dynasty. They employed a high official, the *comes palatinus,* who at first assisted the king in his judicial duties; later he discharged many of these himself. Other counts palatine were employed on military and administrative work and the system was maintained by the Carolingian sovereigns. The word paladin, used to describe the followers of Charlemagne, is a variant of palatine. Instead of remaining near the person of the king, some of the counts palatine were sent to various parts of his empire as judges and governors. Being in a special sense the representatives of the sovereign they were entrusted with more extended power than the ordinary counts. From this usage there naturally arose the employment of the word to denote the districts over which these powers were exercised. By Henry the Fowler, and Otto the Great, counts palatine were sent into all parts of the country to support the royal authority by checking the independent tendencies of the great tribal dukes. We hear of count palatine in Saxony, Lorraine, Bavaria and Swabia, their duties being to administer the royal estates in these duchies. The count palatine in Bavaria became duke of this land, the lower title being then merged in the higher one; with one other exception the German counts palatine soon became insignificant, although, the office having become hereditary, *Pfalzgrafen* were in existence until the dissolution of the Holy Roman empire in 1806. The exception was the count palatine of the Rhine *(see* PALATINATE) who became one of the four lay electors and the most important lay official of the empire. In the empire the term was also used to designate the officials who assisted the emperor to exercise the rights which were reserved for his personal consideration; they were called *comites palatini caesarii* or *comites sacri palatii;* in German, *Hofpfalzgrafen.*

In England the epithet palatine was somewhat artificially applied to counties which stood outside the ordinary course of administration *(see* CHESHIRE; DGRHAM; LANCASHIRE). In the history of Hungary *palatinus* and its derivatives are used in Latin and in other western languages as the translation of *ncidor,* the great dignitary whose office was instituted by St. Stephen. At first the head of the judicial system, the *ncidor* became the most important person in the realm after the king. Cnder the later Habsburg rulers of Hungary the office was held several times by a member of the royal family: the office was abolished after the revolution of 1848. In Polish history *palatinus,* etc., are used to translate *wojewoda* or voivode (*q.v.*).

In America certain districts colonized by English settlers were treated as palatine provinces. In 1632 Cecil Calvert, 2nd Lord Baltimore, received a charter from Charles I giving him palatine rights in Maryland. In 1639 Sir Ferdinando Gorges, the lord of Maine, obtained one granting him as large and ample prerogatives as were enjoyed by the bishop of Durham. Carolina was another instance of a palatine province.

See R. Schroder and E. von Kiinssberg, *Lehrbuch der deutschen Rechtsgeschichte,* 7th ed. (1932).

PALAUNG (also PALE), Burmese terms for various hill people of the Burmese Shan states otherwise known as Katurr, Kunloi, Kwanhai, Manloi, Rumai, Tawngma, Ta-ang, etc. They number about 150,000 and speak various dialects of a common Mon-Khmer language quite distinct from the Thai speech of the Shans with whom they live closely intermingled. Their main centre is Tawngpeng, which is in form a Shan state although the bulk of the population, including the ruling family, is Palaung. This area has a long history as a centre of tea production. Some Palaung groups are organized in patrilineal lineages similar to those of their Kachin neighbours to the north; elsewhere their organization is more like that of the Shans. *(See* SHAN.)

Shan-type Buddhism coexists with various local cults based on ancestor worship. The Palaung language resembles that of the head-hunting Wa farther east but there is otherwise no close cultural connection between the two groups.

See A. A. Cameron, *A Note on the Palaungs of the Kodaung Hill Tracts of the Momeik State* (1912) ; L. Milne, *The Home of an Eastern Clan* (1924). (E. R. L.)

PALAWAN, most southwestern and most remote province and island, Republic of the Philippines, is one of the frontier areas of the country. Pop. (1958 est.): province 130,190; island 66,755. The province (5,693 sq.mi.) comprises the main island, fifth largest in the country (4,550 sq.mi.), and about 1,700 smaller islands and islets, of which the principal groups are the Calamian Islands (*q.v.*) to the north between Palawan and Mindoro, the Dumaran-Cuyo group off the northeastern coast and the Balabac-Bugsuk group off the southern coast. Culion Island (*q.v.*) is a leper colony. A mountain chain runs the entire length of the 270-mi. main island and divides the area into western and eastern Palawan. Mt. Mantalingajan (6,839 ft.) is the highest peak.

The narrow, discontinuous coastal plain extends from 1 to 6 mi. inland. It is best developed in the vicinity of Puerto Princesa, the capital and principal port. Pop. (1948) 15,177. This plain, which has the only all-weather road, is the principal agricultural area and the site of the Iwahig penal colony. The animal life and vegetation on Palawan bears a striking resemblance to that of Borneo, more so than to that of other islands of the Philippines—a result of the land bridge that connected these two islands in recent geological times. Most of Palawan is forest, the home area of primitive tribes of Batacs, Palawanes and Tagbanuas. The kaingin (shifting) system of agriculture is widely practised where rice, corn, beans and sweet potatoes are grown. Christian migrants (Visayans, Tagalogs, Ilocanos and Bicolanos) are settling on the north and east coast and pushing into the interior. There are some Moro settlements in the south. Scattered settlement predominates. Everywhere rice is the principal crop. Much of the mineral development is recent. A mercury mine was opened near Puerto Princesa in 1955; manganese has been mined on Busuanga and there is also guano in the Calamian group. Chromite has been discovered northwest of Puerto Princesa. Minerals, lumber and fish are the principal exports. (AN. C.)

PALAZZOLO ACREIDE, a town of Sicily, It., province of Syracuse, 34 mi. by rail W. of city of Syracuse, 2,285 ft. above sea level. Pop. (1951) 12,078. The ancient city of *Acrae,* founded by Syracuse in 664 B.c., lay on the hill above the modern town, the approach to it being defended by quarries, in which tombs of all periods were discovered. The auditorium of the small theatre is well preserved. Close to it are ruins of other buildings, a small Odeon and some baths.

PALE, a historical term, is a district marked off from the surrounding country by a different system of government and

law or by definite boundaries. The best known district was the English pale in Ireland, dating from the reign of Henry II, although the word "pale" was not used in this connection until the late 14th century. The pale varied considerably according to the strength or weakness of the English authorities and in the time of Henry VIII was bounded by a line drawn from Dundalk to Kells. thence to Naas, and from Kaas east to Dalkey, embracing part of the modern counties of .Dublin, Louth, Meath and Kildare. The pale existed until the complete subjugation of Ireland under Elizabeth; the use of the word is frequent in Tudor times.

There was an English pale or Calais pale in France until 1558, extending from Gravelines to Wissant, and for a time under the Tudors an English pale in Scotland.

PALEARIO, AONIO (also ANTONIO DELLA PAGLIA or DEGLI PAGLIARICCI; AONIUS PALEARIUS) (*c.* 1500–1570). Italian humanist and reformer, was born at Veroli in the Roman Campagna. In 1520 he went to Rome and he entered the brilliant literary circle of Leo X. When Charles of Bourbon stormed Rome in 1527 Paleario went first to Perugia and then to Siena, where he settled as a teacher. In 1536 his didactic poem in Latin hexameters, *De immortalitate animarum,* was published at Lyons.

In 1542 a tract by Paleario, commonly known as *Libellus* de *morte Christi,* was made by the Inquisition the basis of a charge of heresy, from which, however, he successfully defended himself. In Siena he wrote his *Actio in pontifices romanos et eorum asseclas* (posthumously published in 1606), attacking the substitution of traditional for scriptural authority, and certain doctrines, especially that of purgatory. Professor first at Lucca and then at Milan, he was denounced by the inquisitor of Milan in 1567, sent to Rome for trial, condemned in Oct. 1569 and executed in July 1570.

An edition of his works, including four books of *Epistolae* and 12 *Orationes* besides the *De immortalitate,* was published at Lyons in 1552; others followed, the fullest being that of Amsterdam in 1696.

See lives by J. G. Gurlitt, in German (1805); A. Young, 2 vol. (1860); J. Bonnett (1862, Eng. trans., 1864). See also G. Morpurgo, *Un Umanista martire: Aonio Paleario* (1912).

PALEMBANG, a residency of southeast Sumatra, Indonesia, facing the island of Banka. Area 33.342 sq.mi.; pop. (1930) 1,098,725. It extends from the mountains which flank the west coast of Sumatra and form the dividing line between it and the residency of Bencoolen, to the Straits of Banka, and except for the mountainous country in the extreme southwest, is very flat and intersected by numerous rivers, which flow eastward to the sea, and with their many and wide mouths form marshlands about the coast, nhich also has many sandbanks.

The principal of these is the Musi, which has many important tributaries, and on its banks, some 50 mi. from the sea, near which it divides into two main channels, is situated Palembang, a port and the chief commercial town in south Sumatra, population (1957 est.) 321.248, the largest town in Sumatra. It stretches along both sides of the river, its inhabitants and those of the residency, are mostly Malays. The depth and width of the Musi river renders Palembang accessible to large ocean steamers, but they are able to cross the bar at its mouth only at flood tide. The port has wharves on screw piles 250 m. long and is the terminus of the main line of the railway system of south Sumatra.

At Plaju, down the river from Palembang, is a petroleum centre, the oil, raised at Muara Enim, near the hills in the southwest, being carried to Plaju and refined there. Downstream across a tributary, lies Sungehgerong, another refinery centre.

Palembang developed a considerable trade with eastern ports in the Malay peninsula, Thailand and China and there is also important traffic by road and river with the hinterland and regular communication with other ports in Sumatra and Java. Petroleum products constitute much of the value of the exports.

Other exports'are rubber, coffee and coal from the collieries at Tandjong, not far from Muara Enim. Rice is the chief food crop.

The southern part of Palembang residency was in course of development at the time of the Japanese invasion in 1942; in the northern half little had been done and communications were primitive. Apart from Surulangun in the northwest, Talang Betutu (airfield), north of Palembang and Sekaju, on the Musi in central Palembang, each of which has a *controleur,* the nature of the lands about the coast makes extensive settlement impossible

Palembang is one of the places in Indonesia where Islam made its first appearance. Arab colonies in certain Chinese ports, disturbed by Chinese civil war, diverted their commerce to the Dutch East Indies and Palembang was one of the spots selected for the enterprise.

Little, however, is heard about Palembang in history until in 1812 the sultan, although he had recognized British suzerainty (the British occupation of the Dutch East Indies), massacred many Dutch settlers. Thereupon a British force under Colonel Gillespie was landed which drove the sultan from the capital and installed his brother in his stead. Banka and Billiton were ceded to Great Britain and it was during the absence of this force in Sumatra that the Sultan of Jokjakarta endeavoured to destroy European power in Java.

The cession of Banka and Billiton to the Dutch, in return for Cochin in India, because of a dispute as to whether Billiton was included in the cession, brought Palembang very prominently before Dutch notice, the more so as Sir Stamford Raffles encouraged the sultan in his attitude of independence, and in 1325 they abolished the Palembang sultanate and brought the country under their own rule, while recognizing certain chiefs.

The residency was invaded by Japanese troops in Feb. 1942, after most of the petroleum installations had been destroyed. After World War II it became part of the Republic of Indonesia.

(E.E.L.; J.O. M. B.; X.)

PALENCIA, an inland province of Spain, one of the eight into which Old Castile was divided in 1833; bounded on the N. by Santander, E. by Burgos. S. by Valladolid and W. by Valladolid and León. Pop. (1950) 236,008; area 3,096 sq.mi.

The principal rivers are the Pisuerga and the Carrion, which unite at Dueñas and flow into the Duero at Valladolid. The north is traversed by the Cantabrian mountains. the highest summit being the culminating point of the Sierra del Brezo (6,644 ft.). The remainder of Palencia, the "Tierra de Campos," belongs to the great Castilian tableland. In the south is a marsh or lake, known as La Laguna de la Nava. The mountainous district abounds in minerals, but only coal and small quantities of copper are worked. The province is crossed in the southeast by the trunk railway connecting Madrid with France via Irun, while the line to Santander traverses it throughout from north to south; there are also railways from the city of Palencia to León, and across the north from Mataporquera in Santander to La Robla in León. A branch of the Santander line gives access to the Orbo coal-fields. The Canal de Castilla, begun in 1753, and completed in 1832, connects Alar del Rey with Valladolid. Wheat and other cereals, vegetables, hemp and flax are extensively grown, and there are manufactures of linen and woolen stuffs. oil, porcelain, leather, paper and rugs.

The chief tonn is Palencia (*q.v.*). Nationalist armies conquered the province early in the civil mar of 1936–39.

PALENCIA, an episcopal city, the capital of the Spanish province of Palencia; on the left bank of the river Carrion, on the Canal de Castilla, at the junction of railways from León and Santander, and 7 mi. N. by W. of Venta de Baños on the Madrid-Irun line. Pop. (1950) 41,122 (mun.). Palencia is built in the midst of the level plains called the Tierra de Campos, 2,690 ft. above sea level. Palencia, the Pallantia of Strabo and Ptolemy, was the chief town of the Vaccaei. Its history during the Gothic and Moorish periods is obscure, but it was a Castilian town of some importance in the 12th and 13th centuries. The university founded there in 1208 by Alphonso IX was removed in 1239 to Salamanca. The cathedral nas begun in 1321, finished in 1504 and dedicated to St. Antolin; it is a large building in the later and florid Gothic style of Spain. The site was previously occupied by a church erected by Sancho III of Navarre and Castile (1026–

35) over the cave of St. Antolin, which is still shown. The cathedral contains El Greco's San Sebastian and other valuable paintings, old Flemish tapestry, and beautiful carved woodwork and stonework. The hospital of San Lazaro is said to date in part from the time of the Cid (*q.v.*), who here married Ximena in 1074. Manufactures are iron, rugs, alcohol, leather, soap, porcelain, linen, cotton, wool, machinery and matches.

PALENQUE, the modern name of a deserted city in Mexico, in the narrow valley of the Otolum. in the north part of the State of Chiapas, 80 mi. S. of the Gulf port of Carmen. About 30 mi. away, on the left bank of the Usumacinta river, stand the ruins of Men-ché or Lorillard city. The original name of Palenque has been lost, and its present name is taken from the neighbouring village, Santo Domingo del Palenque. Unlike the dead cities of the Yucatán plains, Palenque is surrounded by wooded hills and overgrown by tropical vegetation.

There is less stone carving on the exterior walls, door jambs and pillars of the buildings than on those of the Yucatán peninsula; this is due to the harder and more uneven character of the limestone. Probably owing to the same cause, there is less cut stone in the walls, the Palenque builders using plaster to obtain smooth surfaces. There is, however, considerable carving on the interior walls, the best specimens being on tablets, affixed to the walls with plaster. Modelling in stucco was extensively used. A few terra-cotta images have been found.

The so-called Great Palace consists of a group of detached buildings. apparently ten in number, standing on two platforms of different elevations. Some of the interior structures and the detachcd one on the lower southern terrace are in a fair state of preservation. The plan of construction shows three parallel walls enclosing two corridors covered with the peculiar pointed arches or vaults characteristic of Palenque. A square tower rises from a central part of the platform to a height of about 40 ft., divided into a solid masonry base and three storeys connected by interior stairways. The Temple of Inscriptions, one of the largest and best preserved. is distinguished chiefly for its tablets. which contain only hieroglyphics. Sculptured slabs form balustrades to the steps leading up to the temple, and its exterior is ornamented with figures in stucco, the outer faces of the four pillars in front having life-size figures of women with children in their arms. The small Temple of Beau Relief stands on a narrow ledge of rock against the steep slope of the mountain. Its most important feature is a large stucco bas-relief: occupying a central position on the back wall of the sanctuary. It consists of a single figure, seated on a throne, beautifully modelled in form, and in drapery and ornaments, with the face turned to one side and the arms outstretched. The temples on the east side of the Otolum are distinguished by tall narrow vaults, perforated by numerous square openings giving the appearance of coarse lattice work. The Temple of the Sun stands upon a comparatively low pyramidal foundation. The interior consists of the usual pair of vaulted corridors. The sacred tablet on the back wall of the sanctuary is carved in low relief in limestone, and consists of two figures, apparently a priest and his assistant making offerings. There are rows of hieroglyphics on the sides and over the central design. The Temple of the Cross is a larger structure of similar design and construction. The tablet belonging to this temple has excited controversy, because the design contains a representation of a Latin cross. The Temple of the Cerro, called that of the Cross No. 2, because its tablet is very similar to that just mentioned, stands back against the slope of the mountain, and is in great part a ruin. The ruins of Palenque have been partially investigated by a number of explorers, notably by Stephens, Charnay, Maudslay, Holmes and Blom.

PALÉOLOGUE, MAURICE GEORGES (1859–1944), French diplomat and writer was horn in Paris on Jan 13 1859 He entered the diplomatic service at an early age and went successively to Tangier Kome Germany the east, Korea and Bulgaria He became in 1909 deputy-director and in 1911 director of affairs in the foreign office Shortly before the outbreak of World War I he was appointed ambassador to St I'etersburg (Leningrad) and retained this post until the Bolshevist revolution in 1917. He consolidated the Franco-Russian alliance. and helped to ensure effective military action on the part of Russia. In 1920 he was secretary-general of the ministry of foreign affairs. Paléologue published in 1921–22, under the title of *La Russie des Tsars pendant la grande guerre* (Eng. trans.. 1923–25), records of his diplomatic experiences in St. Petersburg. Among his other publications are literary criticisms on Vauvenargues and Alfred de Vigny (1890) and several novels. He was admitted to the French Academy in 1928. Paléologue died in Nov. 1944.

His works include: *Le Roman Tragique de l'Empereur Alexandre II* (1923, Eng. trans. 1926); *Talleyrand, Metternich, Chateaubriand* (1924, Eng. trans. 1926); *Cavour* (1926); and *Alexandre* I, *un Tsar Enigmatique* (1937, Eng. trans. 1938).

PALERMO (Greek. *Panormos;* Latin, Panhormus, Panormus), a city and port of Sicily and the capital of the autonomous region of Sicily in the Italian republic, and the seat of an archbishop, lies on the northwestern coast at the head of the bay of Palermo, facing east. Pop. (1957 est.) 570,568 (commune). Behind the town is a fertile plain, known as the Conca d'oro, almost entirely devoted to the cultivation of oranges and lemons, and beyond the plain is an amphitheatre of mountains. The Conca d'oro is watered by springs and wells, by the Oreto river and by the artificial lake of Piana degli Albanesi. At the southeastern end of the bay is the promontory of Zafferano, on which are the remains of ancient Soluntum; at the opposite end is Monte Pellegrino ($8\frac{1}{2}$ mi. N. from Palermo) and farther north is the bathing beach of Mondello. Monte Pellegrino (1.988 ft.) has been sacred from the time when the remains of Sta. Rosalia, the mystical 12th-century patroness of the city, were found in a grotto, which then became a shrine.

Palermo's earliest buildings mere on a tongue of land between two inlets of the sea. and the first city was bordered by the present Via Vittorio Emanuele (called the Cassaro) and by the sea. At the time of Polybius the town had expanded north and south as far as two streams. later drained. and during the Saracen period it was called Khalesa, a name that survives as Kalsa. When the former streams were built over, a great part of the old port was encroached upon and all that remains of the latter is a small creek called the Cala. The Marina, or esplanade, runs beside the bay to the west of the Cala. between the shore and the 17th-century Villa Giulia, said to be the oldest public gardens in Europe. The new port is at the foot of Monte Pellegrino and has two main entrances and additional quays. It can take ships of large tonnage.

The earliest civil buildings date from the time of the Norman kings whose palaces and churches were erected in the Saracenic and Byzantine styles, from the mixture of which a unique style later developed. A rich example of this mixed Arabic-Norman style is the cathedral, built in the 12th century by Archbishop Walter of the Mill, an Englishman sent by Henry II of England as tutor to William II of Sicily. It was erected on the site of a 9th-century. or earlier, basilica which became a mosque after the Saracen conquest and was consecrated in 1185, first according to the Greek rite and then according to the Latin. It was badly disfigured by Ferdinando Fuga in 1781–1801, when a dome was added. It contains the tombs of the emperor Frederick II and of his parents—massive sarcophagi of red porphyry with marble canopies.

By far the best example of the Arabic-Norman style of architecture is the Cappella Palatina not iar from the cathedral in the Palazzo Reale at the west end of the city. Built by King Roger II. the Cappella (1132–40) is covered in wonderful mosaics while the roof, in Arabic style. is of inlaid and painted wood. The lower parts of the walls and the floor are set with marble. The Hall of King Roger. now the Sicilian parliament house, is decorated with mosaics of the same period showing hunting scenes. Also in the same style are the kings' country palaces encircling the city: La Favara, Mimnermum. La Zisa and La Cuba, originating from the times of Roger, William the Bad and William the Good.

Churches built in the more typically Byzantine style include two in the Piazza Bellini—the little church of San Cataldo and the adjacent one of La Martorana (1143), which is rich with mosaics. among them the portraits of King Roger and the founder. Both these churches, and that of San Giovanni degli Eremiti, have

BY COURTESY OF ITALIAN STATE TOURIST OFFICE (ENIT)

VIEW OF PALERMO FROM THE BAY. IN THE FOREGROUND IS THE OLD PORT

small red cupolas. In the 12th century, the Cistercians introduced a type of church which, without any great change in style, achieved a noticeably different effect. especially by means of the high choir which took the place of the cupola. The church of Santo Spirito, where the Sicilian Vespers (see VESPERS, SICILIAN) rising started, is an example of this style. Buildings of the 12th and 15th centuries include the Steri or Palazzo Chiaramonti, the Palazzi Sclafani. Abatelli and Xjutamicristo and the churches of Santa Maria della Catena and Santa Maria la Nuova.

In the 16th century new streets were opened, richly decorated palazzi (palaces) 'were built and a general transformation of the city took place. The only two remaining city gates, the Porta Nuova and the Porta Felice. were built at this time in the baroque style which developed charming variations that can be seen in many churches. There was a tendency toward ostentation which in the 17th century increased under Spanish influence. In the latter century a remarkable enlargement was made of the crossing of the main streets. the Via Maqueda and the Corso Vittorio Emanuele, and there the Quattro Canti or Piazza Villena was laid out. Facing this square are majestic buildings decorated with statues, bas-reliefs and other sculptures.

Around the beginning of the 20th century the most important theatres were built. the Massimo and the Politeama Garibaldi, and the town began to spread along the Via della Libertà, a triple carriageway. Palermo's national museum is the richest in the island, possessing prehistoric and architectural objects from Selinus, Greek vases and terra cottas, the famous bronze ram of Syracuse, Etruscan sarcophagi and pottery, mosaics, medieval and Renaissance sculptures and Sicilian majolica. The city's art gallery is housed in the Palazzo Abatelli in the Via dello Alloro, and the municipal gallery of modern art is in part of the Politeama Garibaldi. Other scientific and cultural institutions include the ethnographical museum at the Favorita castle at the foot of Monte Pellegrino, the national library; and the municipal library which is especially rich in incunabula and valuable manuscripts. The university was founded in the second half of the 18th century.

Industries and Communications.— Large shipyards provide the major industry of Palermo while other industries and commercial enterprises have been reconstructed after their destruction during World War II. The chief exports of the city are citrus and other fruits, preserved foods. furniture. glass and textiles: the main imports are grain, meat, coal. paper for printing. machinery, metals, chemical and pharmaceutical products and fertilizers.

Palermo is connected to the mainland by a daily steamship service to Naples and by train and air services. There is a small landing ground for aircraft at Boccadifalco, and in the late 1950s a new international airport was being built at Puntn Raisi.

(M. TI.)

PALES, an Italian god and goddess of flocks and shepherds. The festival called Parilia (less correctly Palilia) was celebrated in their honour on April 21. In this festival the Pales were invoked; the stalls were cleansed and purified with magico-religious substances and the herdsmen leaped three times across bonfires of hay and straw.

It is described in Ovid's Fasti. The Parilia came to be regarded as the birthday celebration of Rome.

PALESTINE, a territory formerly administered by the British government under a mandate from the League of Nations which came officially into operation in 1923 and was relinquished in May 1948 (see ISRAEL). It was bounded on the north by the republics of Syria and Lebanon, on the west by the Mediterranean and on the south by the Sinai district of Egypt and the Hejaz territory of Saudi .Arabia. On the east is the state of Jordan, which is separated from Palestine roughly by the Jordan valley and the Dead sea. but was included in the British mandate. Palestine was roughly 240 mi. long. and about 23 mi. wide in the north and about 80 mi. in the south. Its area (excluding Transjordan) was 10,429 sq.mi.

PHYSIOGRAPHY

Geology.— Palestine formed part of the buckled and foundered western edge of the ancient plateau of Arabia. The most characteristic features of the area are extensive fracture lines running generally north-south; downthrow between two such parallel faults has produced a trough which can be traced from the now extinct Lake Hule on the Lebano-Syrian frontier to the Gulf of Aqaba in

the south. Much of the trough is occupied by the Jordan river system, and its floor is very uneven. Lake Tiberias (Sea of Galilee) stands 696 ft. below sea level and its deepest part 157 ft. lower still; the shore of the Dead sea is 1,286 ft. below sea level and its greatest depth is 1,309 ft. Westward of the rift, the rocks are folded into a single great arch about 3,000 ft. in average height, which forms the plateaus of Judaea and Galilee. On its western side. the plateau slopes fairly gradually down to a low, undulating coastal plain of varying width. A minor feature of the western flank, but important as a highly productive area, is the Shephelah, a shallow depression formed by subsidence along yet another north-south trending fault.

There are also several minor fractures trending from northwest to southeast. Foundering along an irregular line of faults produced the plain of Jezreel (Esdraelon), which links the coast and the Jordan region. As a route from early times the plain has played an important part in the history of the country, both as a highway of commerce and as a highway of war. Other secondary fracture lines may be traced south of Jezreel in the courses of those streams that flow, mostly in the rainy season, from the plateau's edge to the sea. East of Jordan, Arnon, Jabbok and Yarmuk are the main rivers. They tend to follow an east-to-west course, falling into Jordan.

The much-fractured plateau of rocks of pre-Carboniferous and possibly Archaean age is generally concealed by later deposits, except along the eastern margin of the Wadi el-Araba at the foot of the plateau of Edom. Similar rocks attain a greater extension toward the south, forming nearly the whole of Sinai and the hills of the east side of the Gulf of Aqaba. Because of the extensive faulting in the neighbourhood of Jordan, the western (downthrow) side (forming Palestine) is made up of the newer beds (Upper Cretaceous and later), while east of Jordan the older rocks, sometimes down to the Archaean floor, are exposed at the foot of the plateau. The Upper Cretaceous, represented by limestones with bands of chert, covers by far the greater part of the country, capping the plateau lands of Moab and Edom and forming most of the high land between the Jordan and the Mediterranean. It is overlaid toward the west by cherty limestones, which contain nummulites and belong to the Eocene and are followed near the coast by the calcareous sandstones of Philistia of the same date.

Tertiary basic lavas cover large areas immediately east of Galilee. These rocks are able to retain the rain and, when decomposed, form excellent soils for cereal growing. They have been grain lands from early times. Small patches of volcanic material occur in Moab and also west of Jordan, especially near the Sea of Galilee.

The drainage system on the plateau is peculiar. The long and gradually rising western slope carries the main streams which eat back deep channels in the limestone before falling on the western plain. The eastern limit of the plateau falls precipitously into Jordan and is cut deeply by periodic torrents rushing down its slope. So sharp is this eastern edge that Bethlehem, only 14 mi. from the Dead sea, stands 3,842 ft. above its edge and 5,150 ft. above its deepest point.

Natural Regions and Features.—Palestine cannot easily be divided into geographical regions; plain. mountain and valley are closely mingled. It is convenient, however, to describe its main features under three general headings: (1) the maritime plain including the plain of Jezreel, (2) the mountain region and (3) the Jordan valley and the Dead sea depression.

The Maritime *Plain.*—With a few interruptions this fertile strip of land extends along the Mediterranean coast from Lebanon to Egypt. It is formed of raised beaches and sea beds, ranging from the Pliocene period downward, and resting on Upper Eocene sandstone. It varies greatly in width and at Haifa opens into the extensive plain of Jezreel (Merj Ibn Amir) which intersects the whole country. In winter this plain is swampy and in places almost impassable, though the fertility of the region is proverbial. Megiddo guards the entrance to the south and on the southwest it is bounded by the range of hills that terminates in the spur of Carmel. The western part is drained by the Kishon (Nahr el-Muqatta).

South of Haifa, as the promontory of Carmel effaces the plain, the passage along the coast is barely 200 yd. in width, but from Athlit it expands steadily to the plain of Sharon. The maritime plain is crossed by numerous rivers, most of which dry up in summer but are raging torrents in winter. Sand dunes occur along the coast, and when these block the mouths of the rivers marshes and swamps are formed. South of the plain of Sharon there is an increasing amount of sand and consequently the land becomes less and less fertile until it merges into the district called the Negev, a wide, arid, steppe region joined south and east with the deserts of Sinai and northern Arabia.

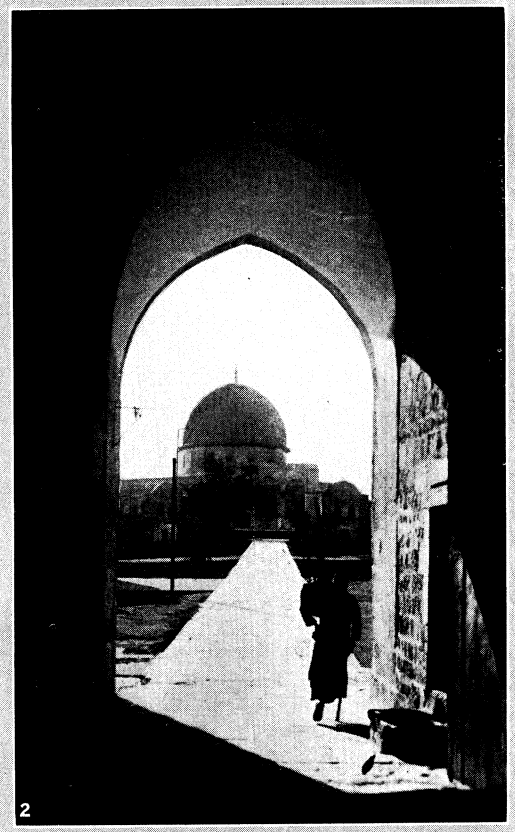
The Mountain Region.—The plain of Jezreel divides the mountain region into two sections, the Galilean mountains and the hills of Samaria and Judaea. The Galilean mountains, north of the plain of Jezreel, fall into two regions defined by a line joining Acre with the north end of the Sea of Galilee. The northern region is in effect a continuation of the Lebanon mountains and consists of an elevated plateau draining into the Kasimiya. Its highest point is Jebel Jermak (Har Meyron [3,963 ft.]), and the descent to the Jordan valley is very abrupt. Much of the region is fertile and partly wooded. The southern region shows somewhat different characteristics. It consists of chains of comparatively low hills, for the greater part running east and west, enclosing a number of elevated plains. The principal of these plains is el-Buttauf (ancient Zebulun), a tract 400 to 500 ft. above sea level, enclosed within hills 1,700 ft. high. It is marshy at its eastern end and very fertile. Among the principal mountains of this district are Jebel Tur'an (1,798 ft.) and Jebel et-Tur (Mt. Tabor; 1,929 ft.); the latter is an isolated mass of irregular shape which commands the plain of Jezreel. Eastward the country falls to the Jordan rift by a succession of steps. The chief valleys of this region are the Nahr Na'aman with its branches, which runs out to the sea south of Acre, and the Nahr el-Muqatta or Kishon, which joins the sea at Haifa.

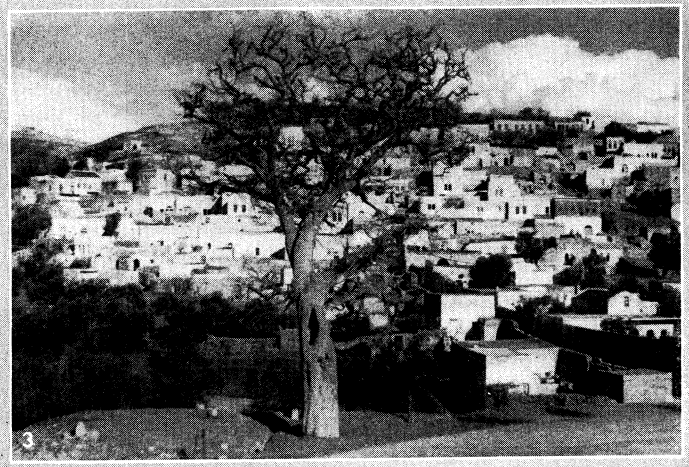
The high ground of ancient Samaria includes the limestone mass of Mt. Ephraim, with the higher ground near the Jordan rift, and also the western plateau which there merges more with the lowland than in Judaea. Jebel Fuku'a forms the watershed at the eastern extremity of the plain of Jezreel and is an outlier of Eocene rocks. Carmel is essentially an outpost of the hill country flanked by the maritime plain on one side and by the plain of Jezreel on the other. The highest land in Samaria is in the neighbourhood of Nablus (Shechem), city of refuge and regional focus. The hills include the bare mass of another Jebel et-Tur (Mt. Gerizim; 2,890 ft.), the smoother cactus-clad cone of Sleimtye (Ebal; 3,084 ft.), and farther south Tell Asur, at which point begins the Judaean range.

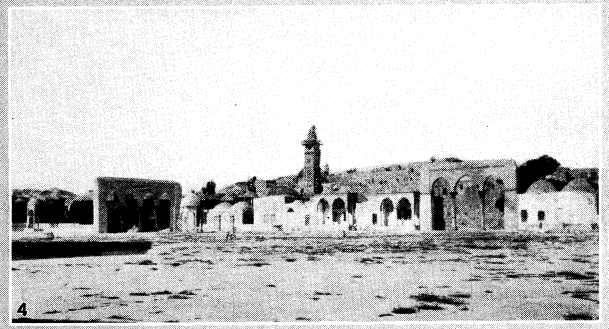
The hill country of Judaea is the nucleus of Palestine. The slopes are bare, rocky and often waterless. A short distance north-northeast of Bethel stands Tell Asur (3.333 ft), an outpost of the high ground which forms the Judaean hills. South of it is the long, zigzag range known as Jebel el-Kuds. The highest point is Neby Samwil (Mizpah), 2,904 ft. above the sea north of Jerusalem, which stands at an altitude of 2,593 ft. To the south of Jerusalem begins the subdivision of the Judaean hills known as Jebel el-Khalil (Mt. Hebron), which stands in an elevated basin about 450 ft. above the city. South of Hebron the limestone ridge finally breaks up and loses itself in the southern desert.

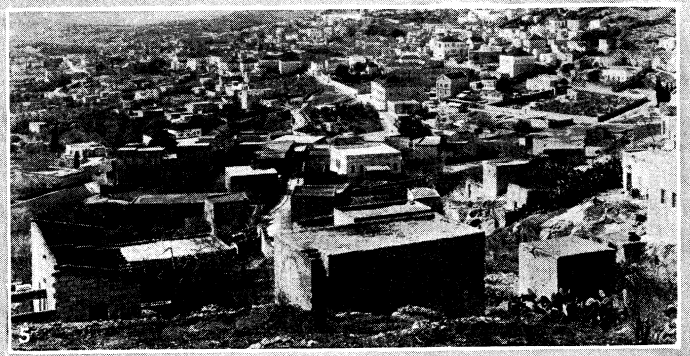
On the western side of the watershed the mountainous district extends about half way to the sea, broken by deep valleys and passes. Among these the most important are the Wadi Selman (valley of Aijalon), which seems to have been the principal route to Jerusalem in ancient times; the Wadi Isma'ip, south of this, along which runs a road from Jaffa to Jerusalem; and the Wadi es-Surar, a higher section of the bed of the Nahr Rubin, with its railway line.

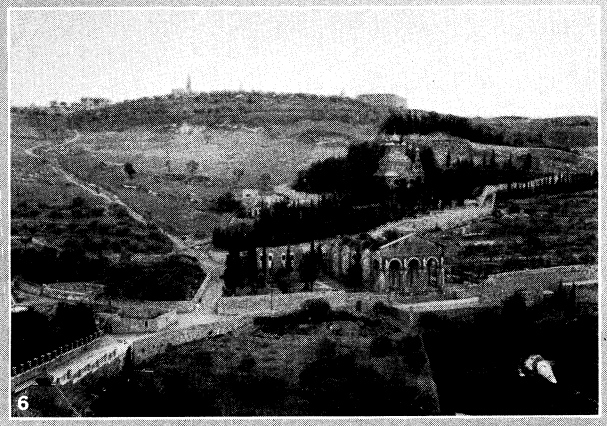
Between the mountainous country of Judaea and the maritime plain is an undulating region anciently known as the Shephelah. It is composed of horizontal strata of limestone, forming groups of hills intersected by a network of small and fertile valleys. In this region, which is of great historical importance, are the remains of many ancient cities.











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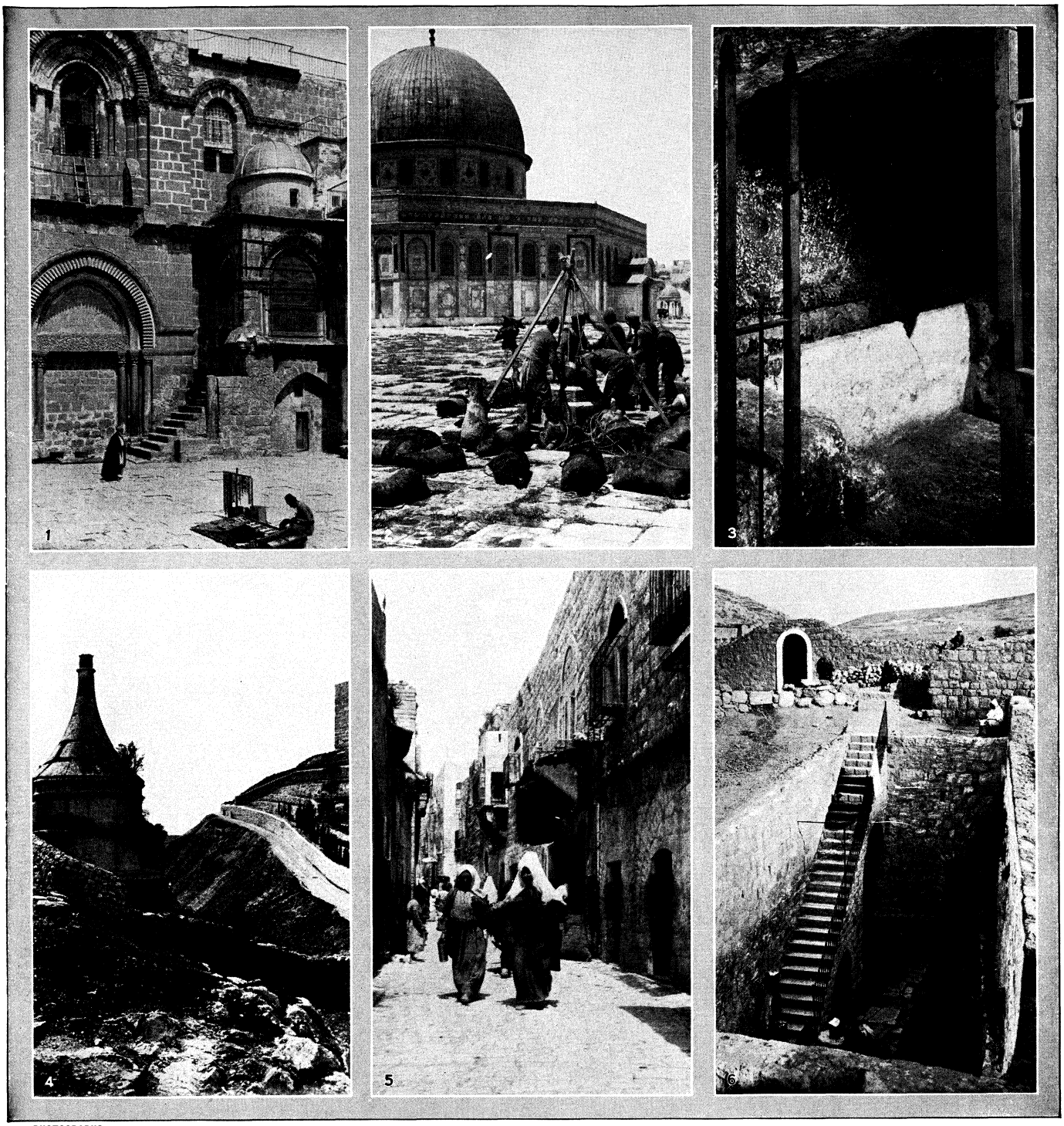
VIEWS IN PALESTINE

1. Jerusalem, with the Dome of the Rock on the left
2. The Dome of the Rock (Mosque of Omar) seen through the doorway of the Mosque of Haram-esh Sherif, Jerusalem
3. The town of Safad, northeast of Nazareth
4. Herod's Palace and the tower of Antonia, Jerusalem, c. A.D. 40
5. View of Nazareth
6. Mount of Olives outside of Jerusalem with the Garden of Gethsemane in the foreground
7. Ruins of a church at Capernaum on the Sea of Galilee, showing a richly ornamented lintel
8. On the east slope of Mount Zion looking towards the Mount of Olives; on the summit of the latter is a modern Russian church

PALESTINE



PHOTOGRAPHS, DONALD MCLEISH

VIEWS IN JERUSALEM AND BETHLEHEM

1. Main façade of the church of the Holy Sepulchre, at Jerusalem, which was finished in its present form by the Crusaders in 1099. The church was first built by Constantine in 336 on the site believed by him to be that of the tomb of Christ
2. Water carriers of Jerusalem filling their goat skin bags at a well in the court of the Dome of the Rock, built or adapted, A.D. 691. This mosque is generally believed to occupy the site of Solomon's Temple
3. "The Garden Tomb," in the rocks outside Jerusalem, which in the opinion of General C. G. Gordon and others was the sepulchre in which Christ was buried. It is sometimes called "Gordon's Tomb of Christ"
4. Tomb of Absalom outside the city walls of Jerusalem. The monument dates from the Graeco-Roman period
5. Street scene in Bethlehem
6. The Pool of Siloam within the city walls of Jerusalem. Excavations here revealed a bath house of the period of Herod (40 B.C.–A.D. 1). The pool is 52 feet long and 19 feet wide

On the eastern side of the watershed the ground slopes rapidly from its height of 2.500 ft. above sea level to a maximum depth of 1,300 ft. below sea level, within a distance of about 20 mi. A wasteland destitute of water and with only scant vegetation. it descends to the level of the Ghor by terraces, deeply cut through by profound ravines.

The Jordan *Valley.*—The Jordan rift extends for 250 mi. from Lake Hule to the Gulf of Aqaba. The whole of this region is sometimes called the Ghor but the name is more often applied to that part from Lake Tiberias to the Dead sea which lies entirely below sea level. Between the site of what was Lake Hule (it has been drained by the Israeli government) and Lake Tiberias (Sea of Galilee) there is a drop of 690 ft. in 10 mi. with the result that the river becomes a narrow, rushing stream and the northern end of the lake is muddy. The lake is 13 mi. long and its southern end is clear; sudden storms often arise on it.

The Jordan comes out through a narrow channel and winds down toward the Dead sea, 600 ft. lower. As it nears the Dead sea the river becomes very salty, because of great evaporation. The shores of the Dead sea (*q.v.*) are salt marsh and salty steppe and the climate there is tropical.

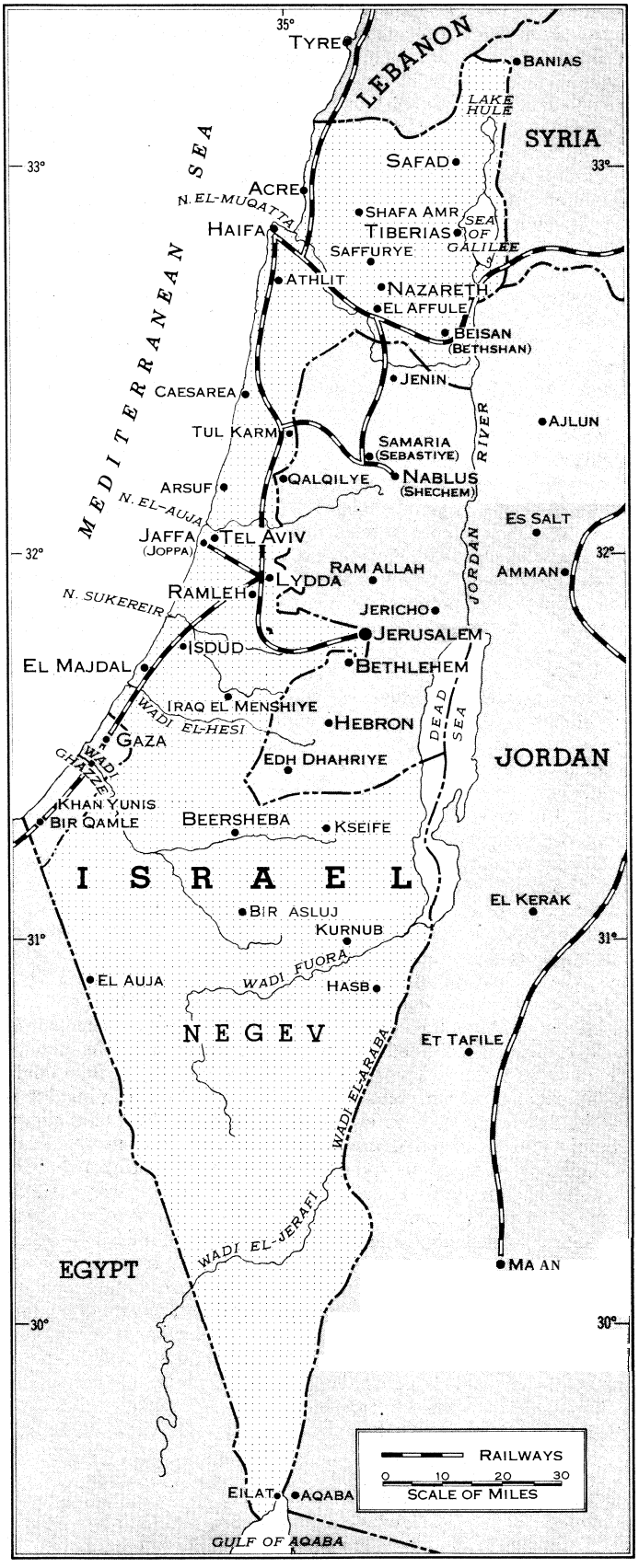
Climate.— The physical structure of the country has a definite bearing upon the many local peculiarities of climate. North and central Palestine are open to the influences of the Mediterranean and thereby escape the excessive drought of the interior of Arabia and Syria, but the south is shadowed by northeast Africa and the Sinai and is arid. Rain-bearing cyclonic disturbances move eastward over the Mediterranean in winter. giving very heavy but intermittent doa·npours over much of Palestine. Bursts of cold. damp. unstable air from Asia Minor and southeast Europe bring a winter snowfall to the Judaean hills and the mountains of the north, though frost is rare on the coast. Even in winter the deep Jordan valley is relatively warm. as the air is heated as it blows down from the north and west. The winter westerlies deposit their rain on the long westward-facing slopes, leaving the eastern scarp of the Jordan rift much drier. The winds are warmed again in the deep valley and on cooling deposit further rain on the slopes of oak-forested Gilead.

The winter rains die away about Easter time with a final, slightly heavier onset. The period from mid-June to mid-September is almost completely rainless, except for a very rare thunderstorm near the hills. In the hot, dry summer: with dust-laden winds blowing from the desert over Palestine, the thermometer occasionally registers 100° F. in the shade: though 80"–go° is more normal. In the Jordan valley the temperature may reach 130°. The temperature can range, within 24 hours, from freezing point to 80°; this daily alternation of temperature may cause the wind to veer round the whole circle of the compass in a day. In October come rains which are the signal for winter plowing. From October onward the winter westerlies set in again. The meàn annual rainfall along the coastal area is about 28 in., although in exceptional years as much as 38 in. is registered.

Much of the rainfall percolates through the large expanses of limestone rock and is thus lost. Springs where the water rushes out from its subterranean channels are important. and wells were eagerly sought after in early times. There are many signs of former works of irrigation. Hot springs are found at el-Hamma, about 1 mi. S. of Tiberias, and at Zerka Xlah'in (Calirrhoe). and there are also hot sulphur springs on the west side of the Dead sea.

Flora.— The distribution of the flora in Palestine follows broadly the physical features of the land, so that Mediterranean, steppe, desert and tropical plants are found. Their general character is xerophytic and in the rainy season the bare land becomes a brilliant garden. About 2,500 species of flowering plants have been identified.

Along the sea coast the sand dunes are colonized by grasses. Behind lies the coastal plain, swampy in places, but, where the swamps have been drained. planted with orange groves. vineyards. etc. Here the flora is Mediterranean in type. with the olive as the characteristic tree. Much of Palestine and Transjordan was once covered with forests of Aleppo pine and oaks (chiefly *Quercus* aegilops, Q. *calliprinos* and Q. infectoria), but only a few remnants are left. They have been succeeded by maquis and garigue. The maquis contains dwarf oaks, bay laurel, terebinth. wild pear, haw-



MAP OF PALESTINE FROM 1948

Of Palestine's area of 10,429 sq.mi., Israel covers 7,993 sq.mi. The central part north and south of Jerusalem and west of the Jordan river is part of the kingdom of Jordan. The Gaza strip was occupied by the Egyptian army from 1949

thorn, etc. *Garigue* is degenerated maquis with smaller and less dense shrubs; *Poterium spinosum* is one of the commonest.

Behind the coastal plain rise the mountains of Samaria and Judaea. covered with maquis and cultivated olive groves. Dense woods of Q. *aegilops* with *Astragalus sanctus,* etc., grow on the eastern slopes of the Judaean mountains, and large areas of forest still remain on the wetter mountains north of the Jezreel valley.

East of the mountains is the Ghor, which includes the Jordan valley and the Dead sea depression. In places the valley is very marshy and there are dense papyrus thickets in the Hule swamps. The Jordan river below Lake Tiberias is lined with poplars, tamarisks, oleanders, etc. Toward the Dead sea its banks are steppe and desert with xerophytes and halophytes such as *Stipa tortilis,* various members of the Chenopodiaceae, *Asphodelus microcarpus* and, in the Negev, *Zygophyllum dumosum, Trigonella arabica* and many more. The chief tree of the desert is the date palm. In the tropical climate of the Dead sea valley flourish xerophytic shrubs such as *Calotropis proccra,* senna plants, *Salvadora* and mallows (*Abutilon*).

Fauna. — Palestine lies on the borders of the Palaearctic and Ethiopian zoogeographical regions. About 8,000 species of fauna are known but this is only roughly a quarter of the actual number. There are many more species of Ethiopian than of Palaearctic mammals. Typical of the latter are shrews. wild boars, badgers, foxes and wolves. Gazelles and allied species, rodents and bats abound in the deserts and steppes. Among the tropical and subtropical mammals are the jungle cat in the reed beds of the Jordan, the honey badger and mongoose in and around the Negev, the Syrian hyrax in the southern deserts and the rocky mountains of the Jordan valley, and the cheetah. jackal and striped hyena.

Animals now extinct in the country include the lion, leopard (there may be a few pairs left). Syrian bear, roe and fallow deer, Arabian oryx, crocodile (whose breeding places were drained and built over) and ostrich. The draining of the Hule swamps was destined to cause the extinction of many birds, insects and other fauna breeding there.

More than 400 species and subspecies of birds have been identified. about 140 of which are residents. The Palestine bulbul and sand grouse are among the most characteristic. The hoopoe, white stork. gray crane. mute and whooper swans are among the migrants; pelicans, geese. ducks and gulls are some of the winter visitors; the bee eater and quail are common summer breeders. The Palestine sunbird and hooded chat breed round the Dead sea, and its highest cliffs are the home of the fan-tailed raven. The brown-necked raven is confined to the Jordan valley, and the hooded crow (which often fosters the great spotted cuckoo) is found only in the Mediterranean regions. Of the many owls the biggest is the eagle owl; buzzards, kites, laminergeier and vultures are everywhere; herons, bitterns, grebes and egrets breed in the Hule swamps. Of the various river fish the most interesting are members of the family Cichlidae found in the Jordan, where freshwater crabs are also common. Dolphins are plentiful off the coast.

Because most of the country is so dry there are few amphibians. In moist places the green toad, edible and tree frogs are found, and terrapins live in all waters. There are a great many snakes, some of them poisonous. Tortoises, geckoes, chameleons and lizards are common everywhere. Insects and other invertebrates abound, particularly in the deserts and steppes. Among them are scorpions and large spiders, bees (famous for their wild honey), tropical crickets, grasshoppers and praying mantes, and locusts and other pests that attack crops. (G. G. A.; W. B. FR.)

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ARCHAEOLOGY

Explorations and Excavations. — Serious exploration of Palestine by men who were not, like the mediaeval pilgrims, exclusively interested in biblical sites began early in the 19th century. Caesarea Philippi, Gerasa and Amman were visited by U. J. Seetzen in about 1806; Petra by J. L. Burckhardt in 1812; the great Hellenistic monument at Araq el-Amir was discovered a few years later by C. L. Irby and J. Mangles; the drawings of Gerasa brought back by W. J. Bankes are still valuable. These are classical remains, however; the first scientific exploration of biblical sites began with the journey made by Edward Robinson in 1838. Others followed him, and in 1865 the Palestine Exploration fund was founded in London for the systematic study of every aspect of the country "for biblical illustration." In the 1870s the survey of western Palestine and part of the country beyond the Jordan was completed. In the 1880s ordnance maps (an inch to the mile) and several volumes of descriptive matter were published by the fund. The surface exploration of half the country seemed to be practically exhausted, and in 1894 George Adam Smith wrote that most of the problems have been run to earth; "it only remains to dig them up."

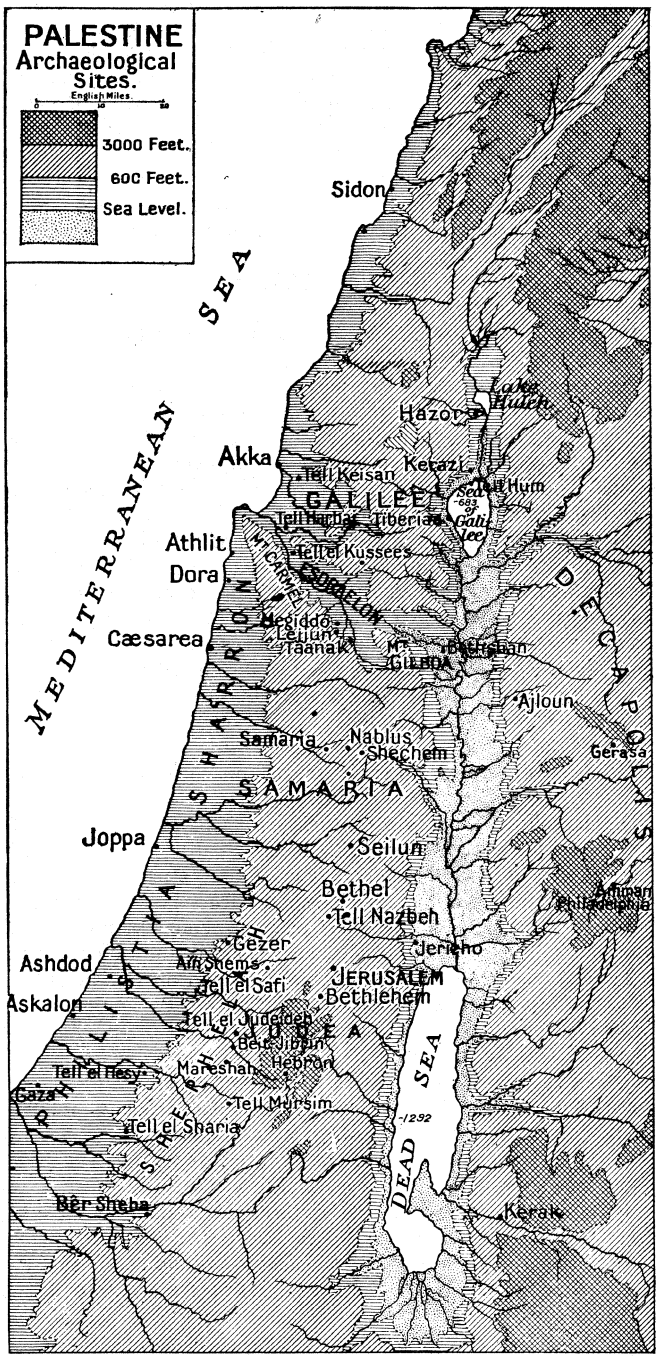
More land east of the Jordan, however, was still virgin country at the beginning of the 20th century. A great work by R. E. Brünnow and A. von Domaszewski, *Die Provincia Arabia* (1904), covered much of the country west of the Arabian desert, and two Dominicans, Fathers J. A. Jaussen and R. Savignac, penetrated farther afield; the work on the Hejaz railway indeed enabled them before World War I to revisit sites which were later barred to archaeologists. The establishment of the Transjordan government in 1921, on the other hand, rendered travel within its frontiers comparatively safe and easy. A far more intensive exploration of the country than ever before became possible, and the many journeys made by Nelson Glueck and others (1933–43) threw a flood of light on the story of civilization in those parts. The pioneer work of exploration was over.

The excavations for which George Adam Smith was asking in 1894 had in fact already started. Four years earlier Sir W. M. Flinders Petrie spent six weeks digging at Tell el-Hesy; it was the first time the stratigraphic methods of excavation evolved in Egypt and elsewhere had been applied in Palestine. and the way in which a city mound had grown and the early contacts of the country with its neighbours were easily demonstrated — too easily, perhaps. A little later, some good topographical mork south of Jerusalem was accomplished by F. J. Bliss and A. C. Dickie by means of tunnelling, and other sites were skimmed; but it was not until 1908 that a major site was attacked with adequate resources: a German expedition, after preliminary investigation~, then started mork at Jericho and a Harvard expedition at Samaria. Work at Jericho was suspended in 1909, and a year later the unsympathetic attitude of the civil authorities led to a similar suspension at Samaria.

After World War I a modern department of antiquities was established in Jerusalem by the mandatory; a law was promulgated to protect ancient remains and to encourage excavation by scientific institutions, and in 1925 steps were taken to extend these activities to Transjordan. A worthy museum was built a few years later, as a result of the generosity of John D. Rockefeller, Jr.

These measures led to a resumption on a vastly increased scale of archaeological research between World Wars I and II. Large expeditions were sent to Bethshan (Beisan) and Megiddo by the universities of Pennsylvania and Chicago; German, Danish and British expeditions excavated at Shechem (Nablus), Shiloh and Lachish, respectively; work was resumed at Jericho, Samaria and Jerusalem. The Hebrew university, the foreign schools of archaeology — American, British and French — the religious orders — Dominican, Franciscan and Jesuit — excavated on many other sites, and the department of antiquities was enabled by further benefaction from Rockefeller to undertake a series of investigations. Apart from the finds of manuscripts in caves near the Dead sea, disappointingly little written material had been discovered by the 1950s, but several new chapters had been added to the history of Palestine from the Stone Age to the time of the Latin kingdom.

Palaeolithic Period. — Numbers of flint implements have been found in all parts of Palestine, but the scientific study of the Stone Age is comparatively recent. As late as the middle of the 19th century the flints picked up on the surface were regarded as the instruments with which the Israelites in the time of Joshua circumcised themselves. Scientific studies began in 1925 when



F. Turville-Petre excavated the deposits in two Galilean caves. one of which contained fragments of a skull with Neanderthaloid characters. Thereafter much richer deposits were found by Dorothy Garrod in some caves on Mt. Carmel. In one cave the accumulations were more than 24 m. thick. Nine layers were distinguished in this cave and an immense number of implements and faunal remains were found. Bones of the rhinoceros and hippopotamus proved that a wet tropical phase had lasted over a long period. The industries were practically identical with those from European sites and followed one another in the same order; in this cave the earliest was Tayacian, the latest middle Aurignacian.

In front of another cave near by nine bodies were discovered. They seem to have been buried with some care; one of them was clasping the jawbone of a boar. Like the Galilean skull they were associated with Levalloiso-Mousterian flints and they lived in a damp tropical phase. They are representatives of an extinct branch of the human family, called *Palaeoanthropus palestinensis* by Sir Arthur Keith and T. D. McCown; they were not the actual ancestors of the Cromagnon but Neanderthaloid collaterals or cousins of the ancestors of that type. Their brains were large; the man was from 1 ft. 8 in. to 5 ft. 11 in. tall. the woman shorter.

Mesolithic Period. — At the same site, above the Palaeolithic layers, Miss Garrod found two phases of a Mesolithic industry which she had identified in 1928 in a cave at Shukba above the Wadi Natuf in Judaea. A characteristic of this Natufian industry, as it is called, is the high proportion of microliths — in the lower Natufian on Mt. Carmel the microlithic group accounts for more than 6,000 of the 8,010 implements recorded. The industry is represented on a number of Palestinian sites. The Natufian station at Helwan in Egypt is plainly intrusive.

The Natufians appear to have been an early branch of the Mediterranean people; they were long-headed, delicate-featured and rather small. They had sickle blades of flints set in bone or wooden hafts, basalt pestles, querns and mortars and bone harpoons; they wore necklaces and pendants of various types, caps and circlets of dentalium shells (one cap was found still in place), and there are the beginnings of sculpture in bone and stone — a young fawn, perhaps from the handle of a sickle. was found at Carmel, and René Neuville discovered a small deer carved in limestone at Umm Zweitina. This culture may have lasted into the fifth millennium before the Christian era.

Neolithic Period. — In 1935, digging at Jericho far below the level reached by his predecessors, John Garstang came, under layer IX, on a series of seven floors, one above the other. the first Neolithic remains recognized in Palestine. The floors were composed of puddled clay and lime, painted red and polished, the walls round them built of hand-moulded lumps of mud; the vessels in use were made of sun-baked marl mixed with chopped straw; there was no burned pottery. Figurines of cattle, goats, sheep and pigs were made of the same material, and two groups of human figures were found in the top layer which may represent a divine mother, her consort and her son. A head built on a reed framework had shells in the eye sockets and indications of the hair and a beard.

Other Neolithic stations were later found on the coast and near Abu Ghosh. On the Abu Ghosh site, on the road from Jerusalem to Jaffa, there were some unbaked figurines of cattle like those from Jericho and stone implements like some from Neolithic sites in Syria — polished axheads and flint arrowheads with oblique barbs. Some writers assign the dolmens scattered on both sides of the Jordan to this period.

In 1952, when work was resumed at Jericho by Kathleen Kenyon on behalf of the British school, the existence there of a strong city wall in the Neolithic period was established, and in 1953 seven skulls of the same period with faces modelled on them in plaster were discovered.

Bronze Age. — The oldest settlement on which any metal tools have been found is close to Jericho, and some of the houses there nere built of similar hand-moulded lumps of mud. The site, Teleilat el-Ghassul, is on the east side of the valley. It was excavated by the Jesuit fathers of the Pontifical institute in Jerusalem. Four layers of occupation were distinguished; the pottery is varied in shape and decoration, the finest pieces being cornet-shaped and well baked, with thin walls and simple painted patterns. Fragments of painted wall plaster were of special interest: one is a picture of an eight-pointed star with some weird dragons floating round it; another. 4.50 m. long, shows the worship, perhaps, of a rayed sun by six or seven persons whose feet only have survived, those of two on footstools; a third, from the last layer but one, shows the open beak and sweeping tail feathers of a bird in naturalistic style. Tno axes and a few other pieces of metal were found; when one piece of metal was analyzed it showed 7% of tin. Paintings and metal both point to contacts with advanced centres. Bronze or copper reached Egypt in the fourth millennium and Palestine perhaps about the same time.

Ghassul stood in an open plain and was not walled so far as is known. Most Palestinian settlements. on the other hand, were perched on hilltops in a common Mediterranean fashion and defended by more or less massive walls. Those excavated — an appreciable number by the 1950s—seem to have been destroyed again and again, and these frequent destructions enabled archaeologists to make almost as many subdivisions as there mere centuries in the Bronze Age before the coming of iron about 1200 B.C. Flints were used throughout the period for expendable tools and weapons such as sickle blades and arrowheads, and the record mould be a dreary one but for some bright spots when something new was introduced from Syria or Egypt. At Megiddo some seal impressions like those from Jemdet Nazr point to relations, doubtless through Syria, with Mesopotamia about 3000 B.C. About 2500 some attractive red and black pottery. highly burnished and fluted, first found at Khirbet Kerak, the ancient Beth Yerah south of the Sea of Galilee, was tracked to north Syria, Asia Minor and the Caucasus. Rich tombs with finer wares, now wheel-made, at Jericho and elsewhere date from the expansion of Egypt under the 12th dynasty, and about a century later when the Hyksos invaded Egypt there were other developments. The art of fortification was revolutionized, deep fosses were dug round the old towns with a high glacis above them and mud walls on the top. Places fortified in this manner were found in north Syria and in Egypt, but for some unclear reason there is a far larger number in Palestine; a particularly beautiful example was found at Lachish with a white revetment still sticking to the glacis.

After the expulsion of the Hyksos from Egypt Palestine was conquered by the vigorous kings of the 18th dynasty. In the great days of the New Egyptian Empire, as it is called. the seaports carried on a flourishing trade with neighbouring countries. Tell el-Ajjûl, near Gaza, was identified as the home of a vase painter whose work was exported on a considerable scale to Cyprus and to Syria. One of the few artists Palestine produced, he painted his pots, tankards, two-handled jars, bowls and jugs in an original style with birds, fish and monsters it would be rash to name. Most of what is known about the country under Egyptian rule is derived from the Tell el-Amarna letters; the collection includes more than 100 sent to Egypt from Palestine in the 15th and 14th centuries, but surprisingly few have been found on Palestinian sites. The Babylonian cuneiform in which the tablets are written is one of many proofs that the country remained fundamentally Asiatic in spite of its many connections with Egypt, which was never a very sympathetic neighbour.

Two finds at Megiddo throw light on conditions at the end of the late Bronze Age. A large hoard of gold and miscellaneous ivories was found in a subterranean treasury under a palace of this period. There were many combs, spoons. shallow bowls and gaming boards, and a casket, perhaps a toilet box, carved in deep relief with figures of lions and sphinxes. Some plaques had tenons showing they had been wrenched from pieces of furniture. The subjects included processions of tribute bearers and captives, chariot battles and feasts, griffins and ibexes, lotus and palm motives and the god Bes. One plaque, inspired by Hittite art, is assigned by the discoverer, Gordon Loud, to the troubled age after the reign of Ikhnaton (Akhnaton) when northern influences may have been strong, perhaps between 1350 and 1200. Others suggest influences from the Aegean or Egypt; the latest appears to be part of a pen case with the cartouche of Rameses III. But none of them could be mistaken for originals from these areas. The life has gone out of them; they are the products of local journeymen, Syrian or Phoenician or Canaanite.

About the time in the 12th century when this collection was made Megiddo was engaged on a colossal engineering scheme: the old passage connecting the town with its water supply at the foot of the hill was abandoned as being too exposed, and a huge shaft was sunk, partly through floors belonging to the middle Bronze Age and the beginning of the late Bronze Age, partly through solid rock, to a depth of 35 m. below the surface where it joined a tunnel 6; m. long leading to the water source. Parallels of different periods exist in other Palestinian towns, such as Gezer and Jerusalem, and possibly also at Lachish, where the inhabitants placed their trust similarly in works of passive defense. At Megiddo their efforts were in vain, for the city of stratum VII to which the shaft and tunnel are ascribed was utterly destroyed, by whom is not known; the latest dated monument which has been found in the stratum is a bronze base of a statue of Rameses VI (c. 1150).

During the Bronze Age conditions were probably like those depicted in the Book of Joshua. The country in western Palestine was parcelled out among a number of petty rulers who exercised a precarious authority over districts whose resources were barely sufficient to feed the people in the cities. Sometimes, no doubt, as on the Euphrates, one king might be followed by others and a rather larger state would come into being. In the Tell el-Amarna correspondence the kings cut a pitiful figure. The biblical record suggests that in the east the kings of Edom and Moab may have ruled wider territories, but we have little real knowledge. A few hieroglyphic inscriptions and some in cuneiform survive, and there are traces also of other scripts, but no informative collection of documents such as those found at Mari and in northern Syria had come to light by the 1950s.

Iron Age. — An iron dagger was one of the treasures in the tomb of Tutenkhamon, but iron was still a rare metal at that time and did not come into common use before the last quarter of the second millennium. In Palestine this is the period when two northern peoples, the Philistines and the Zakkals (Zackaray, Thekels). settled on the coast and the children of Israel were invading the interior. The northerners certainly brought iron with them but it is doubtful whether they added much more to the local culture. Pillars like those described in the Samson saga had long been employed by Palestinian builders, and it is now questioned whether the so-called Philistine pottery was introduced or made by them. This pottery — two-handled bowls and jugs of a new shape painted in a new style with swans and geometrical patterns — appears about this time in the area they occupied, but the natives in the area were quite capable of evolving a ware of this character. combining, as it does, old native elements with Mycenaean elements which had passed out of currency elsewhere. We do not know where the Philistines came from, and this ware has not been found anywhere else.

The Israelites, according to their own account, destroyed far more and added even less to the material culture of the country. Tell el-Ful, a little hill settlement 3 mi. from Jerusalem, mas excavated by W. F. Albright and identified with Gibeah of Saul; the contents are those of the simplest peasant economy, jars to store wine and oil, spinning whorls. a game board and some cooking pots. The dependence of David and Solomon on Hiram of Tyre for carpenters, masons and smiths shows that Palestine was still a poor relation of Syria, at least in all the matters of which archaeologists can take cognizance.

Great developments, however, took place under the monarchy. The archaeological evidence comes from Samaria and Megiddo. At the former an area on the top of the hill! about 200 m. by 100 m., was laid out as a royal quarter such as Solomon is said to have planned in Jerusalem. Two superb malls, built of ashlar. exactly fitted and carefully bonded, ran round the quarter; the outer, casemated wall on the north side was more than ten metres thick. On the south side there was a large courtyard, and at the east end, on both sides of the hill, pilaster capitals of the proto-Ionic type mere found in the debris. The buildings inside this area at Sâmaria had been destroyed out of recognition, but at Megiddo a fine house built in the same style and decoraled with similar capitals was found, and some vast stables, once ascribed to Solomon, with stalls for more than 400 horses. The masonry at Samaria dates from the time of Omri and Ahab (c. 880–850), and masonry of the same style is found at Tyre and Ras Shamra; it is clearly Phoenician in origin—Ahab's wife Jezebel was a Phoenician princess — and it disappeared after the fall of the house of Omri.

Ahab's house of ivory is mentioned in the Book of Kings, and a large number of ivory fragments were found scattered in the lower levels on the north side of the royal quarter. They have something in common with the earlier Megiddo hoard, but are more like some found at Arslan Taih in north Syria and a group of ivories in the British museum from Tell Nimrud (Kalakh). Delicate plaques

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FIG. 1–13. — SPECIMENS OF POTTERY FROM PALESTINE

1. Vessel from cave 2, Gezer, early Bronze Age. 2. Buff clay vessel from a cave at Ophel, Jerusalem, early Bronze Age. 3. Red clay vessel of middle Bronze Age. 4. Bowl of coarse, reddish clay from Beisan (Bethshan), middle Bronze Age. 5. Decorated jug of light-red. gritty clay from Tell Zakariyeh, late Bronze Age (transitional to early Iron Age). 6. Thin bowl of fine buff clay with "wishbone" handle, typical Cypriote "milk bowl" from Gezer, late Bronze Age. 7. Pedestal dish of light-orange clay from Beisan, late Bronze Age. 8. Reddish clay bowl with white wash from Askalon, early Iron Age. 9. So-called Philistine-type jar of light-yellow slip and buff clay from Gezer; early Iron Age. 10. Orange clay jug from Tomb 1, Ainshems, Iron Age. 11. Pedestal vase of buff clay blackened, from Tomb 1 at Ainshems, early Iron Age. 12. Buff clay vessel from Tomb 8, Ainshems, Israelitish period, early Iron Age. 13. Lentoid vessel of light-red clay from Ophel, Jerusalem, Hellenistic period

representing Egyptian figures, the child Horus, Isis and Nephthis, and the god Hah recall the house built by Solomon for his Egyptian wife, while the sphinx-cherubs, palms and lotus are like the decorations of his temple. The feasts and the tribute bearers of the Megiddo group were no longer in fashion, and there is no trace of Assyrian influence. Ninth-century Phoenician letters were scratched on the backs of several plaques to guide the workmen in assembling them, and the Phoenician origin of the collection is plain. The Philistine ware has disappeared, and the pottery in general use at Samaria mas unpainted but of good shapes and finely burnished. It is on shards of this ware that many receipts for mine and oil have been found; they were written in ink and date from one of the successors of Jehu.

The Assyrians captured Samaria in 721. A few years later they were threatening Hezekiah in Jerusalem, and the long water tunnel from the Virgin's Spring to Siloam, an even greater work than that at Megiddo, dates from this time. The next century is a gloomy period: one city after another was razed to the ground by invaders from Assyria or Babylon, and Jerusalem was utterly destroyed by the Babylonians. Some episodes in the Babylonian invasion are the subject of the ostraca (potsherdsj found at Lachish. Written in the lifetime of Jeremiah, they illustrate contemporary script and language.

In 539 the Babylonian empire fell to Cyrus, and it was at Lachish again that the seat of a Persian resident was discovered, built on a Syrian plan on the highest point in the city, one of the few Persian remains found in the interior. On the coast the period is better represented, and in the ports commerce was flourishing. The contents of tombs that have been excavated near the little harbour at Athlit have been compared with those from a Phoenician site in Sardinia; in both there are Egyptian scarabs, Phoenician scarabs and scarabs with Greek subjects. Elsewhere there is evidence of Greek and Macedonian settlers; at Gaza there was a strong Arab contingent engaged in caravan trade with southern Arabia; and potsherds of this period with Aramaic inscriptions and fragments of Attic vases have been found in Tell el-Kheleifeh, a port on the Gulf of Aqaba which is identified with Ezion-Geber, an old foundation attributed to Solomon.

Graeco-Roman Period. — Under the successors of Alexander cities in the interior revived. Some Egyptian papyri of the years 258–256 record manifold activities inland from Gaza to the Hauran by Greek traders and mercenaries, and wherever excavators penetrate strata of the period they find Hellenistic wares displacing native fabrics for all but kitchen purposes. Greek spread; it was the language of the Sidonian colony at Marisa which flourished in the 3rd and 2nd centuries. Most of the Greeks. however, were transients. Towns took Greek names but they were Hellenized only nominally; Greek political constitutions, councils and assemblies were not introduced; no theatres or stadia earlier than the 1st century A.D. have been found in Palestine. People imported Greek pottery from Athens, Rhodes and Alexandria. but in their buildings Syrian and Greek motives are blended. as for example at Araq el-Amir, the greatest surviving monument of the age. The family tombs of the Maccabees were also built in the same hybrid style. so far as can be judged from the description in Josephus.

Herod went further than any previous ruler in his attempt to Europeanize the country. He built theatres and amphitheatres and a modern port at Caesarea, but the tn-o traditions. Syrian and Hellenistic, survived in his architecture — the Temple at Jerusalem and other buildings at Hebron and Samaria are still in some respects as oriental as tomb façades of approximately the same age at Petra. A hundred years later there is a great change; *e.g.*, at Gerasa in the Decapolis, where the south theatre dates from Domitian, the triumphal arch from Hadrian. the chief temples. the north theatre, the baths and other spectacular works from the age of the Antonines. At Petra too the great theatre is now assigned to the

2nd century A.D. The layout of towns like Gerasa and Samaria, with their long bazaar streets and the dominating position and vast precincts of the temples, may be native features, but other oriental elements have been shed and the trappings are now of standardized imperial patterns, perhaps with a provincial accent. The older synagogues also are classical in plan and details.

It was a literate age. In Galilee we know from the Gospels that the Scriptures were being read and expounded in the 1st century A.D. and discoveries prove that this was the case also in a small settlement near the Dead sea now called Khirbat Qumran. In 1947 some biblical and other manuscripts, including a text of Isaiah and a commentary on Habakkuk, were found in a cave on the site. The settlement nas later excavated and the caves in the area re-examined. From the caves thousands of fragments of more manuscripts were collected: most of the Old Testament books and some apocryphal works were represented, and one page was found containing a collection of Messianic prophecies. The discoveries on the site include several cisterns, a large building 37 m. by 30 m., clearly for communal gatherings, a jar identical with those in which the scrolls had been kept, other pottery of the same kind. and coins of the period between the Roman procurators and the first Jewish revolt (A.D. 66–70). The remains seem to belong to a modest Essene settlement 'that was largely abandoned after the revolt. and the scrolls. it is concluded, were deposited about that date though some of them may be much older.

A group of caves about 11 mi. farther south in a very wild part of the country produced some later documents, among them a contract made in the seventh year of Hadrian and letters from Barcocheba, the leader of the second revolt, together with some coins of the revolt (A.D. 132–135).

The Christian Empire.— With Constantine another period of great prosperity begins: the 6th century in particular was an age of almost unprecedented activity. Martyries rose on every site with any sacred pretensions; every village seems to have built a new church or synagogue: in Transjordan alone about 170 churches were listed by two Franciscan fathers, and there are few mounds that are not littered with potsherds of the period. Palestine was in close touch with other parts of Christendom, and the churches, mostly basilicas preceded by an atrium with porticoes round it, are like those built in Constantinople, Greece and Italy during the palaeo-Christian age. In the finest the walls glittered with marble veneering and glass mosaics. the floors with mosaic pavements as varied as any patterned floors in Italy or Dalmatia; but although scores of pavements survive. of the mural mosaics there are only heaps of loose tesserae from the fallen walls. It was long before the Byzantine domical plans of Justinian's age reached Palestine. curiously so, considering that some of the earliest domes on pendentives have been found in classical buildings there.

The Arab **Conquest.**—The mosaics in the Dome of the Rock, which was built in 692, give some idea of the way in which churches were decorated. Old crafts persisted without let under the Omayyad caliphs. It has been discovered that new churches were founded after the Arab conquest, and other finds threw new light on the architecture of the period. Two palaces. Khan Xlinya close to Capernaum and Khirbat Mafjar near Jericho, both of the 8th century, were excavated. Inscriptions of Mafjar show that it was the work of local craftsmen, among them probably some monks, and it is not surprising to find rooms paved with mosaics as fine as, or finer than, any found in the churches. Piles of glass tesserae prove that walls too were decorated in the old style. Other walls. the entrance hall at Mafjar for example, mere sheeted in a new fashion with a stucco revetment covering the surface as completely as a modern wallpaper.

The porches at Mafjar and a Syrian palace of the same date between Damascus and I'almyra were also decorated with a wealth of carved figures, in Syria one of the caliph, at Mafjar several of athletes and dancing women. Rows of birds and animals carved in the round stood on cornices below the domes. These discoveries confirm the late date of the splendid dodo from Mshatta, where similar sculptures were found, and prove once more that Semites are not inherently averse to the representation of living creatures.

This renaissance in Syria rind Palestine was the outcome of the wealth pouring into Damascus from an empire which stretched from India to Spain. It withered away when the Omayyad dynasty was overthrown and the capital moved to Mesopotamia. Bedouin raided the countryside, towns like Gerasa were abandoned, the palaces fell into ruin. Later buildings, Latin, Mameluke and Turkish, were all of alien origin.

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HISTORY

OLD TESTAMENT PERIOD

The history of Palestine before the Macedonian conquest about 330 B.C. was profoundly influenced by its geography. Its position on the Asiatic side of the land bridge connecting Asia with Africa at the Isthmus of Suez meant that virtually all migrations and conquering armies moving from one continent to the other had to traverse it. It mas influenced by all intercontinental streams of culture and was dominated culturally by the rich civiiizations of Egypt and of Mesopotamia from an early phase of sedentary occupation until the end of our period. Being geographically part of the larger unit formed by greater Syria, which extended roughly between the modern frontiers of Egypt and Turkey, it was occasionally influenced by the cultures of ancient Asia Minor, chiefly represented by the Hittites and Horites (Hurrians) of the Bible. Because of its situation along the eastern shore of the Mediterranean, it was open to movements from the sea, such as the importation of Mycenaean products from the Aegean region in the late Bronze Age, the migration of the Philistines from the same direction in the beginning of the Iron Age and the flow of Greek culture which began in the 6th century B.C. The situation of the Phoenicians in the northwest corner of the country made Palestine an inevitable economic partner with the Phoenicians in their exploitation of the trade and natural resources of the western Mediterranean. To the east. Palestine blended imperceptibly with the northern deserts of Arabia, from which innumerable bands of nomads came to harry the sedentary population or to settle down themselves in good time. From the 10th century B.C., or even earlier, the caravan trade between south Arabia and the lands of the Mediterranean brought Palestine more and more closely into touch with Arabia. In spite of its small extent and its subjection to influences from all directions, however, Palestine became historically great because of the unique religious culture of a single people—Israel.

The Palaeolithic Age.—During the interpluvial period, which probably corresponded to the second interglacial of western Europe, the early inhabitants of Palestine, certainly very few in number, made hand axes of flint and left them in open-air stations in the hill country. These hand axes resemble the *coups* de *poing* of the Chellean or Abbevillian of France, dated by geologists more than 250,000 years ago, in appearance and method of fabrication. Men did not begin to live in caves; hollowed out in the limestone of Palestine by the action of water, until the late Acheulian, corresponding to the Tayacian of France. From then on we find accumulated deposits from successive Palaeolithic periods, all hardened to limestone breccia by the passage of time. In three neighbouring caves south of Mt. Carmel, Dorothy Garrod discovered (1929–34) nearly 70 ft. of stratified breccia from the middle and Upper Palaeolithic, in about the middle of which were found a dozen fossil human skeletons from the Mousterian phase, showing mixed Neanderthaloid and modern characteristics. The Llousterian was followed by the Aurignacian, which began at least 50,000 years ago and was replaced by the so-called Atlitian, perhaps about 20,000 years ago. At mid-70th century, no cave art of late Aurignacian type had yet been found in Palestine. and there was no trace of any culture corresponding to the Solutrean

and Magdalenian of western Europe.

The Mesolithic Age.—Knowledge of this age is almost entirely the result of the researches of Dorothy Garrod and René Neuville from 1928 on. The age may have begun about 10.000 years ago (possibly earlier) and have lasted until about 6000 B.C. or later. Radiocarbon counts have stabilized the chronology of the hlesolithic of the old world. and it can be said confidently that grain was already being cultivated in primitive fashion by about 7000 B.C. The chief Mesolithic culture of Palestine was named Natufian by Miss Garrod; it was the earliest partially food-producing (as against food-gathering) culture known.

The Neolithic and Chalcolithic Ages.—These ages, which may be dated with the aid of radiocarbon chronology roughly between 6000 and 3000 B.C., are well represented in Palestine, where the first clear distinction between preceramic and postceramic Neolithic was made by john Garstang in 1935. This important discovery was confirmed by R. J. Braidwood, digging in the Kurdish foothills of Iraq, where Neolithic remains preceding and following the invention of pottery were found in 1950–51. In contrast with the older Stone Age cultures of Palestine, Neolithic flint tools were ground to an edge after flaking. This age was also characterized by massive stone graves, generally grouped in megalithic cemeteries. After decades of uncertainty, the megalithic tombs of Transjordan have been conclusively dated in the sixth and fifth millennia B.C.

After the invention of pottery, which, judging from radiocarbon evidence, took place not long after 5000 B.C., it becomes much easier for the archaeologist to arrange successive periods in chronological order. since broken shards of pottery soon became far more abundant than flint artifacts had ever been. It is not only easier to date stratigraphically (by layers), but the contents of a pottery-bearing stratum are generally much more diversified and instructive than the contents of an open-air station or even of a cave deposit. In Palestine we first find a well-developed ceramic period. called Jericho IX after the level in which it was described, at Jericho. This was follon-ed by late Neolithic cultures whose best-known phase was called Yarmukian by M. Stekelis; earlier and later phases have also been distinguished. These cultures may be dated in the late fifth millennium B.C., and they probably continued for several centuries into the early fourth millennium. Following them, after a probable lapse of some time, came the Chalcolithic Ghassulian culture, first found by Père A. Mallon at Teleilat el-Ghassul in the southern Jordan valley opposite Jericho, and after 1929 identified at numerous other sites in various parts of Palestine. This culture came to an end somewhere in the middle of the fourth millennium; it was characterized by high development of artistic skills, as illustrated particularly by the polychrome frescoes of Ghassul. It was followed by a series of cultural phases contemporary with the late Amratian and the Gerzean of Egypt, as we know from finds of Syro-Palestinian pottery at Ma'adeh near Cairo. The final phase of Palestinian Chalcolithic is often named "Esdraelon" from the plain in northern Palestine where it was first described. It is characterized by extensive town building. The Esdraelon phase came to an end about the 31st century B.C., to employ the minimum Egyptian chronology which dates the beginning of the 1st dynasty in the 29th century; if Egyptian dates are raised, Palestinian ones must be correspondingly raised.

The Early Bronze Age.—This period, which stretches roughly from before 3000 to the 21st century B.C., is generally subdivided into four principal phases: E.B. I (31st–29th centuries), E.B. II (29th–26th centuries), E.B. III (26th–23rd centuries) and E.B. IV (23rd–21st centuries). Its successive periods are dated by Egyptian finds in Palestine and especially by Palestinian (or Syrian) pottery found in Egypt. Thus, E.B. II pottery is found in considerable quantities in the tombs of the 1st dynasty at Sakkara. while E.B. III pottery is abundant in the tombs of the pyramid age at Gizeh. In this age most of the important Canaanite towns of later times were already flourishing places surrounded by massive walls of mud brick or stone. However, very few towns show continuous occupation through the third millennium; almost all places excavated were occupied for only part of the early Bronze Age.

In this age Palestine was occupied by northwestern Semites who probably spoke a tongue closely related to ancestral Hebrew, judging from nhat little we know of it through place names and material filtered through Egyptian channels. We know that there were close trade relations with Egypt throughout the period and that some sort of overlordship over the more thickly settled parts of the country was maintained by the Egyptians during most of the pyramid age (about 2600–2200 B.C.) and perhaps even in the 1st dynasty.

The Middle Bronze Age.—The duration of this period is fixed to the 21st–16th centuries B.C. by Egyptian contacts. During most of the 12th dynasty, Palestine was considered by the Egyptians as part of their empire, though we have no administrative records to give us any idea of the effectiveness of their control. In the course of the 20th century B C.. the towns still left in Transjordan after generations of nomadic incursions seem to have been destroyed as far north as the Yarmuk. This phase of devastation coincides closely with the first successful wave of northwest-Semitic conquest in Mesopotamia, during the transition from Ur III to Larsa, and probably reflects rapid increase of pressure from the nomads who inhabited the fringes of the Syrian desert. The name "Amorite" (which comes from Babylonian *Amurru,* "westerner") is conventionally applied to them by modern scholars; it was actually adopted by the people to which it had been applied, much as the Cymry of Wales adopted the English name of "Welsh" (literally, "foreigner"). The incursions of desert nomads into western Palestine also led to the destruction of many towns of M.B. I west of the Jordan. By 1900 B.C. the population of Palestine had probably reached one of the lowest levels in its history since the late Chalcolithic.

Xmorite settlers in western Palestine reoccupied many abandoned sites and founded new settlements in the course of the next tuo centuries. The Mari tablets of the 18th century B C. give a vivid idea of the political, social and economic life of Syria and Palestine, supplementing archaeological investigation of local sites. In the following century there were great changes in the ethnic and political complexion of the country, because of the conquest of Egypt by Semites coming chiefly from Palestine and of the ensuing irruption of northern peoples into Palestine. The former established the so-called Hyksos kingdom in Egypt, lasting about a century and a half; the latter included the biblical Horites and their Indo-Aryan feudal aristocracy, bearing Old Sanskrit names. With them they brought swift horse-drawn chariots nhich revolutionized the art of mar and made fighting a knightly profession followed by the chariot-owning nobility (the *mariannu* class). The feudal organization which developed around the chariot reduced most of the Canaanites (as the inhabitants of the coastal plain of Syria and Palestine mere now called) to a half-free condition analogous to that of the serfs of the middle ages. Between the settled communities roamed groups of seminomadic folk ahose mode of life resembled that of the Hebrew patriarchs, as described in Genesis. It is generally believed that the patriarchs migrated into Palestine from Mesopotamia in this period, though no basis for an exact chronology of their movements had been found at mid-20th century.

The Late Bronze Age.—There was no sharp break between the middle and the late Bronze Ages in Palestine. Palestine seems to have remained culturally, and perhaps politically. a province of the Hyksos kings until the expulsion of the latter from Egypt. About 1jjo B C.. shortly before the death of Amasis I the first native Pharaoh of the New Kingdom, the Egyptian armies began to conquer Palestine, probably completing their task during his successor's reign. Under Queen Hatshepsut (c. 1490–69), Palestine revolted against Egyptian domination, but the rebellion was put down firmly by her successor. Tuthmosis III, nho established a stable administration, maintained through the reigns of his immediate successors. From Egyptian administrative documents excavated in both Egypt and Palestine, we know in considerable detail how the provincial government was organized and even how it operated during the century 1450–1350 B C. This period is often known as the "Amarna age," and is vividly illustrated by

several hundred cuneiform letters found at Tell el-Amarna, capital of the "heretic king" Ikhnaton. The unusual concern of the Pharaohs with the affairs of Palestine, which was then as poor in relation to its neighbours as in modern times. nas chiefly a result of the fact that control of it was necessary for the defense of Phoenicia and southern Syria, menaced by Mitanni down to *c.* 1375 and by the Hittite empire after that date.

In about 1310 B.C. the increasingly weak rule of the last Pharaohs of the 18th dynasty was replaced by the strong arm of the second and third kings of the 19th dynasty, Seti I and Rameses II (*c.* 1309–1223 B.C.). These kings blunted the southward thrust of the Hittites and consolidated the crumbling Egyptian empire. However, the exactions of foreign bureaucrats, combined with internal decay. had so enfeebled the Canaanite vassal princes of Palestine that it was comparatively easy for the incoming Israelite tribes to occupy most of the hill country of both Transjordan and western Palestine in the course of the closing decades of the 13th century B.C. During the 20 years or so of anarchy that followed the last weak kings of the 19th dynasty, Egyptian rule was completely extinguished, and the ephemeral victories of Rameses III in the early decades of the 12th century scarcely affected Palestinian history.

The Iron **Age:** Israel. — Though the Israelite tribes invaded Palestine before the end of the late Bronze Age. they did not become firmly established in their new home until the early decades of the 12th century. Their number was swelled greatly during the conquest of Canaan by seminomadic Hebrew (*Apiru*, formerly written *Habiru*) tribes already in Palestine. as well as by many settled Canaanites (*e.g.*, the Gibeonites), who joined the invaders against their sedentary neighbours. Excavation has made it clear that the Israelites began building amid the ruins of their precursors and that new settlements sprang up rapidly all through the hill country. Hsd events followed their normal course the resurgent Canaanites, who had not been driven from the coastal plain or the plain of Esdraelon, might have overwhelmed the scattered and unorganized Israelite clans. but this was prevented by the great invasion of the sea peoples in the time of Rameses III, in the early decndes of the 12th century B.C. Among the invaders from the Aegean basin were the Philistines, who were to conquer all Palestine within a century and a half after their settlement in the southern coastal plain. Meanwhile three other peoples were settling down in southern Transjordan : the Edomites in the south. the Moabites east of the Dead sea and the Ammonites on the edge of the Syrian desert east of Gilead. Considered by the Israelites as fellow Hebrews, these peoples had begun to settle down before the Israelite invasion and they remained polytheists until the end of the Old Testament period.

The early Israelites possessed a strong centralizing force in their monotheistic faith, combined with a stern code of ethics, which set them apart from all their neighbours. The Mosaic tradition of the covenant between Yahweh and Israel, made concrete by the 'Tabernacle and its ritual, bound the tribes together in a cultic bond resembling the later Greek amphictyonies. Characteristic of all these organizations was a central sanctuary, surrounded by its worshippers. Straining against this religious bond mere disruptive tribal forces held in leash by a loose alliance between the tribes, which was often severed by civil war. But for the constant attacks launched by its neighbours, Israel would perhaps never have attained any political solidarity. As it was, salvation from its foes lay only in union, and after abortive attempts had been made at one-man rule, Saul became king of all Israel (c. 1020 B.C.).

He defeated the Ammonites and the Philistines, but was killed in battle against the latter c. 1000 B.C. and mas succeeded by David (c. 1000–961). The latter crushed the Philistines (c. 990) and conquered the three Hebrew states of Transjordan, after which the intervention of the Aramaeans from Syria forced him to defeat and annex the states of Aram as far north as the borders of Hamath on the Orontes. Farther east he established some sort of control over the nomadic tribes of the Syrian desert as far as the Euphrates, though it is scarcely probable that Israelite domination was very effective. At home David organized a stable administration based largely on Egyptian models, and according to tradition carried out a census of the population. Death prevented him from completing the execution of his plans, which were put into effect by his successor.

The reign of Solomon (c. 961–922) represents the culmination of Israelite political history. Though he gradually lost control over outlying territories conquered by David, he was extraordinarily successful in organizing the economic life of the country. On the Mediterranean and the Red sea he joined forces with Hiram of Tyre, who was leading the Phoenicians toward the exploitation of Mediterranean trade. Expeditions to Ophir (probably Somaliland and neighbouring areas) brought the rich products of Africa to Palestine. At the same time the Israelite king entered into trade relations with the Arabs as far south as Sheba (Yemen). These activities would have been impossible but for the development of new principles in shipbuilding and for the recent domestication of the Arabian camel and its use in caravans. Among other lucrative undertakings of the king were his development of the copper mines of Edom and his construction of refineries at Ezion-Geber (modern Tell el-Kheleifeh) on the Gulf of Aqaba. Most of the wealth thus gathered was spent in elaborate building operations, which included the Temple and royal palace in Jerusalem, as well as numerous fortified towns and "chariot cities." Best known of the latter is Megiddo, where excavations have disclosed stable accommodations for more than 400 horses. But royal activities on such a vast scale cost more than was produced by foreign trade and the tribute of vassal states, so the Israelites themselves were forced to submit to conscription in royal labour gangs as well as to heavy levies of various kinds. It is not surprising that the people of northern Israel revolted after the great king's death, thus disrupting the united monarchy (*c.* 922).

The rump kingdom of Israel lasted for two full centuries, sharing the worship of Yahweh and the Mosaic tradition with its smaller southern neighbour, Judah. After a period of intermittent warfare between Judah and Israel, King Asa of the former entered into an alliance with the growing kingdom of Damascus by which the latter attacked northern Israel, thus relieving pressure on Judah. This move cost Israel its Transjordan territory north of the Yarmuk river and ushered in a long series of wars between Israel and Damascus, which did not end until the capture of Damascus by the Assyrians in 732.

The best-known phase of Israelite history is the period during which the great prophets. Elijah and Elisha, flourished, under the Omrides of the 9th century. Omri himself, founder of the dynasty, selected Samaria as his capital and began the construction of elaborate defenses and royal buildings, which have been uncovered by excavations. His son Ahab was alternately hero and villain of the principal stories of the prophets; he became involved in complex international manoeuvres, which ended with his ignominious death at Ramoth-Gilead. The dynasty of Omri closed amid torrents of blood (c. 842 B.C.); it was followed by the dynasty of Jehu, which lasted for nearly a century. This was a period of extreme oscillations. from the catastrophic defeat of Israel (c. 815 B.C.) and the destruction of its army by Hazael, king of Damascus, to the triumphs of Jeroboam II (c. 786–746 B.C.). Meanwhile Judah also oscillated between periods of prosperity and weakness; when it was strong it controlled Edom and the caravan routes of the south from Midian to the Mediterranean; when it was feeble it shrank behind its own narrow boundaries. Great kings like Asa (*c.* 913–873), Jehoshaphat (c. 873–849) and Uzziah (c. 783–742) alternated with weaklings.

In 740 the death knell of western independence was sounded by the capture of Arpad in northern Syria by the Assyrian king Tiglath-I'ileser III. Events followed with dizzying speed. In 738 Israel and Judah paid tribute to Xssyria for the first time in decades; in 733 the Assyrians devastated Gilead and Galilee, turning the entire land into Assyrian provinces except for the territory of two tribes, Western Manasseh and Ephraim; in 732 Damascus was captured and Aram ceased to exist as a state; in 724 the siege of Samaria began. Finally, in the first months of 721, Samaria was taken and Israel became politically extinct.

Assyrian and Babylonian Rule. — Judah was now the sole heir of the glories of David and Solomon. I-Iezekiah (*c.* 714–686), lured by promises of Ethiopian aid, attempted to resist Assyria, but was defeated and compelled to pay a crushing tribute. Only the timely intervention of an epidemic which decimated the Assyrian army saved Judah from total devastation. The eloquent guidance of Isaiah restored the morale of the people, and even the weakness of Hezekiah's son Manasseh did not bring complete ruin. Another strong king, Josiah (*c.* 640–609), arose in time to restore the ebbing fortunes of Judah for a few years during which much of the ancient territory of united Israel was brought back under the rule of the Davidic dynasty. Assyria was rapidly declining in power, and in 612 its hated capital. Nineveh, was destroyed by the Medes. Josiah's successful rebellion ended when he fell in battle against a more powerful contender for the Assyrian succession. Necho of Egypt.

Meanwhile the Chaldaean kings of Babylonia were rapidly gaining strength. Nabopolassar of Babylon and Cyaxares of Media divided the old Assyrian empire between them, and the former's son, Nebuchadrezzar, gained control of Syria and Palestine in swift campaigns. However, the defeated Egyptians continued to intrigue in Palestine, whose native states repeatedly joined anti-Babylonian coalitions, all of which collapsed of themselves or were crushed by the Chaldaean armies. Jerusalem was twice besieged, in 598 and after 589. Finally, in Aug. 587, it was stormed and destroyed. The prophet Jeremiah, who had foreseen the tragic denouement and had repeatedly warned his people against their suicidal policy. died in Egypt. Judah was completely devastated and almost completely depopulated.

The Persian Empire. — In j39 Cyrus II of Persia followed up his triumph over Media by conquering Lydia and Babylonia, thus making himself ruler of the greatest empire hitherto known. One oi his first acts was to decree the restoration of Judah and the building of the Temple. A large number of Jewish exiles in Babylonia returned to Jerusalem. and work on the Temple was begun. However, the political situation was extremely unfavourable. since Judah south of Hebron had been occupied by Edomites escaping from Arab pressure. while the tiny remainder north of Hebron had passed under the control of the governor of Samaria. The latter was able by political intrigues to prevent completion of the work of rebuilding the Temple. After the accession of Darius I the Jews took advantage of the civil mars and rebellions which were racking the empire to press work on the Temple, urged on by the fiery prophets Haggai and Zechariah. In March 51 j B.C. the second Temple was finished, but the Jews had meanwhile aroused the suspicion of the I'ersian authorities and further efforts to improve their situation were discouraged.

Matters rested in this unsatisfactory state until 4 j j B.C., when the Jewish royal favourite, Nehemiah. deeply stirred by reports of the sorry condition of Judah and Jerusalem, succeeded in obtaining royal support for a mission to Palestine. Knowledge of the exact sequence of events is complicated by the confused state of documentary sources. and the chronology of events in the time of Ezra and Nehemiah is not certain. It is probable that Ezra was sent to Palestine through the good offices of Nehemiah. However this may be. the two very different leaders were able to establish both the religious autonomy of Judah and the practice of normative Judaism so firmly that they continued with little change for several centuries.

Information concerning the history of Palestine in the period following the age of Nehemiah is very scanty. We hear of Persian intervention in the priestly affairs of Judah in the time of the high priest Johanan (*c.* 400 *B.c.*). We know that the province of Judah continued to be administered by high priests who struck their own coins, and that the province of Samaria and Ammon remained under Yahwist governors of the houses of Sanballat and Tobiah. In *343* Artaxerxes III Ochus is said to have devastated parts of Palestine in connection with his reconquest of Egypt. Thirteen years later the country passed into Macedonian hands after Alexander's conquest of Phoenicia.

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FROM ALEXANDER THE GREAT TO A.D. 70

To Alexander Palestine was, as to many before him, a corridor leading to Egypt, the outlying Persian province. Consequently in his attack on that province after the battle of Issus he confined his attention, in his passage southward. to reducing the coastal cities which might form bases for the Persian fleet. The Jews he left undisturbed in their religion and customs. The high priest remained the head of the Jewish state, perhaps assisted by a council of elders first mentioned in a letter of Antiochus the Great preserved by Josephus (*Antiquitates Judaicae*, xii, § 138 et *seq.*), the authenticity of which is not beyond doubt.

The death of Alexander in *323* B.C. led to the dissolution of his vast empire. But his name lived on in the hearts of all those who had felt the impact of his personality and bore rapid fruit in apocryphal stories praising his prowess and virtues (*see* Alexander III). The Jews, too, had their memories, or created them, and an einhryonic Jewish version of the *Romance of Alexander* is found as early as the time of Josephus.

The **Ptolemies.**—After the death of Alexander. Palestine, with much of Syria and Phoenicia, fell to Ptolemy. the founder of the Ptolemaic dynasty which ruled Egypt for nearly 300 years, n-ho established himself as satrap in Egypt in 323 B.C. and became king in 305 (*see* PTOLEMIES).

The combined successors of Alexander, Ptolemy and Seleucus, defeated Antigonus Monophthalmos (*see* ANTIGONUS I), one of Alexander's generals, who had almost succeeded in recreating under his sole rule Alexander's great empire, at Ipsus in Phrygia in 301 B.C. This victory confirmed Ptolemy in his possession of his territory. although he had arrived too late for the battle, and Seleucus, whose participation in it had been decisive, at first disputed Ptolemy's claim to Syria and Phoenicia and actually occupied northern Syria. This early dispute laid the foundations of a century of bitter antagonism between the house of Ptolemy and that of Seleucus. an antagonism which led to war five times within a century and was finally stilled only by Palestine's passing in 200 B.C. into the hands of the Seleucid dynasty.

The northern boundary of the kingdom established by Ptolemy I lay apparently slightly north of the modern Tripolis, perhaps on the course of the Nahr el-Khabur (ancient Eleuthera), and there are no signs of any important change in this frontier throughout the next century. (*See* W. Otto, *Bayer Abh.*, xxxiv, (I), p. 30 ff. [1928]; and V. Tscherikower, *Mizraim*, iv–v. p. 32 ff. [1937].)

Of Ptolemaic rule in the southern part. of this territory, Palestine. little is known. What little we can discover, mainly from writers of a later period, especially the author of the first book of Maccabees and Josephus. suggests that unlike the northern region. known as Syria and Phoenicia (*qq.v.*), the area was left in much its previous state with considerable power and authority in the hands of the native chieftains.

Of taxation we know more than of administration. The story preserved by Josephus (*Ant. Jud.*, xii. § 154 *et seq.*) of Josephus, kinsman of the high priest Onias in the time when Ptolemy III (Euergetes I) was king of Egypt (246–221), throws light on this. Josephus undertook to collect the taxes for the king, which shows that tax farming was employed for the collection of local taxes. It seems likely that there were additional extraordinary taxes levied by edict from Egypt.

Knowledge of the economic and commercial life of Palestine in the middle of the 3rd century is, on the other hand. both full and reliable. It is drawn from the dossier of letters received and written by Zenon, the confidential business manager of the first minister of Ptolemy II Philadelphus (285–246), who in 259 was sent to Palestine and Syria where his master had commercial interests. These letters speak particularly of a trade in slaves, especially of young girls for prostitution. in whom there appears to have been a brisk trade, with export to Egypt. Zenon's records also testify to a considerable trade in cereals, oil and wine. Inevitably, like

all imports to Egypt. Palestinian exports worked under state monopoly. without which the internal monopolies of Egypt would have been undermined, Palestine, like Egypt and Syria, seems to have had no economic freedom under Ptolemaic rule; in all transactions the hand of the government's agents is clearly visible.

Of the material culture of Palestine in the Ptolemaic period far less is known. The population seems, as in Syria, to have been divided between the Hellenized cities (*poleis*) of the coast, notably Askalon and Joppa. and the rural population living in villages (*komai*). The fact that several cities had Ptolemaic dynastic names (Philadelphia. Philoteris, Ptolemais) must not lead us to overemphasize the desire of the early Ptolemies to urbanize and raise the standard of living of the people of Palestine. It seldom appears that they did more than rename a previously existing city—a practice not infrequent in the Hellenistic world. In fact, unlike the Seleucids, the Ptolemies do not appear to have been great city builders. Nor do they appear to have encouraged the outward forms of independence in local government. It appears likely from the story of the Phoenician tax farmers mentioned above that considerable authority lay in the hands of the wealthy, yet the fact that both Askalon and Joppa issued Ptolemaic regal coinage, but apparently no autonomous bronze coinage, suggests a rigid control. However, the absence of epigraphical evidence from the cities of Ptolemaic Palestine renders any judgment about the conditions of the cities very hazardous. Archaeology, too. helps but little, since the buildings of Roman Palestine have swamped most of the Hellenistic remains. One exception must be noted: the tombs of the Hellenized Sidonian military settlers at Marisa in Idumaea, the walls of which are decorated with frescoes of fine hunting scenes, indicate that Hellenic civilization had penetrated deep into the non-Greek population in this period. (These frescoes are reproduced in M. Rostovtzeff, Social *and Economic* History of *the Hellenistic World,* vol. i, plate lviii.)

The chronic state of hostility between Egypt and the Seleucid house, which in much of the 3rd century B.C. had been concerned with the coastal regions of western Asia Minor, received a new impetus with the accession to the Seleucid throne of the energetic Antiochus III the Great (223–187), who aimed to win southern Syria and I'alestine from Egypt, now weakly governed, and thereby establish the frontier to which Seleucus I had unwillingly renounced his claim in 301 B.C. After his severe defeat by Ptolemy IV at Raphia in 217, however, Antiochus was for several years occupied with internal troubles, and it was therefore not until about zoo B.C. that he could think again of an attack on Egypt. There a child—Ptolemy V Epiphanes—had recently ascended the throne, and the government was in the hands of overpomerful ministers who were more concerned with feathering their own nests than with preserving the integrity of the kingdom. At Panion, on the northern boundary of Galilee, the armies of Antiochus and Ptolemy met and Ptolemy was deieated. Thus the Ptoleinaic possessions north of the Sinai desert, including Palestine, passed into the hands of the house of Seleucus.

The **Seleucids.**—The Seleucids brought to the problem of the administration of Palestine a different tradition from that which had been behind I'tolemaic rule. The latter was based on that careful exploitation of territory which was possible in a small and closely knit land like Egypt, and had thence been extended to the Ptolemaic provinces. This had never been possible for the Seleucids, who had always been masters of regions so vast as to render a unified and absolute control impossible. There is no sign of oppression in Seleucid government of the native peoples—they seem, on the contrary, to have aimed at improving their status as far as possible, largely through bringing them into contact with Greek modes of urban existence.

It might then be supposed that Seleucid rule would have been popular in Palestine. In fact, however, it was under Seleucid rule that the great uprising of the Jewish people, the revolt of the Maccabees, occurred. The explanation of this paradox is perhaps twofold. First, the Seleucids were in need of money, and second, the throne, at a critical time, was occupied by a tactless and neurotic king. Our knowledge of Seleucid rule in Palestine before the accession of Antiochus Epiphanes is very slight. The years from 188 B.C. onward were lean years for the dynasty, since the war with Rome. which had ended (in 189) in a complete Roman victory, had cost it not only almost the whole of Asia Minor but also a yearly indemnity of 15,000 talents. It is therefore not surprising that the first glimpse we have of Seleucid rule in Palestine tells of an attempt by Heliodorus, the leading minister of Seleucus IV (187–17j), to deprive the Temple in Jerusalem of its treasure. His failure mas soon ascribed to divine protection (a common feature of Greek historical writing: compare the stories of the various assaults on Delphi).

With the accession of Antiochus Epiphanes in 175 B.C. relations rapidly deteriorated. Antiochus appears to have aimed at a wholesale restoration of the Seleucid empire in the east, including an occupation of Egypt, as a counter to the loss of the western provinces occasioned by the peace of Apamea. (See SELEUCID DYNASTY.) He made an unwise beginning in Palestine by establishing a philhellenic high priest, and it is clear from this and from his whole subsequent policy that he wished to extirpate Jewish religion from its central stronghold (there is no indication that he persecuted Jews of the Diaspora living in the cities of his kingdom). (See also JEWS: *Antiochus* Epiphanes.)

Antiochus invaded Egypt in 170 or 169 B.C., returning to Syria by way of Jerusalem, where he and his army despoiled the Temple of all its wealth. Two years later, after his humiliating expulsion from the gate of Egypt by the Roman legate (see SELEUCID DYNASTY: *187–164* B.C.), he sent a financial official to exact taxes irom the cities of Judaen. Antiochus' official attacked the city of Jerusalem by guile and largely destroyed it, and built a fortified position on the citadel. called by the Greeks the Akra. This became the symbol of Judah's enslavement, though in itself the presence of a royal garrison in a Hellenistic city was by no means unusual. Its imposition was followed by an open attack on religious practice, many of the rites of which were forbidden.[1] Noncompliance with the order, which contained many items calculated to raise the bitterest resistance in the hearts of lam-abiding Jews, such as the prohibition of circunicision and the abolition of the observance of the Sabbath, was punishable by death. Finally on the 15th day of the Hebrew month Kislev (December), 167 B.C., the "abomination of desolation," namely the altar of Zeus, was set up in the Temple in Jerusalem. It was this above all which summoned forth the resistance of the sons of the aged priest Mattathias led by Judas Maccahaeus. (See MACCABEES.)

The resistance, it must be emphasized, came from only a section of the population. The century and a half of Greek rule had Hellenized much of the upper class of Jerusalem, and some of the characteristic features of Greek city life, such as the ephebic institute and the gymnasia, had been established on the initiative of this section of the ruling class which was able to accept a less radical observance of Judaism and combine it with loyalty to the throne. Throughout the revolt and indeed until the closing days of the Hasmonaean house, there is always this third element to be taken into account.

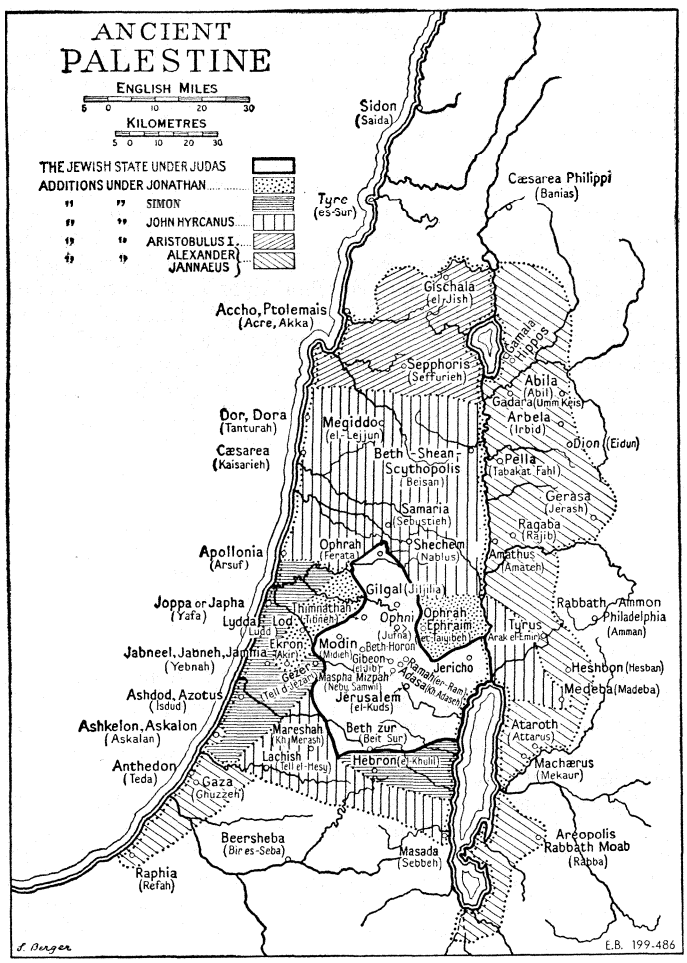
Judas proved himself a leader of high quality. He successfully resisted the weak forces sent by the Seleucid authorities, and after three pears of intermittent warfare he succeeded in purifying the Temple, though the Akra still remained in Seleucid hands (Dec. 165 B.C.).

After the death of Antiochus Ephiphanes the numbers of claimants to the Seleucid throne made a continuous policy toward Palestine impossible, because each claimant felt the need to seek support wherever it might be found. Thus, Jewish high priests were bought and bribed by the kings and dynasts of Syria. This development enabled Judas and those who succeeded him to hold their own and eventually to establish a hereditary dynasty. In 163 an agreement was reached with the Seleucid regent Tryphon (who feared the appearance of a rival in Syria), through which the Jews received back their religious liberty. But at the same time the regular practice of pagan worship, beside the Jew-

[1] According to I Macc. i, 41 if., Antiochus issued an edict imposing uniformity of religious practice in the whole Seleucid empire, but no reference to this occurs in II Maccabees or Josephus, and it can hardly be historical.

ish, was established, and a Seleucid nominee was appointed high priest. Thus were laid the seeds of fresh revolt. Almost immediately Judas again took the field and scored a considerable victory over Nicanor, the Seleucid general. in which Nicanor was killed'. Within two months. however, Demetrius I, the Seleucid king, sent Bacchides to take up a position near Jerusalem, and in the engagement which followed Judas lost his life (161).

The Hasrnonaean Priest-Princes. — In the following years dynastic disputes within the Seleucid empire prevented a succession of rulers from settling the Palestinian question. Jonathan, the brother and successor of Judas (161–143), seems in the opening years of his leadership to have established a sort of secondary government in Michmash near Jerusalem, in opposition to the recognized government in the city itself. It was a sign oi his grow-



ing power and of the importance of favouring the Hasmonaean party generally that in 153 one of the Seleucid pretenders, Alexander Balas, in order to outplay the legitimate king, Demetrius I, granted Jonathan the office of high priest and gave him the Seleucid rank of a courtier, thereby legitimizing his position. Demetrius II, at the request of Simon the successor of Jonathan (143–135), granted the Jews freedom from taxation in 143, and at the same time Simon acquired the status of a recognized secular ruler; the year of his assumption of rule was regarded as the first of a new era. and official documents were dated in his name and by his regnal year.

In 142–141 Simon forced the Syrian garrison on the *Akra* to surrender, and the Jews passed a decree in his honour, granting the right of permanent incumbency to Simon and his successors, until "an accredited prophet" should arise. It was thus in Simon's reign that the rule of the priest-prince was transformed into a secular hereditary rule. The Seleucid king recognized this, granting Simon the right to issue his own coins.

Simon's reign was one of expansion abroad, at the expense of the Seleucid authorities, and peace and prosperity at home. His son, John Hyrcanus I (135–104), reigned as a secular monarch, save that his coins bear the legend "John the High Priest." In the year of his accession Antiochus Sidetes, the last great Seleucid king, set out to reconquer Palestine; he laid waste the country, besieged Jerusalem and imposed harsh terms on Hyrcanus when he surrendered.

The death of Sidetes, however, and the reaccession of Demetrius II, enabled Hyrcanus to reconquer much territory outside Judaea. Toward the end of his reign he conquered and destroyed Samaria, despite opposition both from the reigning Seleucid, Antiochus Cyzicenus, and from his father-in-law Ptolemy Lathyrus. In internal policy. however, he made the grave error of quarrelling with one of the two main Jewish ecclesiastical parties, the Pharisees. who followed the Law with great strictness and with whom the Maccabaean movement had in origin close affinity, and siding with their opponents, the more liberal Sadducees. This is an early instance of that denial of the revolutionary origin of the movement which became very obvious in the reign of Alexander Jannaeus. Hyrcanus I was succeeded by Aristobulus (104–103), who extended Hasmonaean territory northward and is said to have assumed the title of king (basileus), though on his coins he appears. like Hyrcanus I, as high priest.

The reign of his brother and successor Alexander Jannaeus was long (103–76) and largely filled with wars. He imposed his rule rigorously over an increasingly large area, including both Transjordan and the cities of the coast. Still more clearly than Hyrcanus I he attests the change in direction and aim of the Hasmonaean house. He was the bitter enemy of the Pharisees. his coins bear Greek as well as Hebrew legends. and his title on them is simply "King Alexander.!' He was succeeded by his widow, Salome Alexandra, who reversed his policy and was guided by powerful religious advisers, members of the Pharisaean movement. Xfter her death in 67 B.C. her two sons Aristobulus and Hyrcanus II fought for the succession. Hyrcanus was defeated but mas encouraged to reassert his rights by Antipater, an Idumaean. son of the governor of Idumaea and father of the future Herod the Great.

At this stage Rome appeared on the scene. Pompey the Great during his reorganization of the lands of the newly conquered Seleucid kingdom also arranged the afiairs of Palestine (63 B.C.). He attempted to arbitrate between the brothers and eventually, after he had laid siege to and captured Jerusalem! appointed Hyrcanus II as high priest without the title of king adopted by his predecessors. He also imposed taxes on the Jews and curtailed Jewish dominions, removing a number of Greek cities from Hasmonaean rule and transferring them to the jurisdiction of the newly appointed governor of Syria.

After the death of Pompey, however, the power of Antipater and his family greatly increased. Hyrcanus II became a figurehead of no importance, and Antipater himself, in return for services to Julius Caesar, received Roman citizenship and was awarded the title of procurator of Judaea, while his sons Phasael and Herod became respectively governors (*strategoi*) of Jerusalem and Galilee. The unexpected occupation of Palestine by Parthian troops in 40 B.C. altered the situation. Antigonus. of the family of Aristobulus and therefore a legitimate Hasmonaean: won the favour of the Parthians and was established by them as king and high priest of Jerusalem. Phasael committed suicide, while his brother Herod escaped to Rome.

The **Herodean** House and the Roman Procurators. — Herod. in Rome, was recognized by the senate, with the approval of Octavian and Mark Antony, as king of Judaea (40 B.C.) and returned to Palestine in 39 B.C., from which shortly afterward Roman troops expelled the Parthians. whose popularity in Palestine had been and subsequently remained considerable. After struggles against Antigonus, the Parthian nominee, in which he was assisted by Roman troops, Herod eventually captured Jerusalem. and shortly afterward married a niece of Antigonus, thus probably consoling those who remained loyal to the memory of

[1] It was after this that the Jews (if we may believe I Macc. 8) entered into relations with Rome; *see* E. Schürer, *Geschichte des jüdischen Volkes im Zeitalter Jesu Christi*, i, ed. 3-4, 220, note 32.

the now almost defunct Hasmonaean house—Antigonus, when he fell into the hands of his enemies, being executed by order of Mark Antony.

The accession of Herod, the Roman protégé, the Idumaean and Gentile. brought to Palestine the peace which in the years of independence it had often lacked. His long reign (37–4 B.C.) was marked by general prosperity. Between 31 and 20 Augustus restored to him the Jewish territories which Pompey had taken away, and in this enlarged kingdom he created a sound administrative system of Hellenistic type. Toward the end of his life the complex demands of a vast family (he had ten wives at least) led him into difficulties regarding the succession, and it was then that he developed into the gruesome and vicious figure which Christian tradition has made so familiar. On his death the country again entered a period of divided rule, which led to the reestablishment of direct Roman government. Augustus decided in 3 B.C., in the presence of the three sons of Herod, that Archelaus should rule Judaea. Samaria and Idumaea (*i.e.,* central and southern Palestine), Antipas Galilee and Peraea (Transjordan) and Philip Trachonitis, Batanea and Auranitis (the area between the Decapolis and Damascus).

The fate of the rulers (of whom Philip and Antipas were called tetrarchs. Archelaus ethnarch) and their territories was difierent. Philip, the most peaceable of the three, ruled the northern area until his death in A.D. 34. Antipas reigned in Galilee and Peraea until A.D. 39. but was then banished by Caligula on the ground that he had parleyed with Rome's enemies. Archelaus reigned for ten years only; he was removed at the request of his subjects in A.D. 6. The government of southern Palestine then passed to a series of undistinguished Roman procurators, the last of whom (Pontius Pilate, A.D. 26–36) lost office for the unnecessary massacre of some Samaritans. On his removal I'alestine was united under Herod Agrippa I. the protégé of the emperor Gaius. who had already succeeded Philip in the north in A.D. 34. The tetrarchy of Antipas was added on his removal in 39. On the death of Agrippa in 44 the entire kingdom passed under Roman rule and was made a procuratorial province.

Disturbances in the early years of procuratorial rule were frequent and largely caused by maladministration. Serious trouble arose under Ventidius Cumanus (48–52). and under his successor, the imperial freedman Felix (52–60), rebellion was open though sporadic. The attempted extortions of Gessius Florus, procurator 64–66, led in 66 to the decisive and final outbreak.

The organization of the Jews was better than it had previously been, and they nere successful in an early engagement against the governor of Syria, who had advanced to Palestine with two legions to assist the hard-pressed procurator.

In 67, however, Vespasian, the iuture emperor, with his son Titus, arrived with a force of about 60,000 men, and the war became increasingly bitter. By the end of 67 Galilee was captured, anti Judaea was reduced in three campaigns which ended with the fall of Jerusalem in A.D. 70. The Temple was destroyed, though tradition recorded that Titus gave orders that it was to be spared, and the city became the permanent garrison town of a Roman legion. By A.D. 73 all resistance had ceased. Palestine now became the province Judaea (the name of the part being taken for the whole), administered by a legate of senatorial rank commanding the 10th legion, with the title *Legatus Augusti* pro *praetore provinciae Judaeae.*

BIBLIOGRAPHY.—The main ancient sources for the period are Josephus, *Antiquitates Judaicae* and *Bellum Judaicum;* I and II Maccabees (*see* MACCABEES, BOOKS OF for a discussion of their relative values). For other Greek and Latin sources *see* the list in *Cambridge Ancient History,* vol. viii, pp. 778-780. The most valuable general modern work is E. Schürer, *Geschichte des jüdischen Volkes im Zeitalter Jesu Christi,* vol i. ed. 3–4 (Leipzig, 1901), which also gives a list of Hebrew sources. *See* also *Cambridge Ancient History,* vol. viii, is and x; M. Rostovtzeff, *Social and Economic History of the Hellenistic World,* vol. i–ii (Oxford, 1941). For the Maccabaean period *see* Eduard Meyer, *Ursprung und Anfänge des Christentums,* vol. ii (Stuttgart and Berlin, 1921); E. Bevan, *Jerusalem Under the High Priests* (London, 1904); E. Bickermann, *Der* Gott *der Makkabäer* (Berlin, 1937). On the Herodian dynasty *see* W. Otto, in Pauly-Wissowa, *Real-Encyclopädie,* Supplbd. ii (Stuttgart, 1913): A. H. M. Jones, *The Herods of Judaea* (Oxford, 1938). (P. M. F.)

FROM A.D. 70 TO THE TURKISH CONQUEST (1516)

Palestine Under Roman and Byzantine Rule.—The destruction of Jerusalem was followed by the dispersal of the Jews, for whom till then it had been the religious and political centre. The first seat of the Sanhedrin was at Jamnia, where the rabbinic system began to be formulated. The rigid code of dogmas and observances elaborated by the rabbis exercised a singularly uniting power over the scattered nation and prevented an absorption of the Jewish people into the Roman empire.

It would appear that at first, after the destruction of Jerusalem, no specially repressive measures were contemplated by the conquering Romans, who rather attempted to reconcile the Jews to their subject state by a leniency which had proved successful in the case of other peoples brought by conquest within the empire. But they had reckoned without the isolating influence of rabbinism. Here and there small insurrections took place, in themselves easily suppressed but showing the Romans that they had a turbulent and troublesome people to deal with. At last Hadrian determined to stamp out this stubborn Jewish nationalism. He issued an edict forbidding the reading of the Law, the observance of the Sabbath and the rite of circumcision, and determined to convert the still half-ruined Jerusalem into a Roman colony.

The consequence of this edict was the meteorlike outbreak of Barcocheba (132–135). The origin of this person and the history of his rise to power are unknown. It was his recognition as the Messiah by the celebrated rabbi Aqiba (Akiba ben Joseph), then the most influential Jew alive. which placed him in command of the insurrection, with 200,000 men under him. Jerusalem was captured, as well as a large number of strongholds and villages throughout the country. Julius Severus, sent with an immense army by Hadrian, came to quell the insurrection and recaptured Jerusalem. The rebels fled to Bethar—the modern Bittir, near Jerusalem, where the fortress garrisoned by them still remains. under the name Khurbet el-Yahud or "Ruin of the Jews"—and were defeated there and slaughtered in a sanguinary encounter. Hadrian then turned Jerusalem into a Roman colony, changed its name to Aelia Capitolina, built a temple of Jupiter on the site of the Jewish Temple and (it is alleged! a temple of Venus on Mt. Golgotha, and forbade any Jew, on pain of death, to appear within sight of the city.

This disaster was the deathblow to hopes of a Jewish national independence, and the leaders of the people devoted themselves thenceiorth to legal and religious study in the rabbinical schools, which after A.D. 135 developed in various towns in the previously despised province of Galilee.

I'alestine continued directly under Roman rule. East of the Jordan. Cornelius Palma added Gilead and Moab to the empire under Trajan in A.D. 105. In 295 Auranitis, Batanea and Trachonitis were brought within the provincial system.

The conversion of Constantine to Christianity—or rather the profession of Christianity by Constantine—seemed likely to result in another Jewish persecution, foreshadowed by severe repressive edicts. This, however, was averted by the emperor's death.

The spread of Christianity under the political auspices of Byzantium was checked ior a while under Julian the Apostate. who, among other indications of his opposition to Christianity, rescinded the edicts against the Jews on his coming to the throne in 361 and gave orders for the restoration of the Jewish Temple. The latter work was interrupted almost as soon as begun by an extraordinary phenomenon—the outburst of flames and loud detonations. easily explained at the time as a divine judgment on this direct attempt to falsify the prophecy of Christ.

On the partition of the empire, in A.D. 395, I'alestine naturally fell to the share of the Byzantine emperor. For more than 200 years after this there was a period of peace and comparative prosperity in I'alestine, fostered by the development of pilgrimage and of the cult of holy places, varied by occasional persecutions of the Jews. The elaborate building operations of Justinian (527–565) must not he forgotten. The "Golden Gate" of the Temple area and part of the church which is now el-Aksa mosque at Jerusalem are attributable to him.

This interval of tranquillity came abruptly to an end in 611, when Chosroes II *(see* KHOSRAU), king of Persia. made an inroad into Syria; joined by the Jews, anxious to revenge their misfortunes, he swept over the country. carrying plunder and destructiun wherever he went. Jerusalem was taken; the Holy Sepulchre church was destroyed and its treasures carried off; the other churches were likewise razed to the ground; the patriarch was taken prisoner. Thus for a time the province of Syria with Palestine was lost to the empire of Byzantium.

The emperor Heraclius reconquered the lost. territory in 628. But his triumph was short-lived. A more formidable enemy was already on the way, and the final wresting of Syria from the enfeebled eastern Roman empire was imminent.

The Rise of Islam. — The separate tribal units of Arabia, more or less impotent when divided-anti at war with one another, received a powerful if impermanent bond of union from the prophet Mohammed, whose knowledge of human nature (at least of Arab human nature) enabled him to formulate a religious system that was well fitted to command an enthusiastic acceptance by the tribes to which it was primarily addressed. His successor. Abu-Bekr, called on the tribes of Arabia to unite and to capture the fertile province of Syria from the Christians. Heraclius had not sufficient time to prepare to meet this new foe, and was defeated in his first engagement with Abu-Bekr. (For the general history of this period *see* CALIPHATE.) The latter seized Bostra and proceeded to march to Damascus. He died, however: before carrying out his design (A.D. 634), and was succeeded by Omar, who, after a siege of 70 days entered the city. Other towns fell in turn, such as Caesarea, Samaria (Sebastiya), Nablus (Shechem), Lydda (Ludd) and Jaffa.

Meanwhile Heraclius was not idle. He collected a huge army and in 636 marched against the Arabs. The latter retreated to the Yarmuk river. where the Byzantines met them. Betrayed, it is said. by a Christian who had suffered personal wrongs at the hands of certain of the Byzantine generals: the army of Heraclius was utterly deieated, and with it fell the Byzantine empire in Syria and Palestine.

Omar's army then marched against Jerusalem, which after a feeble resistance capitulated. The terms of peace imposed upon the Christians were moderate, the humiliating conditions afterward ascribed to Omar being in reality the product of a later period. when Moslem condescension and intolerance had hardened. When the terms were signed Omar, under the leadership of the Christian patriarch Sophronius, visited the Holy Rock (the prayer place of David and the site of the Jewish Temple). This he found to be defiled with filth, spread upon it by the Christians in despite of the Jews. Omar and his followers in person cleaned it and established the place of prayer which, though later rebuilt, has borne his name ever since.

Dissensions and rivalries soon broke out among the Moslem leaders, and in 661 Mu'awiyah, the first caliph of the Omayyad dynasty, transferred the seat of the caliphate from Mecca to Damascus. where it remained till the Abbasids seized the sovereignty and transferred it to Baghdad (750). Rivals sprang up from time to time. The caliph Abdalmalik (Xbd ul-Malik), in order to weaken the prestige of Mecca, set himself to beautify the holy shrine of Jerusalem: and built the Kubbet es-Sakhrah, or Dome of the Rock, which still remains one of the most beautiful buildings in the world. In 831 the Church of the Holy Sepulchre was restored: but about 100 years later it was again destroyed as a result of the revolt of the Karmatians (*q.v.*), who in 929 pillaged Mecca. This produced a Moslem exodus to Jerusalem. The Carmathian revolt, one of the most far-reaching splits in the Moslem world, was followed by others; in 936 Egypt declared its independence. under a line of caliphs which claimed descent from Fatima, daughter of the prophet *(see* FATIMITES): and in 096 Hakim bi-Amrillah mounted the Egyptian throne. This madman caused the Church of the Holy Sepulchre to be entirely destroyed and claimed himself to be the incarnation of deity. His cult was founded by two Persians. Darazi and Hamza ibn Ali, in Lebanon, where among the Druses it still persists *(see* DRUZE).

The contentions between the Abbasid and Fatimite caliphs continued till 1072, when Palestine suffered its next invasion. This was that of the Seljuk Turkomans from Khorasan. On behalf of their king, the Khwarizmian general Atsiz invaded Palestine and captured Jerusalem and Damascus, and then marched on Egypt to carry out his original purpose of destroying the Fatimites. The Egyptians, however, repulsed the invaders and drove them back, retaking the captured Syrian cities.

The Crusades. — The sufferings of the Christians and the desecrations of their sacred buildings during these troubled times created widespread indignation through the west. The church responded, and a motley crowd, principally of Frankish origin, set out in 1096 for the Holy Land. Others, under better generalship, followed; but of the 600,000 who started from their homes only about 40,000 succeeded in reaching Jerusalem; ill discipline, famine and battles by the way having reduced their ranks. They captured Jerusalem. however. in July 1099, and the leader of the assault, Godfrey of Bouillon, was made ruler of Jerusalem.

So the Latin kingdom of Jerusalem was founded, on a combination of genuine, if misdirected, religious fervour with the land hunger of the younger sons of the nobility of feudal Europe, the enterprise of the rising merchant class of the Mediterranean and the opportunism of the still half-barbarous rank and file *(see* CRUSADES). It was not a combination calculated to endear the Frankish invaders to the native population: and relations between Moslems and Christians were embittered by it.

The abortive second crusade (1147), led by the kings of France and Germany* came to aid the rapidly weakening Latin kingdom after its failure to hold Edessa against Nureddin, the ruler of northern Syria. In 1174 Nureddin died, and his kingdom was seized by Saladin (Salah ed-Din), a Kurd who, with his uncle Shirguh, the general of Nureddin, had previously captured Egypt. Saladin almost immediately set himself to drive the Franks from the country. The Frankish king was the boy Baldwin IV, who was afflicted with leprosy. After being defeated by Saladin at Banias, the Franks were compelled to make a treaty with the Moslem leader. The treaty was broken, and Saladin proceeded to take action. The unhappy leper king meanwhile died. his successor, Baldwin V, also a young boy, was poisoned. and the kingdom passed to the factious Guy de Lusignan, who in the following year (1187) was crushed by Saladin at the battle of Hattin, which restored Palestine to the Moslems.

The third crusade (1189) to recover Jerusalem was led by Frederick I of Germany. Acre was captured, but quarrels among the chiefs of the expedition made the enterprise ineffective. It was in this crusade that Richard Coeur de Lion was especially distinguished among the Frankish warriors.

Saladin died in 1193. Within the next 28 years took place the fourth and fifth crusades, even less effective than the third. But Saladin's successors, being less warlike than he, proved more accommodating to the Franks, and in 1229 the free-thinking emperor Frederick II, while actually under excommunication by the pope for his procrastination in embarking upon the crusade. negotiated a treaty with the sultan of Egypt which gave the Franks Jerusalem, Bethlehem and Nazareth, and a strip of territory connecting them with the coast, for ten years.

A new element, the Mongolians of central Asia, now burst on the scene. The tribes from east of the Caspian had conquered Persia in 1218. They were driven westward by pressure of the Tatars, and in 1228 had been called by the ruler of Damascus to his aid. In 1230, however, they transferred their alliance to the sultan of Egypt and pillaged northern Syria. Driven downward through Galilee they seized Jerusalem, massacred its inhabitants and plundered its churches. They then marched on to Gaza, where the Egyptians joined them. and together they inflicted a crushing defeat on the Christians and Moslems of Syria, for once compelled to unite by the common danger.

The Khwarizmians and Egyptians afterward quarrelled, and the former were compelled to retire, leaving Palestine under the rule of the Mameluke sultans of Egypt. Shortly afterward however, another central Asiatic invasion, that of the Tatnr tribes, took place. Under their leader Huiagu these tribes came by nay of Baghdad, which they captured in 1258, and in 1260 attacked and

captured Damascus and ravaged Syria. Bibars (Beibars, Baibars), general of the Egyptian sultan Kotuz. met and drove them back and, having murdered his master, became sultan in his stead. He then proceeded to attack and destroy the relics of Christian possession in Palestine. One after another — Caesarea, Safad, Jaffa, Antioch — they fell, leaving at last Acre (Akka) only. Bibars died in 1277, and in 1291 Acre itself was captured by Khatel, son of Kala'un, who put an end to Frankish rule.

During the 14th and 15th centuries there is little of interest in the history of Palestine. Early in the 14th century the Christians made efforts to creep back to their former possessions and churches were rebuilt in Jerusalem, Bethlehem and Nazareth; but another devastation followed the ferocious inroads of the Mongolian Timur (Tamerlane) in 1400.

FROM THE TURKISH CONQUEST TO 1918

Four centuries of Ottoman Turkish rule were inaugurated in 1516 when the war between the Turkish sultan Selim I (the Grim) and the Mameluke rulers of Egypt resulted in the transference of the country to the victorious Turks. This change of rulers produced little change in the administration or condition of the country. Local governors were appointed from Constantinople where revenues were annually sent; various public works were undertaken such as the rebuilding of the walls of Jerusalem by Soliman the Magnificent in 1537; but on the whole Palestine ceases from this point to have a history till the 19th century. Its annals record little save the sanguinary quarrels of local sheikhs and the oppression of the peasants by them or by the officials. The most interesting personality in a dreary period is that of the Druse prince Fakhr ed-Din (1595–1634). In defiance of the Turkish sultan he established a Lebanese kingdom which included northern Palestine as far as Acre; he also took a dilettante interest in art, a consequence of his temporary exile in Italy.

The order imposed by the Turks on a turbulent country did not endure. The German botanist Leonhard Rauwolf, who visited Palestine in 1575, left a vivid description of the difficulties that beset even so simple a journey as that from Jaffa to Jerusalem. He found Jaffa in ruins. A safe-conduct had to be obtained from the governor of Ramleh before the party could proceed. At Yazur they were stopped by an official who extorted heavy blackmail on the ground that the sultan had given him charge of the holy places and had forbidden him to admit anyone to them without payment. Farther on they had a scuffle with certain "Arabians" and at last, after accomplishing the passage of the "rough and stony" road that led to Jerusalem, they were obliged to dismount before the city gate till they should receive licence from the governor to enter.

Toward the close of the 18th century a chief named Dhahir el-Amir rose to power in Acre. To him fled from Egypt an Albanian slave named Ahmad, who bore the surname of el-Jazzar (the Butcher) because of the obedient skill with which he had rid his Mameluke master of numerous rivals. He had, however, incurred punishment for indiscipline and so took refuge with the Palestinian chief, After five years his former master died and el-Jazzar returned to Egypt. Soon Dhahir el-Amir revolted against the Turkish government and el-Jazzar, because of his long residence with and full knowledge of his protector, was commissioned to quell the rebellion. He succeeded and was installed as governor of Acre in Dhahir's place. He had crude aesthetic tastes and Acre owes some public buildings to him, but he was also capricious and tyrannical and lived up to his surname. Till 1791 there was a colony of French merchants with factories and ofiices at Acre; el-Jazzar that year summarily ordered them to quit the town. In 1798 Napoleon Bonaparte after conquering Egypt invaded Palestine in pursuit of his scheme of stirring up revolt against the Turk in Syria and conquering the near and middle east at the head of an adventurer army with a French core. He defeated el-Jazzar and besieged him in Acre, while a relieving column of Turks and local Arab irregulars was completely defeated by his lieutenant. Gen. J. B Kléber, near Jebel et-Tur (Mt. Tabor). But the timely arrival of British warships commanded by Adm. Sir Sidney Smith saved Acre. A final attempt to storm the town was repulsed and Napoleon withdrew to Egypt.

The traveller Constantin François, comte de Volney, visiting Palestine in 1785, estimated the population of el-Jazzar's pashalik of Acre (which extended northnard beyond Beirut. eastward to the Anti-Lebanon range and southward to Caesarea) at 300.000 and that of the remainder of Palestine at only 50,000, of whom perhaps 20.000 were in Jerusalem, 5.000 at Hebron and rather more at Nablus, 3,000 at Bethlehem and 2,000 at Gaza; the economy of the country was probably more decayed than it had been at any time for at least 2,000 years. But the 19th century was to see a change for the better. In 1831 Palestine came under the government of the Albanian Mohammed Ali the Great, pasha of Egypt, who was virtually independent of his nominal master the sultan. The international consequences of his attempt to carve an empire for himself out of the Ottoman dominions are described elsewhere (see EASTERN QUESTION, THE).

Palestine, which had welcomed the new ruler, soon found that, like Aesop's frogs, it had exchanged Ring Log for King Stork. A rising in 1834 was ruthlessly suppressed. Finally in 1840 the appearance of the British, Austrian and Russian fleets off Beirut and the advance of a Turkish army from the north led to a general revolt in which Palestine joined. Acre surrendered and the Egyptians hastily evacuated the whole country.

After 1840 the Turkish government gradually strengthened its hold on Palestine. The political power of the local sheikhs was greatly reduced, to the unmixed advantage of the whole country; and the increase of European interests led to the establishment of consulates and vice-consulates of the greater powers in Jerusalem and in the ports. The rivalry of religions continued. In 1847 the dispute between Greek Orthodox and Latin ecclesiastics in the Church of the Nativity at Bethlehem, about the right to mark with a star the birthplace of Christ, became one of the prime causes of the Crimean War.

On June 30, 1855, on the occasion of the visit of a European prince, the cross was for the first time since the crusades borne aloft through the streets of Jerusalem. Three years later the sacred area of the Haram esh-Sherif — the mosque on the site of the Temple of Jerusalem — was for the first time thrown open to Christian visitors. The last 40 years of the century were marked by a remarkable process of colonization and settlement — French and Russian monastic and other establishments, some semireligious and semipolitical; German colonies, followed after the imperial visit in 1898 by more imposing official foundations; fanatical or freakish American communities; Zionist agricultural settlements — all, so to speak, nibbling at the country and each so intent upon gaining a step on its rivals as to be forgetful of the gathering storm. In 1896 Theodor Herzl (*q.v.*) issued his proposal for the establishment of a Jewish state in Palestine and in 1898 went to the country to investigate its possibilities (see ZIONISM). The same year was marked by the picturesque visit of the German emperor, William II. (R. A. S. M.; G.E.K.)

1900–1918. — Fresh signs of danger from European rivalries and Turkish pan-Islamic ambitions became visible early in the 20th century, when schemes for the extension of the Turkish pilgrim railway to the Egyptian border were discussed and surveys undertaken. In 1906 came the significant dispute between Great Britain and Turkey concerning the frontier of the Sinai district of Egypt. After crossing the border at Rafa south of Gaza and at Aqaba, the Turks recoiled before an ultimatum and the frontier was delimited. In the same year the opening of a narrow-gauge railway from Der'a on the Damascus line to Haifa increased the trade and prosperity of that port. The Young Turk revolution of 1908 passed off quietly in Palestine where the officials and small garrisons declared for the new regime, and the population acclaimed it with less fervour.

Immediately before the outbreak of World War I Palestine mas passably prosperous. Jewish colonization. foreign philanthropy and an increasing tourist and pilgrim traffic greatly mitigated the natural poverty of the country. The presence of relatively large numbers of foreigners — a few consuls, traders and professional men, many missionaries and teachers and the Zionist and German colonists — improved the amenities of the larger towns and exer-

cised a restraining effect on Turkish officialdom. In spite of the rivalry of foreign interests and the mixture of creeds rind races the country was spared the crude scandals of Macedonia and Kurdistan. Education—of a sort—was fairly diffused among the townsfolk, more especially ainong the Jews and Christians, though the missionary schools too often made the Xrab into a poor imitation of a European or American rather than into a good citizen of the Ottoman empire. Below the peaceful surface there were stirrings; .the example of Egyptian progress under British control helped to promote a weak but perceptible Arab nationalism only aiming in Palestine at some form of local autonomy. The pan-Islamic movement, supported by the Turkish authorities, was a little stronger. Arab nationalists and pan-Islamists alike watched Zionist activities with increasing suspicion.

The outbreak of war between the Entente and Turkey (Sept. 1914) brought this quiet period to an end. For more than two years I'alestine was the base of large Turkish forces which occupled Sinai and made two major attacks on the Suez canal. There were Allied naval demonstrations on the Palestinian coast. Ahmed Jemal Pasha, governor general of Syria and commander of the Turkish forces. ruled the country with a rod of iron. The cessation of remittances proved fatal to large numbers of the Jews of the *halukkah* (dole), who died oi sheer want. The Zionists, after enjoying Jemal's favour, incurred his suspicion and suffered much minor persecution; his hand was heavy on all Arabs suspected of nationalism; locust plagues, conscription and the extreme corruption of the Turkish officers and officials bled the peasantry white. The British counteroffensive which began in the winter of 1916 and the conquest of Palestine are described elsewhere (see PALESTINE, OPERATIONS IS; WORLD WAR I). The fall of Jerusalem marked its first stage. The Turks and a German contingent retained most of Samaria and all Galilee until their final and coinplete overthrow in Sept. 1918. The victors, whose behaviour was generally admirable. were well received by the inhabitants of the country. It had suffered much in the past four years, but cruelly as the war had thinned the population and wasted the resources of Palestine. it had had one good result—the linking of the Haifa and Jerusalem railways with the Egyptian system and the construction by both combatants of a number of wells and bridges and a network of metalled roads. (P. GR.)

FROM 1918 TO THE OUTBREAK OF WORLD WAR II (1939)

Growth of Tension Between Arabs and Zionists.—Palestine under the Ottoman government was an integral portion of Syria. although the sanjak of Jerusalem, because of its peculiar problems and importance, was governed by a mutessarif referring directly to Constantinople. The last years before 1914 had witnessed, as in all other parts of Syria, a growth of Arab national sentiment demanding the decentralization of the Ottoman state and Arab autonomy. At the same time Zionist settlers founded the first co-operative agricultural colonies and laid in Tel Aviv. on the sand dunes north of Jaffa, the foundations of modem urban development. World War I had caused great hardship in Palestine, and the British military administration took the necessary measures to remedy the situation and to establish more modern methods of administration. Its task was made more difficult by the still-prevailing uncertainty about the future of the country in view of Xrab nationalism and of Zionist aspirations which were given official recognition by the declaration of the British foreign secretary, Arthur Balfour, on Nov. 2, 1917. This declaration read:

> His Majesty's Government view with favour the establishment in Palestine of a national home for the Jewish people, and will use their best endeavours to facilitate the achievement of this object, it being clearly understood that nothing shall be done which may prejudice the civil and religious rights of existing non-Jewish communities in Palestine, or the rights and political status enjoyed by Jews in any other country.

This declaration was endorsed by the principal Allied powers, especially the United States. but its terms were vague and allowed diderent interpretations. The British government had insisted from the beginning that there was no case for creating a Jewish state or commonwealth in Palestine at present, since 90% of the inhabitants were Arabic-speaking peoples whose political leaders had expressed demands for national status and seif-determination. Some statesmen, horn-ever (notably Pres. Woodrow Wilson. David Lloyd George and Gen. Jan C. Smuts), had committed themselves to the personal view that if Zionist settlement proved successful it might ultimately achieve statehood. The Zionists. for their part, had pressed on the British government "the principle of recognizing Palestine as the National Home of the Jewish people" and steadfastly continued to interpret the Balfour declaration in this sense. despite the British government's insistence on the actual formula of the declaration, whereby it could acknowledge a "dual uridertaking" toward both Zionist and Arab rights and aspirations. While the Zionists thus misrepresented the British undertaking, the Arabs feared that! whatever the verbal limitations, continuous Jewish immigration with its great economic strength must ultimately lead to the creation of a Jewish majority and the relegation of the Arabs to a subordinate place in Palestine. British policy. which tried to reconcile the two opposite aspirations of the Zionists and of the Arabs, could satisfy neither and found itself attacked from both sides. The military administration had to cope with these difficulties which were inherent in the situation. It tried to maintain peace and to re-establish the economic life, and it introduced Hebrew as the third official language in Palestine with equal status with English and Arabic. Though the prevailing conditions restricted Jewish immigration, nevertheless violent Xrab riots in April 1920, especially in Jerusalem, revealed the dangerous dissatisfaction of the Arab population.

The Mandate and the Constitution.—On July 1, 1920, Sir Herbert Samuel (later Viscount Samuel) was named high commissioner of Palestine and a civilian administration replaced the military one. Yet unrest did not subside. A serious Arab uprising occurred in 1921 in Jaffa, and Arabs and Zionists alike tried to influence the wording of the forthcoming mandate. which was finally passed by the council of the League of Nations on July 24, 1922, and entered into force on Sept. 29, 1923.

The mandate received an official interpretation in the British statement of policy issued by Winston Churchill as colonial secretary in June 1922, which rejected the suggestion that the Arabic population, language or culture might be subordinated to that of the Zionists. The latter, however, were in Palestine "as of right and not on sufferance,'! and might display their capacities in the "free development" of the national home "in order that it may become a centre in which the Jewish people as a whole may take . . . an interest and a pride."

This statement of British policy was accepted by the Zionist organization but rejected by the Arabs. who proclaimed a policy of nonco-operation with the government so long as the latter adhered to the Balfour declaration. The Arab movement was centred on associations comprising Moslems and Christians and on the Palestine-Arab congress, which elected in May 1921 a delegation of six to four Mohammedans and two Christians. with Musa Kasim Pasha el-Husaini as its leader. They demanded in London a Palestinian constitution with a democratic government. The negotiations met with no success and the Arab delegation complained that the British government "has placed itself in the position of a partisan in Palestine of a certain policy mhich the Arab cannot accept because it means his extinction sooner or later."

The Palestine constitution of Aug. 10, 1922, fell very short of the Arab expectations. It created a legislative council of 10 officials and 12 elected members—10 Arabs (8 Moslems and 2 Christians) and 2 Jews—under the chairmanship of the high commissioner, who was to have the right to veto all its decisions and the duty to do so when they conflicted with the mandate. The Palestinian Arabs decided to boycott the elections. As a result the legislative council was not constituted. The policy of nonco-operation which the Arab executive. elected by the Arab congress, pursued was opposed by a more moderate Arab party under the leadership of Raghib an-Nashashibi. the mayor of Jerusalem. Within the Arab executive the mufti of Jerusalem and president of the supreme Moslem council. Hajj Amin el-Husaini. gained more and more influence. When Sir Herbert Samuel left I'alestine in 1925 and was replaced by Lord Plumer. the constitutional problem

was not yet solved, but general tranquillity reigned, the country enjoyed a growing prosperity, its finances were in excellent order and Sir Herbert could point out manifold progress achieved during his tenure of office. Yet the years of tranquillity were not to last for long. Lord Plumer's successor, Sir John Chancellor, who assumed office in the summer of 1928, was presented with a resolution of the seventh Arab congress which met in Jerusalem on June 20, 1928: this demanded that "after ten years of absolute colonial rule in Palestine" a democratic system of government should be granted "in accordance with the covenant of the League of Nations and pledges and declarations made to the Arabs by the Allies."

Growth of the Jewish National Home.—During the first years of the mandate the foundations of the Jewish national home were firmly established. Jewish immigration began to increase until it reached its first peak in 1925, when 33,801 persons immigrated, mostly from eastern Europe. From that year on immigration began to decline, and a severe economic crisis gripped the Jewish settlement in Palestine. In 1927 emigration of Jews from Palestine exceeded the immigration, and not until 1929 was the trend definitely reversed, though even in that year the net immigration amounted to only 3,503. For the whole first decade (1920–29) the net immigration of Jews into Palestine, according to official figures, amounted to 77,063. The successful settlement of such a number of new immigrants in a small country and on a relatively very high standard is a testimony to the energy and devotion with which Zionist work was carried out. While in the census of Oct. 1922 the Jews formed 12.9% of the settled population, in July 1929 they were estimated to form 18.9%. The majority settled in the cities, where they began to develop new industries. The centre of their urban settlements was Tel Aviv, now rapidly growing into a thriving city very distinct from the more traditional character of neighbouring Jaffa. In Haifa and in Jerusalem the new Jewish settlers built modern residential quarters, and near Haifa the first large-scale industries were established.

A smaller part of the Jewish population settled in villages, partly devoted to citrus plantation but more and more to mixed farming. In these villages the most modern methods of agriculture were employed and all the labour was done exclusively by Jewish workers. Hebrew was rejuvenated as a modern written and spoken language, while Yiddish and the European languages were discouraged by the Zionist movement. The Hebrew school system was crowned in 1925 by the opening of the Hebrew university on Mt. Scopus near Jerusalem. Special attention was paid to public health and to child welfare. The two most important economic concessions in the country, the Palestine Electric corporation and the Palestine Potash company for the exploitation of the mineral wealth of the Dead sea, were both established by Jewish enterprise. At the Zionist congress in Zürich, Switz., in Aug. 1929, a Jewish agency was created, consisting of Zionists and representatives of non-Zionists, to promote the further development of the Jewish national home with larger subventions than formerly from persons in the U.S.

The Disorders of 1929.—In Aug. 1929 serious Arab riots broke out at Jerusalem, Hebron and Safad, as a result of the growing religious and national feeling which had started with agitation around the respective Jewish and Moslem rights concerning the Wailing Wall, one of the sacred places in Jerusalem. The riots were quickly suppressed by the British, and a commission of inquiry reported that Arab fears of Jewish immigration and Jewish land purchase had formed the fundamental cause of the riots and suggested closer control of Jewish immigration and protection for the Arab peasants and tenants. The British government accepted these recommendations in a White Paper in May 1930. Its attitude provoked violent protests from the Zionists. The views of the government were, however, supported by Sir John Hope Simpson, who was sent to investigate the problems of land and immigration. The statement on policy published by the British government on Oct. 20, 1930, as a result of his findings was regarded by the Zionists as so hostile to their aspirations that Chaim Weizmann resigned in protest his presidency of the Zionist organization, thus obtaining from the prime minister, Ramsay MacDonald, a much more favourable "interpretation" of the White Paper. The Arabs, who had demanded the establishment of a democratic government and the promise of Palestinian independence, were bitterly resentful of this volte-face under Zionist pressure.

Influences From Outside.—By 1931 complete order was restored in Palestine, at least outwardly. Events both in the Jewish and in the Arab world tended, however, soon to upset the *status quo*. An official census taken on Nov. 18, 1931, fixed the population of Palestine at 1,035,154, among them 759,952 Moslem Arabs and 90,607 Christians, mostly Arabs, as against 175,006 Jews, who thus formed 17% of the population. Thus, in spite of a remarkable growth of the Jewish population in ten years, the attainment of a Jewish majority seemed far away, if not out of the question. This situation changed after 1933. The wave of violent anti-Semitism which swept over Germany and Poland after Hitler's rise to power augmented the pressure for Jewish emigration from central and eastern Europe. Many of the new immigrants brought with them relatively large means which they invested in urban development, in new industries and in citrus plantations. In 1940 the population of Palestine was estimated at 1,529,559, of whom 456,743 or about one-third were Jews. By 1946 the population was officially estimated as 1,887,214, of whom 1,143,336 were Moslems, 583,327 were Jews and 145,063 were Christians. The remainder, comprising Druses, Samaritans, Bahais, Sikhs, Hindus, Metawilehs and persons professing no religion, numbered 15,488. Between 1920 and 1947 the total legal number of Jewish immigrants was 412,389. While the increase among the Moslem population was a result of their very high birth rate, the Jewish increase was largely caused by immigration, as is shown by the accompanying table. These official figures are probably lower than the actual figures, since there was a large amount of clandestine Jewish immigration, estimated in the aggregate at 30,000–40,000 in 1939.

Jewish Immigration–Emigration, 1920–38

Year	Immigrants	Emigrants
1920–1924	42,784	5,476
1925–1929	57,022	18,501
1930–1934	91,258	2,345
1935	61,854	396
1936	29,727	773
1937	10,536	889
1938	12,868	1,095

On the other hand, Arab political development was quickened by events in the neighbouring Arab countries. Everywhere the movement for independence and democratic institutions had made great progress. The Arabs in the neighbouring backward Transjordan enjoyed a large measure of independence and had received in 1929 representative institutions. Iraq, like Palestine, originally a mandated country under Great Britain, had seen the mandate terminated in 1932 and was admitted to the League of Nations. In Syria, a territory under French mandate, negotiations between France and Syria for the early independence of the country resulted in the treaty of Sept. 9, 1936. The complete independence of Egypt was recognized by Great Britain in the same year. Under these circumstances, tension in Palestine between the Jewish and Arab elements was steadily mounting; Arab discontent was voiced, for the time being, in strongly worded demands for independence and democratic self-government. The government announced at the end of Dec. 1934 its intention of establishing a legislative council "to secure the advice and assistance of the people of the country in carrying on the government of the country." While the Arabs expressed dissatisfaction with "the insufficient representation of the Arabs," they were nevertheless willing to work it; on the other hand, the Zionists rejected it uncompromisingly, and skilfully organized British parliamentary opposition to the proposals. Thereupon all the Arab parties united in Nov. 1935 and presented to the high commissioner a memorandum demanding the establishment of democratic government, the prohibition of the transfer of Arab lands to Jews and stoppage of

Jewish immigration until the absorptive capacity of the country had been determined. These demands were not accepted.

The Arab Revolt of 1936–38.—The long-smouldering Arab discontent flared up in an Arab revolution of unprecedented scope in April 1936. Local national committees under an Arab higher committee were organized throughout the country, and a general strike was prochimed which lasted until October. Soon armed bands of Arabs were formed and engaged British military detachmerits in battle. Arabs from Syria and Iraq joined the Palestinian Arabs, arid the rulers and leaders of Iraq. Egypt and Saudi Arabia became actively interested in their cause. The Arab higher committee, formed on April 25, 1936, consisted of ten members, among whom were two Christians. In spite of increased emergency powers of the government and the arrest of many Arab leaders, the disturbances grew in violence. The British government dispatched a royal commission under Lord Peel to Palestine to investigate the trouble and sent military reinforcements.

In July 1937 the commission reported that the Arab and Jewish positions were irreconcilable and that the only hope of a solution lay in a partition of the country. The mandate should be terminated as in Iraq and Syria: and Great Britain should conclude treaties with an independent Arab state, consisting of Transjordan and the hill country of Palestine, and an independent Jewish state, consisting of the maritime plain and Galilee. while Jerusalem and Bethlehem and a narrow corridor connecting them with the sea should remain mandated territory, A transitional period was foreseen. The British government endorsed the findings of the commission. While one section of the Zionists was prepared to accept this scheme, at least as a temporary measure and with an extension of the area suggested for the Jewish state, the Arabs rejected any scheme of partition. In the fall, armed resistance was again widespread in spite of the energetic measures of the government. Military courts were established lo deal with the disorder. A strict censorship was imposed. The Arab higher committee and all Arab national committees were outlawed on Oct. 1, the Arab leaders were deported to the Seychelles Islands (Hajj Amin el-Husaini fled abroad). and a large number of important Arabs were imprisoned. The energetic measures of the government brought no peace. On the contrary, in 1938 Arab warfare was organized on a larger scale than ever before. and the Arabs controlled the country in most parts outside the large cities and the Jewish settlements. British troops, supported by aircraft. were engaged in many military operations. Extremist Zionist terrorist organizations resorted to violent reprisals in which many Arabs were killed. Civilian traffic throughout the country was suspended for varying lengths of time.

Strong military reinforcements, however, succeeded by the spring of 1939 in putting down the worst of the rebellion. Meanwhile the Pnlestine Partition commission under Sir John Woodhead had in Nov. 1938 set out three possible principles on which a partition might theoretically be effected. with suggested boundaries in each case, but had concluded by emphasizing the great political, economic and security objections inherent in any conceivable scheme. By this time Hitler's first dismemberment of Czechoslovakia had brought Europe to the brink of a general war, and the British government, with its vital strategic communications and other interests in the middle east. could not contemplate the prospect of continuing. indeed growing. hostility in the Arab countries, which the axis was able to exploit on the Palestine issue. In the light of the Woodhead report, Great Britain decided that the creation of independent Arab and Jewish states in Palestine was impracticable and that an effort should be made to promote a direct understanding between the Arabs and the Jews. With this end in view Great Britain invited representatives of the Palestinian Arabs and of the neighbouring Arab states, on the one hand, and of the Jewish agency, on the other, to meet in London early in 1939.

Since neither party was prepared to abate its extreme demands. the British government proposed its own solution in a White Paper of May 1939. It declared that the establishment of a Jewish state in Palestine would be contrary to British obligations to the Arabs and promised, aiter a period of ten years, the establishment of an independent Palestine in which Arabs and Jews would share authority in government with complete security for the essential interests of both. During the next five years 75,000 Jews were to immigrate and illegal immigration was to be checked. In certnin parts of I'alestine the Arab farmer should be protected in the possession of his land. These British proposals did not satisfy either party, the reaction of the Zionists being especially violent; and the Permanent Mandates commission of the League of Nations, to which they now appealed, ruled by a majority of four to three that the White Paper was not in conformity with the mandate. A decision by the council of the League was, however, prevented by the outbreak of the war.

FROM 1939 TO THE END OF THE MANDATE (1948)

World War II.—While the Palestine Arabs, their extremist leaders being now in exile, maintained an innocuous neutrality in World War II, the Zionists with greater foresight co-operated fully with the Allies, both because of their intense hatred of Nazi Germany and because of their desire to build up political credit with the Allies. (H. Ko.; G. E. K.)

Small Jewish units served with the British army in the campaigns in Iraq, Syria and the desert in 1941. There n-as a great deal of agitation for the organization of a Jewish army. enthusiasts arguing that 200,000 could be recruited in the United States alone. but the British did not act until 1944, when a Jewish brigade was trained in Egypt. This was not popular with tlie Jews and recruits failed to complete the 6,000 expected. 'The unit saw action the last week of the war on the north Italian front. Eventually about 25,000 Jews were recruited in various British formations. About g, joo Arabs volunteered.

Palestinian economy expanded with the war. Immense contracts were let to supply the British 8th and 9th armies. Since tht: Jewish community was far better prepared industrially, it received tlie lion's share of the prosperity. The greatest damage came to the citrus fruit industry. whose markets were cut off by the war.

Limitation of Jewish immigration into I'alestine added to the terrors of anti-Semitism in Europe and resulted in the phenomenon of illegal or unauthorized immigration. Jews were encouraged to escape from Europe on obsolete boats, veritable deathtraps. which sailed for Palestine without quota assignments. At first the British tried to turn back some of these ships or transport the immigrants to other places, such as Mauritius. but later they were allowed to land their passengers and have them charged against the quota. Two tragedies occurred in the meantime. In Nov. 1940 the "Patria" was tied up at the Haifa dock. loaded with 2,000 deportees. Zionist sympathizers decided to prevent tlie sailing and scuttled the ship, but it capsized and drowned 252 of the refugees. In Dec. 1941 the S.S. "Struma" left a Black sea port and was detained in the Dardanelles; on Feb. 23, 1942, it was ordered back to the port of sailing. An explosion sank the overloaded vessel the next day with a loss of 700 lives.

In 1942 there was a large-scale effort to enlist the influence and wealth of the 5,300,000 Jews in the United States in the Palestine cause. David Ben-Gurion. chairman of the Jewish agency executive, toured the country and presented his recommendations to the U.S. Zionists assembled in New York city. On May 11 they approved his "Biltmore program" which repudiated the White Paper policy, for the first time called for the recognition of a Jewish commonwealth and a Jewish army, urged that responsibility for immigration be vested in the Jewish agency and restated the necessity to co-operate with the Xrahs. The Inner Zionist council waited only one week after the victory at El Alamein had finally disposed of the axis threat to Palestine before adopting by an overwhelming majority tlie Biltmore program.

In the United States resolutions favouring Zionist goals were presented to state legislature': and pushed in both houses of congress, most of them being passed in routine manner. Lest it immobilize Allied forces in tlie middle east, the senate resolution was finally delayed because of military considerations, in anticipation of the invasion of France.

Thefts of arms became notorious during 1943. In the spring two British army deserters were given large sums of money and all the necessary forged countersigned documents to steal lend-

lease arms by the truckload. Apprehended later, they indicated that two Jews had suborned them. In September a trial was held which made clear that some large Jewish organization with vast ramifications within the British army was at work. Only one bullet was recovered. The Jew in whose home the bullet, along with pads of British army requisition blanks, was found received a prison sentence. The two Britishers and two implicated Jews were also given prison terms. All the Jews were later released.

At the same time, the Polish army was in training in Palestine. Because of strong traditional anti-Semitism in Poland, about 3,500 Jews within the Polish ranks seized the opportunity to desert, often with arms. They mere quickly absorbed by the Jewish community. Searchers for the deserters were impeded, and a noncooperative attitude was adopted by the settlers. (X.)

The Zionist Revolt **of** 1945.—From 1943 onward, the Zionists systematically prepared for their postwar struggle, notably by equipping their clandestine armed force, the Haganah. A fortnight after the end of the war in Europe they requested the immediate acceptance by the British government-of the full Biltmore program. The British Labour party, which had previously uncritically committed itself to Zionism. now came into power and realized Britain's vital interests in the Arab world, especially as the Soviet "cold war" became ever more menacing. The Labour government endeavoured, therefore, to gain the co-operation of the United States in reaching and carrying out a jointly agreed policy for Palestine, if possible one acceptable to both Jews and Arabs. Pro-Zionists among U.S. Jewry opposed such compromise proposals and gave their wholehearted financial and political support to the Jews in Palestine. Meanwhile, the Jewish agency leaders in Palestine, impatient at the noncompliance of the British government, had embarked in the autumn of 1945 on a Jenish resistance movement in co-operation with the dissident extremists who had been actively engaged in a terrorist campaign against the British since the beginning of 1944. By the end of July 1946 British countermeasures, and revulsion from the outrage at the King David hotel, Jerusalem, on July 22, which had cost the lives of 91 British, Arab and Jewish public servants, had dislocated the resistance movement and caused the Jewish agency to modify the Biltmore program in favour of "a viable Jewish State in an adequate area of Palestine." A new British attempt to bring about a compromise between the Jews and Arabs failed, and in Feb. 1947 the British government, despairing of U.S. co-operation, harassed both at home by the growing incompatibility of Socialist aspiration with the hard postwar realities and in Palestine by the redoubled audacity of the Jewish terrorists, but satisfied that the Soviet threat to the middle east had been temporarily contained by the U.S. acceptance of responsibility expressed in the Truman doctrine, resolved to refer the Palestine problem to the United Nations, as Winston Churchill had urged six months before.

The Zionist **War** of Independence.—On Sept. 1, 1947, a United Nations special committee, having spent six weeks in the middle east, recommended the partition of Palestine, and, in an attempt to be as just as possible, suggested a fantastic dissection into no fewer than seven parts. Powerful Zionist pressure barely managed to secure the requisite two-thirds majority for these proposals in the United Nations general assembly in New York on Nov. 29. The British government had meanwhile announced that it would take no part in enforcing a plan that was not acceptable to both Jews and Arabs, and that it would terminate the mandate and nithdraw British troops at its own convenience. The attempt of the Palestine Arabs, begun immediately after Nov. 29, to prevent by force the carrying out of partition, and the vigorous Jewish counteraction, rapidly led to a country-wide guerrilla struggle. At the end of March 1948 the situation of the Zionists was grave; but their discipline and desperate determination proved more than a match for the mercurial Arabs. The Arab upper class had already begun to seek safety in the neighbouring Arab countries. and the slaughter by Jewish terrorists of about 250 Arab villagers, half of them women and children, at Dair Yasin on April 9 precipitated a panic flight from the coastal plain. In the month before the termination of the British mandate on May 14 the distracted Arabs let slip the towns of Haifa, Jaffa, Tiberias and Safad before the redoubled Jewish attacks; and while the forces of the Arab league prepared to intervene, the state of Israel was proclaimed by the Jews. (See ISRAEL.)

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(H. Ko.; G. E. K.)

THE HOLY PLACES

For centuries Jerusalem has been a holy city to Jews. Christians and Moslems. To Jews it was the site of the Temple; to Christians the place of the death and resurrection of Christ; to Moslems a place of pilgrimage second only to Mecca in sacredness. Its sacred sites have aroused the most passionate emotions in members of all three creeds. In the 1st century the Temple nas the scene of the bitterest fighting, and a little later, when all Jews were expelled from the city, the prohibition was lifted for one day in the year to permit them to worship and lament beside the Wailing Wall. It was interference with the pilgrimage to the Holy Sepulchre which led to the crusades.

The records of old travellers are full of the angry dissensions which broke out between pilgrims of different confessions inside the church, sometimes with fatal results. The breach which ended in the Crimean War began in a quarrel at Bethlehem between monks of the Orthodox and Roman Catholic churches. In still later days there were ugly disturbances at the Wailing Wall between Jews and Moslems. Troubles of this sort and their wide repercussions created the problem of the holy places.

Successive governments tried to solve the problem in different ways. The permit given to the Jews to pray at the Wailing Wall may be regarded as the Roman solution. At another site. especially holy both to Jews and Moslems, the Haram at Hebron, which is supposed to be built above the tombs of the patriarchs Abraham, Isaac and Jacob, the Jews have been forbidden on pain of death to climb above the seventh step of the flight leading to the entrance. Despite this prohibition, however, childless Jewish women are permitted to send petitions through a hole in the wall on the fifth step which is said to communicate with Sarah's grave. The tombs themselves are so jealously guarded that the archaeologists who were allowed to study the building were forbidden to enter the tombs and the date of them is therefore unknown. The churches of the Holy Sepulchre and the Nativity have been partitioned among the communities to which most of the pilgrims belong, and in parts which they hold in common the rights of each have been precisely laid down. At Bethlehem, for example, which is shared by Greeks, Latins and Armenians. the Greeks have six lamps in the grotto, the Armenians five and the Latins four. and the holy places in Jerusalem are shared by Greeks, Latins, Armenians, Copts, Syrians and Abyssinians. This division may be taken as the Turkish solution.

A firman of the sultan Abdul Mejid in 1852 is said to have been the first formal declaration of the policy of the *status* quo. This principle was endorsed in article 62 of the treaty of Berlin in 1878, and the first suggestion of the possibility of a change is found in the League of Nations mandate drafted in 1922. Article 14 prescribed the appointment of a commission "to study, define. and determine the rights and claims in connexion nith the Holy Places and the rights and claims relating to the different religious communities in Palestine"; pending the adoption of the report of this commission, the *status* quo should be maintained. A British proposal, however, to implement article 14 was turned down by the

League couricil "owing to failure to secure agreement as to the representatives of the confessions upon such a commission," a failure which reflects the delicate character of the issues at stake.

A few years later grave clashes between Jews and Moslems at the Wailing Wall led to the appointment of an international commission to determine the rights and claims of the two parties. The commission, which consisted of three jurists. one from Sweden, one from Switzerland and one from the Netherlands. reported in 1931 in favour generally of the *status quo:* the Wall was Moslem property but the Moslems were not to modify it in any way which would interfere with the access of the Jews for devotions, and the Jews were not to erect any structure or furniture on the pavement near the wall.

Political demonstrations were banned.

After Great Britain's relinquishment of the mandate the United Nations proposed to internationalize Jerusalem and Bethlehem. and responsible lenders both in Israel and Jordan declared their readiness to protect the holy places arid secure iree access to them for pilgrims and worshippers. (*See* also SEPULCHRE. THE HOLY.)

(J. W. CT.)

PALESTINE, OPERATIONS IN. The British campaigns of 1914–18 in Palestine, Egypt and Syria covered an extensive tretch of territory, from the Suez canal to Aleppo, a distance by the land route of considerably more than 500 mi. This land route. the oldest highway in the history of the civilized world, along which the tides of thought and trade and war have flowed between Asia and Africa since time immemorial. traverses a remarkable variety of soil and scenery: the inhospitable desert of Sinai: the iertile plains of Palestine, flanked by the high rocky citadel of the Judaean hills; the deep trench of the Jordan valley: and. finally. the Syrian plateau with those cities of ancient tale. Damascus and Aleppo.

The fighting was as diversified as the terrain: it comprised battles in the desert and in fertile country. combats in steep bleak hills and in a sweltering valley below sea level. periods of close-locked siege warfare and intervals of rapid movement. The story of the successive advances of the Egyptian expeditionary force (as the British army in this theatre came to be called) and of the gradual extension of its objective—from the passive defense of the canal to the delivery of the *coup de grâce* to the Turkish empire—falls under the following headings:

I. The Problem of the Suez Canal
   The Turkish Advance
II. The Sinai Desert
   British Advance on El 'Arish
   Occupation oi El 'Arish and Rafah
   The Palestine Offensive
   Attacks on Gaza
III. Palestine
   Allenby's Plan Outlined
   Disposition of the Troops
   Capture of Beersheba
   Before Jerusalem
   Rising of the Arabs
   Plans ior 1918
   Preliminary Operations in 1918
IV. Syria
   The September Offensive
   The Final Victory
   Conclusions

I. THE PROBLEM OF THE SUEZ CANAL

When Turkey entered World War I on the side of the Central Powers at the beginning of Nov. 1914. it was obvious that an advance from southern Palestine against the Suez canal and Egypt was likely to form part of the Turkish strategical program: largely inspired from Berlin.

Seizure of the canal would paralyze the most vital line of communication with the British empire and seriously hamper the gathering of its armies. Even the threat must immobilize considerable numbers ior passive defense. The dream of reasserting dominion over their former province of Egypt was an additional lure to the Turks.

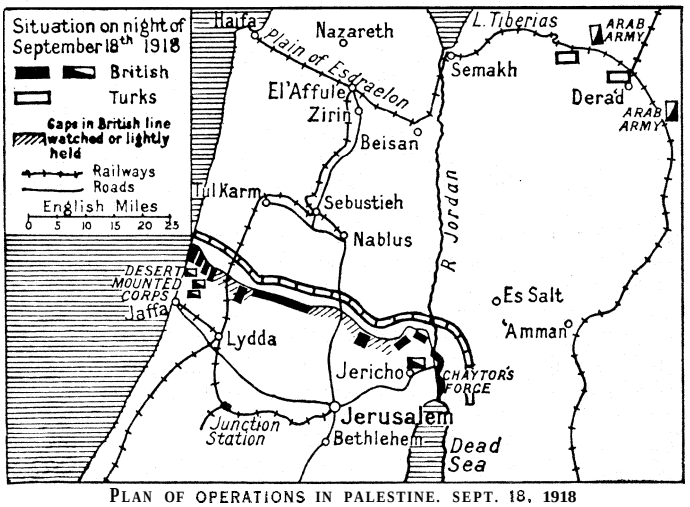
The Turkish Advance.—Between the southern frontier of Palestine and the Suez canal lay more than 100 mi. of almost waterless desert. It mas crossed by three routes. of which the northern, near the coast, through Rafah, El Arish and Qatiya **to** El Qantara, mas the easiest and best. The Turks made their main effort on the centre route. from El Auja by the Wadi Muksheib, which reaches the canal about Tussum. south of Ismailia; hut they also sent smaller forces by the coast road and by the southern route through Nekhl to Suez. the most difficult of the three. The Turkish commander in Syria. Jemal Pasha, directed the enterprise, but its real brain was his Bavarian chief of staff. Col. Kress von Kressenstein. In spite of the difficulties, a force of 12,000 to 15,000 Turks was brought within striking distance of the canal by the first days of Feb. 191 j.

The British were not unaware of the danger—though they underestirnated the Turkish effort—and were ready. The line of defense. which was held mainly by Indian troops, lay on the western hank of the canal, leaving the canal itself as an obstacle between the defenders and the enemy. A territorial division (the 42nd) and some Australian and New Zealand troops, who were completing their training near Cairo, formed the reserve. Warships in the canal provided gun support and compensated for the scarcity of land artillery. On the night of Feb. 2–3 the Turks made their effort. reached the canal. and actually succeeded in pushing three pontoons full of troops across it, These were all killed or captured. An attack next day had no better success and the Turks withdrew, unmolested by any serious pursuit.

This first Turkish raid. though it failed. proved the desert passable to large bodies of troops and thus compelled the retention of considerable forces in Egypt for the protection of the canal. It also showed the unsuitability of the defense on the west bank, since this line could not prevent the attackers from reaching the canal and interfering with the passage of shipping. No change was made in the system of defense, however. until after Lord Kitchener's visit in Nov. 191 j. During the summer and autumn of 1915 the Gallipoli campaign was in full swing and absorbed the principal efforts of both Turkey and Britain. The Senussi rising in the western desert. too. occupied the attention of the general officer commanding in Egypt, Gen. Sir John Maxwell. After the evacuation of Gallipoli at the end of 191 j and beginning of 1916 Egypt contained close to 400.000 British troops, reorganizing and recuperating after that gallant but ill-starred adventure. For a short time there existed within Egypt three separate. independent commands, hut in March 1916 all three were united under Sir Archibald Murray.

Meanwhile, early in 1916, a line was taken up in the desert, some 8 to 10 mi. to the east of the canal. Many miles of entrenchments were dug and reveted in the shifting sand, metalled roads constructed and pipe lines laid. For Turkey. freed from concern for the safety of its cnpital. was obviously contemplating a fresh advance on Egypt and the canal. It had in fact been busy with preparations ever since the repulse of its first effort.

This system of entrenchments. extending for some 80 mi. along practically the whole length of the canal, war expensive in men



PLAN OF OPERATIONS IN PALESTINE. SEPT. 18, 1918

as well as in material. This fact originated the first advance of the Egyptian Expeditionary Force and led to the crossing of the Sinai desert, an achievement made possible by sound and thorough organization, and by the fine quality of the mounted troops, mainlv Australians and New Zealanders.

II. THE SINAI DESERT

Sir Archibald Murray's objective was to secure control of the Sinai desert, which he saw could be effected by an advance to El 'Arish near the Egyptian frontier. A position here would bar the northern route across the desert and flank the more southerly routes. It would also enable offensive operations to be undertaken against enemy forces concentrating in southern Palestine. But an invasion of Palestine was not seriously contemplated at this time; the advance was initiated to safeguard Egypt and the Suez canal. Murray estimated the force necessary at five divisions and four mounted brigades, a much smaller force than that needed adequately to garrison the defensive system along the canal. Moreover, the farther the defence was removed from Egypt the less chance there was of a sympathetic rising there.

British Advance on El **'Arish.**—The first step was to occupy the Qatiya oasis, 25m. east of the canal, and thus deny to the enemy the only district within striking distance where a sufficiency of water permitted the assembly of a large force. The construction of a broad gauge railway from El Qantara towards Qatiya was begun, and large numbers of camels were collected to form the transport of the force, since in the soft sand of the desert wheeled transport was impossible. For the guns, special "pedrails" were constructed and teams doubled. Towards the end of April 1916 the Turks made a raid on the Qatiya oasis and surprised and captured some advanced posts of yeomanry. The Anzac Mounted Division, formed in March from Australian and New Zealand troops reoccupied the area next day. The object of the Turkish raid seems to have been to cause alarm and thus to prevent the further withdrawal of troops from Egypt for France, which had been going on during the spring of 1916.

By July the advance had reached Romani at the western end of a scattered group of oases extending for some 15 to 20m , when a strong Turkish force entered the eastern end. This force consisted of the 3rd Division and certain other units, totalling about 18 000 men under Rress von Rressenstein. After a pause for preparation, at dawn on Aug. 4, it attacked the British position at Romani, held by the 52nd and 42nd Divisions, the Anzac Mounted Division and some yeomanry, in all about 30,000 men, under Lt.-Gen the Hon. H. A. Lawrence. The Turks made a determined assault but were heavily repulsed and pursued as far as Bir el Abd. Their losses, including some 4 000 prisoners, amounted to nearly half their total force They may perhaps be accounted fortunate to have escaped at all, tor intense heat and lack of water precluded the more vigorous action in pursuit, which might have made possible the annihilation of the Turkish force.

The defeated Turks retreated to El 'Arish, leaving a small detachment at Bir el Mazar till the middle of September, when it was dislodged by the Anzac Mounted Division. There was no further fighting till December. The progress of the British force (now under Lt -Gen. Sir Charles Dobell) towards El 'Arish was governed by the rate (about 20m a month) at which the railway and its accompanying pipe-line could be laid. The water supply available in Sinai was too brackish for constant drinking by troops; even the railway locomotives could not use it for long without loss of efficiency. The Sweetwater canal, which runs from the Nile at Cairo to the Suez canal. was the source of the pipe-line supply; from large reservoirs and a great pumping station built at El Qantara it was forced through a 12-in. pipe to railhead. In 1917 this pipe-line was extrnded up to Gaza.

Occupation of El 'Arish and **Rafah.**—Early in December the railhead was within 20m. of El 'Arish. Elaborate water and transport arrangements were now made to enable the advanced guard of the British force to capture El 'Arish. This advanced guard was known as the Desert Column, and consisted at this time of the Anzac Mounted Division and 42nd and 52nd Divisions, under Lt.-Gen. Sir Philip Chetwode. Just as all was ready the enemy withdrew and El 'Arish was occupied Dec. 20.

The nearest Turkish force (1,600 infantry with four guns) was located at Magdhaba, some 20m. south of El 'Arish. A flying column under Gen. Chauvel, consisting of the Anzac Division and Imperial Camel Corps, was at once despatched against it. After a night march Chauvel attacked the Turks in an entrenched position at dawn on Dec. 23. By late afternoon, at a cost of under 150 casualties, he had accounted for practically the whole enemy force, capturing 1,300 prisoners and burying 100 dead. Only 200 Turks survived the engagement.

The only Turkish force now remaining within the Egyptian frontier was a detachment of about 2,000 near Rafah, 25m. east of El 'Arish. This was dealt with in a similar fashion by the mounted troops under Chetwode. After a night march, he surrounded the Turkish position at dawn on Jan. 9. Some hard fighting followed, for the Turks were in a strong position and put up a stout defence. It was not till close on dark that the position was assaulted. The entire Turkish force was accounted for, while the British casualties were under 500. These two brilliant actions cleared the Egyptian province of Sinai from enemy occupation. They were striking examples of the power of boldly handled mounted troops, a power the Turk was to experience very thoroughly before the end of the World War. Murray had now obtained his original objective, since the possession of Rafah and El 'Arish secured the safety of the Suez canal and Egypt.

Towards the end of 1916 he had, however, received instructions which imposed on him a more active rôle than the mere defence of Egypt. While this defence was still to be the main consideration, it was made clear to him that the war cabinet expected some more spectacular result of the "Exodus" across the desert than the negative one of giving checkmate to Turkish designs on Egypt. At the same time they were not prepared to give Murray the additional troops he asked for. Indeed. one of his four divisions, the 42nd, was early in 1917 withdrawn to France, leaving him only three in place of the five which he held to be the minimum to fulfil the rôle demanded of him. He had the nucleus of a fourth division—the 74th—to be formed from dismounted yeomanry; and the liquidation of the western campaign enabled him to add a second mounted division to the force on the Palestine border.

The situation in the early spring of 1917 was this: railhead was close to the Egyptian frontier at Rafa, some 2om. from Gaza; the British war cabinet's policy for the Egyptian theatre had finally crystallized into instructions to Sir Archibald Murray to prepare during the summer for an offensive campaign into Palestine in the autumn; and the Turk—now definitely on the defensive—had suddenly evacuated a forward position which he had prepared at Shellal, and had sketched out a position for the defence of Palestine between Gaza and Beersheba.

The Palestine **Offensive.**—Gaza and Beersheba, some 25m. apart, are the two natural gates into Palestine from the south, the former by reason of its commanding position on the coast road, the latter as the last water base on the confines of the mountainous desert to east and south. Between Gaza and Beersheba, in an almost direct line, runs a series of ridges which form a natural defensive position. Murray saw that in order to carry out his instructions to prepare for an autumn offensive, it was desirable to push his railhead forward out of the desert up to the cultivated plain of south Palestine. The conditions of transport would then be entirely different and camels could be largely replaced by wheeled transport. Moreover, the capture of Gaza would make it impossible for the Turk to hold the Gaza-Beersheba line as his main defensive position.

It was decided therefore in March to attempt the capture of Gaza by a *coup* de *main* similar to those at Rafah and Magclhaba, but on a much larger scale. The difficulties of concentration. of supply and of secrecy were of course much increased by the necessity to employ infantry in addition to mounted troops. The Turks had at the time some 7.000 fighting troops in Gaza, another 7,000 at Tel esh Sheri'a. half-way between Gaza and Beersheba, and a small garrison in Beersheba.

The plan was, briefly, for the mounted troops to pass east of Gaza, cut the garrison's line of retreat, and hold off the arrival of

any Turkish reinforcements from the north or east. The 53rd Division was to assault the heights east and south of Gaza, while the 54th Division protected the exposed right flank from the direction of Tel esh Sheri'a.

Attacks on Gaza.—The enterprise took place on March 26. Unfortunately, a dense sea fog came up with the dawn and caused a delay of two precious hours in the deployment of the infantry. This delay, which could not have been foreseen nor prevented, was the direct cause of the loss of the battle. For the Turkish position was strong, and it was not till 5 P M. that the 53rd Division secured the 'Ali el Muntar ridge which dominates Gaza from the east; at the same time, a part of the mounted troops were in the north-eastern outskirts of the town. The victory was to all appearances won. In fact the garrison. as was afterwards known, was on the point of surrender. But Turkish reinforcements from the north and east were already pressing on the protective screen oi the mounted troops; the horses were without water, and darkness was coming on. It had been agreed beforehand that the enterprise should be abandoned if Gaza had not fallen by dark. The reports received did not indicate a successful issue; owing to a breakdown of communications, news of the success of the 53rd Division did not reach the British commander till about 11 P M. Sir Charles Dobell hesitated to involve his infantry in the intricate network of cactus hedges which surrounds Gaza, while Chetwode was against exposing his mounted troops, exhausted by want of water, to the danger of being overwhelmed by the approaching Turkish reinforcements. The withdrawal of the mounted troops was ordered. This exposed the right of the 53rd Division, which had to be drawn back from the 'Ali el Muntar heights to gain touch with the left of the 54th. The battle was resumed next morning, but the Turkish garrison had been reinforced and had taken heart of grace at the unexpected respite of the previous evening. It was found impossible again to make good the 'Ali el Muntar ridge, the key to Gaza; and finally the whole force was withdrawn to the Wadi Ghazze.

This first battle of Gaza has been a matter of dispute and conjecture. By many of the troops who took part, it was held that the decision to withdraw threw away a victory already won. On the other hand, it is impossible to question that in the circumstances the order for retirement was justified. The two-hour delay in the morning lost the battle. Other contributory causes were the breakdown of communications (partly due to shortness of equipment) and lack of accurate maps. which made it impossible for HQ. to obtain timely information of the progress of the fight.

Though the enterprise had failed, the force had secured a position on the Wadi Ghazze which would enable railhead to be advanced to within a short distance of Gaza in preparation for the autumn campaign. hlurray now, however, received instructions to commence an offensive movement at once. A fresh assault on Gaza was therefore prepared. But the conditions were now very different; the Turk had closed the gap between Gaza and Beersheba by a series of works, and had greatly extended and strengthened the defences of Gaza. He had some five divisions in line and a considerable quantity of heavy artillery, so that Gen Dobell's force had no easy task. Much hope was placed in some tanks, which were to be used in Eastern warfare for the first time The attack was made in two stages, of which the first, on April 1;. was designed to gain a position from which the final thrust on Gaza could be made. It was successful But, the decisive attack on April 19 failed with heavy loss; the tanks developed mechanical defects in the heavy sand or were put out of action by the well-placed Turkish guns; and the weight of artillery supporting the British attack was insufficient to demolish the formidable defences of Gaza. The British casualties were 7.000.

Operations before Gaza now settled into regular trench warfare. The Sinai campaign nas at an end. It had fulfilled its object: the security of Egypt; and the careful and thorough organization which had conquered the desert had laid a solid foundation for the future British successes For this Sir Archibald Murray deserves the greatest credit He had never been given the number of troops necessary for more extended successes.

III. PALESTINE

A long pause in active operations followed the second battle of Gaza. The Turks, under German leadership, were now gathering their last resources at Aleppo for an attempt to recaptare Baghdad. They christened this force the "Yilderim" ("lightning") group. The British General Staff decided to forestall this enterprise by an attack in I'alestine which would divert this army southwards from Aleppo and remove the danger to Baghdad. The British Government also no doubt hoped by a spectacular success in the East to remove some of the disappointment caused to the public by the failure of Nivelle's offensive in France and the military collapse of Russia. Gen. Sir Edmund Xllenby succeeded Sir Archibald Murray in July 1917, with instructions to report on the conditions in which offensive operations could be undertaken against the Turkish forces on the Palestine front.

Allenby's Plan Outlined.—Allenby based his plan on an appreciation made some time previously by Lt.-Gen. Sir Philip Chetwode, who now commanded on the Gaza front. The obvious line of advance was by Gaza, which would allow of naval co-operation, directly cover the lines of communication, and present comparatively small difficulties of water supply. But the defences of Gaza were too solid to be broken except by a slow anti costly process of siege. The Turkish centre was also strong and the approach to it difficult. There remained the Turkish left, which rested about Abu Hureira, some 7m. west of Beersheba; the defences here were weaker and less complete, and might perhaps be rapidly overwhelmed. This would provide an opportunity for the mounted troops, the arm in which lay the chief superiority of the British force over the Turkish.

A preliminary operation was necessary to capture Beersheba, which the Turks held by a detached force; for there was not room to manoeuvre between Beersheha and the Turkish left; moreover, possession of the water supply at Beersheba was essential to further operations. The difficulties of capturing Beersheba and of placing a sufficient force within striking distance of the Turkish ieft were, however, serious. The three principal problems to be solved were those of transporr. water supply and secrecy. Until the Gaza-Beersheba line had been passed and the cultivated plain of Palestine reached, it was not practicable to use motor lorries, and the force was dependent on horse transport and camels. This limitation greatly increased the difficulties of water supply, which was the second main problem. Its seriousness is illustrated by the fact that the striking force estimated as necessary for operations against the Turkish left required some 400,000gal. of water daily. Of the 30,000 camels available the majority would be required to carry water. The third great difficulty was to concentrate a striking force sufficient to overwhelm the garrison of Beersheba rapidly and then attack the Turkish left, without the Turks becoming aware and taking steps to counter or avoid the blow.

In spite of the difficulties to be overcome, Gen. Allenby decided to attack the Turkish left. He estimated the total force required at seven divisions and three mounted divisions with additional artillery and aeroplanes. Four divisions and two mounted divisions were to attack the Turkish left. three divisions were to make a subsidiary attack on Gaza, and one mounted division was to watch the centre between these two wings, which mould be separated by some 20m. during the operations.

The number of divisions was made up to the required total by the 10th and 60th from Salonika and by the completion of the 75th, already in process of formation. Allenby formed his three mounted divisions into the Desert Mounted Corps, under Lt.-Gen. Sir H. Chauvel, an Australian, and his seven divisions into two corps, the 20th, under Lt.-Gen. Sir Philip Chetwode. and the 21st, under Lt.-Gen. Sir E. Bulfin. The elaborate preparations necessitated by the character of the forthcoming operations occupied the summer and early autumn. The railway across the desert was doubled and arrangements were made for its rapid extension during operations; ammunition and other stores were accumulated and the troops underwent special and intensive training. The development of the water supply was also a constant preoccupation.

Meanwhile, Gen. von Falkenhayn, in command of the Turkish

army at Aleppo, had realised that the security of the Palestine front was essential to the successful prosecution of the plan for the recapture of Baghdad. It was accordingly decided to drive the British back into the Sinai desert before committing the Yilderim force to the Mesopotamian adventure. All troops available at Aleppo (only three divisions) were ordered to south Palestine during September.

Both Turks and British were thus aiming to strike a blow on the Palestine front in the autumn of 1917, and each hoped to forestall the other. The poverty of the Turkish lines of communication decided this issue by the delay it imposed on the southward movement of men and stores. From Haidar Pasha, the Turkish main base on the Asiatic shore of the Bosporus, to railhead in Palestine was a distance of 1,275m., with a single line of rail only, which, up to Aleppo, had also to serve the Mesopotamian front. The incomplete tunnels in the Taurus and the differences in gauge of the various lines necessitated five or six transhipments of all stores before they reached Palestine. Scarcity of fuel and jealousies between the German commanders and staff and the Turkish officials who controlled the working of the communications further accentuated the difficulties. Consequently, the supply problem crippled Turkish movements throughout these campaigns. The force from Aleppo was still in process of arrival on the Palestine front when Allenby struck his blow.

Disposition of the Troops.—During the days previous to Oct. 31, the date fixed by Allenby for the attack on Beersheba, the Desert Mounted Corps and the 20th Corps (10th, 53rd, 60th, 74th Divisions) were gradually and secretly moved across to the right wing from behind Gaza, where they had been in training camps by the sea. There could be no question of concealing entirely the preparations for a movement against Beersheba; but Allenby did hope to persuade the Turks that this movement was only a feint and that the real main attack was against Gaza To this end the 21st Corps (52nd, 53th and 7jth Divisions), left opposite Gaza, began on Oct. 26 a heavy bombardment of the Turkish defences, assisted by British and French warships from the sea. The intended deception as to the real point of attack was aided by the natural nervousness of the Turk of operations by sea against his right flank. He was also aware of the great difficulties of transport and water supply in the country opposite his left flank, which he believed was sufficiently safeguarded by these natural obstacles.

The Turkish forces at the end of Oct. consisted of the 8th Army (six divisions) under Kress von Kressenstein, holding Gaza and the Turkish centre, and the 7th Army (three divisions), holding Beersheba and the Turkish left. The 7th Army was not yet complete, one of the divisions from Aleppo being still on the lines of communication. Falkenhayn, who was to combine the action of these two armies, only arrived at Jerusalem on Nov 1 The approximate fighting strengths of the Turkish and British forces were: Turks, 50,000 rifles, 1,500 sabres, 300 guns; British, 95,000 rifles, 20,000 sabres, 500 guns.

Allenby s plan for Oct 31 was as follows: Two divisions of the 20th Corps, the 60th and 74th, were to attack the south-western defences of Beersheba, which lay some 4m. from the town itself, with the 53rd Division protecting the left flank of this attack The Anzac and Australian Mounted Divisions, which had concentrated at El Khelasa and Bir 'Aslūj, were to reach a position east of Beersheha by dawn, close the Beersheba-Hebron road, and then attack and carry the town as rapidly as possible, before the Turks could destroy the wells.

Capture of **Beersheba.**—During the night of Oct. 30–31 the assaulting infantry and artillery moved some 8m. to their positions of deployment, while the mounted troops undertook a ride of over 25m to reach a position east of Beersheba These long and complicated night movements were only made possible by careful preparation and good staff work. At dawn on Oct. 31 the attack of the 20th Corps commenced A Turkish forward work, Hill 1030, had to be taken, to allow the artillery to get within wire-cutting range of the main position Hill 1030 nas taken at 8 30 A M ; the main assault was delivered at 12 1j P M. and was successful; by early afternoon the British infantry were masters of the Turkish defences south-west of the town; they were still, however, some miles from the town itself. Meanwhile, the mounted troops, after closing the Hebron road, had been held up by a Turkish strong point at Tel es Saba, 3 mi. east of Beersheba. When this was at last taken, little time remained if the town was to be captured before dark. Gen. Chauvel accordingly ordered a mounted attack at 4 P.M. The 12th Australian Light Horse Brigade charged over the Turkish trenches and rode straight into the town. This daring and well-executed charge resulted in the capture of over 1,100 prisoners and 10 guns, and saved the all-important wells from demolition. The infantry had captured another goo prisoners, and the Turkish 27th Division had suffered practical annihilation. While the preparations for the decisive attack on the Turkish left were being made, the 21st Corps carried out a holding attack at Gaza on the night of Nov. 1–2. A considerable portion of the Gaza defences was carried and heavy losses caused to the Turks.

Left to themselves, the Turkish commanders would now probably have retired to a fresh position while there was yet time. But Falkenhayn, imbued with German principles of defence and ignorant of the qualities of the Turkish troops he led, ordered a counter-attack with all available reserves to the north of Beersheba. This led to three days' heavy fighting against the British 53rd Division, which had been sent into the hills to guard the right flank of the 20th Corps. The 53rd Division held its own; consequently, when at dawn on Nov. 6 the remainder of the 20th Corps (10th, 60th and 74th Divisions) attacked and broke through at Abu Hureira, the Turks had no reserves to restore the situation. By nightfall Gaza was being evacuated and the whole Turkish force was in full retreat.

The pursuit by Allenby's mounted troops was hampered by lack of water; and the Turkish rear-guards were well handled. A gallant charge at Huj on Nov. 8 by some squadrons of Worcestershire and Warwickshire Yeomanry captured three batteries of guns; but no large bodies of Turks were cut off; and the supply question limited the number of divisions which could be used in the pursuit.

On Nov. 11 the Turks took up a position to cover Junction Station, where the railway to Jerusalem branches off the main line. After a short pause to organize for attack, Allenby's pursuing troops attacked on Nov. 13 and soon dislodged their enemy, in an action remarkable mainly for a dashing charge by a brigade of yeomanry on a strongly held hill above the village of El Mughaiyir. On the following day Junction Station was captured; Jaffa was occupied on the 16th. The capture of Junction Station definitely divided the Turkish armies; the 7th was left in the hills to defend Jerusalem, while the 8th was in the plain to the north of Jaffa; there was no good communication between the two armies south of the line Tul Karm-Nablus.

Before Jerusalem.—Allenby had originally intended to wait until the development of his communications allowed of his whole force being brought up before turning into the difficult hills towards Jerusalem. He now decided to oppose the Turkish 8th Army with a detachment, while with the remainder of his force he turned east and advanced on Jerusalem at once. It was a bold decision, since he had only three infantry and two mounted divisions immediately available, and the supply of these strained the resources of his transport to the utmost; the troops available had already done much hard marching and fighting; little was known of the hill country save that it was very difficult and that there was only one road fit for wheels. The Anzac Mounted Division and the 54th Division were left to hold the Turkish 8th Army in the plain, while the remaining three divisions advanced into the hills. the 75th up the main road, the 52nd on its left and the Yeomanry Mounted Division on the left of the 52nd Both these two latter divisions were entirely dependent on pack transport. The intention was to pivot on the 75th, when that division arrived within a certain distance of Jerusalem, and to swing the left across the Jerusalem–Nablus road north of the city. It was hoped thus to compel the surrender or withdrawal of the defending Turks and to avoid fighting in vicinity of the Holy City

There was some hard fighting on Nov. 20 and 21; the 75th Division captured the crest of the ridge at Enab in a fog on Nov.

20 and on the 21st stormed the commanding hill of En Nabi Samweil; the 52nd made similar progress; and the yeomanry were at one time within a short distance of the Nablus road. But the British effort had shot its bolt; the men were suffering much from cold and wet. and the artillery support available was insufficient against strong prepnrcd positions. The yeomanry were counter-attacked and driven back, and the 52nd and 75th could make no headway; by Nov. 24 it was evident that without fresh troops and a period of preparation Jerusalem could not be taken. The difficult passes through the hills had, however, been secured and the boldness of the advance justified.

A pause now took place while the British army improved its communications and thus enabled the 20th Corps to be brought up from Gaza, where it had been left. for convenience of supply. It took over the line opposite Jerusalem, releasing the troops which had made the first attempt to strengthen the line in the plain. Falkenhayn during this period ordered small local counter-attacks all along the line in the hope of disorganizing Allenby's plans. But these attacks had no effect and merely wasted the best remaining elements of the Turkish force.

The second attack on Jerusalem was delivered at dawn on Dec. 8, in mist and rain. The brunt of the fighting fell on the 60th (London) Division, assisted on the left by the 74th Division and on the right by the 53rd Division, which had previously moved up from Beersheba along the Hehrou road to within striking distance. By the evening the Turks had decided to withdraw. and the city surrendered next morning. Allenby made an official entry on Dec. 11. His brilliant campaign effectively removed all danger to Baghdad from the Yilderim army, the whole of which had of necessity been used in Palestine. The last reserves of Turkish man-power were practically exhausted; and Turkey was now in a far worse plight than when Germany had, at the commencement of 1917, undertaken the re-establishment of her military prestige by driving the British out of Baghdad. Falkenhayn had completely failed to grasp either the conditions of the theatre or the idiosyncrasies of Turkish troops. He was replaced early in 1918 by Liman von Sanders.

Rising of the Arabs.—The encouragement given by the British success to the Arab revolt caused an additional drain on Turkish resources. The Arab revolt had broken out a year previously, when Hussein, the Sherif of Mecca, induced the Hejaz to rise against the Turk. Jeddah and Mecca were soon captured, but the Medina garrison held out. The revolt would probably have ended in the re-establishment of the Turks, or in desultory warfare with little result: had there not appeared a young Englishman with an understanding of the Arabs and a gift for guerrilla tactics. As Col. Lawrence he became famous. He persuaded Feisal, a son of Hussein, who led the Arab forces in the field, that the true policy lay not in assaults on the Turkish garrison in Medina. which if successful would merely rid the Turks of an embarrassment. but in gradually spreading the revolt northward up to the very gates of Damascus, with propaganda as the principal weapon. and in ceaseless raiding on the long exposed Turkish communications to Medina, which would form a constant drain on the enemy's resources.

In pursuance of this policy, Feisal, with Lawrence as his adviser, moved his base of operations from opposite Medina, first to Wejh and nest to Akaba, which Lawrence had captured by a dashing raid. Gen. Allenby was quick to realize the service which the Arab rising was rendering to hi's operations, and was always sympathetic to Lawrence's requests for equipment or other aid.

Allenby's next aim was obviously to secure sufficient room for manoeuvre in front of Jerusalem in the hills and Jaffa in the plain. On Dec. 20 and 21 the 52nd Division forced a passage of the river El 'Auja, and drove the Turks 8m. north of Jaffa, thus improving the position in the plain. In the hills, all preparations had been made for an operation to drive the Turks farther from Jerusalem, when information was received that the Turks themselves were about to attack. Reinforcements, including the 1st Division, had reached them, and Falkenhayn was determined on an attempt to recapture the Holy City. The attack was pressed with great gallantry on Dec. 26, but made no impression: on the following days the counter-attack of the British 20th Corps carried them some 5 or hm. forward and safeguarded Jerusalem from the north. Later, the eastern flank was secured by the capture of Jericho, which took place on Feb. 21. Early in March, the line was pushed still farther north, both in the hills and in the plain, by a series of small operations. Thus by the spring a strong line had been secured, which might have been held by a reduced force in the exhausted state of the Turks.

Plans for 1918.—Meanwhile, the future of the Palestine campaign in the general plan of the Allies for 1918 had become the subject of considerable discussion. In view of the expected great German offensive in the West, there was a considerable body of opinion amongst those who directed the Allied strategy in favour of closing down as far as possible all commitments in minor theatres and of concentrating on the vital Western Front all reinforcements that could be spared from them. It was also pointed out that the maintenance of large forces on the Palestine front entailed heavy losses in shipping—which was likely to prove the Achilles' heel of the Allies—since the submarine menace was especially serious in the hlediterranean.

On the other hand, it was believed by many that neither side could force an issue on the Western Front, so formidably entrenched, and that the war could be won by the elimination of Germany's weaker Allies. They held that one more blow would force exhausted Turkey to sue for peace; and consequently advocated a further offensive in Palestine. This policy was eventually adopted. Two divisions, the 3rd and 7th Indian, were moved from Mesopotamia to reinforce Allenby's army, and all preparations for a fresh great offensive were being made, when the storm broke on the Western Front. The success of the German offensive of March 21 caused a demand on Allenby for all the troops he could spare, which of course necessitated the postponement of his operations. During April and May, two complete divisions (the 52nd and 74th), 24 additional British battalions: nine regiments of yeomanry and $5\frac{1}{2}$ heavy batteries were withdrawn from the Egyptian Expeditionary Force and despatched to France. These were gradually replaced by Indian cavalry from France and Indian units from India, and the Egyptian Expeditionary Force was reorganized on an Indian basis. It required much training and organization to weld all these new, and in some cases raw, units into an effective whole; but by the end of the summer the Egyptian Expeditionary Force was again ready to strike a decisive blow.

Preliminary Operations in 1918.—Meanwhile, in March and May, Allenby had carried out two raids to the east of the Jordan. These raids were an important part of his strategical plan. He had decided that his next great advance should be initiated from his left flank along the coastal plain, where his great superiority in the mounted army could be exploited. Therefore, the more of the Turkish army he could draw over to the opposite flank, east of the Jordan, the easier would it be to break through on the coast when the time came. The railway junction at Deraa was a vital point in the Turkish communications. If the Turkish command could be persuaded by demonstrations east of the Jordan that a move in force up the Hejaz railway was a possibility, and if Feisal's Arabs could be encouraged to attack Deraa and the railway where it ran down the Yarmuk valley, the Turks would be obliged to move troops east of the Jordan. With these objects the raids east of the Jordan were undertaken. Neither was a complete tactical success. The first raid reached the railway near Amman and cut it in several places, but failed to capture Amman before supply difficulties caused by vile weather necessitated its withdrawal. In the second raid, the mounted troops reached Es Salt; but the Turks could not be driven from their strong positions in the Shunet Nimrin pass; and the defeat of the left flank guard of the mounted troops, with the loss of nine guns, compelled their withdrawal from Es Salt.

But the two raids had the desired effect of seriously alarming the Turks for their left flank. After the second, Liman von Sanders, who was now in command, had been induced to place one-third of his total force east of the Jordan. with a corresponding weakening of his forces west of the Jordan. Allenby kept

alive the opposing commander's fears for this flank by maintaining throughout the summer, in spite of the heat, a considerable force in the valley of the Jordan. In July the German units operating with the Turks made an abortive attack on part of the position of the Desert Mounted Corps.

IV. SYRIA

At the end of the summer of 1918 the Turkish forces were distributed as follows, on a front of 65m.: the 8th Army (five divisions and three German battalions), in the coastal plain and the foothills, faced the British 21st Corps; the 7th Army (four divisions), in the Judaean hills astride the Nablus road, faced the British 20th Corps; while the 4th Army (two divisions, one cavalry division, and one composite division), in the Jordan valley and east of the Jordan, was opposed to the Desert Mounted Corps. The total fighting strength of the Turks amounted to 32,000 rifles, 3,500 sabres, 350 guns; and that of the British to 57.000 rifles, 12,000 sabres, 540 guns.

Gen. Allenby's plan was the reverse of that of the Gaza-Beersheba battle; then, he had struck the Turkish left while persuading them that his real effort was to be made along the coast against their right; now, he proposed to advance along the coast, while deceiving the Turks into thinking that their left flank was threatened. Steps were skilfully taken to simulate a concentration of troops in the Jordan valley, whereas in fact only a skeleton force, the Anzac Mounted Division and a few battalions, was left there. The real concentration was being secretly made in the coastal plain, to which the bulk of the Desert Mounted Corps and the 60th Division of the 20th Corps were transferred. For the success with which this concentration was concealed from the Turks to the last, British superiority in the air was largely responsible.

A simple statement in figures shows how well Allenby had succeeded in obtaining an overwhelming superiority of force at the decisive point. When his concentration was complete, he had on a 15m. front in the coastal plain 35,000 infantry and 400 guns against only 8,000 Turks with 130 guns; and behind that mass of infantry were three cavalry divisions waiting to exploit success. On the remaining 45m. of front he left only 22,000 infantry with 150 guns, facing 24,000 Turks with 270 guns. The Turks were still unaware of his intentions or of the distribution of his force.

The September Offensive. — The attack was made at 4.30 A.M. on Sept. 19. The preliminary bombardment lasted only 15 min., and the infantry assault, pushed at great speed and in overwhelming strength on a broad front, was rapidly successful. By 7.30 A.M. the leading cavalry division was through the enemy's lines. The orders to the mounted troops were to ride straight north, disregarding any hostile troops that did not directly bar their path, cross by the passes near Megiddo into the Plain of Esdraelon, and secure El Affule and Beisan to block the Turkish lines of retreat.

The leading troops of the 5th Indian Cavalry Division reached Nazareth, Liman von Sanders' headquarters, just 24 hours after their start, having covered jam.; they failed only by accident to capture the person of the enemy commander-in-chief. The 4th Cavalry Division, moving farther to the cast, covered 70m. to Beisan in 34 hours. The advance mas carried out with great dash arid there were several instances of successful mounted attacks. A regiment of the 5th Cavalry Division rode over a Turkish battalion in the Plain of Esdraelon; and a brigade of the Australian Mounted Division galloped into the village of Jenin, occupied by a numerous force of Turks and Germans, thus scaling one of the main exits from the trap in which the Turkish 7th and 8th Armies were now caught. Meanwhile the British infantry of the 21st Corps, after breaking through the Turkish fortified system in the plain, had wheeled to the right and driven the remnants of the Turkish 8th Army into the hills. The 60th London Division (Maj.-Gen. Shea) actually reached Tulkeram before dark on the 19th, having fought. arid marched 18m. over very heavy going.

During the two days following Sept. 19 the 21st Corps continued to press their pursuit, while the 20th Corps also pushed forward along the Judaean hills to Nablus. The infantry of these two corps thus shepherded the straggling remains of the Turkish 7th and 8th Armies into the hands of the mounted troops. The Royal Air Force, with bombs and machine-gun fire, caused havoc amongst the bewildered Turkish transport, penned in and crowded on narrow hill roads. Only a few of the most determined Turks and some of the better fed and disciplined German units managed to break out to the east and cross the Jordan. The Germans fought well throughout the retreat.

Meanwhile, the Turkish 4th Army had remained inactive, ignorant of the fate of the other armies. On the 22nd it began a hurried retreat on Amman, hoping thence to escape up the Hejaz railway to Damascus. It paused at Amman till Sept. 25, awaiting the arrival of the Maan garrison from the south. But the 4th Army was now not only too late to rescue this force, but too late to secure its own safety. Feisal's Northern Arab Army was already between it and Damascus, and the whole countryside was rising against the Turks. The Arabs under Lawrence had already contributed largely to the discomfiture of the Turks by their raids on the lines of communication near Deraa, which they cut effectively from Sept. 17 onwards. They were thus in a position to delay and harass the 4th Army in its march north.

The Final Victory. — The Turkish 7th and 8th Armies having been disposed of, Allenby ordered a part of his mounted troops to occupy Haifa, which was captured on Sept. 23 by a most gallant charge of the Indian Imperial Service Brigade. The remainder were despatched east and north-east to cut off the 4th Army and to capture Damascus. The 4th Cavalry Division was to cross the Jordan near Beisan and move on Deraa, while the Australian Mounted Division was to make direct for Damascus by the road which runs from Nazareth to the west of Lake Tiberias, crossing the Jordan at Jisr Benat Yakub. On Sept. 25 there was a fierce fight at Tell es Semakh at the southern end of Lake Tiberias. The 4th Australian Light Horse Brigade charged in the dark over unknown ground and captured the village after hand-to-hand fighting with a force composed largely of Germans.

The Turkish 4th Army passed Deraa before the 4th Cavalry Division could head it off, but under pressure from this division and from the Arabs it gradually disintegrated. The end came on Sept. 30, when the Australian Mounted Division, which on Sept. 28 had overcome some determined opposition to its crossing of the Jordan, succeeded in getting astride the Damascus-Beirut road just outside the city, cutting off the remains of the 4th Army. Damascus was occupied next day, Oct. 1. Immediately after the capture of Damascus, malaria and influenza broke out and placed a great proportion of the British mounted forces out of action. It also seriously affected the very numerous Turkish prisoners.

There was now no formidable Turkish force in southern Syria. To complete its occupation, two columns advanced. The 7th Division left Haifa on Oct. 1 and moved up the coast to Beirut, which it reached on the 8th, and then on to Tripoli, which was occupied on the 18th; the jth Cavalry Division, which though less affected by malaria. and influenza than other formations: was considerably below establishment, advanced from Damascus by Homs (Oct. 16), Hama (Oct. 20) to Aleppo, which was occupied on Oct. 26. The last fighting took place north of the town on the 28th. On the 31st an armistice was concluded. Between Sept. 19 and Oct. 26 the British army had moved its front forward a distance of 360 miles. During this period the 5th Cavalry Division had actually covered over 500 miles. The captures included 72,000 Turks and nearly 4.000 Germans and Austrians. 3jo guns. 800 machine guns, and large quantities of transport and other material. History records few victories, if any, more striking anti complete.

Conclusions. — These campaigns of the Egyptian Expeditionary Force are of great strategical interest. For the military student they will always remain classic examples of the use of mounted troops and of the value of mobility. Conditions of war change. and it may be that some mechanical form of transport will entirely replace the horse as the means by which mobility can be secured. Hut the power of mobility as a strntegical weapon in the hands of a commander who has the knowledge and the determination to use it as did Gen. Allenby will only he enhanced. A second strategical lesson is the advantage gained by a commander who can conceal his intentions from his opponent. In

both his great battles against the Turk, Allenby completely deceived his adversary as to his plans, and had thus secured a decisive superiority before the battle was joined. Only constant foresight and careful preparation can effect this. Air superiority is a factor of increasing importance in this question of concealment of plans and movements.

Finally, the dependence of all strategy on the communications may be stressed. The Turks added to the initial handicap which their long and difficult lines of communication imposed on them by their neglect to improve these and by the inefficiency of their working. Falkenhayn, during his command, entirely failed to adapt his strategy to the limitations necessitated by his means of transport. On the British side, the greatest care was devoted to developing the communications in accordance with the strategical plan, and the supply services were thus able to cope even with such problems as were presented by the rapidity of the advance to Damascus and Aleppo.

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PALESTRINA, GIOVANNI PIERLUIGI DA (1526–1594), Italian composer, was born in Palestrina (the ancient Praeneste), at the foot of the Sabine mountains, in 1526. He appears in the musical publications and other documents of his day under all manner of designations derived from his birthplace and his baptismal names. The full Latin signature is Joannes Petraloysius Praenestinus; and the most elusive designation is Gianetto, which has sometimes concealed the authorship of a first-rate Palestrina madrigal.

Palestrina seems to have been at Rome from 1540 to 1544, when he is supposed to have studied under Gaudio Mell, a person of doubtful identity, but not to be confused with Goudimel. On June 12 Palestrina married Lucrezia de Goris. By Lucrezia Palestrina had four sons, three of whom died after showing early promise in compositions published in an earlier volume of their father's works. (Of the three, Ridolfo, Sylla and Xngelo, it is thought that Sylla may he a brother or cousin.) The surviving son Igino, is not viewed with favour by the biographers, who ascribe to him unworthy motives for the publication of certain posthumous works which his father is supposed to have wished suppressed.

Palestrina, more than any other composers except Victoria and Morales, devoted himself whole-heartedly to the service of the Church, and aimed at the perfect harmony of musical art. not only with the spirit of Catholic devotion, but with liturgical convenience in the humblest practical matters. Palestrina's official career as a composer under papal protection began in 1551. when Julius III. had him appointed magister cappellae and magieter puerorum at the Cappella Giulia, S Pietro in Vaticano Three years later Palestrina published, and dedicated to Pope Julius, his first hook of masses. The *Missa Eccc sacerdos* is a noble if long-ninded work, and other masses in the volume show that Julius had chosen one of the greatest composers of his day as an object of his protection. (The beautiful *Missa Pro Defunctis* was added to later editions.)

In 1555, on Jan. 13, Julius appointed Palestrina a singer in the Sistine chapel. Palestrina's friend, Xniinuccia (q v.) succeeded him at the church of S. Giulia Palestrina enjoyed this position for only seven months Five weeks after Palestrina's appointment Julius died; his successor, Marcellus II., reigned 1or 23 days. and was folloned by Paul IV who. at the end of July, began setting his house in order by pensioning off Palestrina and two other married members of the Sistine choir A few months later Palestrina nas appointed choir-master of the church of St. John Lateran. but this did not prove to be a full compensation for the loss of his positioh in the Sistine chapel.

During Palestrina's tenure of his post at St. John Lateran, which he gave up in 1558, he composed a book of Lamentations (*i.e.*, settings of the Holy Week lessons from the Lamentations of Jeremiah) and a book of Magnificats for all the eight Ambrosian tones or modes. Neither of these books was published till long after Palestrina's death, and the elaborate Magnificats with their numerous canonic movements in Flemish style were hardly known at all until their inclusion in the modern edition of Palestrina's complete works in score published by Breitkopf and Härtel. Palestrina's famous Lamentations, used in the Sistine chapel and known as his first book, are really his third and last book, being published in 1588. From the earlier period, however, comes an opusculum of enormous importance, closely allied to the later Lamentations in its syllabic declamation, its note-against-note harmony, and its profoundly devout .pathos. This is the Improperia, sung on Good Friday. The Improperia immediately made a profound impression, and Pope Pius IV. ordered a copy to be made for the Sistine chapel. Palestrina accordingly began again to compose specially for the Papal choir; and in the *Missa Ut Re Mi Fa Sol La* we find the perfectly mature Palestrina style in a work constructed on the quaintest of Flemish formulas.

The first of Palestrina's four books of masses was republished in 1591 with the addition of a *Missa Pvo Defunctis,* a very beautiful work in which no attempt is made to set the *Dies irae,* and a *Missa Nasce la gioja mia.*

The *Missa Papae Marcelli* appeared in 1567 as the last item in Palestrina's second book of masses. The volume is dedicated to the king of Spain; and in the dedication Palestrina says that, following the advice *gravissimorum, et religiosissimorum hominum*, he has given his best energies to the composition of masses *novo modorum genere*. Dr. Knud Jeppesen, in his treatise *Palestrina and the Dissonance* (Copenhagen and Oxford. 1927), has pointed out exactly where the problem lay, if I'alestrina was not to reduce the whole music of the mass to note-against-note harmony or *falsobordone* like his Improperia and Tallis's Responses. Simple statistics show that, whereas in earlier masses I'alestrina develops his polyphony so that the voices are hardly ever singing the same words together, in the *Missa Papae Marcelli* each clause of the text is heard in the highest voice, or in several voices simultaneously before the polyphony is allowed to make the clauses overlap, and this is a general feature of Palestrina's mature style.

Yet there was no need for Palestrina to write a work specially to meet this demand. He had already formed the style for it, and his reference to masses *novo modorum genere* applies to six other masses besides the *Missa Papae Marcelli.* The Improperia had already revealed him as the greatest master of harmonic colour in note-against-note declamation; this very mastery made him content to write most of his early madrigals in a homophonic style which rash critics might deem primitive; he was, on the other hand, a polyphonist to whom canonic devices were a child's play, the rules of, which it was no trouble to follow and no sin to disregard. Any volume of Palestrina's works would have revealed to the cardinals that here was the man they needed. Every volume, except the earliest, contained works of more than one period: Palestrina published his works, not when he wrote them, but when he could afford to publish them. as the dedication of his First Book of Lamentations (really his last) plaintively shows.

The third book of masses. which appeared in 1570, shows at least three styles. It is difficult to suppose that the *Missa Repleatur os meum* can be anything but an early work; it is the heaviest and, for the most part, the dullest music Palestrina ever wrote. The materials of *Missa Brevis*, the *Missa De Feria* (a quiet work without Gloria and Credo), the *Missa L'Homme Armé,* and the above-mentioned *Missa Ut Re Mi Fa Sol La*, show how futile is any attempt to guess the quality of Palestrina's work from its theoretic or formal origins. *L'Homme Armé* is the notorious old tune on which Flemish composers based puzzles; and Palestrina bases on it an encyclopaedia of rhythmic problems. Yet his result here. and in the obviously ridiculous scheme of *Ut Re Mi Fa Sol La* is of the quality of the *Missa Brevis* and not far below the *Missa Papae Marcelli* itself.

In 1571 Palestrina was reappointed as choir-master of St. Peter's, on the death of Animuccia. In 1577 Gregory XIII. commissioned Palestrina and his colleague, Zoilo, to "purify" the musical text of the liturgical (or Gregorian) chsnt. St is not surpris-

ing that Palestrina, and his colleagues and successors in the task, conceived that to purify was to simplify. The Spaniards knew better, and protested. Palestrina's share in the work soon ceased; but the Palestrinian tradition of plain-chant remained official until the musical liturgiologists of Solesmes restored the ancient style at the beginning of the 20th century. (*See* MUSIC, sec. 3.)

In 1581 a fourth book of masses appeared, with all offending titles omitted, though it really contains another *L'homme armé.*

In 1584 appeared Palestrina's wonderful setting of the Song of Solomon, in 29 motets, which he describes in his dedication as of a "genus alacrior," while he deplores that he had ever sung of a profaner love. Neither madrigals nor motets can give a complete view of Palestrina if this unique work, which is neither liturgical nor secular, is unknown. Like all Palestrina's music, it is practically difficult to know; the work cannot be appreciated in less than its entirety; and its entirety is that of a bound volume of a magazine There is no occasion on which it can be periormed as a whole in public. We must live with it, and form ourselves into groups of singers who can produce it among themselves.

The famous book of Lamentations, known as the first book, appeared in 1588, with a dedication to Pope Sixtus V. in which Palestrina complains of the poverty which compels him in his old age to publish this work in a small format and to leave many other things unpublished. The latter complaint is nobly justified by the enormous number and importance of his posthumous works. He published six books of masses. His son, Igino, published the seventh; but another seven posthumous volumes followed year by year, and late in the 19th century Haberl filled yet another volume with some of Palestrina's greatest works.

A set of hymns for the whole year appeared in 1589. They are severe and elaborate compositions, treating the themes of the plain-chant in close fugue. Only the alternate stanzas are set, the rest being left to unharmonized plain-chant

It is possible that the *Missa Pro Defunctis,* which appears in the 1591 edition of the First Book of Masses may have been written for Sixtus V., who died in 1590. The *obiter dicta* of this pontiff, as cited by Brini, have given a bad reputation to the harmless *Missa Tu et pastor ovium,* and have not exaggerated the glories of the *Missa Assumpta est Maria.* During the two years' pontificate of Gregory XIV., Palestrina produced a double set of Magnificats in the eight tones, on the lines of his hymns, one set giving the odd verses in polyphony. and the other set the even. In 1593, in the reign of Clement VIII , Palestrina dedicated to the abbé Anton Baume another great volume of Offertories for the whole year, in his finest motet style. His last publication was a book of Madrigali Spirituali, also one of his greatest and most deeply felt works. He was preparing a seventh volume of masses when he died on Feb. 2, 1594.

It is immensely significant that the interest in an almost homophonic harmonic colour was already present in Palestrina's early madrigals, whíle at the same time he was capable of absorbing himself in abstruse Flemish puzzles. Facile he never was; and his weaker works are heavy. Haberl, in speaking of the *First* (really the last) *Book of Lamentations,* finely characterizes Palestrina's special power as "the capacity to remain true to a fundamental mood." The range of Palestrina's fundamental moods is wide. The despair of Job has never found deeper and truer expression than in Palestrina's *Paucitas dierum* in the Fifth Book of Motets; nor has any more glorious music than that of *Dum complerentur* in the Second Book of Motets been made to tell us of the ecstasy that came with the mighty rushing wind and fiery tongues of Pentecost. And it is all achieved in and by a style which is the quintessence of purity. The severest discipline of present-day academic counterpoint has no more to do with it than Tertullian's Latin has with the style of Virgil. R O. Morris has shown, in *The Technique of Counterpoint* (Oxford University Press), how far our school teaching has travelled from the true Palestrina discipline; and Jeppesen, in the work above cited, shows how minutely accurate Palestrina's obedience to his own discipline is. And this is not asceticism. It denies itself nothing; for it is God-intoxicated and its peace is in the Will that inspires it.

Palestrina's works, as contained in the complete edition published by Breitkopf and Härtel, comprise 256 motets in seven volumes, the last two consisting largely of pieces hitherto unpublished, with one or two wrongly or doubtfully ascribed to Palestrina; 15 books of masses, of which only six were published in Palestrina's lifetime, the seventh being incompletely projected by him, and the 14th and 15th first collected by Haberl in 1887 and 1888; three books of magnificats, on all the customary tones; one volume of hymns; one volume (two books) of offertories for the whole year; a volume containing three books of litanies and several 12-part motets; three books of lamentations; a very large volume of madrigals containing two early books and 30 later madrigals collected from mixed publications; two books of *Madrigali spirituali,* and four volumes of miscellaneous works, newly discovered, imperfectly preserved and doubtful. The fourth volume of motets contains the Song of Solomon; and the fifth volume is a collection designed for use throughout the Church year.

(D. F. T.)

PALEY, FREDERICK APTHORP (1815–1888), English classical scholar, born at Easingwold, Yorks., was the grandson of William Paley and was educated at Shrewsbury and St. John's College, Cambridge. His conversion to Roman Catholicism forced him to leave Cambridge in 1846, but he returned in 1860 and resumed his work as a "coach," until in 1874 he was appointed professor of classical literature at the newly founded R.C. University at Kensington. This was closed in 1877 for lack of funds, and Paley removed to Boscombe, where he died on Dec. 8, 1888. His most important editions are: *Æschyli quae supersunt omnia* (1844–47; 4th ed., 1879); *The Tragedies of Euripides,* 2nd ed. (1872); *The Epics of Hesiod, with English "Votes,* 2nd ed. (1883); *The Iliad of Homer, with English Notes,* 2nd ed. (1884); *Sophocles, with English Notes* (1880); *Select Private Orations of Demosthenes,* 3rd ed. (1896–98); *Theocritus, with short Latin Notes,* 2nd ed. (1869). He possessed considerable knowledge of architecture, and published manuals of *Gothic Architecture* (1846) and *Gothic Mouldings,* 6th ed. (1902).

PALEY, WILLIAM (1743–1805), English divine and philosopher, was born at Peterborough. He was educated at Giggleswick school, of which his father was head master. and at Christ's College, Cambridge. He graduated in 1763 as senior wrangler, became fellow in 1766, and in 1768 tutor of his college. He lectured on Clarke. Butler and Locke, and also delivered a systematic course on moral philosophy, which subsequently formed the basis of his well-known treatise on the *Evidences of Christianity.* The subscription controversy was then agitating the university, and Paley published an anonymous *Defence* of a pamphlet in which Bishop Law had advocated the retrenchment and simplification of the 39 articles. In 1776 he was presented to the rectory of Musgrave in Westmoreland, supplemented at the end of the year by the vicarage oi Dalston, and presently exchanged for that of Appleby. In 1782 he became archdeacon of Carlisle. At the suggestion of his friend John Law (son of Edward Law, bishop of Carlisle and formerly his colleague at Cambridge), Paley published (1785) his lectures. revised and enlarged, under the title of *The Principles of Moral and Political Philosophy.* The book at once became the ethical textbook of the University of Cambridge, and passed through 1j editions in the author's lifetime. He strenuously supported the abolition of the slave trade, and in 1789 wrote a paper on the subject. *The Principles* was followed in 1790 by his first essay in the field of Christian apologetics, *Horae Paulinae, or tkc Truth of the Scripture History of St. Paul evinced by a Comparison of the Epistles which bear his Name with the Acts of the Apostles and with one another,* probably the most original of its author's works. It was followed in 1794 by the celebrated *View of the Evidences of Christianity.* Paley's latitudinarian views are said to have debarred him from the highest positions in the Church, but he became a canon of St. I'aul's, subdean of Lincoln. and rector of Bishopwearmouth. During the remainder of his life his time was divided between Bishopwearmouth and Lincoln. In 1802 he published *Natural Theology, or Evidences of the Existence and Attributes of the Deity collected from the Appearances of Nature,* his last book. He died on May 2j, 1805.

The face of the world has changed so greatly since Palcy's day that the modern critic is apt to do less than justice to his undoubted merits. He is nowhere original and nowhere profound. but his strong reasoning power, his faculty of clear arrangement and forcible statement place him, in the opinion of many, in the first rank of expositors and advocates.

An edition of Paley's *View of the Evidence of Christianity,* annotated by Richard Whateley, was published in 1953.

For his life. *see* Lives by G. W. Meadley (1809) and his son Edmund Paley, prefixed to the 1825 edition of h i works; Leslie Stephen in *Dictionary of National Biography; Quarterly Review,* ii (Aug. 1809), ix (July 1813). On Paley as a theologian and philosopher, *see* Leslie Stephen, *English Thought in the Eighteenth Century,* i, 405 *seq.,* ii, 121 seq.

PALGHAT, a municipal town in the Palghat district of Kerala state, India, on a short branch of the Southern railway from Olavakkod. Pop. (1951) 69,504. As the key to Travancore and Malabar from the east. it was of strategic importance. The fort fell to the British in 1768; it was the basis of many of the operations against Tipu.

The easy ascent by the Palghat pass affords the chief route from the west coast to the interior. The town is the site of the government Victoria college. affiliated with the University of Travancore.

PALGRAVE, SIR FRANCIS (1788–1861), English historian, was born in London in July 1788. He edited several volumes for the record commission. In 1832 he was knighted. and he became deputy keeper of the public records in 1838, holding that office until his death at Hampstead on July 6, 1861.

Palgrave's most important work is his *History of Normandy and England* (4 vol., 1851–64), which deals with the history of the two countries down to 1101.

He also wrote *History* of *England, Anglo-Saxon Period* (1831); *Rise and Progress of the English Commonwealth* (1832); *Essay* Upon *the Original Authority of the King's Council,* etc.

His collected historical works were edited by his son, Sir R. H. I. Palgrave, in 1919

PALGRAVE, FRANCIS TURNER (1824–1897), English critic and poet. eldest son of Sir Francis Palgrave, was born at Great Yarmouth. on Sept. 28. 1824. He was educated at Charterhouse and at Balliol college, Oxford. In 1546 he interrupted his university career to serve as assistant private secretary to Gladstone, hut returned to Oxford the next year, and took a first class in literae humaniores.

From 1847 to 1862 he was fellow of Exeter college, and in 1849 entered the education department at Whitehall. In 1850 he became vice-principal of Kneller Hall Training college at Twickenham. There he came into contact with Tennyson, and laid the foundation of a lifelong friendship. When the training college was abandoned. Palgrave returned to Whitehall in 185j, becoming examiner in the education department, and eventually assistant secretary.

He married, in 1862, Cecil Grenville Milnes. daughter of James Milnes-Gaskell. In 1885 he succeeded John Campbell Shairp as professor of poetry at Oxford. He died in London on Oct. 24, 189;.

Palgrave published some volumes of poetry, *Visions of England,* (1880–81), *Amenophis* (1892), and others; but his work as a critic was by far the more important. His *Landscape in Poetry* (1897) showed wide knowledge and critical appreciation of one of the most attractive aspects of poetic interpretation.

Palgrave's principal contribution to the development of literary taste was contained in his *Golden Treasury of English Songs and Lyrics* (1861). an anthology of the best poetry in the language constructed upon a sound and spacious plan and followed out with a delicacy of feeling which could scarcely be surpassed. It subsequently went through many editions.

Palgrave followed it with a *Treasury of Sacred Song* (1889) and a second series of the *Golden Treasury* (1897) including the nork of later poets, but neither of these was as distinguished as the famous *Golden Treasury of English Songs and Lyrics.*

Among his other works were *The Passionate Pilgrim* (1858), a volume of selections from Robert Herrick entitled *Chrysomela* (1877), a memoir of Arthur Clough (1862) and a critical essay on Sir Walter Scott (1866).

See Gwenllian F Palgrave, F *T. Palgrave* (1899).

PALICI, in antiquity, a pair of local Sicilian gods who presided over the twin geysers still called Lago dei Palici, near Palagonia The mysterious phenomenon awed the ancients. who held the place holy and swore by it oaths of the greatest neight. The site became an asylum for escaped slaves, nhence its importance as a symbol during the Sicilian slave revolts. The Palici nere only local, volcanic gods, divine derivatives of the geysers which they represented, but the mythographers made them the offspring of Zeus or Hephaestus.

See Diodorus Siculus, xi, 89; J. H. Croon, "The Palici," in *Mnemosyne,* vol. v, pp. 116–129 (1952). (T. V. R.)

PALIKAO, CHARLES GUILLAUME MARIE APPOLLINAIRE ANTOINE COUSIN-MONTAUBAN, COMTE DE (1796–1878), French general and statesman. was born in Paris on June 24, 1796. He served as a cavalry officer in Algeria, and captured Abd-el-Kader, the amir of Mascara. He was promoted general of division and commanded the province of Constantine. receiving a home command in 1858. In 1859 he led the French troops in the joint French and British expedition to China. In 1862 Napoleon III gave him the title of comte de Palikao. In 1865 he commanded the 4th army corps at Lyons.

After the first disasters of 1870 had shaken the Ollivier ministry the empress regent made him minister of war, and he became president of the council (Aug. 10). He reorganized the military resources of the nation and claimed to have created three new army corps. 35 new regiments and 100.000 *gardes mobiles* in 24 days. His scheme to send the army of Châlons to raise the blockade of Metz ended with the disaster of Sedan. After the capitulation of the emperor the dictatorship was offered to Palikao. but he refused to desert the empire and proposed a council of national defense. But the chamber was invaded by the mob. and Palikao fled to Belgium. In 1871 he published *Un Ministère de la guerre de vingt-quatre jours.*

Palikao died at Versailles on Jan. 8, 1878.

PALI LANGUAGE is the language of the canonical texts and commentaries thereon, collectively called Tipitaka, of the Hīnayāna Buddhist scriptures. The term *pāli* meant first of all the canonicnl texts of these scriptures: its present use is a shortening of *pālibhāsā* "the language of the canon." The texts are preserved in Ceylon, as well as in Burma and Thailand to which they were carried from Ceylon. They originated however in north India in the first few centuries of Buddhism, and tradition has it that they were brought to Ceylon by the emperor Aśoka's son Mahinda (3rd century B.C.). At an unknown period after the introduction into Ceylon the use of Pali died out in India.

The language is a literary one based on a Middle Indo-Aryan dialect. Sanskrit. the literary language of the Hinduism to which the Buddha was in opposition, was expressly forbidden by him as a vehicle of teaching. This was presumably because it was already in his lifetime a learned language and not readily intelligible to the people he wished to convert. He preferred that his teachers should use their own vernaculars and those of the people in their preaching and teaching. Numerous Middle Indo-Aryan vernaculars were involved as time went on. and in all of them their own linguistic versions of the Buddha's words and sermons were preserved. As great centres of Buddhist learning grew up, certain of the versions attained prestige. None of them was unmixed; there must certainly have been great wandering teachers whose dialect versions were adopted in part even in the great centres.

Because of this multiplicity of dialects, all of which enjoyed equal authority, it has not been possible to assign a locality of origin to Pali. The Buddha himself was a native of Kosala (modern Oudh) and preached both there and in Magadha (the modern districts of Patna and Gaya), both localities being in or near the modern Bihar. The term Māgadhī "the language of Magadha" was applied to Pali in Ceylon. But the Pali documents are written in at least two chief dialects of different chronological periods, one found in the old verses of the canon. the other one in the prose: both canonical and noncanonical, and in late verses. Neither dialect is closely related to Māgadhī Prakrit. of which a good

deal is known through later documents and grammarians. Some Magadhi-like forms are found in the Pali texts, but they are considered to be borrowings into the more original non-Māgadhī dialect. There have been many conjectures as to the true locality of origin of Pali. Nearly all scholars find themselves forced to think of regions farther west in northern India than Magadha. Takṣaśīlā, the great university of the northwest, has been suggested, but perhaps Ujjayini (Ujjain), the capital of Avanti, is most favoured by modern scholars. The great mixture of divergent dialectal forms seen in Pali is caused by the imposition of the variant linguistic versions on this basic western or west central dialect.

Characteristics of the Language.— Pali is the Middle Indo-Aryan language that is on the whole closest to Old Indo-Aryan, *i.e.*, Vedic and Sanskrit. It shows in general the same type of relationship to these that all the other Middle Indo-Aryan languages do. It is difficult, that is, to derive it entirely from either of the well-documented older dialects. Its basis is in all probability some other Old Indo-Aryan dialect than these two. Evidence for this is seen in such items as *idha* "here" beside Vedic and Sanskrit iha (cf. Avestan *iδa*), or the enclitic third personal pronoun *sē,* which is found in Avestan Se, Old Persian *šaiy,* but not in Vedic or Sanskrit.

Phonology.—Of the Sanskrit vowels, *ṛ* is represented by a, i or *u*. The long diphthongs *āi* and *āu* coalesce with *ē* and *ō*. In general, long vowels remain only in open syllables and are shortened in close syllables; this produces two new vowels in Pali, short *e* and *o; e.g.,* ottha- "lip"; Sanskrit *ōṣṭha-*.

Single Sanskrit consonants generally remain unchanged, except that d and dh become *ḷ* and *ḷh* respectively (as in the Rgveda). and the three sibilants coalesce as *s*. Consonant clusters in general show assimilation and simplification to two consonants only; *e.g.,* satta "seven"; Sanskrit sapta, aggi- "fire"; Sanskrit agni-, *tikkha-* "sharp"; Sanskrit *tīkṣṇa-*. All final consonants disappear; *e.g., vijju* "lightning"; Sanskrit *vidyut.*

Nouns.—The declension has been simplified in comparison with that of Sanskrit; *e.g.,* the dual number is lost. The eight-case system is reduced. The dative has almost entirely coalesced with the genitive; in the commonest declension, that in a, this case does remain to denote direction of motion and a few less common meanings. In the a- declension, the instrumental plural ends in -8hi (*e.g., dhammēhi*) which derives from a form like Vedic *-ēbhis* rather than from Sanskrit *-āis*. The ablative plural has coalesced with the instrumental plural and the dative plural with the genitive plural in all declensions. Stems ending in consonants have usually been converted to vowel declension types, either by loss of final consonants of the stems or by addition of a vowel after the consonant; *e.g.,* Sanskrit *āpad-* "misfortune" is represented by *āpā-* or *āpadā-*.

Verbs.—Changes in the verb system are even greater than in that of the noun. The middle voice is obsolescent, more so in the younger dialect than in the older. The passive system has active endings instead of middle. The perfect tense has almost disappeared. The past tense is an amalgam of imperfect and aorist forms, with complicated rules for the appearance or nonappearance of the prefix a-. The optative continues to be found; traces of the Vedic subjunctive are found in the old dialect.

Many of the verbs of the numerous types of the Sanskrit present system have been shifted to the commonest type which has a suffix -a-, the thematic type. There has also been a spread of a type with suffix -d-, which derives from Sanskrit denominative verbs with suffix *-aya-; e.g.,* Sanskrit *kathayati* "he tells"; Pali kathdti, besides which there appears vaddti "he says" as well as the old type vadati, *maññēti* "he thinks" as well as *maññati* (Sanskrit *manyatē*). The present stem tends to spread through all other parts of the verb system, though some verbs retain a few historically correct forms, even besides the new ones, in the future or the past participle or elsewhere. An example of the spread of the present is seen in forms of the verb meaning "to drink," which in Sanskrit has a reduplicated present *pibati* "he drinks," hut future *pāsyati* "he will drink" and gerund *pītvā* "having drunk"; in Pali corresponding forms are *pivati, pivissati* (and *passati*), *pivitvā* (and *pitvā*), and there are past forms *pivāsiṃ* "I drank," *apivi* "he drank."

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(M. B. E.)

PALI LITERATURE. Most of the extant older literature in the Pali language is arranged as the *Tipiṭaka* Pali, the canon of the Theravāda school of Buddhism (see also BUDDHISM). Though it claimed to be the only orthodox tradition, the Theravada was one of a number of schools which gradually became separated as Buddhism was propagated over northern India after the *Nirvāṇa* (Sanskrit; Pali, *Nibbāna*) of the Buddha (see GAUTAMA BUDDHA). Located originally in central and western India, this school apparently rehearsed its canon orally in a dialect of that region (of the 5th–3rd century B.C.), in accordance with the Buddha's injunction that his followers should remember his teaching in their own dialects (rather than in the Sanskrit of Brahmanical learning). Comparison with what remains of other canons shows that the Pali canon consists largely of a common heritage of teaching ascribed to the Buddha, in which minor modifications may have been made and to which certain secondary texts have been appended. The latest important additions are compositions of about the 2nd century B.C. From the essential similarity of the older texts to those of other schools, and from their contents, it may be said that the Pali canon represents primarily the literature of the middle Ganges basin and the empire of Magadha (*q.v.*) between the 6th and the 4th centuries B.C., with a secondary and later extension to the west.

Some time before the 5th century A.D. the language of the canon came to be regarded (through a new gloss on the Buddha's injunction, which happened to be ambiguous: "own" being either "his own" or "my own") as the Buddha's own language, and moreover as Māgadhī, the northeastern dialect. No longer a current vernacular, Pali came to be used as the standard and international language of Theravāda Buddhism. This literary language flourished in India, especially south India, down to about the 14ih century A.D.; in Ceylon, where it was introduced by the 3rd century B.C.; Burma, where it spread from Ceylon by the 11th century A.D.; Siam (Thailand), Cambodia, Laos and Vietnam, where it was still in use in the 20th century. It also flourished briefly in Indonesia in about the 11th century. The Pali canon was ritten down in Ceylon in the 1st century B.C.—the prejudice in favour of oral transmission having broken down under the stress of practical needs—while the later literature is a purely written literature.

Divisions of the Canon.— The *Tipiṭaka* ("Threefold Basket"), Sanskrit, *Tripitaka,* is arranged in three parts: Vinnya *Pitaka,* an elaboration of 227 rules of the Buddhist monastic discipline. with an account of the founding of each by the Buddha, which includes also a brief life of the Buddha to his founding of the order and a record of events in the order down to the first great schism (*c.* 386 B.C.); Sutta-pitaka, the doctrines (*dhamma*) of Buddhism developed in dialogues (*sutta* or suttanta), stories and poems; and *Abhidhamma Piṭaka,* a collection of treatises in which Buddhist philosophy is elaborated systematically in accordance with Theravāda teaching. As literature in the narrower sense it is the *Sutta* which is the most interesting of these divisions; it is much the largest and it includes the earliest texts. The *Abhidhamma* is a secondary systematization of the doctrines of the *Sutta;* the *Vinaya* is mainly legalistic in content, though it has a few incidental narratives of literary merit and much matter of sociological interest.

The "Sutta."—The dialogues contain discussions on philosophical and metaphysical topics (such as the nature of the universe; whether there is a "soul"; "immortality"; transmigration; free will; the deity; causation; and ethics) and on the good life—on the unsatisfactory nature of the pursuit of transient worldly happiness and on the Buddhist Way of renunciation, harmless living, self-control, self-possession, wisdom and meditation leading to equanimity or detachment, *upekhā,* in which state *nibbāna* ("enlightenment") may be attained. The Buddha is described travel-

ing in various countries of eastern India and engaging in these dialogues, given in direct speech in a lively, incisive style, on meeting with Brahmanical priests, other wandering philosophers and ascetics, kings arid nobles and men and women of many professions in the cities. To those living "in the world" (*i.e.*, not renouncing it for the life of a wanderer seeking detachment), social virtues and good friendship are recommended as promoting the happiness of the individual and of society. Humour abounds in the discourse of the Buddha, for example when he narrates stories to illustrate the degeneration of society which resulted from the attempts of a king to prevent crime in his own way, in disregard of External Law (*dhamma*), or the pompous humbug of a deity ("God") who pretends to be omnipotent and omniscient and claims to have created the universe, but is chiefly concerned to avert having his ignorance exposed before the other inhabitants of heaven. The best dialogues are the longer ones, collected in the *Dīgha-nikaya*!"Collection of Long Dialogues"), which is probably the most ancient and authentic part of the *Sutta,* judging from the richness and fluency of its language and the variety and originality of its episodes. Sometimes verses or short poems occur in the dialogues; for example, a spontaneous verse (*udāna*) uttered under the inspiration of some event, usually with metaphorical allusion to Buddhist teaching, or a concise summary of doctrine, or even on one occasion a love song accompanied on the *viṇā.* One dialogue with numerous incidental verses in elaborate lyric metres (describing the qualities of a Buddha) is said to have been added by the disciple Ānanda (*q.v.*) after the Buddha's *Nibbāna;* another contains some curious folklore verses on the guardian spirits of the four quarters of the earth. one of whom rules over a utopian realm where there is no property and no work. The *Dīgha,* with three other *Nikayas*—the *Majjhiṃa* ("Medium-length"), *Saṃyutta* ("Classified") and *Aṅguttara* ("Enumerating[n]")—form the interlocking but not quite homogeneous *Four Nikāyas.*

The poetry of the canon, except as noted above and the songs (*geyya*) in the first section of the *Samyutta,* is collected in a fifth *nikāya,* the *Khuddaka-nikāya* ("Collection of Minor Texts"). This perhaps originated as a collection of poems by followers of the Buddha, including, however, some short dialogues attributed to the Buddha himself. The Buddha is said to have disapproved of poetic composition as a worldly means of gaining a livelihood (though he recommended the hearing of songs and his discourse abounds in similes, stories and occasional verses, which seem to give a lead to the poetic presentation of *dhamma*), hence after his *Nibbāna* the official recension of doctrine may at first have excluded the *Khuddaka* tests. These were greatly expanded down to at least the 3rd century B.C., and new genres were exploited for the propagation of Buddhist teaching.

Pali poetry may be classified into lyric, in which nearly 30 different metres are used, and word music and a great variety of rhythmical patterns prevail; and epic, restricted in the main to a single narrative metre having a very flexible line which can avoid monotony. Pali metres are quantitative! but whereas the narrative metre, which is archaic, permits of variation of rhythm except in the final cadence by the substitution of one short for one long syllable and is based on the number of syllables in the line (16 in two groups of 8, the half-cadence contrasting with the final cadence), the lyric metres are strictly quantitative: two short syllables are exactly equal to, and may sometimes be substituted for, one long. Most Pali lyric metres imply a musical phrase as basis, a structure which was new to Indian poetry in the 5th century B.C. Along with certain features of style, figures of speech, vocabulary and content, these new metres of Pali poetry are the prototypes of those of the *kāvya* literature in Sanskrit and Prakrit and eventually in Apabhramśa, classical Hindi, etc. It is to obscure Pali (or originally Miigadhi) pioneers, such as Vāgisa, Tālaputa and Ananda, that we owe the forging of the medium of India's greatest poetry. Certain dramatic dialogues in verse implying some kind of performance have been adduced as evidence concerning the development of the Indian drama in this period.

In the *Khuddaka* the *Jātaka* (*q.v.*), in its longer stories, contains the best examples of Pali epic poetry. It is interesting to compare the storytelling technique seen in the *Dīgha* (which contains a few *jātakas,—i.e.,* stories of the Buddha's births or incarnations—but in prose) with that of the *Jātaka* itself (in verse), particularly as some stories are common to both works. An epic narrative (*akkhāna*) could be iti prose or verse; it was only later that the two forms diverged sufficiently from the basic popular tradition of storytelling to become the contrasting Sanskrit *kāvya* genres of prose *akkāyikā* ("history") and verse *mahākāvya* ("epic"). Many *Jātaka* pieces have too few verses to narrate a story: and give only the climax or most significant speech or the moral of a once well-known story (to be freely extemporized when required). In a few cases the full story is preserved in ancient form in the *Dīgha* or elsewhere. The *Jātaka* is a remarkable treasury of ancient folk tales (with only a veneer of Buddhist ethics) and a rich source of data on ancient society. The *Khuddaka* also includes four inferior narrative books in verse, compiled as edifying material for routine preaching (*e.g.,* lives of Buddhas, *Buddhavaṃsa;* legends of monks and nuns, *Apadāna*). Then there are the lyric anthologies (the work of several hundred authors,. both men and women), the *Dhammapada, Suttanipāta* and *Theragāthā* and *Therigāthā,* the last three containing also ballads and some fine though short epic episodes. Besides five other miscellaneous books, the Khuddaka includes also an extensive philosophical compendium (*Paṭisambhidāmagga*) similar to the *Abhidhamma* books.

The *"Abhidhamma."*—The Abhidhamma originated as an elaboration and explanation of certain lists and summaries of points of doctrine called *Mātikā* ("notes"). Most of the constituent *mātikās* and much of the explanation are to be found scattered in the *Sutta,* the basic list being promulgated in the *Dīgha* account of the Buddha's instructions to the monks before his *Nibbāna.* It consists of the *Vibhaṅga,* the basic synopsis of *mātikās* and explanations; the *Dhammasaṅgaṇi* and *Dhātukathā,* which are primarily cross-classifications of points of doctrine (on ethics, psychology, physics) leading toward a synthetic system of natural and moral philosophy; the *Puggalapaññatti,* which enumerates types of character; the *Kathāvatthu,* consisting of polemic on points disputed with other schools of Buddhism and exemplifying early techniques of debate and logic; and the Yantaka, a manual of exercises in formal logic. The *Paṭṭhāna* is a grandiose elaboration of a general theory of causality synthesized from elements of causal theory (fundamental to the early Buddhist doctrine of the nature of the universe and of man's predicament in it) in the Sutta and *Vibhaṅga.*

Later Pali Literature.— This begins with a long dialogue (in the *Dīgha* style), cast in the external framework of a "history" or historical novel (*akkāyikā*), the *Milindapañha.* The work seems to have grown gradually by large accretions to a kernel of (probably) the 1st century B.C. The *Netti* and *Peṭakopadesa,* theoretical works on exegesis, are of about the same period. These are Indian works, as is the earliest extant grammar (Kaccayana's, of unknown date) but in about the 5th century A.D. the Mahāvihara (Great Monastery) in Anuriidhapura, the ancient capital of Ceylon. became the main centre of Theravāda studies. In India new schools and movements in Buddhism adopted new languages and eclipsed the Theravāda school, which adhered to its canon in the ancient Pali. From the 3rd century B.C. the Sinhalese had translated oral commentarial (*Aṭṭhakathā*) traditions into the ancient Sinhalese language in order to interpret the canon. By about A.D. 100 this Sinhalese commentary had attained comprehensive scope and was closed. In Pali (verse), successive writers in Ceylon, down to the 4th century A.D., compiled the *Dīpavamsa* ("History of the Island").

In the 5th century A.D. Indian Buddhists studying at Anurādhapura undertook a translation into Pali of the essential parts of the Sinhalese commentary, to make them accessible wherever Pali was known. An entirely new style of Pali was evolved. Buddhaghosa wrote the *Visuddhimagga* (an introductory exposition of the whole range of doctrine according to the Sinhalese tradition) and running commentaries on the *Vinaya, Four Nikāyas, Abhidhamma* and two Khuddaka tests. Commentaries on the remaining Khuddaka books and the *Netti* were written by Dhammapāla,

Buddhadatta, Upasena. Mahānāma and the anonymous authors of the *Jātaka Commentary* (which includes full stories for all the *Jātakas*), *Dhammapada Commentary* (which adduces more than 400 illustrative stories) and *Apadāna Commentary.*

At the beginning of the 6th century AD. Mahānāma wrote the *Mahāvamsa* ("Great History"), a verse chronicle based on the *Dīpavaṃsa* but unified in treatment and much more polished in style. It may be said to inaugurate a new phase in Pali literature: that of the later *kāvya.* This is not continuous with the old Pali *kavya* in the canon. the direct successors of which were in Sanskrit and Prakrit, but derives its style from these successors after they had carried *kāvya* through several centuries of fashion and refinement Mahānāma states that his aim is to inspire good people with religious emotion. His chronicle, like the *Dīpavaṃsa*, narrates the history of Buddhism from the Buddha's complete Enlightenment to the 3rd century B.C. in India and the 4th century A.D. in Ceylon. Influenced by the conventions of an epic *kāvya*, Mahānāma interrupts his annals to celebrate elaborately the deeds of the two great Sinhalese kings primarily responsible for the introduction and firm establishment of Buddhism in Ceylon, Devānampiyatissa (3rd century B.C.), and Duṭṭhagāmaṇi (1st century B.C.), who is regarded as a national hero who freed his country from Tamil rule. Later poets in Ceylon wrote supplements (often called *Cūlavaṃsa,* "Little History") to the *Mahāvamsa.* The first and longest* written by Dhammakitti (13th century), centres on the epic treatment of Parakkamabahu I (12th century) as a national hero.

The chronicle epic was adopted for the histories of various countries of southeast Asia and for other narratives, particularly the life of the Buddha: *e.g.,* Medhaṅkara's (Ceylon; 13th century) *Jinacarita,* and the anonymous Mālālaṅkara (Burma; 18th century). The Buddhālaṅkāra of Sīlavamsa (Burma; 15th century) tells the favourite story of the Buddha's previous incarnation as Sumedha, when he first resolved to become a Buddha. Several other works deal with specific aspects of religious history. The prose (*Mahā*) *Bodhivaṃsa* (by Upatissa, *c.* A.D. 970), on the bringing of a cutting of the Buddha's Enlightenment Tree to Ceylon, is of great stylistic interest as displaying much of the vocabulary of contemporary Sanskrit *kāvya* assimilated to Pali. The style of the true Sanskrit *mahākāvya* (with its several cantos in different metres, often of lyric origin, instead of in the ordinary narrative metre only) is exemplified in Dhammakitti's *Dāthāvamsa* (Ceylon, *c.* 1200) on the Tooth Relic. There are 20th-century *mahākāvyas* such as Medhānanda's (Ceylon) *Jinavamsadīpa* (published 1917), a life of the Buddha. Of biography may be noted Mahāmaṅgala's (? Ceylon, ? 14th century) *Buddhaghosuppatti,* a popular religious novel on the life of the saint, and the learned Ñāṇābhivaṃsa's *Rājādhirājavilāsini* (Burma; 18th century) which celebrates the deeds of the contemporary king of Burma, Bodōpayā.

The later lyric *kāvya* is well exemplified by the anonymous (? 10th century) *Telakaṭāhagāthā,* on renunciation, recited by a monk thrown into a caldron of boiling oil but miraculously remaining alive for a time because of his innocence, and the *Pajjamadhu* of Buddhappiya (an Indian monk living in Ceylon; 13th century), describing the Buddha. The much longer *Samantakūṭavaṇṇanā* of Vedeha (Ceylon; 13th century) is on the borderline of epic and lyric, describing the Buddha's life and (mythical) visits to Ceylon, culminating with that to its highest peak (Adam's peak). Vedeha's descriptions of Sinhalese scenery are remarkable.

The genre of *citrakāvya*, or poem displaying virtuosity in word play and in the mere technicalities of *kāvya* composition as an end in themselves, is represented in extreme form by the *Jinālankara* of Buddharakkhita (Ceylon; 12th century) on the life of the Buddha (this life being as it were the form, and virtuosity in composition the content. of the poem).

Ānanda's (late 12th century) *Saddhammopāyana* is a simple but effective didactic poem in 19 cantos urging the reader to seize the opportunity of following the Buddhist Way. The description of the sufferings of animals, especially as beasts of burden, is a fine example of his art.

The anonymous 13th-century *Hatthavanagallavihāravamsa* ("History of the Hatthavanagallavi Monastery") is a *kdvya* in mixed prose and verse (a *campu*) in which Pali prose receives its most elevated and elaborate treatment, imitating the style of the Sanskrit novels of Bāṇa. Vedeha's *Rasavāhinī* is an outstanding collection of popular old stories.

Exegesis did not end with the Pali versions of the commentaries nor with the numerous handbooks on various aspects of philosophy (*e.g.,* the nine "Little Finger" manuals) and the discipline. Much old Sinhalese material remained untranslated. After about the 8th century the Pali commentaries were provided with subcommentaries (*tīkā*) which explained their words and thus incidentally elaborated the exposition of the basic canonical texts. As a rule the *tīkās* are more technical than the commentaries, and they provide a thorough basis for modern lexicography. The earliest cycle of *tīkās*, of the 8th or 9th centuries, consists of Ānanda's (an Indian working in Ceylon) work on the *Abhidhamma,* Dhammapāla's on the *Four Nikāyas* and the *Jātaka* and Vajirabuddhi's (also Indian) on the *Vinaya.* A Dhammapāla, a pupil of Ananda, wrote a sub-subcommentary on his teacher's *tīkā.*

In the 12th century Sāriputta (Ceylon) wrote detailed *tīkās* on the *Vinaya* and the *Four Nikāyas,* while his contemporary Kassapa in south India wrote a succinct *Vinaya tikd* which might be more easily assimilated by his pupils. There is a cycle of *tīkās* (undated) on the *Kkuddaka,* and many *tīkās* on such treatises (regarded as "commentaries") as the *Visuddhimagga.* A "new" *Dīgha tīkā* was written in Burma in the 18th or 19th century.

See also SANSKRIT LANGUAGE AND LITERATURE; GAUTAMA BUDDHA.

BIBLIOGRAPHY.—*Texts:* Most of the canon and commentaries, the *Mahāvamsa* (1912), *Cūlavaṃsa* (1929), *Bodhivaṃsa* (1882), numerous handbooks and several *kāvyas* have been published by the Pali Text Society, London, and also in Ceylon, Burma and Thailand; and some in Cambodia and India. *Vinaya,* 5 vol. (1879–83) and *Dīpavaṃsa* (1879) were ed. by H. Oldenberg; *Jātaka* and its *Commentary,* by V. Fausbøll, 7 vol. (1877–97); *Milindapañha,* by V. Trenckner (1880); *Visuddhimagga,* "Harvard Oriental Series," no. 41 (1950); *Jinālaṅkāra,* ed. and trans by J Gray (1894). Some *Tīkās* have been published in Burma and Ceylon, but many remain neglected; there is an excellent edition of the best grammar, Aggavamsa's *Saddaniti,* by H. Smith, (1928–30, index volumes in progress); other works on grammar, lexicography, poetics, etc., and the *Rasavāhinī,* have been published in Ceylon.

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PALIMPSEST, from the Greek *palimpsestos,* "scraped again," a term referring to any inscribed surface from which one text has been removed so that the space could be used again for another. In antiquity the word was applied loosely to any writing material that had been cleared and re-used, *e.g.,* to papyrus and waxed tablets, although the former was surely too fragile to withstand the rubbing or scraping that is implicit in the etymology of the word. Plutarch says that Plato found Dionysius like a *biblion palimpseston,* in that his tyrant nature, being *dusekplutos,* "hard to wash out." showed through like imperfectly erased writing. The reference here is quite clearly to washing the writing off papyrus. Extant palimpsests are almost exclusively of vellum or parchment.

In late classical and medieval times the scarcity and costliness of vellum were so great that it was quite frequently salvaged after the text, which had been inscribed thereon, fell into neglect. One method of preparing parchment for re-use, described in a codex of Munich, was to soak it overnight in milk, sprinkle it with flour,

dry it under pressure and then scour it with pumice and chalk. Rarely a book might be doubly palimpsest, *i.e.*, exhibit two erased texts with a third one overlying them. The texts marked for obliteration were usually those of the longer classical works such as those of I'lautus. Cicero. Sallust, Livy and Fronto. S o complete work. however. has been found in the original text of a palimpsest, portions of different hooks having customarily been used to supply the material ior the new volume. Prejudice against pagan authors seems not to have been involved. even in the monasteries. in the selection of books from which the writing was to be expunged. Any codex no longer in regular use was liable to suffer this fate. For example, an uncial text of the Bible was destroyed in the 9th century to make room For the works of Probus and other grammarians. In the case of Greek manuscripts, however, a synodal decree of A.D. 601 forbade the destruction of intact manuscripts of the Scriptures or of the church fathers.

Palimpsests are especially frequent among the hooks written at Bobbio and St. Gall. Unquestionably the practice of reusing inscribed parchment resulted in the destruction of vast quantities of early texts which would be of immense value to modern scholarship. But. in view of the disuse into which they had fallen! it may be doubted how many of them would have been preserved. and the superimposed text was responsible for the preservation of some which might otherwise have been lost. Important texts of Cicero. Livy, Plautus, the two Plinys and Seneca survive in palimpsests, The pioneer in the study and reading of palimpsests m s Angelo Mai

To bring out the original writing of a palimpsest chemical agents, such a5 tincture of gall and hydrosulfate of ammonia nere oiten used While temporarily effective, these were likely to cause permanent damage to the surface to which they nere applied; ultraviolet photography has taken their place as the safest and most satisfactory tool in the decipherment of obscure palimpsest texts. The basis for the technique is the fact that some substances fluoresce under ultraviolet light more strongly than others: and that often the remnants of the ink of the original writing. which may be quite invisible to the naked eye, operate to "kill" the fluorescence of the underlying material so that the old writing appears dark against a fluorescing background. The process can sometimes be aided by the application of anthracene ($C_{14}H_{10}$) in alcohol. which is harmless to vellum. as well as to paper. and serves to increase their fluorescence for a period of about one week. If there is underwriting on both sides of the leaf. each side must be treated separately, and a sufficient time will have to elapse for the anthracene crystals to evaporate from the first side before the other can be examined.

Sre for important palimpsests, Wattenbach, *Schriftwesen,* 3rd ed., pp. 299–317; also *Exempla Codicum Latinorum* of Zangemeister and Wattenbach. (A. F. St.)

PALINDROME, a word. sentence or verse which runs the same when read either backward or forward.

Words: madam, deified. Sentence: "Lewd did I live. & evil I did dwel" or "Able was I ere I saw Elba." Verse: "Roma tibi suhito motibus ibit amor."

Some have refined upon the palindrome and composed verses each word of which is the same read backward as forward; for instance, that of William Camden:

> Otlo tenet mulum, madidam mnppam tenet Anna,
> Anna tenet mappam madidam, mulum tenet Odo.

The following is still more complicated. as it can he read in four ways—upward and downward as well as backward and forward:

S A T O R
A R E P O
T E N E T
O P E R A
R O T A S

(G. W. A.)

PALINGENESIS (Gr. *palin* "again," *genesis* "birth," "becoming"), a term meaning rebirth or regeneration and used, with its variant Palingenesia, in several senses.

1. Palingenesis may he used generally as a synonym of metempsychosis (*q v.*). In an analogous but more specific sense, Arthur Schopenhauer used it to denote the way in which the will manifests itself afresh in new individuals.

2. Ancient writers use *palingenesia* occasionally in metaphorical senses. *e.g.,* to mean physical revival or a revival of good fortune, whether personal or national.

3. In the Greek New Testament the word *palingenesia* is used twice. In Matt. xix. 28, it has been interpreted to mean either the establishment of the kingdom of Cod at the second coming of Christ or the spiritual regeneration of Christians during their mortal life. In Tit. iii. 5, it refers clearly to the regenerative effect of baptism.

4. In biology. Ernst Haeckel used the term palingenesis to denote the reappearance, in an organism's embryonic and larval stages, of inherited characters supposed to represent those of various adult stages through which its ancestors had passed in the course of evolution — as distinct from caenogenesis (Gr. *kainos* "new") or the appearance of characters that could not represent any adult stage.

PALISSY, BERNARD (1510–1589), French Huguenot potter and writer. particularly associated with decorated rustic faïence, was horn in 1510 at Agen, Lot-et-Garonne. At first he learned glass painting. but eventually, after journeys in the south and in the Ardennes that brought him into contact with great humanists, he settled as a surveyor and potter in Saintes. near La Rochelle. Persecuted as a I'rotestant. he was imprisoned until the constable Montmorency employed him in the decoration of the château d'Ecouen. Then in 1570. helped by his sons. Palissy built a pottery grotto for Catherine de Médicis in the garden of the Tuileries. His appointment, about 1565. as "inventor of rustic pottery to the king and the queen-mother" had enabled him to work in Paris near the Louvre and to come in contact with the sculptor Jean Goujon.

From 1575. in Paris. he gave public lectures on natural history which. published in 1580 as *Discours Admirables*, became extremely popular. In these are revealed a writer and scientist. a creator of modern agronomy and a pioneer of the experimental method. His scientific views generally were much in advance of those of his contemporaries.

Palissy was shown a white, glazed cup. probably Chinese porcelain. which so pleased him that he determined to discover the secrets of its manufacture. Palissy described in *De l'Art de la terre* his first laborious researches, undertaken despite his poverty and harassment as an ardent Huguenot.

Again menaced by the growing struggle against Protestants, Palissy took refuge in the homes of the princess of Sedan and Robert de la Marck. in eastern France. but returned to Paris in 1575. Iniprisoned again for religious reasons in the Conciergerie in 1588. he was transferred to the dungeons of the Bastille, where he died in 1589.

Palissy's Pottery. — Derived from the rustic pottery made in Europe during the 15th century, Palissy's pottery generally consists oi oval or circular dishes, ewers, *tazze* and sauceboats. It can he grouped into four successive phases: (1) subjects at times modeled from nature. pieces with cleverly marbled surfaces; (2) animal and vegetable: (3) allegorical and mythological low reliefs; and (4) about the 1580s, reproductions of the metal work of François Briot and others.

It is almost certain that Palissy never used the potter's wheel. His best-known pieces evidently have been pressed into a mold and then finished by modeling or by the application of ornament. based on contemporary engravings, molded in relief. The pottery is a firm. nonporous paste resembling faience, glazed in two kinds of hard, transparent lead enamel. S o signature or mark has ever been found on Palissy's authentic productions. His molds were again used during the 17th century at Avon near Fontainebleau and at Manerbe, Calvados, where a few enameled earthenware statuettes were produced. The influence of the great potter was revived between 1840 and 1870 through the copies executed by E. Avisseau of 'Tours and later by Georges Pull of Paris.

The best collections of Palissy's ware are in the Louvre and the

Cluny museum, Paris, in the museum at Sèvres; in England, in the Victoria and Albert museum, the British museum and the Wallace collection. all in London.

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PALITANA, a town and *tehsil* of Gohilwad district, Gujarat state, India. Pop. of town (1951) 24.097. Westward is Satrunjaya, a Jain sacred hill, which pilgrims ascend in performing the "Ninety-nine," a circumambulation of its principal temple daily for 99 days in honour of the 99.000 visits (to Satrunjaya) of a Jain saint. There also is the Muktdwara or "door of bliss," a hole in a large stone, creeping through which ensures eternal beatitude.

PALITANA TEHSIL (pop. 1951, 115,745) corresponds roughly with the former princely state of that name (area 300 sq.mi.; pop., 1941, 76,432) merged with Saurashtra, Feb. 15, 1943. (Saurashtra, in turn, merged with Bombay on Nov. 1, 1956.) It was controlled under British paramountcy through the Baroda residency (and before 1944 the Western India States agency); the ruler or *thakor* was a Gohel Rajput. Palitana is noted for horse breeding. Area of modern *tehsil* 368 sq mi.

PALK STRAITS, a channel, 33 mi. wide, between India and Ceylon. It is named after Sir Robert Palk, governor of Madras in 1763–66. The straits lie northeast of the line of reefs called Adam's Bridge, and the Gulf of Mannar lies southwest of it.

PALLA, PALA or IMPALA. a reddish African antelope of the size of a fallow deer, characterized by the large black lyrate horns of the bucks and by the presence in both sexes of glands on the back of the hind feet bearing a tuft of black hairs. On the east side the palla (*Aepyceros melampus*) ranges as far north as the southern Sudan; in Angola it is replaced by a race (*Ae. petersi*) with a black "blaze" down the face. Pallas associate in large herds in the neighbourhood of water. *See* ANTELOPE.

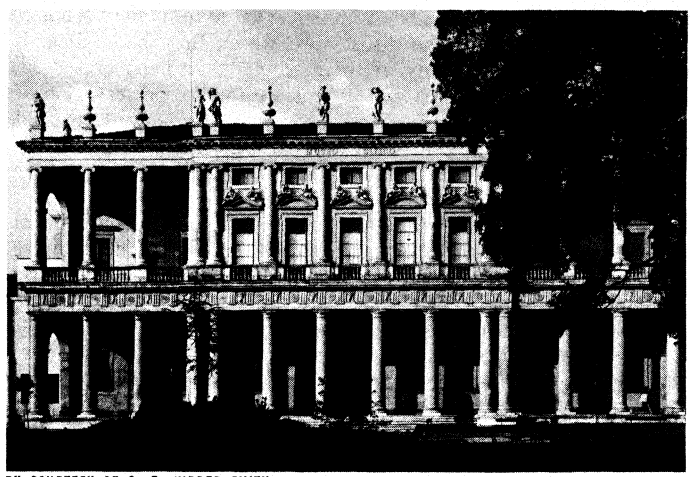
PALLADIANISM, a term applied to any architecture similar to that of Andrea Palladio (*q.v.*) in northern Italy. Palladio, however, did not originate the so-called Palladian motif, which is believed to have been used first by Bramante. The term is specifically applied to the architecture of the period 1715–60 in England when British taste relied heavily on the designs of Palladio and those of Inigo Jones (1573–1651) who had introduced High Renaissance architecture into England. Palladian architecture is characterized by symmetry, monumentality and an academic use of classical forms.

A Palladian window or motif is composed of a central arched opening flanked by a smaller rectangular opening on each side. Columns usually separate the openings. The motif derives its name from Palladio's use of the arrangement in the town hall at Vicenza, the so-called basilica (1549–1614). (A. K. L.)

PALLADIO, ANDREA (1508–1580), Italian architect who had a profound influence on the 18th-century classical revival; was born ANDREA DI PIETRO on Nov. 30, 1508, either in Padua or Vicenza. He began his career as a stonemason and sculptor. About 1536 he came to the attention of the humanist scholar Giangiorgio Trissino, who became his patron, arranged for him to study in Rome and later took him into the "Accademia Trissiniana." In 1540 Trissino gave Andrea the name Palladio, after the angel in his poem "L'Italia Liberata dai Goti" who explains the divine significance of geometrical forms in architecture. The name was well chosen, for Palladio's lasting importance rests on his theoretical treatises on proportion in architecture generally and in Roman architecture in particular. Most influential of these was I *Quattro Libri dell' architettura* (Venice, 1570, with many later editions and translations).

Palladio's greatest influence was not on the, architecture of his own time hut on that of the 18th century, when his work and writings inspired much imitation and emulation, particularly in England and America (*see* PALLADIANISM). His two guidebooks on the antiquities of Rome (Rome, 1554) and his illustrations of D. Barbaro's edition of *Vitruvius* (Venice, 1556) were the earliest publications to treat Roman buildings with scientific scholarship, and they remained standard reference works on Roman architecture through the 18th century; his buildings in Vicenza, which had little more than local fame in his lifetime. became models for a great body of 18th-century architecture. Paradoxically. perhaps. Palladio's own architectural development shows a steady retreat from that strict observance of classical rules with which Palladianism is associated toward the much freer handling of classical elements typical of mannerist art during the later 16th century in Italy.

Those of his works that follow Roman models most closely and were most admired by 18th-century neoclassicists were all early and built in or near Vicenza. The basilica (Palazzo della Ragione), so-called because it was supposed to re-create a Roman basilica, was conceived as early as 1538 and begun in 1549; the Palazzo



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PALAZZO CHIERICATI (NOW THE MUSEO CIVICO). VICENZA. ITALY. BY ANDREA PALLADIO. MID-16TH CENTURY

Chiericati. a much-copied exercise in the correct handling of Roman orders. was begun in 1550; and the Villa Rotunda (or Capra), most influential of all Palladio's dozen-odd villas and perhaps of all his buildings, was built 1550–53. With identical porticoes on all four arms of its Greek-cross plan, the Rotunda demonstrates Palladio's early adherence to the strictest symmetry, as well as his mistaken belief that such porticoes were found on the facades of Roman houses.

By contrast. Palladio's late works all show distinctively mannerist and proto-baroque characteristics. Most important of these are three churches in Venice: the façade of S. Francesco della Vigna (begun in 1566), S. Giorgio Maggiore (begun 1566, completed by Vincenzo Scamozzi 1602–10) and Il Redentore, one of his finest works (dedicated 1576, completed 1592). In designing their façades, Palladio interlocked two classical temple fronts with truly mannerist complexity; mannerist, too, are the optical and psychological effects he produced by ingenious arrangements of interior colonnades and interpenetrating spatial units. Palladio's last work was the Teatro Olimpico in Vicenza, begun in 1580, three months before his death on Aug. 19. Although Vitruvius' description of a classical theatre was his immediate inspiration, the receding vistas and optical tricks he employed are likewise imbued with the quite un-Palladian spirit of mannerism.

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PALLADIUM, an image of Pallas (Athena), especially the archaic wooden image of the goddess standing and armed that was preserved in the citadel of Troy as a pledge of the safety of the city. It was said that Zeus threw it down from heaven when Ilus

was founding the city of Ilium, and that Odysseus and Diomedes carried it off from the temple of Athena, thus making the capture of Troy possible. Many cities in Greece and Italy claimed to possess the genuine Trojan Palladium (tho ancients spoke of at least two, a false one that had been exposed to public view in Troy, and the true one in the temple of Athena there), but it was particularly identified with the figure brought to Italy by Aeneas and preserved in the shrine of Vesta at Rome.

The Palladium was a common subject in Greek art, as was its theft in literature. The story of its fall from heaven perhaps signifies that the Palladium was originally a baetylus (*q.v.*).

(T. V. B.)

PALLADIUM is a chemical element which is a precious silver-white metal, one of the six platinum metals (*see* PLATINUM METALS). With a specific gravity of 12.03, it is the lightest of the platinum metals. It has also the lowest melting point of the group, 1,550° C. It boils above 2,500° C. but very gradually loses weight by volatilization below its melting point. As a metal, palladium is ductile and easily worked. The chemical symbol for palladium is Pd; atomic number is 46 and atomic weight is 106.4.

Palladium is not tarnished by the atmosphere at ordinary temperatures. Consequently, the metal and its alloys serve as substitutes for platinum in jewelry and in electrical contacts, and the beaten leaf is used for decorative purposes. Relatively small amounts of palladium alloyed with gold yield a white gold. Palladium is useful for the preparation of dental alloys. Since it is much lighter than platinum, palladium has been used for the construction of astronomical and other fine instruments.

Palladium occurs as a minor constituent of most native platinum-bearing alloys, and is associated with a number of gold, silver and nickel ores. William Wollaston first isolated palladium from crude platinum in England. Instead of announcing the discovery of the element in the customary way, he circulated an anonymous advertisement of the new metal for sale in 1803. Because of this unorthodox procedure the claim that the new metal was not an element but an alloy of platinum and mercury was widely accepted for a time. However, Wollaston explained his source of the palladium in 1804 together with his announcement of the discovery of the element, rhodium. He named the element in honour of the newly discovered asteroid Pallas.

Surfaces of palladium function as excellent catalysts for many chemical reactions. They are especially effective in reactions involving the gases, hydrogen or oxygen. These catalysts are normally very thin deposits of palladium on an inert supporting material. They have proved valuable in the laboratory for the reduction or hydrogenation of organic compounds. In gas analyses, it is possible with careful temperature control to burn hydrogen and olefin-hydrocarbons with oxygen on a palladium surface so that methane and saturated hydrocarbons do not react.

The exceptional behaviour of hydrogen with palladium has been carefully studied. Under suitable conditions the metal absorbs more than 900 times its own volume of hydrogen. The metal expands and becomes harder, stronger and less ductile in the process. A metallic or alloylike hydride, which is a reducing agent, is formed: and a composition corresponding to the formula Pd_2H can be obtained. The hydrogen can be completely removed by increased temperature and reduced pressure. Since hydrogen passes rapidly through the metal at high temperatures, heated palladium tubes which are completely impervious to other gases function as practical semipermeable membranes and can be used to pass hydrogen into and out of closed gas systems. It for hydrogen purification.

Palladium is attacked more readily by acids than any of the other platinum metals. It dissolves slowly in nitric acid to give $Pd(NO_3)_2$, and with concentrated sulfuric acid it yields $PdSO_4$. A series of palladium compounds can be prepared with the normal +2 oxidation state.

A number of the complex compounds closely resemble corresponding compounds of platinum, although complexing groups are usually replaced more rapidly ior palladium. A yellow hydroxide, soluble in either acid or alkali solutions, is insoluble in water. The hydroxide can be dehydrated lo give the black PdO by heating to just below it.; decomposition temperature of 850° C. The oxide also forms as a thin blue coating on the surface of massive metal heated to just above 750° C. in the air, and can be prepared by heating the metal in a fused potassium hydroxide and potassium nitrate mixture. PdO can be oxidized to a brown unstable Pd_2O_3 by ozone or by electrolysis. Strong oxidizing agents can be used to prepare a series of palladium compounds with the +4 oxidation states, including hydrous PdO_2. These compounds, aimilar to corresponding compounds of platinum (IV), are, however, more readily reduced. Palladium can he separated from other platinum metals by precipitation of insoluble palladium (II) cyanide or by precipitation with the organic reagent, dimethylglyoxime. All palladium compounds are easily decomposed or reduced to the free element. Ignition of its compounds produces the sponge metal. An aqueous solution of potassium tetrachloropalladate (II), K_2PdCl_4, serves as a sensitive detector for carbon monoxide or olefin gases because a black precipitate of the metal appears in the presence of exceedingly small amounts of these gases.

(D. S. MN.)

PALLADIUS, RUTILIUS TAURUS AEMILIANUS, a Roman author of the 4th century A.D. He wrote a poem on agriculture (*De re rustica*) in 15 books, the material being derived from Columella and other earlier writers. The work is conveniently arranged but far inferior in every other respect to that of Columella.

PALLANZA, a town and summer and winter resort of the province of Novara, Piemonte, It., 659 ft. above sea level. Pop. (1951) 8,640.

It occupies a position of great natural beauty, on a promontory on the west of Lago Maggiore, with a semicircle of mountains behind and the lake and Borromean Islands in front. 62 mi. N. of Novara.

PALLAS, PETER SIMON (1741–1811), German naturalist and traveler who journeyed extensively in Asia and made important natural history collections and geological observations, was born in Berlin on Sept. 22, 1741, the son of Simon Pallas, professor of surgery in Berlin. He was intended for the medical profession and studied at Berlin, Halle, Göttingen and Leiden, but he early displayed a strong leaning toward natural history and at the age of 15 had outlined new classifications of certain groups of animals. In 1761 he went to England to study collections and make geological investigations; he was elected a foreign member of the Royal society at the aye of 23. He then went to Holland and the results or' his investigations were published at The Hague in 1766 in his *Elenchus Zoophytorum* and *Miscellanea Zoologica* and in 1767–1803 in his *Spicelegia Zoologica* (Berlin).

He was appointed professor of natural history in the Imperial Academy of Science, St. Petersburg, in 1768 and the same year appointed naturalist of a scientific expedition to Russia and Siberia. He spent six years on the journey, going by Kazan to the Caspian; lived among the Kalmucks; crossed the Urals to Tobolsk; visited the Altai mountains; traced the Irtysh to Kolyvan; went to Tomsk and the Yenisei, crossed Lake Baikal; and extended his travels to the frontiers of China. The leading results of this famous expedition were given in his *Reise durch verschiedene Provinzen des rüssischen Reichs* (3 vol., St. Petersburg, 1771–76), richly illustrated with coloured plates. Special results of that journey include the publication of *Sammlungen historischer Nachrichten über die mongolischen Völkerschaften* (2 vol., St. Petersburg, 1776–1802); *Novae species Quadrupedum* (1778), contributions to the dictionary of languages of the Russian empire 1786–89; *Icones insectorum, praesertim Rossiae Sibericae et cuaianum* (1781); *Zoographia Rosso-Asiatica* (3 vol. 1831), and articles in the *Transactions* of the St. Petersburg and Berlin academies.

The empress Catherine II bought his collections but allowed him to keep them for life. She also gave him a large estate at Simpheropol and 10,000 rubles toward establishing a home. He went there toward the end of 1795, but Pallas found the climate of the Crimea too extreme and after the death of his second wife in 1810 went back to Berlin where he died on Sept. 8, 1811. During the 15 years spent in the Crimea he continued his studies and

devoted considerable efforts toward improving the cultivation of vines. Pallas' industry was remarkable and embraced not only all branches of natural history but extended into geology, geography, ethnology and many other fields. He was credited by Baron Cuvier with having changed geological ideas. for his observations on the two great mountain chains of Siberia led him to a general theory on the formation of mountains and the succession of different types of rocks. His memoir gave birth to a new geology and was the forerunner of the ideas developed by his contemporaries, H. B. de Saussure, J. A. Deluc and A. G. Werner (*qq.v.*).

Although prematurely aged by the incredible hardships undergone during his travels and suffering from chronic dysentery most of his life, he continued his activities to the very end, and even in his last years made plans for the study of natural history collections in France and Italy.

See the essay of C. A. Rudolphi in the *Transactions* of the Berlin academy for 1812; G. Cuvier's *Eloge* in his *Recueil des éloges historiques . . .*, vol. ii (1819–27); and W. J. Jardine, *The Naturalist's Library*, vol. iv (1833–43). (ED. HE.)

PALLAVICINO, SFORZA (1607–1667), Italian cardinal, historian and theologian, author of a history of the Council of Trent written in refutation of Paolo Sarpi's (*q.v.*), was born in Rome on Nov. 28, 1607. He joined the Society of Jesus in 1637 and became successively professor of philosophy (1639) and theology (1643) at the Roman college. In 1651 he was appointed by Pope Innocent X to the commission on Jansenism. His elevation to the cardinalate in 1657 was published in 1659. He died in Rome on June 5, 1667.

Pallavicino's *Istoria del concilio di Trento*, 2 vol. (1656–57), is only one of the many books on philosophy and theology published in the incomplete collection of his works. 33 vol. (1844–48).

See C. Sommervogel, *Bibliothèque de* la *compagnie de Jésus*, vol. vi, col. 120–143 (1895); biography by I. Affò, 5th ed. (1845). (E. J. Bs.)

PALLES, CHRISTOPHER (1831–1920), lord chief baron of the court of exchequer in Ireland, whose judgments are cited as high authority in the English and U.S. courts. was born in Dublin on Christmas day. 1831. He was educated at Clongowes Wood college and Trinity college. Dublin, and was called to the Irish bar in 1853. He took silk in 1865. In politics, he was a Liberal and served successively as solicitor general and attorney general for Ireland before being made chief baron of the Irish exchequer in Feb. 1873, just before the fall of Gladstone's first ministry.

He retained his precedence and title of chief baron until his retirement in 1916, notwithstanding the merger of the court of exchequer with the Queen's bench division in 1897.

His reputation for clarity of exposition and learning in the common law was outstanding. and even in his lifetime was not confined to the circle of those who practised before him in Ireland. Palles also did much in the development of higher education in Ireland. He died at Dundrum, County Dublin. on Feb. 14. 1920.

See F. Elrington Ball, *The Judges in Ireland 1221–1921* (1926). (R. G M. B.)

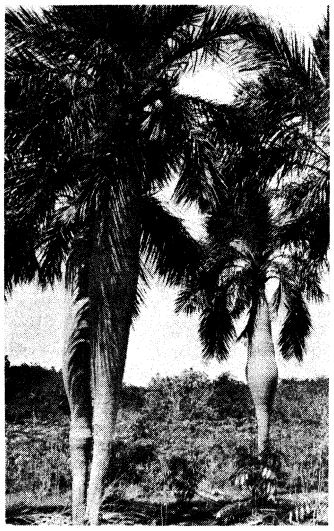
PALL-MALL, an obsolete English game of French origin, resembling croquet, called in France *paille-maille* (from *palla*, ball, and *malleus*, mallet). Thomas Blount's *Glossographin* (ed. 16 jo) describes it as follows: "Pale Maille, a game wherein a round bowle is with a mallet struck through a high 'arch of iron (standing at either end of an alley) which he that can do at the fewest blows, or at the number agreed on, wins. This game was heretofore used in the long alley near St. James's and vulgarly called Pell-Mell." The pronunciation here described as "vulgar" afterward became classic, a famous London street having been named after a Pall Mall alley. A mallet and balls used in the game were found in 1845 and are now in the British museum.

PALLONE (Italian for "large ball," from *pala*, ball), the national ball game of Italy. It is descended as are all other court games, such as tennis and pelota, from the two ball games played by the Romans, in one of which a large inflated ball, called *follis*, was used. The other, probably the immediate ancestor of pallone, was played with a smaller ball, the *pila*. Pallone was played in Tuscany as early as the 14th century and is still very popular in northern and central Italy. It is played in a court *(sfcristerio)*, usually 100 yds. long and 17 yds. wide. A white line crosses the middle of the court, which is bounded on one side by a high wall, the spectators sitting round the other three sides, usually protected by wire screens. One end of the court is called the *battuta*, and the other the *ribattuta*. At the end of the *battzrta* is placed a spring-board, upon which stands the player who receives the service The implements of the game are the *pallone* (ball) and the *bracciale* (bat). The *pallone* is an inflated ball covered with leather, about $4\frac{3}{8}$ in. in diameter. The *braccialc* is an oak gauntlet, tubular in shape, and covered with long spike-like protuberances. It weighs between five and six pounds and is provided with a grip for the hand. The game is played by two sides—blues and reds—of three men each, the *battztore* (batter), *spalla* (back) and *terzino* (third). At the beginning of a game the *battitore* stands on the spring-board and receives the ball thrown to him on the bound by a seventh player, the *mandarino*, who does duty for both sides. The batter may ignore the ball until it comes to him to his liking, when he runs down the spring-board and strikes it with his *bracciale* over the centre line towards his opponents. The game then proceeds until a player fails to return the ball correctly, or hits it out of bounds, or it touches his person. This counts a point for the adversary. Four points make a game, counting 1 j, 30, 40 and 50

See G. Franceschini, *Il Giuoco del pallone* (1903).

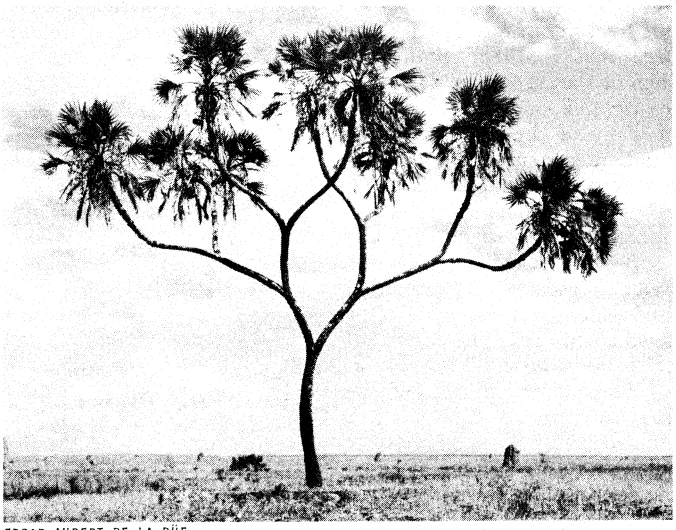
PALM. The palms, botanically classified in the family Palmae, were termed the princes of the plant kingdom by the great botanist Linnaeus. Indeed, they are noble in appearance, most of them being tall and stately. Palms are usually characterized by the presence of an unbranched stem bearing a tuft of leaves at the tip; these leaves. often gigantic in size, are firm in texture and are divided in a pinnate or palmate fashion. The flower clusters are borne on simple or branching spikes generally associated with leaf-like structures called spathes. Each flower consists of a perianth of six greenish inconspicuous segments arranged in two rows and, when bisexual, six stamens and a pistil containing one to three carpels, each with a single ovule. The fruit is either dry or fleshy and the seed consists almost entirely of endosperm along with the very minute embryo. Some of the more important modifications may be noted briefly.

Stem.—In many palms the stem is relatively tall (as much as 200 ft. in the genus *Ceroxylon*), erect, unbranched, cylindrical or dilated below so as to form an elongated cone, either smooth or covered with the projecting remnants of the former leaf petioles, or marked with circular scars indicating the position of those leaves which have dropped off. It varies in diameter from the thickness of a cattail stem (as in *Chamaedorea*) to a sturdy pillar-like structure as in the royal palm. Chilean wine palm. palmyra palm and the talipot palm. In other cases the slender stem is prostrate, or scandent by means of hooked prickle5 (as in *Calamus*, the rattan palm) which enable the plant to support itself on adjacent trees and permit the stem to grow to great lengths (*see* LIANAS). Sometimes the trunk, or that portion of it above ground, is so short that the plant is said to be "stemless." as in *Nipa fruticans* which grows in and along tidal streams in the Indo-Pacific region and in *Serenoa repens*, the saw palmetto of the southeastern United States. In



W. H. HODGE

FIG. 1.—CUBAN ACROCOMIA (A. ARMENTALIS)



EDGAR AUBERT DE LA RÜE

FIG. 2.—DOUM PALM HAVING SEVERAL STEM FORKS. A VARIETY OF HYPHAENE FOUND IN TANGANYIKA

many species of palms the trunk is covered with a dense network of stiff fibres (as in the coconut), often compacted together at the free ends into spines (*e.g., Acrocomia armentalis*). This material, which is so valuable for cordage, consists of the fibrous tissue of the leaf stalk, which in these cases persists after the decay of the softer portions. Some palms, especially those growing in shallow soils, characteristically produce adventitious roots at the base of the stem which apparently anchor the trees more firmly in the soil. The underground stem of some palms (*e.g., Calamus*) is a rhizome which lengthens horizontally by development of a terminal bud. Lateral suckerlike branches form thickets of canelike stems. Branching of the main stem above ground is unusual; however, in the doum palm of Egypt (*Hyphaene thebaica*) the stem forks, often more than once.

The internal structure of a palm stem does not differ materially irom that of most monocotyledons. Woody tissue is scattered in bundles throughout the stem rather than being concentrated in a ring, or rings, around a central soft pith as in woody dicotyledons. The trunk becomes progressively harder and more woody as a result of the sclerification of new fibre strands or, in a few species, by the formation of secondary "conjunctive" tissue containing new vascular bundles. In addition to this, palms do not produce a true bark, *but* develop an outer hard layer of strong tough fibres instead. In fact, this outer layer is sometimes so tough thst only the sharpest ax can penetrate it.

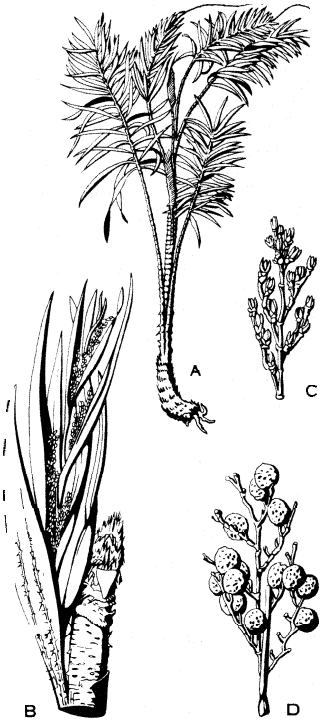


FIG. 3.—RATTAN PALM (DAEMONOROPS DRACO)
(A) Young shoot (much reduced), (B) Part of stem bearing male inflorescence, (C) Part of female inflorescence, (D) Ripe fruits

Leaves.—Leaves of palms are arranged either at more or less distant intervals along the stem as in *Calamus* and *Daemonorops*, or are clustered in tufts st the end of the stem, thus forming those noble cron-ns of foliage generally associated with the idea of a typical palm. The adult leaf usually has a sheathing base tapering upward into a stalk or petiole to which the blade is attached. In *Copernicia* and *Coccothrinax*, the petiole develops spines of various sizes. The size of palm leaves varies within wide limits, some being only several inches long, as in *Chamaedorea humilis*, while those of some species of *Raphia* may reach a length of 65 ft. In form the leaves are rarely simple or undivided except in the juvenile stages of some species; usually they are more or less divided, either in a palmate fashion as in the fan palms, *Latania, Borassus, Chamaerops, Sabal*, etc., or pinnately as in the feather palms. *Areca, Kentia, Calamus, Daemonorops* (*see* fig. 3), etc. The shape of the leaflets is generally more or less linear, but in *Caryota* and *Martinezia* they are broad and wedge-shaped. Palm leaves are often covered with hairs or spines, and sometimes coated with fairly thick deposits of wax, as in many species of *Copernicia*.

Flower. — The inflorescence of palms ranges from a simple fleshy spike to a much-branched axis which is studded with numerous small flowers (as many as 60 million per plant in the talipot palm) and enveloped by bne or rnore spathes. The average palm inflorescence ranges from 2 to 6 ft. long, but in the talipot palm it is often more than 20 ft. in length. This latter palm flowers only once (between 30 and 40 years of age); it develops the huge inflorescence and, after the fruit ripens, the whole tree dies.

BY COURTESY OF UNITED FRUIT COMPANY

FIG. 4.—BETEL NUT (ARECA CATECHU)

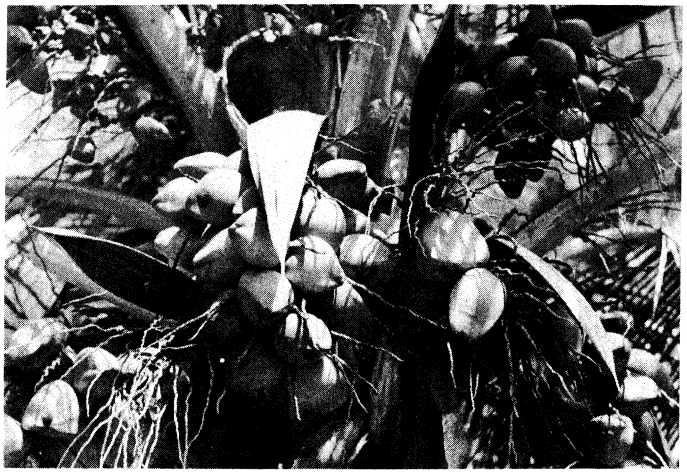
The individual flowers are usually greenish and inconspicuous; their general structure has been described above. They are either bisexual or unisexual. When unisexual, the male and female flowers are usually produced on the same tree (*i.e.*, monoecious, as in the tribe Areceae and a number of genera in other tribes) but not always in the same season, for a tree in one year may produce male flowers and in the next year female flowers. In some cases the male and female flowers are on separate trees, *i.e.*, dioecious, as in *Rhapis, Lodoicea, Hyphaene, Ceroxylon, Latania* and *Phoenix*. Sometimes the flowers are modified by an increase in the number of parts; thus the normal 6 stamens may be increased to 12, 24 or even hundreds. Pollen is carried from the anthers by wind or insects to the stigma of another flower. This is sometimes facilitated by the elastic movements of the filaments and anthers which liberate the pollen so freely that the atmosphere is visibly clouded with pollen. This often occurs in the case of the Egyptian date palm.

Fruit. — Palm fruits vary in size, shape and structure. In the date and betel nut they are fleshy or relatively soft, enclosing a hard seed. The coconut fruit is similar to a plum or cherry: the fibrous outer portion corresponds to the outer fleshy portion and the shell corresponds to the stone or pit of these two plants. The coconut seed is actually the edible fleshy and liquid parts inside the shell. Other fruits, like those of *Raffia, Mauritiella* and *Metroxylon*, are covered with a series of overlapping scales.

The seeds are variable in size and shape, but always consist of a mass of endosperm, a tiny embryo and a seed coat. The hard date seed, the fleshy and liquid parts of the coconut seed and the hard seeds of the vegetable ivories, *e.g., Phytelephas macrocarpa* of tropical America and *Metroxylon amicarum* of the Caroline islands, are primarily endosperm tissue.

Distribution.—Although the palms are incompletely known, there are thought to be about 210 genera with probably between 3,000 and 4,000 species. These are mainly tropical, but with some representatives in temperate regions. Most palms will not usually grow above 4,000 ft. in altitude, but some species of *Ceroxylon* are found at 13,000 it, or over (2,000 ft. above timber line) in the northern Andes. *Chamaerops humilis*, of the Mediterranean

region. is the only native European palm; the date palm from the same region is of African origin. A number of other species of palms are distributed in various parts of the African continent. In eastern Asia they extend along the coast reaching Korea and southern Japan, whereas in western Asia the northern limit is Afghanistan. In North America several genera occur in the southern United States, and in South America the southern limit is reached by *Jubaea spectabilis* of Chile. at about 37° S. latitude. New Zealand is the southernmost point of palm distribution in the old world.



PHILIP GENDREAU

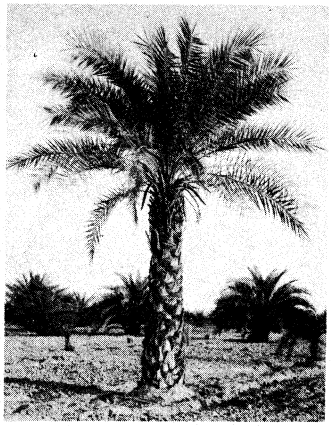
FIG. 5.—FRUITING COCONUT PALM (COCOS NUCIFERA)

The palms native in the continental United States comprise 14 species belonging to 9 genera. In California one palm is native, *Washingtoniu filifera;* this plant occurs around the borders of the Colorado desert, in canyons along streams or in seepage places in the open; it also occurs in southwestern Arizona. *Sabal texana* is native in Texas near the mouth of the Rio Grande; *Sabal minor,* the dwarf palmetto. is native in eastern Texas, Oklahoma, Arkansas. Alabama, the Carolinas and Florida; *Serenoa repens,* the saw palmetto, is almost a weed in the pinelands ranging from South Carolina to the Keys of Florida and along the Gulf coast to Louisiana ; *Sabal louisiana* is found only in Louisiana and Texas; *Sabal palmetto* ranges from North Carolina to Florida along the coast; and *Rhapidophyllum hystrix,* the needle palm. occurs from Mississippi to Florida and South Carolina, All the other palms native in the United States are confined to Florida, and most of these are found in the warmer parts practically from the latitude of Miami southward. They include *Thrinax microcarpa,* T. *parviflora, Coccothrinax argentea, Acoelorraphe wrightii, Pseudophoenix sargentii, Sabal etonia* and *Roystonea regia.*

The great centres of distribution are tropical America (with some 500 species concentrated in Brazil alone) and tropical Asia. Large genera confined to tropical America include *Bactris, Geonoma, Mauritiella, Chamaedorsa* and *Attalea,* whereas those found only in the old world tropics are *Calamus, Daemonorops, Areca, Hyphaene* and *Livistona.* The genus *Raphia* has species in both the new world and old world tropics, and *Cocos nucifera* is apparently pantropical in its native state.

Palm genera are arranged, according to Max Burret, in seven tribes, distinguished by the kind of leaves, the sexual condition of the flowers, the character of the seed. the position of the raphe, etc. Other characteristics of minor importance are the habit of the plant; the position of the spathes; the estivation of the flowers; and the nature of the stigma, ovary and fruit.

Economic Aspects. — Palms are of the greatest economic importance. They iurnish food, shelter, clothing, timber, fuel, building materials. fibres, paper, starch, oil. sugar, wax, wine, tannin, dyeing materials, resin and a host of minor products which make them most valuable to native populations in the tropics and to tropical agriculturists. The coconut palm and date palm are treated in separate articles. Sugar and liquids capable of fermentation are produced by *Caryota urens, Nipa fruticans, Cocos nucifera, Borassus flabellifer, Rhapis vinifera, Arenga pinnata* and *Mauritiella vinifera.* Starch is procured in abundance from the stem of the sago palm, *Metroxylon rumphii,* and others. Leaves of many of the palms are used as a thatching material for primitive tropical homes. The fruit of the African oil palm. *Elaeis guineensis,* yields palm oil when crushed and boiled, and dried coconut endosperm produces an oil used widely in commerce. Wax is obtained from the leaves of *Arikuryroba schizophylla* and *Copernicia cerifera.* Fruits of the date palm are the staple food of some districts of north Africa; edible fruits are also produced by the pejibaye, *Guilielma gasipaes,* of tropical America. Many species, *e.g., Roystonea oleracea, Sabal palmetto, Cocos nucifera, Euterpe globosa* and others, are valued for their "cabbage," the terminal bud, the removal of which causes the death of the tree. The terminal bud of some of these species is served. under the name "millionaire's salad." by some of the finest restaurants in the United States. *Lodoicea sechellarum,* "coco de mer" or double coconut, is found only in the Seychelles islands. Its fruit is huge, weighing up to 40 lb.. and contains a pair of seeds. *Areca catechu,* betel nut, is cultivated in tropical Asia and certain Pacific islands for its fruits which are chewed wrapped in a peppery leaf with a pinch of lime.



J. HORACE MCFARLAND CO.

FIG. 6.—DATE PALM (PHOENIX DACTYLIFERA)

In the United States several species of palms can be grown successfully out-of-doors as far north as Oregon, from 42° to 46° N. latitude; in England, at latitudes of 50° N., it is possible to grow the following species out-of-doors: *Chamaerops humilis, Trachycarpus fortunei, Phoenix canariensis* and *Jubaea spectabilis.* Some palms, such as *Rhapis flabelliformis, Chamaerops humilis* and several species of *Clzamaedorea,* are suited for ordinary greenhouse culture and the dry atmosphere of living rooms.

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(V. H. B.; L. H. Ba.; S. F. G.)

PALMA, JACOPO (PALMA VECCHIO, originally JACOPO NEGRETI) (*c.* 1480–1528), Venetian painter of the High Renaissance, a distinguished minor painter whose craftsmanship and finish were superlative, was born at Serinalta, near Bergamo. His namesake and more prolific great-nephew is knonn as Palma Giovane (Palma the Younger). A competitor of Titian. and a follower of the tradition of Giorgione and Giovanni Bellini Palma occupies an inferior position in both popular and critical esteem. He has been called a painter of dull pictures, though this is an undiscerning estimate. As with the work of other Venetian Renaissance masters, it is only in a work entirely by him that the effect is one of subtle nobility. What may in the work of a follower appear as dullness or lack of inspiration is gentle serenity in the master's work.

Palma made the type of Venetian contemplative religious picture known as the *sacra conversazione* (*i.e.,* a group of historically unrelated sacred personages grouped together, usually in a landscape setting) particularly his own. To his late 15th-century subject matter he applied the vision of Giorgione in colour and fused soft-focus effects. Palma's particular refinement of the Giorgionesque technique was his use of transparent glazes, most of which later deteriorated. Palma's figures have a monumentality

about them, a characteristic especially noticeable in his finest work, the Sta. Barbara altarpiece in Sta. Maria Formosa, Venice. Probably in imitation of such half-length female figures by Titian as the "Flora" or "Woman With a Mirror" (Paris), Palma developed an ideally feminine, blonde. pretty type, a bit heavy in form. Examples of this type may be found in Palma's works in Berlin, London and Vienna. An especially striking late version is the "Three Sisters" (Dresden). This work, along with many of his last products, shows the influence of Lorenzo Lotto. Forty of Palma's works remained unfinished at his death and were finished hy his pupils. Presumably this accounts ior the variable quality of his work. (Florence)

PALMA GIOVANE (Jacopo Palma) (1544–1628), the grandnephew of Palma Vecchio, was born and died in Venice. The last. Venetian mannerist. he continued the style after it had become completely outmoded. 'Though prominent, he was never really a leader, so he easily painted tasteful pieces matching the work of greater men. His lack of an original style made him an able assistant to the aged Titian whose last work, the "Pietà," he finished and signed. Palma Giovane's drawings have always been esteemed by corinoisseurs for their vigorous, varied style and rich imagination, without the triviality of his oils. (J. MN.)

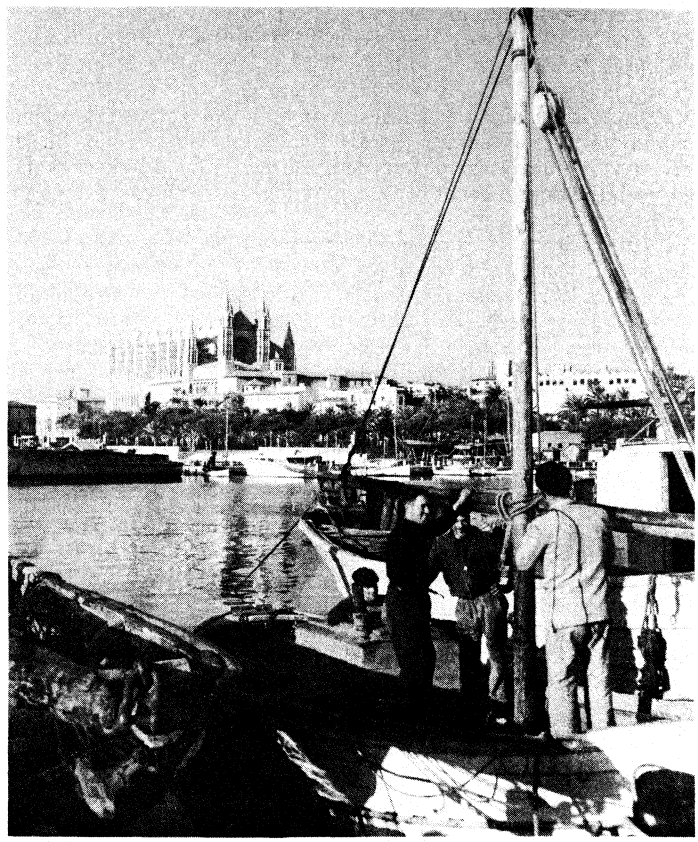
See C. Ridolfi, Le *Maraviglie dell'Arte,* ed. by D. V. Hadeln (vol. 1, 1914; vol. 2, 1924) and A. Spahn, *Palma Vecchio* (1932).

PALMA, RICARDO (1833–1919), Peruvian man of letters, best known for his legendary sketches of colonial Peru, one of the most popular collections in Spanish-American literature. was born in Lima on Feb. 7. 1833. At the age of 20 he joined the navy, and in 1860 was forced by political exigencies to flee to Chile, where he devoted himself to journalism. Six years later he returned to Lima to join the revolutionary movement against Spain. He also took part in the War of the Pacific (1881), and during the Chilean occupation courageously protested against the vandalistic destruction of the famous National library by Chilean soldiery. After the war he was director of *La Prensa* in Buenos Aires, but soon was recalled to Peru to rebuild the National library: he remained its curator until his death in Lima, Oct. 6. 1919. In 1887 he founded the Peruvian academy.

Palma's literary career began in youth with light verses. romantic plays and translations from Victor Hugo. His *Anales* de la *inquisición* de *Lima* (1863) was followed by several volumes of poems. His iame derives chiefly from his charmingly impudent *Tradiciones peruanas*—short prose sketches, which mingled fact and fancy, of the pageantry and intrigue of colonial Peru. Their sources were the folk tales, legends and racy gossip of his elders, plus historical bits gleaned from the National library. The first six volumes of this series appeared between 1872 and 1883; they were followed by *Ropa vieja* ("Old Clothes") (1889), Ropa *apolillada* ("Moth-Eaten Clothes") (1891), *Mis últimas tradiciones* (1906) and *Apéndice* a *mis últimas tradiciones* (1910).

See for selections in English and bibliography, Palma's The Knights *of the Cape,* trans. by Harriet de Onis (1945). (J. C. D.)

PALMA or **PALMA DE MALLORCA,** the capital of the Spanish province of the Balearic islands, the residence of a captain-general, an episcopal see, and a flourishing seaport 13j mi. S.S.E. of Barcelona, on the S.W. coast of Majorca, at the head of the fine Bay of Palma, which stretches inland for about 10 mi. between Capes Cala Figuera and Regana. Pop. (1960 est.) 162,155 (mun.). It probably owes, if not its existence, at least its name (symbolized on the Roman coins by a palm branch)! to Metellus Balearicus, who in 123 B.C. settled 3,000 Roman and Spanish colonists on the island. The bishopric dates from the 14th century. About 1 mi. S.W. of Palma is the castle of Bellver, the ancient residence of the kings of Majorca. The more conspicuous buildings are the cathedral. the exchange. the royal palace, later occupied by the captain-general, and the law courts, the episcopal palace, a late Renaissance building (1616), the general hospital (1456) and the town-house (end of the 16th century). The cathedral was founded in 1230 and finished in 1601. Palma has a seminary founded in 1700, archives dating from the 14th century, a school and museum of fine arts, a nautical school and an institute founded in 1836 to replace the old university (1503).



SILBERSTEIN FROM MONKMEYER

HARBOUR OF PALMA DE MALLORCA. IN THE BACKGROUND IS THE GOTHIC CATHEDRAL

The harbour was formed by a mole, 387 yd. long, in the 14th century and has been considerably improved at subsequent intervals. Palma has a thriving trade in grain, wine, oil, almonds, fruit, vegetables, silk, foodstuffs and live stock. There are manufactures of alcohol, liqueurs, chocolate, sugar, flour, soap, leather, earthenware, glass, matches, paper, linen, woollen goods and rugs.

PALMA, or SAN MIGUEL DE LA PALMA, a Spanish island in the Atlantic ocean: forming part of the Canary Islands (*q.v.*). Pop. (1950) 67,225; area 281 sq.mi. Palma is 26 mi. long. with an extreme breadth of 16 mi. It lies 67 mi. W.N.W. of Teneriffe. It is traversed from north to south by a chain of mountains. the highest of which is 7.000 ft. above sea level. At the broadest part is a crater 9 mi. in diameter, known as the Caldera (*i.e.*, cauldron,. The bottom of the crater has an elevation of 2,300 ft., and it is overhung by peaks that rise more than 5,000 ft. above it.

Santa Cruz de la Palma (mun. pop. 11,609) on the east coast is the chief town.

PALMAS DE GRAN CANARIA, LAS: see LAS PALMAS.

PALM BEACH and **WEST PALM BEACH,** sister cities of Palm Beach county, Fla., U.S., are located on the Atlantic coast. 287 mi. S. of Jacksonville and 67 mi. N. of Miami. Palm Beach, known as Palm City until 1887, occupies an ancient sandbar and is separated from West Palm Beach by a lagoon known as Lake Worth. It is one of the most luxurious winter resorts in the U.S., with palatial hotels, clubs and private estates. 'Three bridges span the lake which is usually dotted with yachts and small boats. West Palm Beach occupies an elevated ribbon of land for eight miles along the sand ridge common to most of the Florida east coast. It is also a pleasure resort but in addition is a commercial and financial centre of a wide area. Both cities are on the Atlantic Intracoastal waterway which traverses Lake Worth.

Because of their southerly location and the marine influences. the Palm Beaches have an equable climate that attracted settlers after the American Civil War. They did not become fashionable

as winter resorts until after Henry M. Flagler extended his Florida East Coast railroad into the area in 1894 and built several luxurious hotels to attract northerners. Within a few years Palm Beach became known as the American Riviera and was frequented by wealthy and famous personages, many of whom later built and maintained winter homes there. For years West Palm Beach served as a transfer point and domicile for Palm Beach workers, but with the development of transport facilities it became a major tourist centre.

On the creation of Palm Beach county in 1909, West Palm Beach became the county seat and in the intervening years far outstripped its more exclusive sister city in growth and population. Population for West Palm Beach was 56,208 in 1960; for comparative population figures see table in FLORIDA: *Population.* The population of the West Palm Beach standard metropolitan statistical area in 1960 was 228,106. Both cities adopted the commission-manager form of municipal government, West Palm Beach in 1919 and Palm Beach in 1922. The former is the hub of a rapidly expanding metropolitan area with business and financial interests catering to local service and to county industries allied to farming, cattle raising and commercial fishing. West Palm Beach also benefited from the state's increasing industrial activity, and in the 1950s and early 1960s many new industrial plants located in Palm Beach county, including a jet engine facility.

The Palm Beaches are served by rail, road and air. The port of Palm Beach became one of the busiest in the state, visited by tanker and cargo vessels, and barges going to the Lake Okeechobee ports through the St. Lucie canal. Tropical storms occasionally visit the Palm Beaches, the hurricane of Sept. 1928 being notably devastating.

The cultural facilities of the two cities include Palm Beach Junior college (1933), one of the state's largest, the Norton Art Gallery and theatre and Memorial library. A popular recreation is the excellent fishing in the nearby Gulf stream and from the piers, bridges and beaches. (J. E. D.)

PALM CIVET, the name of several members of the family Viverridae (see CARNIVORE). The common palm civet (*Paradoxurus*), about the size of a domestic cat, yellowish gray and spotted, is found from central China and India to the Molucca Islands. The masked palm civet (*Paguma*) lacks spots and has a blackish facial mask. The small-toothed palm civet (*Arctogalidia*) has three dorsal stripes, the lateral ones often broken into spots. These two forms are found from China to Sumatra and Borneo. The banded palm civet (*Hemigalus*) occurs from Tenasserim to Borneo; it is marked by dark transverse dorsal bands. These all feed on small animals, fruit and vegetation. (J. E. HL.)

PALMELLA, a town of Portugal, in the district of Setubal at the northeastern extremity of the Serra da Arrabida, and on the Lisbon-Setubal railway. The municipal population in 1960 was 23,395. Palmella is an ancient and picturesque town, surrounded by ruined walls and dominated by a medieval castle.

PALMER, ALEXANDER MITCHELL (1872–1936). U.S. lawyer and government official, who gained nationwide attention as a militant foe of Bolshevism in 1919–20, was born at Moosehead, Pa., on May 4, 1872. He graduated from Swarthmore college (Swarthmore, Pa.) in 1891, studied law for two years and began to practise in Stroudsburg. Pa. He became an active member of the Democratic party and served in the U.S. house of representatives for three terms (1909–15). Palmer lost a three-cornered contest for the U.S. senate in 1914 but received successive appointments from Pres. Woodrow Wilson as judge on the U.S. court of claims (1915), as alien property custodian (1917) and as attorney general (March 4, 1919). In the latter post, he helped to promote the postwar "red scare" and pressed for the deportation of alien radicals.

Palmer made an unsuccessful bid for the presidential nomination in 1920 and resumed his law practice in Stroudsburg the next year. He died there on May 11. 1936. (G. H. MA.)

PALMER, SIR CHARLES MARK, BART. (1822–1907), English shipbuilder, was born at South Shields on Nov. 3, 1822. His father, originally the captain of a whaler, removed in 1828 to Newcastle upon Tyne, where he conducted a shipowning and ship-broking business. After two years' experience at Marseilles Palmer entered his father's business at Newcastle, and in 1842 he became a partner. He then became a colliery manager and eventually purchased large colliery interests. Palmer built, largely according to his own plans, the "John Bowes," the first iron screw-collier, and several other steam-colliers! in a yard established by him at Jarrow, then a small Tyneside village. He later purchased iron mines in Yorkshire and erected along the Tyne at Jarrow large shipbuilding yards, blast furnaces, steelworks, rolling mills and engine works, fitted on the most elaborate scale.

The firm produced warships as well as merchant vessels, and their system of rolling armour plates, introduced in 1856, was generally adopted by other builders. In 1865 he turned the business into Palmer's Shipbuilding and Iron Company, Limited. In 1886 his services in connection with the settlement of the costly dispute between British shipowners and the Suez Canal company (of which he was then a director) were rewarded with a baronetcy.

Sir Charles Palmer died in London on June 4, 1907.

PALMER, EDWARD HENRY (1840–1882), English orientalist. was born at Cambridge, on Xug. 7, 1840. He entered St. John's college, Cambridge university, in 1863, and in 1867 was elected a fellow on account of his attainments as an orientalist, especially in Persian and Hindustani. During his residence at St. John's he catalogued the Persian, Arabic and Turkish manuscripts in the university library, and in the libraries of King's and Trinity. In 1867 he published a treatise on *Oriental Mysticism*, based on the *Maksad-i-Aksā* of Aziz ihn Mohammed Nafasī. He was engaged in 1869 to join the survey of Sinai, undertaken by the Palestine Exploration fund. and in the next year explored the desert of El-Tīh in company with Charles Drake (1846–74). They completed this journey on foot and without escort. making friends among the Bedouin, to whom Palmer was known as "Abdallah Effendi." After a visit to the Lebanon and to Damascus he returned to England in 1870 by way of Constantinople and Vienna. In 1871 he became Lord Almoner's professor of Arabic at Cambridge.

In 1881 Palmer left Cambridge and joined the staff of the *Standard* newspaper to write on nonpolitical subjects. He was called to the English bar in 1874, and early in 1882 he was asked by the government to assist the Egyptian expedition by his influence over the Arabs of the El-Tīh desert. He was instructed, apparently, to prevent the Arab sheikhs from joining the Egyptian rebels and to secure their noninterference with the Suez canal. He went to Gaza, without an escort made his way safely through the desert to Suez—an exploit of singular boldness—and was highly successful in his negotiations with the Bedouin. He was appointed interpreter-in-chief to the force in Egypt, and from Suez he was again sent into the desert with Capt. William John Gill and Flag-Lieutenant Harold Charrington to procure camels and gain the allegiance of the sheikhs by considerable presents of money. On this journey he and his companions were led into an ambush and murdered (Aug. 1882).

Palmer is remembered chiefly for his travels, especially the heroic adventures of his last journeys. His brilliant scholarship is displayed more in the works he wrote in Persian and other eastern languages than in his English books, which were generally written under pressure. Though his works show a great linguistic range and versatile talent, he left no permanent literary monument in English.

His chief writings are *The Desert of the Exodus* (1871), *Poems* of *Behā ed Din* (Ar. and Eng., 1876–1877), *Arabic Grammar* (1874), *History of Jerusalem* (1871), by Besant and Palmer—the latter wrote the part taken from Arabic sources; *Persian Dictionary* (1876) and *English and Persian Dictionary* (posthumous, 1883); translation of the Koran (1880) for the *Sacred Books of the East* series, a spirited but not very accurate rendering.

PALMER, JOHN McAULEY (1817- goo), U.S. soldier and political leader, was born at Eagle Creek, Ky., on Sept. 13, 1817. In 1831 his family moved to Illinois, and in 1839 he was admitted to the bar in that state. In 1852–55 he was a Democratic member of the state senate. hut joined the Republican party

upon its organization and became one of its leaders in Illinois. During the Civil War he served in the Cnion army, rising from the rank of colonel to that of major general in the volunteer service and taking part in the battles of Stone river and Chickamauga, and. under Gen. G. H. Thomas. in the Atlanta campaign. He was governor of Illinois from 1869 to 1873. In 1872 he joined the Liberai-Republicans. and eventually returned to the Democratic party. In 1891–97 he was a Democratic member of the U.S. senate. In 1896 he was nominated for the presidency, by the "Gold-Democrats," but received no electoral votes. He died at Springfield, Ill., on Sept. 25, 1900.

See The *Personal* Recollections of John *M*. Palmer-—The Story oj an *Earnest Life,* published posthumously in 1901.

PALMER, SAMUEL (180j–1881), English landscape painter and etcher, whose water-colour landscapes are distinguished by a dreamy, poetic quality. was born in London on Jan. 27, 1805. He first exhibited at the Royal Academy in 1820 and at the British institution in 1821. Palmer was deeply influenced by William Blake. He died at Reigate on May 24. 1881.

Palmer's English metrical version of Virgil's *Eclogues,* which was published posthumously in 1883, contains reproductions of his water colours, and etchings completed by his son A. H. Palmer. His paintings may be seen in a number of galleries, including the Tate gallery and the Victoria and Albert museum in London.

PALMER, a pilgrim who as a sign or token that he had made pilgrimage to Palestine carried a palm branch attached to his staff, or more frequently a cross made of two strips of palm leaf fastened to his hat (see PILGRIMAGE). The name "palmer" or "palmer worm" is often given to many kinds of hairy caterpillars, specifically to that of the destructive tineid moth. *Ypsilophus ligulellus,* which chiefly attacks the apple; also to the grubs of various beetles. Artificial flies used in angling, covered with bristling hairs. are known also as "palmers" or "hackles."

PALMERSTON, HENRY JOHN TEMPLE, 3RD VISCOUNT (1784–1865). English statesman, was the dominating personality in English politics for 20 years whose forceful handling of foreign affairs promoted his country's influence among the nations. He was born at Broadlands, Hampshire. on Oct. 20, 1784, the son of Henry, 2nd Viscount Palmerston and his wife Mary Mee. Part of Palmerston's childhood was spent in Italy, and he was sent to Harrow school at 11. He had just left school when, in 1802, he succeeded his father in the peerage, an Irish one. which did not prevent membership of the house of commons. From Harrow he went to Edinburgh, where he attended the lectures of the philosopher Dugald Stewart, with whom he boarded. He entered St. John's college: Cambridge, in 1803; in 1806 he began his political career.

He fought and lost two contested elections for the University of Cambridge. but entered parliament for a pocket borough. Newport (often mistakenly called Newtown), Isle of \Tight, in May 180; on the condition. imposed by the donor, that he never set foot there. Influence secured for him a junior lordship of the admiralty in the Portland administration of 1807. He delivered his maiden speech in the house of commons (Feb. 1808) in defense of the expedition against Copenhagen. When Spencer Perceval formed his government in 1809, he offered this young man of 25 the chancellorship of the exchequer. Palmerston, however, preferred the less important office of secretary at war, charged with the financial business and the supplies of the army, without a seat in the cabinet. He remained in this position, without any signs of an ambitious temperament or great political abilities, for 20 years (1809–1828) under five prime ministers: steadily refusing preferment until he entered the: cabinets of George Canning and Lord Goderich in 1827. During that period Palmerston was chiefly known as a man of fashion, with little influence on the general policy of the cabinet. Some of the most humorous poetical pieces of the *New Whig Guide* were from his pen; and he was entirely devoted to the body of "Mr. Pitt's friends" who formed the governing party of that day. Palmerston. never a Whig, still less a Radical. was a statesman of the old English aristocratic type, liberal in his sentiments. favourable to the march of progress, but entirely opposed to claims for universal suffrage. He had been elected M.P. for Cambridge university in 1811, and sat for this constituency until 1831 when he was defeated because he had adopted reform principles. Rletchingley (1831). South Hampshire (1832) and 'riverton (from 1835) provided his later seats.

After Aug. 1822. strong dissensions existed in the cabinet. Palmerston supported the measures of Canning and his friends. The "Canningites"—Palmerston, William Huskisson. Charles Grant, William Lamb (Lord Melbourne, after 1829) and Lord Dudley—were included by Wellington in his cabinet of 1828, but a dispute between the duke and Huskisson soon led to Huskisson's resignation, and his friends resigned with him. By June 1828 Palmerston. finding himself in opposition, appears to have directed his attention to Europe. He had made several visits to Paris, where he foresaw the impending revolution; and on June 1. 1829, he made his first great speech on foreign affairs. Palmerston was no orator. for his language was unstudied and his delivery somewhat embarrassed, but he addressed the house of commons in language adapted to the capacity and temper of his audience. Wellington sought in Sept. 1830. to induce Palmerston to re-enter the cabinet, but he refused because he was then committed to parliamentary reform, and from that time on he may be said to have associated his political fortunes with those of the Whig party. Lord Grey placed the department of foreign affairs in his hands upon the formation of the ministry of 1830, and Palmerston entered on the duties of an office where he continued to exert his powerful influence. both in and out of office, for 20 years.

Foreign Secretary.— Revolutions in France and Belgium in July and August 1830 had just given a strong shock to the existing settlement of Europe. The British foreign office was especially concerned with the fate of Belgium. in revolution against the king of the Xetherlands and coveted by France. In the end the policy of England prevailed; numerous difficulties were overcome by a five-power conference and. although Europe was on the verge of war. peace was maintained. Prince Leopold of Saxe-Coburg was placed upon the throne of Belgium. The independence of Belgium was a solid success for Palmerston's diplomacy.

Other problems faced the new foreign secretary. In 1833 and 1834 the youthful queens Donna Maria of Portugal and Isabella of Spain were the representatives and hope of the constitutional party in those countries, assailed and hard pressed by their absolutist kinsmen Dom Miguel and Don Carlos. Palmerston conceived and executed the plan of a quadruple alliance of the constitutional states of the west to serve as a counterpoise to the northern alliance. A treaty for the pacification of the peninsula was signed in London on April 22, 1834; and, although the struggle was somewhat prolonged in Spain. it accomplished its object. But Louis Philippe of France was accused of secretly favouring the Carlists, and he positively refused to be a party to direct interference in Spain. The hesitation of the French court on this question was probably one of the causes of the extreme personal hostility Palmerston showed toward the French king till the end of his life. Nevertheless, at this same time (June 1834) Palmerston wrote that "Paris is the pivot of my foreign policy." Louis Thiers was then in office. Unfortunately differences with France increased each succeeding year; a constant but sterile rivalry was kept up, which ended in results humiliating and injurious to both nations.

In near eastern politics Palmerston had been from the beginning a strenuous supporter of the claims of the Greeks against the Turks and of the execution of the Treaty of London, between France, Great Britain and Russia (1827), which proposed that Greece would become a tributary dependency of Turkey. with a large measure of self-government. But from 1830 the defense of the Ottoman empire became one of the cardinal objects of his policy. He believed in the regeneration of Turkey. His two principal aims were to prevent the establishment of Russia on the Bosphorus and of France on the Nile. He regarded the maintenance of the authority of the Porte (Turkish government) as the chief barrier against both these aggressions. Toward Russia he nas suspicious and hostile. He regarded with apprehension the treaty of Cnkiar Skelessi which Russia extorted from the Porte in 1833 (see EASTERN QUESTION, THE). When the poner of Mehemet Ali in Egypt appeared to threaten the existence of the Ottoman dynasty he effected a

combination of all the powers, who signed the collective note (July 27, 1839) pledging them to maintain the independence and integrity of the Turkish empire. On three occasions, in 1833, 183; and 1839, the Turkish policy of Palmerston was overruled by the cabinet, but in 1830 it mas accepted. France, though its ambassador had signed the collective note in the previous year. declined to be a party to measures of coercion against Mehemet Ali. Palmerston, irritated at France's Egyptian policy, turned to the northern powers, and the treaty of July 15, 1840, between England, Russia, Austria and Prussia, agreeing to assist the sultan against Mehemet Ali, was signed in London -without the knowledge or concurrence of France. This measure was not taken without strong opposition by several members of the British cabinet. At the same time, though acting with Russia in the Levant, the British government engaged in the affairs of Afghanistan to defeat her intrigues in central Asia, and a contest with China was terminated by the conquest of Chusan, later exchanged for the island of Hong Kong.

By then Palmerston was regarded as one of the most powerful statesmen of the age. He had earned this position by indefatigable hard work; he read and thought much more about foreign affairs than any of his colleagues, or his rivals abroad; and he always had the current business of the foreign office at his finger tips.

After the fall (1841) of the Melbourne administration Palmerston remained for five years out of office. The crisis was past, but the change which took place by the substitution of François Guizot for Thiers in France, and of Lord Aberdeen for Palmerston in England, was a fortunate event for the peace of the world. Palmerston, distrusting France, helieved that war between the two countries was inevitable. Aberdeen and Guizot, by mutual confidence and friendly offices, entirely succeeded in restoring cordial understanding between the two governments, and the irritation which Palmerston had inflamed gradually subsided. During the Peel administration (1841–46) Palmerston led a retired life, but he attacked with characteristic bitterness the Ashhurton treaty with the United States, which closed successfully other questions he had long kept open. Palmerston approached questions of foreign policy with a passion, personal animosity and imperious language which rendered him in the eyes of the queen and his colleagues a dangerous minister. Lord John Russell's failure to form a ministry (Dec. 1845) was partly due to Lord Grey's refusal to join a government in which Palmerston would have the direction of foreign affairs, but a few months later the Whigs returned to power, and Palmerston to the foreign office (July 1846). with a strong assurance that Russell should exercise a strict control over his proceedings. A few days sufficed to show the futility of this expectation.

The French government regarded Palmerston's appointment as a sign of renewed hostility, and a dispatch in which Palmerston had put forward the name of a Coburg prince as husband for the young queen of Spain, served as an excuse for a breach of the agreements entered into between Guizot and Aberdeen. The efforts of the British minister to defeat the French marriages of the Spanish princesses, by an appeal to the treaty of Utrecht (1714j which had included clauses designed to prevent the union of France and Spain, and to the other powers of Europe, were wholly unsuccessful *(see* SPAIN).

The general upheaval of 1848 spread through Europe, and shook every throne on the continent except those of Russia, Spain and Belgium. Palmerston's sympathies had been awakened by the cause of Italian independence. He supported the Sicilians against the king of Naples, and the king of Sardinia against Austria. The British government. or at least Palmerston as its representative. was regarded with suspicion and resentment by every power in Europe, except the French republic; and even that was shortly to be alienated by Palmerston's attack on Greece.

This state of things was regarded with the utmost annoyance by the British court and most of the ministers, without whose knowledge Palmerston had on many occasions taken important steps which they disapproved. Over the foreign office he asserted and exercised an arbitrary dominion, which the feeble efforts of the prime minister could not control. The queen and the prince consort (see VICTORIA, QUEEN) did not conceal their indignation at the position in which he had placed them with all the other courts of Europe. When Lajos Rossuth, the Hungarian leader. landed in England, Palmerston proposed to receive him at Broadlands, a design which was only prevented by a peremptory veto by the cabinet. In 1850 he took advantage of David Pacifico's questionable claims against the Greek government to organize an attack on the little kingdom. Greece being under the joint protection of three powers. Russia and France protested against its coercion by the British fleet; and the French ambassador temporarily left London. which promptly led to the termination of the affair. But it was taken up in parliament and after a memorable debate (June 1;), Palmerston was censured by a vote of the house of lords. The house of commons was moved by J. A. Roebuck to reverse the sentence (June 29) by a majority of 46, after having heard from Palmerston the most eloquent and powerful speech ever delivered by him. in which he sought to vindicate, not only his claims on the Greek government for Pacifico. but his entire administration of foreign affairs. It was in this speech. which lasted nearly five hours. that Palmerston made the well-known declaration that a British subject — "civis Romanus sum (I am a Roman citizen)" — ought everywhere to be protected by the strong arm of the British government against injustice and wrong. Peel's accidental death, just after this great debate, removed his most eminent rival. Yet. notwithstanding this parliamentary triumph. there were many of his own colleagues and supporters who condemned the spirit in which the foreign relations of the crown were conducted.

In that same year the queen addressed a memorandum to the prime minister recording her dissatisfaction at the manner in which Palmerston evaded the obligation to submit his measures for the royal sanction as insincerity to the crown; however. Palmerston did not resign upon receiving it. This distrust and uneasiness reached their climax when Palmerston expressed to the French ambassador in London. without the concurrence of his colleagues, his personal approval of the coup d'état of Louis Napoleon. Upon this Russell dismissed him from office (Dec. 1851). Palmerston avenged himself by turning out the government on a militia hill. Although he survived for many years, and twice filled the highest office in the state, his career as foreign minister was ended. and he never returned to the foreign office. Indeed. he assured his friends, in 1853, that he did not wish to resume the seals of that department.

Home Secretary. — Upon the formation of Aherdeen's cabinet of 1852, which was composed by the junction of surviving I'eelites with Whigs. Palmerston accepted with the best possible grace the office of secretary of state for the home office. At one time he withdrew from it, ostensibly because Russell persisted in presenting a project of reform which appeared to him entirely out of season. He advocated. with reason, measures of greater energy on the approach of war. which might possibly, if they had been adopted, have averted the contest with Russia. As the difficulties of the Crimean campaign increased. it was not Palmerston but Russell who broke up the government by refusing to meet Roebuck's motion of inquiry. Palmerston remained faithful and loyal to his colleagues in the hour of danger. After the resignation of Aberdeen and the failure of Lord Derby to form a ministry, the general sentiment of the house of commons and the country called Palmerston to the head of affairs. He entered on Feb. 5, 1855, at the age of 70, upon the high office which he retained, with one short interval, to the day of his death.

Prime Minister. — A series of fortunate events followed his accession to power. In March 1855 the death of Nicholas of Russia removed his chief antagonist. In September Sevastopol was taken. The administration of the British army was reformed by a consolidation of offices. In the following spring peace was signed in Paris. Never since William I'itt had a minister enjoyed a greater share of popularity and power, and, unlike Pitt. Palmerston had the prestige of victory in war. He was assailed in parliament by the eloquence of Gladstone, the sarcasms of Disraeli, and the pious animosity of the Manchester Radicals, but the country was with him. Defeated by a hostile combination of parties in the house of commons on the question of the Chinese war in 1857 and the alleged insult to the British flag in the seizure of the lorcha "Arrow," he dissolved parliament and appealed to the nation. 'The result

was the utter defeat of the extreme Radical party and the return of a more compact Liberal majority. The great events of the succeeding years, the Indian mutiny and the invasion of Italy by Napoleon III, belong rather to the general history of the times than to the life of Palmerston; hut it was fortunate that a strong and able government was at the head of affairs.

Lord Derby's second administration of 1858 lasted but a single year, Palmerston having been surprisingly defeated on a measure for removing conspiracies to niurder abroad from the class of misdemeanour to that of felony (introduced in consequence of Felice Orsini's attempt on the life of Napoleon III). But in June 1859 Palmerston returned to power, and it was on this occasion he proposed that Richard Cobden, one of his most constant opponents, take office; on his refusal Milner Gibson was appointed to the hoard of trade, although he had been the prime mover of the defeat of the government on the Conspiracy hill. Palinerston had learned that it was wiser to conciliate an opponent than to attempt to crush him.

Although Palmerston approved the objects of the French invasion of Italy in so far as they went to establish Italian independence, the annexation of Savoy and Nice to France revived his old suspicions of the good faith of Napoleon III. He believed that war with France was a contingency to be provided against and he induced the house of commons to vote £9,000,000 for the fortification of British ports and arsenals.

Palmerston resisted the Suez canal project of Ferdinand de Lesseps. He did not foresee the advantages to be derived by British commerce from this great work, and he was strongly opposed both to the establishment of a powerful French company on the soil of Egypt, and to any more direct British interference there.

Upon the outbreak of the American Civil War in 1861, Palmerston acknowledged that it was the duty of the British government to remain neutral, hut his own opinion led him rather to desire than to avert the rupture of the union which might have been the result of a refusal on the part of England and France to recognize a blockade of the southern ports, which was notoriously imperfect, and extremely prejudicial to the interests of Europe. The cabinet was not of this opinion and, although the belligerent rights of the south were promptly recognized, the neutrality of the government was observed. When, however, the southern envoys were taken by force from the "Trent," a British packet, Palmerston insisted upon a full and complete reparation. But the difficulty with the U.S. government over the "Alabama," and other vessels fitted out in British ports to help the Southern cause, was settled finally in 1872 (see ALABAMA ARBITRATION) by a payment felt to be extremely onerous in England. His policy in South America at the same time was marked by what can only be called the bullying of Brazil in 1862; a type of policy that was shortly to lead to a rebuff elsewhere.

The last transaction in which Palmerston engaged arose out of the attack by the Germanic confederation, under the leadership of Austria and Prussia, on the kingdom of Denmark and the duchies of Schleswig–Holstein. There was strong British feeling as to the dishonest character of that unprovoked aggression. Palmerston endeavoured to induce France and Russia to concur with England in maintaining the Treaty of London, which had guaranteed the integrity of the Danish dominions. But those powers, for reasons of their own, stood aloof, and the conference held in London in 1864 was without effect. A proposal to send the British fleet into the Baltic was overruled, and the result was that Denmark was left to her own resources against her formidable opponents. His domestic policy remained strictly conservative: he remarked in Feb. 1564. "We cannot go on adding to the Statute Book ud *infinitum*." In the following year, on Oct. 18, 1865, Palmerston died at Brocket hall, Hertfordshire, after a short illness, two days before his 81st birthday. He was buried in Westminster abbey.

Political and Personal Characteristics.—Palmerston's career in politics spanned the transition from Fox and Pitt to Gladstone and Disraeli, in a period marked by fundamental changes in the relative positions of crown, ministers and parliament. The great Reform act of 1832, which he helped to pass, implied an eventual widening of the franchise, and the stranglehold of the party machines that began soon after his death. Yet his great abilities, combined with a self-assurance equally great, enabled him to keep English politics, for the last 20 years of his life, in the mould that suited him; this was the mould of the 18th rather than of the 19th century. From Peel's death in 1850 until his own, sheer strength of personality made Palmerston the dominant figure at Westminster. No measure he disapprover1 was likely to pass through parliament, no government could stand secure without him and even the monarch had to fall in with his prejudices. Queen Victoria wrote to her uncle, just after Palmerston's death, "We had, God knows! terrible trouble with him about Foreign affairs"; the remark would have been echoed in every chancellery on the continent, for he was credited abroad with an almost diabolical capacity for forwarding England's interests against those of other powers.

It is by his successes as foreign secretary that he is chiefly remembered. The most durable of these, little noticed at the time, concerned what he once called the main object of his public life: "the extirpation of that abominable crime," the transatlantic slave trade. The creation of Belgium is also much to his credit; the state he planted prospered and struck root. Otherwise, what most caught men's imagination was his constant, high-spirited assertion of British power, based on the existence of a British navy universally regarded as invincible. Just this assertion of strength endeared him to his countrymen, who were convinced that they were the greatest people on earth; they admired his patriotism and his straightforwardness, and had they known that his capabilities as an administrator were extraordinary even in that industrious age, they would have admired those too. A Victorian sketch of his personal character may he given in conclusion:

"Although there was much in the official life of Palmerston which inspired distrust and alarm to men of a less ardent and contentious temperament, he had a lofty conception of the strength and the duties of England, he was the irreconcilable enemy of slavery, injustice and oppression; and he laboured with inexhaustible energy for the dignity and security of the empire. In private life his gaiety, his buoyancy, his high breeding, made even his political opponents forget their differences; and even the warmest altercations on public affairs were merged in his large hospitality and cordial social relations. In this respect he was aided with consummate ability by the tact and grace of Lady Palmerston, the widow of the 5th Earl Cowper, whom he married at the close of 1839, and who died in 1869."

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PALMERSTON NORTH, a town in the Wellington land district of the North Island, New Zealand. It lies on the Manawatu river at the crossing of the main trunk railway, 80 mi. N.E. of Wellington. Pop. (1961) 30,998; area 10 sq.mi. The town has a large central square and numerous parks and gardens: it is the seat of a university college, of the Massey agricultural college and of the Dairy Research institute.

Palinerston North's industries include manufacturing works, knitting mills, a box factory and a printing plant. It is the market and distribution centre for the fertile surrounding pastoral district. The town is served by the national airline and is a railway and road junction. (A. M. P. H.)

PALMETTE, any decorative form consisting of radiating petals or scales, symmetrically disposed, and growing from a single focus at the bottom. The word is especially used of certain lotus (*q.v.*) derivatives in Egyptian and Asiatic art, and for somewhat similar forms occurring in the Byzantine and Romanesque styles. The classic palmette is usually termed an anthemion (*q.v.*).

PALMETTO, a popular name for *Sabal palmetto*, the palmetto palm; a native of the southern United States, especially in

Florida. It has an erect stem, 20 to 80 ft. high, and deeply cut fan-shaped leaves, 5 to 8 ft. long; the fruit is a black drupe $\frac{1}{3}$ to $\frac{1}{2}$ in. long. The trunks make good piles for wharves! as the wood resists the attacks of borers; the leaves are used for thatching. The palm is grown as a pot plant in greenhouses. A similar species, the Texas palmetto (S. *texana*), occurs in southern Texas and Mexico. The terminal bud or cabbage is eaten. There is also a third species, or dwarf palmetto (S. *minor*). The *Chamaerops humilis* of southern Europe is also called palmetto.

PALMGREN, SELIM (1878–1951), Finnish pianist and composer who helped establish the school of Finnish national music. Born at Bjorneborg (Pori), Feb. 16, 1878, he entered the Helsinki conservatory in 1895, studying composition with Martin Wegelius and the piano with Walter Petzet. From 1899 to 1901 he studied with Busoni in Germany. He continued his studies in Italy, and in 1909 was appointed conductor at Åbo, Finland, where his opera Daniel *Hjort* was produced the following year. From about 1912 he toured Europe as a pianist. sometimes accompanying the singer. Maikki Pakarinen (d. 1929), whom he married in 1910. He visited the United States (1920–21) and in 1923 taught composition at the Eastman School of Music, Rochester, N.Y. In 1930 he was a music critic in Helsinki, and in the same year married the singer, Minna Talwik. From 1939 to 1951 he was professor of composition at the Sibelius academy at Helsinki, where he died Dec. 13, 1951.

Palmgren was best known for his smaller piano pieces, among them "Finnish Lyric Pieces," inspired by folk songs. In his larger piano works, notably his piano concertos, he was influenced by Liszt. His memoirs were published in 1948.

PALMIET (*Prionium Palmita*), a shrubby, aloelike, south African plant of the rush family (Juncaceae), reaching a height of 6 or 7 ft., growing on the edges of streams. The stem is covered with the fibrous remains of old leaves. The plant propagates vegetatively by runners.

PALMISTRY (CHIROMANCY), a predictive system whereby the various irregularities and flexion folds of the skin of the hand are interpreted as being associated with mental or moral dispositions and powers as well as with the current of future events in the life of the individual. It is impossible to say how early this system was used, but it is said to have existed in China as early as 3000 B.C., and in Greek literature it is treated even in the most ancient writings as well-known belief.

Palmistry is practised in nearly all parts of China, where it is combined with podoscopy (divination by means of the feet). Chiromancy is also extensively practised in India. In Syria and Egypt the palmist can be seen plying his trade at the cafés, and among the Arabs chiromancers are consulted as to the probable success of enterprises. It was probably from their original Indian home that the traditional fortunetelling of the gypsies was derived.

This system of divination has the charm of simplicity and definiteness, as an application of the "doctrine of signatures" (see SIGNATURE). In the course of ages every detail has been brought under a formal set of rules, which need only mechanical application. In past times there were considerable divergences in the practice, but at present there is a fairly uniform system. One school lays special stress on the general shape and outline of the hand. Corvaeus enumerates 70 varieties, Pamphilus cuts them down to 6. John de Indagine to 27 and Tricassus Mantuanus raises them to 80. The characters of softness or hardness, dryness or moisture, etc., are taken into account in these classifications.

The lines of cardinal importance are shown in the accompanying drawing. These lines isolate certain swellings or monticuli, also illustrated. The relative sizes of these mountains are assigned definite correlations with characters: the mount of Venus with charity, love, libertinage; the mount of Jupiter with religiosity, ambition, love of honour, pride. superstition; the mount of Saturn with wisdom, good fortune, prudence (or when deficient improvidence, ignorance, failure); the mount of the Sun when large makes for success, celebrity, intelligence, audacity, when small meanness or love of obscurity; the mount of Mercury indicates love of knowledge, industry, aptitude for commerce, and in its extreme forms on the one hand love of gain and dishonesty, on the other slackness and laziness. The mount of Mars is related to degrees of courage, resolution, rashness or timidity; the mount of the Moon indicates sensitiveness, morality and good conduct, or immorality, overbearing temper and self-will.

The swellings on the palmar faces of the phalanges of the several fingers are also indicative, the first and second of the thumb, respectively, of the logical faculty and of the will; the first, second and third of the index finger, of materialism, law and order, idealism; those of the middle finger. humanity, system, intelligence; of the ring finger, truth, economy, energy; and of the little finger, goodness, prudence, reflectiveness.

PALM SHOWING DETAILS EXAMINED IN PRACTICE OF CHIROMANCY

(A) first phalanx denotes will; (B) second phalanx denotes logic; (C) mount of Venus; (D) mount of Jupiter; (E) mount of Saturn; (F) mount of Apollo; (G) mount of Mercury; (H) mount of Mars; (I) mount of the Moon; (J) plain of Mars; (aa) line of life (numbers indicate years): (bb) line of the head; (cc) line of the heart; (dd) line of Saturn or fate: (ee) line of the liver; (ff) line of Apollo or fortune; (gg) ring of Venus; (h) the quadrangle; (i) triangle; (j) upper angle; (k) inner angle; (mmm) rascettes or bracelets

Over and above these there are other marks, crosses, triangles, etc.. of which more than 100 have been described and figured by different authors, each with its interpretation; and in addition the back of the hand has its ridges.

To the anatomist the roughnesses of the palm are of considerable interest. The folds are so disposed that the thick skin shall be capable of bending in grasping, while at the same time it requires to be tightly bound down to the skeleton of the hand, else the slipping of the skin would lead to insecurity of prehension. For this purpose the skin is tied by connecting fibres of white fibrillar tissue to the deep layer of the dermis along the lateral and lower edges of the palmar fascia and to the sheaths of the flexor tendons. The folds. therefore, which are disposed for the purpose of making the grasp secure, vary with the relative lengths of the metacarpal bones, with the mutual relations of the sheaths of the tendons and the edge of the palmar fascia, somewhat also with the insertion of the palmaris brevis muscle.

The sulci are emphasized because the subcutaneous fat, which is copious in order to pad the skin for the purpose of firmness of holding. being restricted to the intervals between the lines along which the skin is tied down, makes these intervals project, and these are the monticuli.

The swelling of the mountain of Venus is simply the indication of the size of the muscles of the ball of the thumb and can be increased by their exercise. Similarly the hypothenar muscles for the little finger underlie the three ulnar marginal mountains. the sizes of which depend on their development and on the prominence of the pisiform bone.

The belief that these purely mechanical arrangements have any psychic. occult or predictive meaning is a product of the imagination alone. As there can be no fundamental hypothesis of correlation. discussion of chiromancy does not lie within the province of reason. *See* also DIVINATION; HAND. (A. MAC.)

PALMITIC ACID, is one of the more important long-chain fatty acids (*see* CARBOXYLIC ACIDS). It occurs in practically all natural fats and oils. often associated with stearic acid; because of its wide occurrerice it is often regarded as the characteristic saturated acid of natural fats. Many fish oils contain about, 10%, cottonseed oil about 20% and palm oil up to 40% of palmitic acid. Like the other fatty acids. it does not occur in the free state, but is normally found as an ester of glycerol, called a glyceride. or as an ester of a long-chain alcohol. Tripalmitin (*see* below), the tricster of glycerol and palmitic acid. is a typical example of a triglyceride.

Palmitic acid, $CH_3(CH_2)_{14}CO_2H$, is a colourless solid existing in various crystalline forms of which the one melting at 62.9° C. is the most stable. It is a monocarboxylic acid and shows all the reactions typical of this class of compound, such as the formation of esters by reaction with alcohols. *e.g.:*

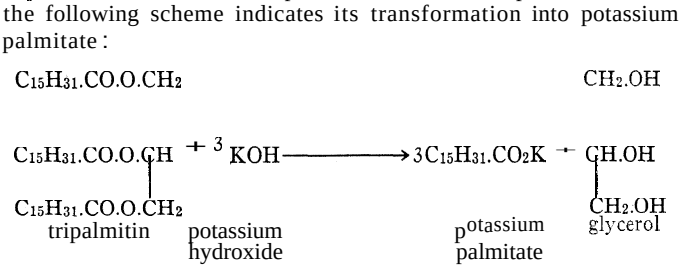
$$C_{15}H_{31}.CO_2H + MeOH \longrightarrow C_{15}H_{31}.CO_2Me + H_2O$$

in which Me represents the methyl group, Another example is the formation of its acid chloride by treatment with phosphorus pentachloride or oxalyl chloride.

$$C_{15}H_{31}.CO_2H + PCl_5 \longrightarrow C_{15}H_{31}.COCl + POCl_3$$

Soaps are the sodium or potassium salts of long-chain carboxylic acids and the potassium salt of palmitic acid is the major constituent of shaving creams and some liquid soaps. However, its use in these cases is diminishing as a result of the adoption of other detergents.

Soap manufacture is the alkaline hydrolysis of glycerides and is often referred to as saponification. Hydrolysis of the triglyceride tripalmitin is a reaction representative of this saponification and the following scheme indicates its transformation into potassium palmitate:



It has been established that palmitic acid. which contains 16 carbon atoms is biosynthesized from acetic acid which contains 2 carbon atoms by a process involving acetyl-coenzyme-A as the intermediate. The transformation in *vivo* of palmitic to stearic acid is possible by a further condensation involving acetic acid.

See K. S. Markley, *Fatty Acids, Their Chemistry and Physical Properties* (1937); A. E. Bailey, *Industrial Oil and Fat Products* (1945). (W. D. Os.)

PALM OIL: see OIL PALM; OILS: FATS ASD WAXES.

PALM SPRINGS, a city of Riverside county. in southern California, U.S., celebrated as the originator and model of the desert resort city. Almost 100 mi. E. of Los Angeles, it enjoys popularity as a resort from January through April. The climate is dry, warm and stimulating. Even in summer, when the heat is excessive, many persons, often aided by air-conditioning, live in Palm Springs. The town is beautifully situated in the Coachella valley, immediately under the precipitous slopes of Mt. San Jacinto.

The Agua Caliente Indians. who live in the area, possess (under treaty) alternate sections of land in the city. Palm Springs' modern history began in 1909 when Ellie Kaufman founded a sanatorium there. This later became the Desert. Inn. The potentialities for a general resort began to be realized in the 1920s under the leadership of Philip L. Boyd, who became the city's first mayor when it was incorporated in 1938.

For comparative population figures see table in CALIFORNIA: *Population.* (A. C. TR.)

PALM SUNDAY, the Sunday before Easter, so called from the custom, still observed in the Roman Catholic Church. of blessing palm branches and carrying them in procession in commemoration of Christ's triumphal entry into Jerusalem. In the Western Church. Palm Sunday is counted as the first day of Holy Week. and its ceremonies usher in the series of services. culminating in those of Good Friday, which commemorate the Passion.

The ceremonies on Palm Sunday as celebrated now in the Roman Catholic Church are divided into: (1) the solemn blessing of the palms; (2) the procession; (3) the mass.

In the Orthodox Eastern Church Palm Sunday (*4 κυριακὴ ἑορτὴ τῶν βαΐων, ἑορτὴ βαϊοφόρος,* or *ἡ βαϊοφόρος*) is not included in Holy Week, but is regarded as a joyous festival commemorating Christ's triumphal entry into Jerusalem. There is no longer a procession; but the palms (in Russia willow twigs) are blessed and are held by the worshippers during the service.

Of the reformed churches. the Church of England alone includes Palm Sunday in the Holy Week celebrations. The blessing of the palms and the procession were, however. temporarily abolished at the Reformation, and the name "Palm Sunday." though it survives popularly, is not mentioned in the Book of Common Prayer.

BIBLIOGRAPHY.—*See* article "Palmsonntag" in Wetzer and Welte, *Kirchenlexikon,* 2nd ed., ix, 1319 *sqq.;* "Woche, grosse," by Drews in Herzog-Hauck, *Realencyklopädie,* 3rd ed., xxi, 415 (1908); Wiepen, *Palmsonntags Prozessionen und Palmesel* (1903); *L.* Duchesne. *Origines du culte chrétien,* 2nd cd.. p. 237 (1808). For ceremonies anciently observed in England on Palm Sunday *see* M. E. *C.* Walcott, *Sacred Archaeology* (1868); J. Brand, *Popular Antiquities* (1870). See also *Catholic Encyclopaedia, s.v.* "Palm Sunday."

PALMYRA, the Greek and Latin name of a famous city of the east. now a mere collection of Arab hovels but still an object of interest on account of its wonderful ruins. In II Chron. viii, 4, and in the native inscriptions it is called Tadmor, and this is the name by which it was known among the Arabs in the 20th century and, it would seem, as far back as the 12th century B.C., for "Tâdmar which is in the land of the Amurru" occurs in an inscription of Tiglath-Pileser I c. 111 j–1100 B.C. (Dhorme in *Rev. Bibl.,* pp. 106 ff.. 1924). The site lies 150 mi. N.E. of Damascus and five days' camel journey from the Euphrates, in an oasis of the Syrian desert. 1,300 ft. above sea level. At this point the great trade routes met in ancient times. the one crossing from the Phoenician ports to the Persian gulf, the other coming up from Petra and south Arabia.

In II Chron. viii, 4. Solomon is said to have built "Tadmor in the wilderness"; I Kings ix, 18, however, from which the Chronicler derived his statement, reads "Tamar" in the Hebrew text, with "Tadmor" in the Hebrew margin; there can be no doubt that the text is right and refers to Tamar in the land of Judah (Ezek. xlvii, 19; xlviii. 28). The Chronicler, it must be supposed, altered the name because Tadmor was a city more renowned in his day, or possibly because he wished to increase the extent of Solomon's kingdom. The date of the Chronicler may be placed about 300 B.c.. so Palrnyra must have been in existence centuries before then. Of its remoter history. except for the allusion in Tiglath-Pileser's inscription. nothing is known. It may be supposed that after the fall of the Babylonian empire (6th century B.C.) Arabian tribes began to take possession of the partly cultivated lands east of Canaan and learned to speak and write in Aramaic, the language most widely current throughout the region west of the Euphrates in the time of the Persian empire (6th–4th century B.C.). It is not till much later that Palmyra

first appears in Western literature. We learn from Appian (Bell. civ. v. 9) that in 42–41 B.C. the city was rich enough to excite the cupidity of Mark Antony. The series of native inscriptions, written in Aramaic, begins a few years after; the earliest bears the date 304 of the Seleucid era, *i.e.*, 9 B.C. (Cooke, North-Semitic *Inscriptions* No. 141 = Vogüé, Syrie Centrale No. 30*a*); by this time Palmyra had become an important trade-post between the Roman and the Parthian states. Its characteristic civilization grew out of a mixture of various elements, Arabic, Aramaic, Greek and Roman. The bulk of the population was of Arab race, and though Aramaic was used as the written language, in common intercourse Arabic had by no means disappeared. The proper names and the names of deities, while partly Aramaic, are also in part unmistakably Arabic: it is suggestive that a purely Arabic term (*faḥd*, NSI. No. 136) was used for the septs into which the citizens were divided.

Originally an Arab settlement, the oasis was transformed in the course of time from a mere halting-place for caravans to a city of the first rank, and a religious centre, with the worship of the Sun-god dominating that of inferior deities.

The chief luxuries of the ancient world, silks, jewels, pearls, perfumes, incense and the like, were drawn from India, China and southern Arabia. The trade followed two routes; one by the Red sea, Egypt and Alexandria, the other from the Persian gulf through the Syro-Arabian desert. The latter, when the Nabataean kingdom of Petra (q v.) came to an end (A.D. 105), passed into the hands of the Palmyrene merchants. Their caravans (*συνοδίαι*) travelled right across the desert to the great entrepôts on the Euphrates, (*NSI.* Nos. 113–115). The trade was enormously profitable, not only to the merchants but to the town, which levied a duty on all exports and imports; at the same time formidable risks had to be faced both from the desert-tribes and from the Parthians, and successfully to plan or convoy a great caravan came to be looked upon as a service to the state, often recognized by public monuments erected by "council and people" or by the merchants interested in the venture. These monuments, a conspicuous feature of Palmyrene architecture, took the form of statues placed on brackets projecting from the upper part of the pillars which lined the principal thoroughfares. Thus arose, beside minor streets, the imposing central avenue which, starting from a triumphal arch near the great temple of the Sun, formed the main axis of the city from south-east to north-west for a length of 1,240 yards, and at one time consisted of not less than 750 columns of rosy-white limestone, each 55ft. high.

Local industries do not seem to have been important. The prominent townsmen were engaged in the organization and even the personal conduct of caravans, the discharge of public offices such as those of *stratēgos*, secretary, guardian of the wells, president of the banquets of Bel, chief of the market (see NSI. Nos. 114, 11j, 121, 122), sometimes the victualling of a Roman expedition. The capable performance of these functions, which often involved considerable pecuniary sacrifices, ensured public esteem; and to these honours the head of a great house was careful to add the glory of a splendid tomb, consecrated as the "long home" (lit. "house of eternity," cf. Eccles. xii. 5) of himself, his sons and his sons' sons for ever. These tombs, which lie outside the city and overlook it from the surrounding hills, a feature characteristically Arabic, remain the most interesting monuments of Palmyra. Some are lofty towers containing sepulchral chambers in stories; others are house-like buildings with a single chamber and a richly ornamented portico; the sides of these chambers within are adorned with the names and sculptured portraits of the dead. As a rule the buildings of Palmyra do not possess any architectural individuality, but these tombs are an exception. The style of all the ruins is late classic and highly ornate, but without refinement.

The rise of Palmyra to a position of political importance may be dated from the first imperial period, when the city must have admitted the suzerainty of Rome, for decrees respecting its custom-dues were issued by Germanicus (A.D. 17–19) and Cn. Domitius Corbulo (AD. 57–66). At the same time the city had by no means surrendered its independence; even in the days of Vespasian (A.D. 69–79) the distinctive position of Palmyra as an intermediate state between the two great powers of Rome and Parthia was carefully watched. The splendid period of Palmyra (A.D. 130–270), to which the greater part of the inscribed monuments belong, started from the overthrow of Petra (A.D. 105), which left Palmyra without a competitor for the Eastern trade. Hadrian treated the city with special favour, and on the occasion of his visit in A.D. 130, granted it the name of Hadriana Palmyra (הדרינא תדמר *NSI.* p. 322). Under the same emperor the customs were revised and a new tariff promulgated (April, A.D. 137), cancelling the loose system of taxation "by custom" which formerly had prevailed. The great fiscal inscription, which still remains where it was set up, gives the fullest picture of the life and commerce of the city. (NSI. pp. 313–340). The government was vested in the council (*βουλή*) and people (*δῆμος*), and administered by civil officers with Greek titles, the proedros (president), the *grammateus* (secretary), the archons, syndics and *dekaprōtoi* (a fiscal council of ten), following the model of a Greek municipality under the Roman Empire. At a later date, probably under Septimius Severus or Caracalla (beginning of 3rd century), Palmyra received the *ius italicum* and the status of a colony; the executive officials of the council and people were called *stratēgoi*, equivalent to the Roman *duumviri* (*NSI.* Nos. 121, 127); and Palmyrenes who became Roman citizens began to take Roman names, usually Septimius or Iulius Aurelius, in addition to their native names.

It was the Parthian wars of the 3rd century which brought Palmyra to the front, and for a brief period raised her to an almost dazzling position as mistress of the Roman East. The inscriptions enable us to follow the rise of one house in particular, which prefixed to their Semitic names the Roman *gentilicium* of Septimius; its members, therefore, had received the citizenship under Septimius Severus (A.D. 193–211). In the next generation Septimius Odainath or Odaenathus, son of Hairan, had attained the rank of Roman senator (*συγκλητικός*, Vogüé No. 21, *NSI.* p. 285 n.) conferred no doubt when Alexander Severus visited Palmyra in A.D. 230–231; his son again, Septimius Hairan, seems to have been the first of the family to receive the title of Rās Tadmor ("chief of Tadmor") in addition to his Roman rank (*NSI.* No. 125); while his son, the famous Septimius Odainath, commonly known as Odaenathus (*q.v.*), the husband of Zenobia, received even higher rank, the consular dignity (*ὑπατικός*) which is given him in an inscription dated A.D. 258, in the reign of Valerian (*NSI.* No. 126). The East was then agitated by the advance of the Parthian Empire under the Sassanidae, and the Palmyrenes with their Roman honours and their Roman civilization, which did not really go much below the surface, had to choose one side or other. Their choice leaned towards Rome mainly because the Roman emperor was further off than the Persian king. In the contests which followed there can be no doubt that the Palmyrene princes cherished the idea of an independent empire of their own, though they never threw over their allegiance to the Roman suzerain until the closing act of the drama. Their opportunity came with the disaster which befell the Roman army under Valerian at Edessa. The Persians swept victoriously over Asia Minor and North Syria; not, however, without resistance on the part of Odaenathus, who inflicted considerable losses on the bands returning home from the pillage of Antioch. It was probably not long after this that Odaenathus, with a keen eye for his advantage, made overtures to the Persian king, Shapur I., and when they were rejected he threw himself into the Roman cause. After the death of Valerian, Gallienus succeeded to a merely nominal rule in the East, and made no effort to recover the lost provinces. Thereupon the two leading generals of the Roman army, Macrianus and Callistus, renounced their allegiance and proclaimed the two sons of the former as emperors (AD. 261). During the crisis Odaenathus remained loyal to Gallienus, and was rewarded for his fidelity by the grant of a position without parallel under ordinary circumstances; as hereditary prince of Palmyra he was appointed dux Orientis, a sort of vice-emperor for the East (AD. 262). He started promptly upon the work of recovery. With his Palmyrene

troops, strengthened by what was left of the Roman army corps, he took the offensive against Shapur, defeated him at Ctesiphon, and in a series of brilliant engagements won back the East for Rome. During his absence at the wars, we learn from the inscriptions (A.D. 262–267) that Palmyra was administered by his deputy Septimius Worod, "procurator ducenarius of Caesar our lord," also styled "commandant," as being Odaenathus' viceroy (ἀργαπέτης, *NSI.* Nos. 127–129). Then in the zenith of his success Odaenathus was assassinated at Ḥoms (Emesa) along with his eldest son Herodes (A.D. 266–267). The fortunes of Palmyra now passed into the vigorous hands of Zenobia (*q.v.*), who had been actively supporting her husband in his policy. Zenobia seems to have ruled on behalf of her young son Wahab-allath or Athenodōrus as the name is Graecized, who counts the years of his reign from the date of his father's death. Under Odaenathus Palmyra had extended her sway over Syria and Arabia but now the troops of Zenobia, numbering it is said 70,000, proceeded to occupy Egypt; the Romans under Probus resisted vigorously but without avail, and by the beginning of A.D. 270, when Aurelian succeeded Claudius as emperor, Wahab-allath was governing Egypt with the title of "king." His coins of 270 struck at Alexandria bear the legend *v(ir) c(onsularis) R(omanorum) im(perator) d(ux) R(omanorum)* and display his head beside that of Aurelian, but the latter alone is styled *Augustus.* Meanwhile the Palmyrenes were pushing their influence not only in Egypt but in Asia Minor while still professing to act under the terms of the joint rule conferred by Gallienus. Then in the course of the year A.D. 270–271 came the inevitable and open breach. In Palmyra Zenobia is still called "queen" (βασίλισσα, *NSI.* No. 131; cf. Wadd. 2628), but in distant quarters, such as Egypt, she and her son claim the dignity of Augustus; Wahab-allath (jth year) begins to issue coins at Alexandria without the head of Aurelian and bearing the imperial title; and Zenobia's coins bear the same. It was at this time (A.D. 271) that the two chief Palmyrene generals Zabdā and Zabbai, set up a statue to the deceased Odaenathus and gave him the sounding designation of "king of kings and restorer (or perhaps corrector) of the whole city" (*NSI.* No. 130). These assumptions marked a definite rejection of all allegiance to Rome. Aurelian, the true Augustus, quickly grasped the situation. At the close of A.D. 270 Probus brought hack Egypt into the empire; then in 271 Aurelian made preparations for a great campaign against the seat of the mischief itself. He approached by way of Cappadocia, where he reduced the Palmyrene garrisons, and thence through Cilicia he entered Syria. At Antioch the Palmyrene forces under Zabdā attempted to resist him, but they were compelled to fall back, and at Emesa they were defeated in a stiffly contested battle. The way was now open to Palmyra and probably in the spring of A.D. 272 Aurelian captured the city. In accordance with the judicious policy which he had observed in Asia Minor and at Antioch, he granted full pardon to the citizens; only the chief officials and advisers were put to death; Zenobia and her son were captured and reserved for his triumph when he returned to Rome. But the final stage in the conquest of the city was yet to come. A few months later, in the autumn of 272—the latest inscription is dated August 272 (Vogüé, No. 116)—the Palmyrenes revolted, killed the Roman garrison quartered in the city, and proclaimed one Antiochus as their chief. Aurelian heard of it just when he had crossed the Hellespont on his way home. He returned instantly before any one expected him, and took the city by surprise. Palmyra was destroyed and the population put to the sword. Aurelian restored the walls and the great Temple of the Sun (A.D. 273); but the city never recovered its splendour or importance. The famous Palmyrene archers, however, served in the Roman army in Africa and elsewhere, even in Britain, as the inscription now at South Shields gives evidence (NSI. pp. 250. 312; Lidzbarski, *Ephemeris,* ii, 92).

Language.— The language spoken at Palmyra mas a dialect of western Aramaic, and belongs to the same group as Nabataean and the Aramaic spoken in Egypt. In some important points. however, the dialrct was related to the eastern Aramaic or Syriac (*e.g.* the plur. ending in *6';* the dropping of the final *ī* of the pronominal suffix third pers, sing. with nouns, and of the final *ū* of the third pers. pl. of the verb; the infin. ending *ū,* etc.). But the relation to western Aramaic is closer; specially characteristic arc the following features: the imperf. beginning with y, not as in Syriac and the eastern dialects with *n* or l; the plur. ending *-ayyā';* the forms of the demonstrative pronouns, etc. As the bulk of the population was of Arab race, it is not surprising that. many of the proper names are Arabic and that several Arabic words occur in the inscriptions. The technical terms of municipal government are mostly Greek, transliterated into Palmyrene; a few Latin words occur, of course in Aramaic forms. The writing is a modified form of the old Aramaic character, and especially interesting because it represents almost the last stage through which the ancient alphabet passed before it developed into the Hebrew square character.

The names of the months were the same as those used by the Nabataeans, Syrians and later Jews, viz., the Babylonian. The calendar was practically a reproduction of the Julian, which Roman influence disseminated throughout Syria. Dates were reckoned by the Seleucid era; from Oct. 312 B.C.

Religion.— The religion of Palmyra did not differ in essentials from that of the north Syrians and the Arab tribes of the eastern desert. The chief god of the Palmyrenes was a solar drity, called Samas or Shamash ("sun"), or Bel, or Malak-bel, transcribed Μαλαχβῆλος, Malagbelus (*NSI.,* p. 268; Lidzbarski, Ephemeris, ii, 84, 92), whose great temple is still the most imposing ieature among the ruins of Palmyra. Both Bel and Malak-bel were of Babylonian origin. Sometimes associated with the Sun-god was ʿAgli-bol the Moon-god, who is represented as a young Roman warrior with a large crescent attached to his shoulders (Chabot. *Choix d'Inscr. de Palmyre,* Pl. xix, 1). The great goddess of the Aramaeans, ʿAthar-ʿatheh, in Greek Atargatis (*q.v.*), and Allath, the chiei goddess of the ancient Arabs, were also worshipped at Palmyra. Another deity whose name occurs in votive inscriptions, is Baal-shamin, *i.e.,* "Baal of the heavens." = Ζεὺς μέγιστος κεραύνιος, sometimes called "lord of eternity." Another interesting divine name is that of a distinctly Arabic deity "Sheʿa-alqūm the good and bountiful god who does not drink wine'? (*NSI.,* No. 140 B); the name means "he who accompanies, the protector of, the people"—the divine patron of the caravan. A common formula in Palmyrene dedications runs "To him whose name is blessed forever, the good and the compassionate"; out of reverence the name of the deity was not pronounced; was it Bel or Malak-bel? It is worth while noticing that this epithet like "lord of eternity" (or, "of the world"), has a distinctly Jewish character. Altogether about 22 names of gods are iound in Palmyrene; some of them, however, occur only in compound proper names.

After its overthrow by Aurelian, Palmyra was partially revived as a military station by Diocletian (end of 3rd century A.D.), as we learn from a Latin inscription found on the site. Before this time Christianity had made its way into the oasis, for among the fathers present at the council of Nicaea (A.D. 325) was Marinus, bishop of Palmyra. The names of two other bishops (jth and 6th centuries) have come down to us and the foundations of two churches have been discovered, the larger of which, 148 ft. by 88 ft., may have held the seat of the bishop. About A.D. 400, Palmyra was the station of the first Illyrian legion (*Not.* dign. i, 85, ed. Boecking); Justinian in 527 furnished it with an aqueduct, and built the wall of which the ruins still remain (Procopius, Dr aedij, ii, 11).

At the Moslem conquest of Syria, it capitulated to Khālid b. al-Walid without embracing Islam (Yāqūt, i, 831). The town became a Moslem fortress and received a considerable Arab colony. The ruins of Palmyra greatly interested the Arabs, and are commemorated in several poems quoted by Yāqūt and others; they are referred to by the early poet Nábigha Dhubyani as proofs of the might of Solomon and his sovereignty over their builders the Jinn (Derenbourg, *Journ. As.,* xii, 269). References to Palmyra in later times have been collected by Quatremtre, ,Sultans *Mamlouks,* ii, pt. I, p. 255 *seq.* All but annihilated by earthquake in the 11th century, it recovered considerable prosperity; when Benjamin of Tudela visited the city, which was still called Tadmor, he found 2,000 Jews within the walls (12th century). It was still a wealthy place as late as the 14th century; but in the general decline of the east, and because of changes in the trade routes, it sunk at length to a poor group of hovels gathered in the courtyard of the Temple of the Sun. The ruins first became known to Europe through the visit of Dr. William Halifax of Aleppo in 1691 (see P.E.F.Q. *St.* [1890]). The architecture was carefully studied by Wood and Dawkins in 1751, whose splendid folio (*The Ruins* of *Palmyra,* London, 1753) also gave copies of inscriptions. But the epigraphic wealth of Palmyra was first opened to study by the collections of William H. Waddington (vol. iii) and Charles de Vogüé (La *Syrie centrale*) made in 1861–62. Since that time the most valuable document which. has come to light is the great fiscal inscription discovered in 1882 by Prince Abamelek Lazarew.

See also J. Mordtmann, *Palmyrenisches* (1899); C. S. Clermont-Ganneau. *Études d'arch.* ov. i, *Receuil. d'arch. or.* iii, v, vii, viii; M. Lidzbarski, *Ephemeris,* i and ii; Sobernheim. *Palm. Inschr.* (1905). The *Répertoire d'épigr. sém.* contains the new texts which were published after 1900. Chabot, *Choix d'Inscriptions de Palmyre,* 1922, is a valuable collection of texts and photographs. For the dialect, *see* T. Nöldeke, *ZDMG.,* xxiv, 85–109, and S. A. Cook JQR., xvi, 274 ff. Critical discussions of the history will be found in T. hlommsen. *Provinces* of *the Roman Empire* (Eng. trans., 1886), pp. 92 sqq. An expedition was made in 1914 by Pères Jaussen and Savignac, under the auspices of the Académie des Inscriptions et Belles-Lettres; the report

is given in the *Revue Biblique,* pp. 359–419 (1920). The whole site was explored afresh (1927) for the académie by Prof. A. Gabriel, see *Syria,* viii, pp. 71–92 (1927). (G. A. C.)

PALO ALTO, a suburban city of the U.S., in Santa Clara county. California. and the seat of Stanford university (*q.v.*). is about 30 mi. S.E. of San Francisco. It is one of a string of cities along the densely built-up bay shore of the San Francisco peninsula. Rolling hills and a spur of the coast range separate it from the Pacific ocean 18 mi. S.W. Gaspar de Portolá's 1769 expedition is said to have camped near El Palo Alto, the tall redwood tree from which the city derived its name. Palo Alto was laid out in 1891 as a "dry" village, for Stanford university. and deeds still prohibit liquor sales in the original townsite; the population, however. soon pushed boundaries into surrounding "wet" territory. World War II began an inrush of industries and boosted the population of the little residential city to 52.287 (1960). (For comparative population figures *see* table in CALIFORNIA: *Population.*) As expansion in other directions was blocked by neighbouring cities and the bay shore, Palo Alto, by annexation, continued to press into the western hills. Charter revisions in 1950 brought a city manager and a centralized administration.

Pioneer radio experiments by Lee de Forest and others paved the way for a concentration of electronics laboratories and plants. The Ames Aeronautical laboratory and Stanford Medical school attracted various types of industry and research admitted under stringent planning requirements. (E. V. C.)

PALO ALTO, a battlefield in Cameron county. Texas, between Point Isabel and Matamoras, about nine miles northeast of the latter. There on May 8. 1846. took place the first battle of the war between Mexico and the United States (1846–48). Brigadier General Zachary Taylor's forces of about 2,200 regulars, in an effort to join with beleaguered troops at Fort Brown, came upon a superior number of Mexicans (variously estimated between 4.000 and 6,000) under General Mariano Arista. Between the *chaparral* and the marshes the two lines were drawn up opposite each other, the hfexicans astride the road to Ft. Brown. Taylor's artillery, better handled than the Mexican heavy pieces, cut great swaths in the enemy's lines in process of forming. An attempt to turn the U.S. right by a superior force of Mexican cavalry was met by a hollow square of the jth infantry. The grass was set on fire by the shells. so that a dense smoke screen kept the two armies from seeing each other well. In this haze, the trained and disciplined subordinate leaders of the U.S. forces met the Mexican attempt to encircle the left. Samuel Ringgold's and James Duncan's batteries moved and fired handily in spite of the smoke. When darkness closed the issue for the day the Mexican loss was, according to estimate. about seven times that of the U.S. The engagement was the first instance where superiority of training against an organized enemy rested with the Americans.

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PALOLO WORM. A polychaete (Annelida, *q.v.*) worm, *Palola viridis,* also often referred to the genus *Eunice* (= *Leodice).* that inhabits coral reefs in the South Pacific and exhibits remarkable lunar periodicity in its reproduction. The eggs and spermatozoa mature in the epitokous posterior ends of the worms, which ends are cast off.swimming as a swarm to the surface of the sea where the sexual products are discharged. The principal swarming, known in Fiji as "bololo levu" takes place in November at the third quarter of the moon, but a small "bololo lailai" may occur in October. The worms of the large swarm are collected for food. Comparable phenomena are exhibited by other polychaets, notably the *vermiculi marini,* locally called "wawo," that George Eberhard Rumphius observed swarming at Amboina two or three days after the Feb.–March moon, 1684–94, and which were later described as *Lysidice oele,* and by a West Indian species, *Eunice schemacephala* (= *E. fucata*) of which the main swarm occurs about the third quarter of the June–July moon. This Atlantic palolo has been the subject of much experimental research which appears to indicate that moonlight rather than tidal changes determine the swarming. There is some evidence that both total illumination and its rate of daily change are involved.

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PALOMINO DE CASTRO Y VELASCO, ACISCLO ANTONIO (1653–1726), Spanish painter and writer on art. Although negligible as an artist, he produced a work on art, *El Museo pictórico y escala óptica* (1715–24), the third volume of which is a mine of biographical material relating to Spanish artists. On the strength of this he has been called "the Spanish Vasari." The work was partially translated into English in 1739; an abridgment of the original *(Las Vidas de los pintores y estatuarios españoles)* was published in London in 1742.

PALOVERDE (Span. *palo verde,* green tree), the name given to the genus *Cercidium* of the Leguminosae, comprises a small group of trees and shrubs scattered through the arid regions of southwestern United States, Mexico, Central America and Venezuela. Three species are indigenous to the United States, two of which become arborescent. Blue paloverde (C. *floridum*) is a grotesque tree, 1j to 20 ft. high, found in desert areas of southern California. Arizona and Mexico, including lower California. It is usually a short-trunked, intricately branched tree, with smooth, conspicuously green bark and minute leaves which quickly wither and fall. their function being assumed by the green elements (chlorophyll) in the bark. The bright yellow flowers, borne in axillary clusters, are followed by cylindric beanlike pods about three inches long. The paloverde is a characteristic woody plant along washes in the Colorado desert. Border paloverde (C. *macrum*) is a Mexican tree which attains its northern limits in southeastern Texas. It may be distinguished readily from the former species by its flattened, podlike fruits. (E. S. HR.)

PALUDAN-MÜLLER, FREDERIK (1809–1876), Danish poet whose work expresses a moral criticism of the aestheticism of the romantic movement. The son of a clergyman who later became bishop of Aarhus, he was born on Feb. 7. 1809, at Kerteminde on the island of Fünen. In 183j he graduated in law at Copenhagen. but meanwhile he had gained fame as a poet with *Danserinden* (1833), an epic in three cantos written in Byronic ottava rima. The narrative is interrupted by numerous digressions. mainly expressing ideas of love and passion also borrowed from Byron.

The world-weariness expressed in Paludan-Muller's poetry at this time was not a mere literary fashion, however. In the 1830s the popular young poet passed through a mental and religious crisis, during which he was nursed by his cousin. Charité Borch, whom he married in 1838. With her he was able to achieve the mental harmony and spiritual strength preached in his later work. He withdrew from society and until his death (in Copenhagen, Dec. 28, 1876) lived almost in seclusion.

His main work, *Adam Homo,* the first part published in 1841, the remaining two parts not until 1848, is an epic in 12 cantos, again in ottava rima. Its hero, the gifted and good natured son of a clergyman, climbs the ladder of social success and ends by becoming a baron. The poem is a satire on human nature: Adam, as he becomes successful, also becomes shallow, and gradually loses his individuality. It is only through the faithful love of Alma Stjerne, whom he has jilted, that, in the apocalyptic final canto. he is saved from doom. The story unfolds against the background of contemporary Danish society, which is described with satirical wit, and when the first part appeared, it was received as the beginning of a Danish *Don Juan.* Paludan-Müller no longer shared Byron's conception of love, however, and through Alma he expounds his new theory of will and obedience.

His later works are mainly imaginative and philosophical poems expressing a lofty idealism. They include dramatic poems based on mythology *(Venus,* 1841; *Dryadens Bryllup* and *Tithonus,* both

1844); biblical epics (*Abels Død*, 1844); a narrative in dialogue form (*Benedikt fra Nurcia*, 1861); a drama (*Kalanus*, 1854, in which Alexander the Greai kneels before the Indian prophet of renunciation): and *Adonis*, his last poem. published in 1874. Paludan-Müller's *Poetiske Skrifter* were publishecl in 8 vol. (1878–79). A selection was edited by Carl S. Petersen, 3 vol. (1909).

Paludan-Müller's theme, constantly discussed and amplified in his poems, is the fundamental conflict between passion and intellect. pleasure in the world and renunciation of it, life and death. He stands as the counterpart of Adam Öhlenschläger (*q.v.*), and *Adam Homo* may be regarded as a revised *Aladdin*, the drama in which Öhlenschläger had expressed the spirit of Danish romanticism.

See V. R. A. Andersen, *Paludan-Müller* (1910). (O. A. F.)

PALWAL, a town in Gurgaon district. Punjab, India. Pop. (1951) 13,915. It is a place of great antiquity supposed to figure in the earliest Aryan traditions under the name of Apelava, part of the Pandava kingdom of Indraprashtha.

PAMIERS, a town of southern France in the *département* of Ariège, 40 mi. S. by E. of Toulouse on the railway to Foix. Pop. (1954) 11,067. Pamiers was originally a castle built in the early 12th century by Roger II, count of Foix, on lands of the abbey of St. Antonin de Frédelas. The abbots of St. Antonin, and afterwards the bishops, shared the authority over the town with the counts, which gave rise to numerous disputes. Pamiers was sacked by Jean de Foix in 1486, again during the religious wars, when the abbey of St. Antonin was destroyed, and finally in 1628, by Henry II of Bourbon prince of Condé. Pamiers is the seat of a bishopric dating from the 13th century. The cathedral (chiefly 17th century) with an octagonal Gothic tower, is a mixture of the Graeco-Roman and Gothic styles; the church of Notre-Dame du Camp (17th and 18th centuries) has a crenelated and machicolated façade of the 13th century. Iron and steel of good quality are among its products. There are nursery gardens in the vicinity, and the white wine of the district is well known.

PAMIRS. The name of a chain of mountains in Central Asia. Our estimate of the extent of Pamir conformation depends much on the significance of the word Pamir. If we accept the Persian derivation of the term, ***pai-mir,*** or "the foot of mountain peaks," we have a definition which is by no means an inapt illustration of the actual facts of configuration. The plateau of Tibet and the uplands of the Pamirs are not analogous in physiography, and do not merge into each other. Littledale points out (R.G.S. *Journ.*, vol. vii.) that the high-level valleys of glacial formation which distinguish the Pamirs have no real counterpart in the Chang-t'ang or high plains of Tibet. The latter are 2,000 ft. higher, intersected by narrow ranges, are drained by no rivers of importance, but form a region of salt lakes and stagnant marshes, relieved by wide flat spaces of open plateau country. The absence of any vegetation beyond grass or scrub is a striking feature common to both Pamir and Chang-t'ang, but there the resemblance ceases, and the physical conformation of mountain and valley to the east and to the west of the upper sources of the Zarafshan is radically distinct.

The Pamirs are divided by the great meridional mountain chain of Sarikol with Muztagh-ata (24,388 ft.). This chain divides the high-level sources of the Oxus on the west from the streams which sweep downwards into the Turkestan depression of Kashgar on the east. There are the true Pamirs (*i.e.*, valleys reaching up in long slopes to the foot of mountain peaks) on either side, and those on the west differ in some essential respects from those on the east. On the west the following are generally recognized as distinct Pamirs: (1) the Great Pamir, with Lake Victoria; (2) the Little Pamir, separated from the Great Pamir on the north by the Nicolas range; (3) the Pamir-i-Wakhan; the narrow trough of the Wakhan tributary of the Oxus, the term Pamir applying to its upper reaches only; (4) the Alichur—the Pamir of the Yeshil Kul and Ghund—immediately to the north of the Great Pamir; (5) the Sarez Pamir, the valley of the Murghab river, which has here found its way round the east of the Great Pamir and the Alichur from the Little Pamir, and now mnkes westwards for the Oxus. At the foot of the Sarez Pamir stands Murghabi. To the north-east of the Alichur are the Rang Kul and the Kara Kul Pamirs. Rang Kul lake occupies a central basin or depression; but the Kara Kul drains away north-eastwards through the Sarikol (as the latter, bending westwards, merges into the Trans-Alai) to Kashgar and the Turkestan plains. Similar characteristics distinguish all these Pamirs. They are hemmed in anti separated by snow-capped mountain peaks and ridges, which are seamed with glaciers terminating in moraines. Long sweeps of grassy upland bestrewn with boulders lead from the streams up to the snowfields, yellow, grey or vivid green. according to season and the measure of sunlight, fold upon fold in interminable succession, their bleak monotony being only relieved by the grace of flowers for a short space during the summer.

To the east of the Sarikol chain is the Taghdumbash Pamir which claims many of the characteristics of the western Pamirs at its upper extremity, where the Karachukar, which drains it, is a comparatively small stream. But where the Karachukar, joining forces with the Khunjerab, flows northwards to Tashkurghan, dividing the two parallel ranges of Sarikol and Kandar, which together form the Sarikol chain, the appellation Pamir can hardly be maintained. This is the richest portion of the Sarikol province. Here are stone-built houses collected in scattered detachments, with a spread of cultivation reaching down to the river. Here are water-mills and many permanent appliances of civilization suited to the lower altitude (10,500 ft., the average height of the upper Pamirs being about 13,000), and here we are no longer near the sources of the river at the foot of the mountain peaks. One other so-called Pamir exists to the east of Sarikol, separated therefrom by the Kandar, which is known as Mariom or Mariong. But this Pamir is situated nowhere near the sources of the Zarafshan or Raskam river; which it borders, and possesses little in common with the Pamirs of the west. The Mariom Pamir defines the western extremity of the Kuen Lun, which stretches eastward for 250 mi. before it becomes the political boundary of northern Tibet.

The Muztagh Chain and Karakoram Extension.— The Muztagh chain, which holds within its grasp the mightiest system of glaciers in the world, forms a junction with the Sarikol at the head of the Taghdumbash, and also with the Hindu Kush. The political boundary between Kashmir and Sinkiang is carried by the Zarafshan or Raskam river to a point in about 79° 20′ E. where it is transferred to the watershed of the Kuen Lun. Within the limits of these partially explored highlands, lying between the Pamirs and the Tibetan table-land, exact geographical definition is impossible. Godwin-Austen considers the main chain of the Muztagh to merge into the central system of the Tibetan Chang-t'ang, its axis being defined and divided by the transverse stream of the Shyok at its westward bend; whilst the Karakoram range, in which the Shyok rises, is a subsidiary northern branch. The pass over the Karakoram (18,290 ft.) is the most formidable obstacle on the main trade route between Leh (*q.v.*) and Kashgar.

The Taghdumbash **Pamir.**—The Taghdumbash Pamir occupies a geographical position of some political significance. One important pass (the Beyik. 15,295 ft.) leads from the Russian Pamirs into Sarikol across its northern border. A second pass (the Wakhjir, 16.150 ft.) connects the head of the Wakhan valley of Afghanistan with the Sarikol province across its western head, whilst a third (the Kilik, 15,600 ft.) leads into the head of the Hunza river and opens a difficult and dangerous route to Gilgit.

Glacial Sources of the Oxus.—The true source of the Oxus probably lies in the snowfields of the Nicolas range and Lakes Chakmaktin (13,020 ft.) and Victoria (13,533 ft.) may be regarded as incidents, diminishing in volume day by day, in the course of glacial streams, rather than original springs or sources. The Nicolas glaciers also send down streams to the Panja or Wakhan river, below its junction with the ice stream from Wakhjir.

Climate and **Population.**—What is known of the climate of the Pamirs is based on observations taken at Pamirski Post, on the Murghab river. The rainfall is that of the steppe régime, most rain falling in late spring and early summer. The air is remarkabiy dry. especially in summer. The mean winter (January)

temperature is −1°, and the mean summer temperature (July) 58°. A very strong south-west wind blows up the valleys by day throughout the year. There is much snow in the valley bottoms, but the ridges are snow free and without glaciers. At the height of 12,000 ft. the rainfall is only 2 in. per annum.

The population is mainly nomadic and includes a variety of "drifts" from various surrounding regions. The main element is usually called Pamiri, and is very broad-headed, with a white, fresh skin, often much bronzed, and abundant brown hair, inclined to be curly; the men have much face hair. The stature is slightly above the average (say 5 ft. 6½ in.), the nose is narrow, prominent and straight or aquiline, the eyes are straight, as in Europeans, and may be light. Among the Pamiri tribes the purest are the mountaineers called Galchas. To the south are Dardi elements more related to the people of north-west India, but not usually with such extreme long heads as are found among the Rajputs and Sikhs. To the west occur the broad-headed Kirghiz, with yellowish-white skin, usually bronzed, very broad heads, large cheekbones, rather narrow noses, dark eyes of European type, and a tendency to stoutness. The first, or Pamiri type is, in practically every feature, akin to the Alpini type of Europe. Some of the Pamiri peoples are nearly related to the gypsies. There are Jews in the towns below the Pamirs.

The Kirghiz are Sunni Mohammedans, but are said to retain traces of ancient Nestorian Christianity in their ritual practices, and it is thought that a Christian bishopric survived at Yarkand till about a century after its presence there was noted by Marco Polo. The last Gurkhan of the Kara Kitai Empire in the early 13th century (the legendary Prester John) was a member of a Christian tribe named Naiman, mentioned by Ney Elias and claiming kinship with the Kipchaks.

Through the Pamirs have passed famous trade routes, *e.g.*, from Yarkand, via Tashkurgan and Rang Kul, to the stations in Turkistan north of the Oxus, or, via Tashkurgan and Lake Victoria, to Badakshan, while the Buddhist pilgrim route from Yarkand, and other cities of Sinkiang, across the Baroghil pass to Chitral, is also of historic importance.

Exploration. — Native explorers from India first began to be busy in the Pamirs about 1860, and in 1874 the mission of Sir D. Forsyth to Yarkand led to the first systematic geographical exploitation of the Pamir country. In 1885 Ney Elias made his famous journey across the Pamirs from east to west, identifying the Rang Kul as the Dragon lake of Chinese geographers—a distinction which has also been claimed by some geographers for Lake Victoria. Lockhart and Woodthorpe in 1886 passed along the Wakhan tributary of the Oxus from its head to Ishkashim in Badakshan, and completed an enduring record of most excellent geographical research. Bonvalot in 1887, Littledale in 1888, Cumberland. Bower and Dauvergne, followed by Younghusband in succeeding years, extending to 1890; Dunmore in 1892 and Sven Hedin in 1894–95, have all contributed to Pamir geography; but the honours of successful inquiry in those high altitudes still fall to the late Lord Curzon, whose researches in 1894 led to a singularly clear and comprehensive description of Pamir geography, as well as to the best map compilation made up to that time. Meanwhile Russian explorers and Russian topographers had been equally busy from the north. The famous soldier Skobelev was probably the first European to visit the Great Kara Kul. He was followed by scientific missions systematically organized by the Russian government. In 1883 Putiata's mission started south. Gromchevsky was hard at work from 1888 to 1892. Yano began again in 1891, after a short spell of rest, and has left his mark as a permanent record in the valley of Sarhad (or Wakhan), between the Baroghil pass and Bozaí Gumbaz. Finally, in 1895, the Russian mission under General Shveikovsky met the British mission under General Gerard on the banks of Lake Victoria, and from that point to the Chinese frontier eastward demarcated the line which thereafter divided Russian from British interests in highest Asia.

PAMPA, LA: *see* LA PAMPA.

PAMPANGA, an agricultural province in the heart of the central plain, Luzon, Philippines, drained by several rivers and their tributaries which empty into Manila bay. Most of the province is level and is used for the production of rice and sugar cane. The western border is within the foothilis of the Zambales mountains. The lower delta land, bordering on Manila bay. is an area of mangrove and nipa palm swamps, some of which have been converted into fish ponds. Candaba swamp, on the Pampanga-Bulacan border, is a huge, shallow lake during the wet season, but during the dry season the water recedes and its floor is the principal melon-producing district of the Philippines. Area 827 sq.mi.; pop. (1959 est.) 510,340.

The principal towns are San Fernando, the capital, Guagua and Angeles. Clark Air Force base, near Angeles, is the largest U.S. military installation in the orient. (AN. C.)

PAMPAS, a vast plain stretching across central Argentina from the Atlantic coast to the foothills of the Andes and bounded by the Chaco in the north and Patagonia in the south. The name comes from a Quechua Indian word meaning "a flat surface" and South Americans use it in the singular, *la pampa.* Several smaller plains in other parts of South America, such as the desert of northern Chile, are also referred to as pampa.

The area of the Argentine pampa is about 293,000 sq.mi. The pampas has a very gradual slope from southeast to northwest, from 66 ft. above sea level at Buenos Aires to about 1.640 ft. at Mendoza. At that latitude the distance across is about 620 mi. Apart from a few sierras in the northwest and south, most of the region appears perfectly flat. The soil consists chiefly of fine sand, clay and silt washed down toward the Atlantic by the great rivers or blown in dust storms from the west. The climate varies; summers are hot in the northwest, but near the coast they are cooled by the Falkland current.

Periodically cool winds from the south meet the warm air from the tropical north, creating violent gales accompanied by heavy rain in the neighbourhood of Buenos Aires. These storms are known as pamperos.

The pampas is divided into two distinct zones. In the west is the dry pampas, largely barren, with great saline areas, brackish streams and sandy deserts. Some parts are covered with stunted scrub. To the east of this arid zone lies the temperate, well-watered humid pampas, economic heart of Argentina and the main source of its wealth. Originally the humid pampas was covered with tussocks of rough prairie grass and it was destitute of trees except for an occasional, solitary *ombú,* the "lighthouse of the pampas."

From the middle of the 19th century the region mas transformed. Previously the Spaniards had introduced cattle and horses but had made no attempt to develop the land. The animals were rounded up by *gaucho* cowboys, who were celebrated for their horsemanship, hardihood and lawlessness. After the liberation from Spain, and with the progressive extermination of the wild Indians who roamed the plains, landowners began to employ immigrants (chiefly Italians) to cultivate. their *estancias,* solving alfalfa (lucerne) for fodder and maize and finer pastures. They fenced their lands with barbed wire and imported pedigree cattle and sheep from Great Britain. Railways were built across the pampas. The gauchos gradually became *peones* (labourers), and horses have been increasingly replaced by tractors.

The southeastern area between Mar del Plata and Tandil, being relatively cool and containing much swampy land, has been devoted to the breeding of high-grade sheep and cattle, with almost no agriculture. A second (western) belt extending in a curve for about 600 mi. from Bahia Blanca in the south to Santa Fe in the north is used principally for the cultivation of alfalfa and wheat, with some cattle raising. Around Rosario maize and flax are the chief crops, with some cattle. The vicinity of Buenos Aires has been developed to supply the capital with vegetables, fruit and milk. (GE. P.)

PAMPERO: *see* WIND: *Local Winds.*

PAMPHILUS (1st century A.D.), a Greek grammarian, of the school of Aristarchus. He was the author of a comprehensive lexicon, in 95 books, of foreign or obscure words, the idea of which was credited to another grammarian'. Zopyrion, himself the compiler of the first four books. The work itself is lost, but an epitome by Diogenianus (2nd century) formed the basis of the

lexicon of Hesychius. A similar compilation, called *Deimon* ("meadow") from its varied contents. dealing chiefly with mythological marvels. was probably a supplement to the lexicon.

See M. Schmidt, appendix to hid edition of Hesychius (1862) vol. iv.

PAMPHLET, a small tract especially of topical interest (probably from Fr. *pamphilet,* derived from the 12th century poem *Pamphilus seu de amore*). The first use of the word is found in 1344 in Richard de Bury's *Philobiblon.* The leaflets and broadsides of the 15th and 16th centuries were concerned with religious controversy. In the 17th century the more iamilinr type of polemical pamphlet became common, famous examples being Milton's *Areopagitica,* and the anti-Cromwell tract *Killing no Murder* (1657). But it was not until the 18th century that the pamphlet first in the hands of Addison and Swift. and so down to Burke and Rousseau became a regular weapon of political controversy, the medium as well for a stately argument as for a bitter personal assault. Less pugnacious and less adroit in the 19th and 20th centuries, the pamphlet has become increasingly a means of propaganda. The corn laws. the Indian mutiny. Schleswig-Holstein, Irish home rule, the eastern question, vaticanism (and every sort of religious dispute), Drcyfus. tariff reform, prohibition, nationalization, etc.; all have produced a flood of pamphlet controversy. Generally speaking the pamphlet tends essentially to present one side of an argument and is usually more remarkable for its vigour than its balance.

PAMPHYLIA, the region in the south of Asia Minor, between Lycia and Cilicia, extending from the Mediterranean to Mt. Taurus. It was bounded on the north by Pisidia and was a country of small extent, having a coast-line of about 75 miles with a breadth of about 30 miles. There can be little doubt that the Pamphylians and Pisidians were originally the same people; but the distinction between the two seems to have been established at an early period. Herodotus. who does not mention the Pisidians, enumerates the I'amphylians (i. 28) among the nations of Asia Minor, while Ephorus mentions them both. correctly including the one among the nations on the coast. the other among those of the interior. The early I'amphylians, like the Lycians, had an alphabet of their own. partly Greek, partly "Asianic," which a few inscriptions on marble and coins preserve. Cnder the Romans the term Pamphylia was extended to include Pisidia and the whole tract up to the frontiers of Phrygia and Lycaonia. The country consisted almost entirely of a plain.

The chief towns on the coast were: Olbia. the first town in Pamphylia. near the Lycian frontier; Antalya (*q.v.*); and Side (*q.v.*). On a hill above the Eurymedon stood Aspendus (*q.v.*) and above the river Cestrus was Perga (*q.v.*). Between the two rivers, but somewhat farther inland. stood Sylleum, a strong fortress. which even ventured to defy the arms of Alexander. The coins of Aspendus, though of Greek character. bear legends in a barbarous dialect; arid probably the Pamphylians were of Asiatic origin and mixed race. They became largely hellenized in Roman times. and have left magnificent memorials of their civilization at Perga, Aspendus and Side. The I'amphylians are first mentioned among the nations subdued by the Mermnad kings of Lydia, and afterwards passed in succession under the dominion of the Persian and Macedonian monarchs. After the defeat of Antiochus III in 190 B.C. they were included among the provinces annexed by the Romans to the dominions of Eumenes of Pergamum; later they joined with the I'isidians and Cilicians in piratical ravages. Pamphylia was for a short time included in the dominions of Amyntas, king of Galatia, hut after his death lapsed into a district of a Roman province.

See *Cambridge Ancient History,* vol. iii. (with useful bibliography); C. Lanckomiski, *Les Villes de la Pamphylie et de la Pisidie* (1890).

PAMPLONA, the capital of the Spanish province of Navarre, and an episcopal see; 1,387 ft. above sea level. on the left bank of the Arga, a tributary of the Ebro. Pop. (1960 est.) 84.936 (mun.). It has a station on the Ebro railway connecting Alsasua with Saragossa. From its position it has always been the principal fortress of Navarre. Originally a town of the Vascones. it was rebuilt in 68 B.C. by Pompey the Great. whence the name Pompaelo or Pompelo (Strabo). It was captured by Euric the Goth in 466 and by the Franks under Childehert in 542; it was dismantled by Charlemagne in 778, but repulsed the emir of Sarapossa in 907. In the 14th century it was greatly strengthened and beautified by Charles III, who built a citadel on the site now occupied hy the Plaza de Toros and by the Basilica de S. Ignacio, the church marking the spot where Ignatius de Loyola received his wound in defending the place against André de Foix in 1521.

The citadel. southwest of the city, was constructed by order of Philip II (1556–98), and was modelled on that of Antwerp. The cathedral is a late Gothic structure begun in 1397 by Charles III (El Noble) of Navarre, who is buried within its walls: of the older Komanesque cathedral only a small portion of the cloisters remains. The fine interior is remarkable for the peculiar structure of its apse, and for the choir-stalls carved in English oak by Miguel Ancheta (1530). The principal façade is Corinthian, from designs of Ventura Rodriguez (1783). The same architect designed the aqueduct by which the city is supplied with water from Monte Francoa. some nine miles off. Pamplona has a flourishing agricultural trade, besides manufactures of cloth, linen stuffs, flour, soap. leather. cards, paper, earthenware, iron and nails. The yearly fair in connection with the feast of San Fermin (July 7), the patron saint of the city. attracts a large concourse.

PAN, originally an Arcadian deity who came to be worshiped throughout. the Greek world. although he never attained any high moral development or prominent place in cult outside Arcadia. The name is a Doric contraction of *paōn,* "pasturer." but was commonly supposed in antiquity to be connected with *pan,* "all." The spread of his ancient cult was relatively late; he was unknown to Homer. although he is the subject of one of the later Homeric hymns. He was associated by the Romans with Faunus (*q.v.*). His father is generally said to be Hermes; as his mother is often named Penelope (*q.v.*), probably not the wife of Odysseus but commonly identified with her. one or another of the characters in the *Odyssey* is sometimes called his father. Pan is represented as more or less bestial in shape. generally having the horns, legs and ears of a goat; in later art the human parts of his form are much more emphasized, the bestial characteristics dwindling to a little pair of horns. His activities are those of a giver of fertility, and he is thus represented as vigorous and lustful. His chief concern is with flocks and herds. not with agriculture; hence he can make men, like cattle, stampede in "panic" terror; like a shepherd, he is a piper. a late legend representing him as the lover of a nymph Syrinx ("Panpipe"), who disappeared into a reed bed when he pursued her. Pan making the first pipe from the reeds (Ovid, *Metamorphoses,* i. 689–712). Like a shepherd, again. he rests at noon. and dislikes having his sleep disturbed; he can also send visions and dreams. Again like a shepherd, he haunts the high hills and another late story makes him love or be loved by the nymph Pitys ("pine tree").

Two picturesque stories are told of him. When the Athenians sent the runner Philippides to ask help of Sparta before Marathon, he encountered Pan. who asked why Athens did not honour him, seeing that he was her friend and would be so again. After the battle, a cult of him was instituted, presumably because he had sent panic among the Persians (*see* Herodotus, vi, 105). In the time of Tiherius. as related by Plutarch. one Thamus, pilot of a ship making for Italy, was thrice called by name and bidden to give the news that "great Pan was dead." It was plausibly suggested by S. Keinach, although several scholars reject the idea, that what was really heard was "Tammuz, Tammuz, Tammuz the all-great is dead." a ritual lament for Tammuz-Adonis. "Thamus, the great Pan . . ." and "Tammuz the all-great . . ." in Greek would be practically indistinguishable in pronunciation.

Pan is insignificant in literature, aside from Hellenistic bucolic, but he is a very common subject in ancient art. His rough figure was antithetical to, for example, that of Apollo, who represented culture and sophistication; hence the story of their musical contest (*see* MIDAS).

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PANAETIUS (*c.* 180–109 B.C.), the founder of Roman Stoic philosophy, and a friend of Scipio Aemilianus and of Polybius, mas born at Lindus in Rhodes. A pupil in Athens of Diogenes of Seleucia and of Antipater of Tarsus, he also studied the philosophies of Plato and of Aristotle. Many years resident in Rome, he was an influential member of the Scipionic circle and was invited to be Scipio's sole companion on an ambassadorial visit to the orient c. 140 B.C. Succeeding Antipater as head of the school, he passed the last 20 years of his life in Athens. While adhering to fundamental Stoic teaching, Panaetius tempered the rigid austerity of the ancient Stoa and introduced a new humanist note. He appears to have written less voluminously than other leading Stoics, and none of the five treatises attributed to him is extant. His important ethical treatise On *the Appropriate* was Cicero's model for the first two books of the *De Officiis*. His chief disciple was Poseidonius of Apamea. *See* STOICS.

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PANAMÁ (REPÚBLICA DE PANAMA), a Central American republic lying between Costa Rica and Colombia, its boundary with the latter marking the division between Central and South America. The Panama canal, crossing the lowest and narrowest point of land between the Atlantic and Pacific, bisects the republic from ocean to ocean. Panamb is bounded on the north by the Caribbean sea, an arm of the Atlantic. east by Colombia, south by the Gulf of Panamá and the Pacific, and west by Costa Rica. The coast line on the Atlantic side is 477 mi., on the Pacific side 767 mi.

This article is divided into the following sections:

I. Physical Geography
II. Geographical Regions
III. History
IV. Population
V. Administration and Social Conditions
VI. The Economy

There are short articles on the provinces. Geographical, historical, economic and political aspects of Panamá may also be found in CENTRAL AMERICA.

I. PHYSICAL GEOGRAPHY

Geology.—West of the Canal Zone the mountain backbone of Panamá consists of pre-Tertiary granite and metamorphic rocks, capped in the west by explosive deposits of several high Miocene and Pleistocene volcanoes. Pre-Tertiary rocks cover the southern half of Azuero peninsula and west of it they extend from the Pacific to the Caribbean. Mountain flanks and plains in northwestern and southwestern Panamá, northern Azuero peninsula, hills of the Canal Zone and plains bordering the Gulf of Panamá are made up of Oligocene, Miocene and Pleistocene marine sediments and recent alluvium.

Pre-Tertiary granite and metamorphic rocks cover most of Panamá east of the Canal Zone and include the larger of the Pearl Islands (Archipiélago de las Perlas); however, in southeastern Panamá, between two broad areas of the above rocks, are Oligocene and Miocene marine sediments.

Relief and Drainage.—Three fifths of Panamá consists of rolling hills to rough mountains. In the rugged Sierra de Chiriqui and Cordillera de Veraguas. 20 to 35 mi. aide, are several volcanic peaks, the highest Chiriqui (11,410 ft.). Terrain in the Canal Zone region consists of deep valleys and rounded hills. Eastward the rough Cordillera de San Blas, 7 to 18 mi. wide with summits nearly 3,600 ft. high, borders the Caribbean to Colombia. Caribbean lowlands are limited to alluvial-coastal plains, 5 to 20 mi. wide and mostly poorly drained, in Bocas del Toro and just west of the canal. Piedmont-alluvial-coastal plains, 5 to 20 mi. wide, fringe the Gulf of Chiriqui, cut across the base of Azuero peninsula. and border the Gulf of Panamá to San Miguel gulf. East of the Canal Zone these and the Bayano, Tuira-Chucunaque and Balsas alluvial plains are poorly drained. Coiba Island, Azuero peninsula, several Pearl Islands and Serrania del Sapo are hilly to rough.

Many short rivers flow from the mountains to the coasts; the Chagres, Trinidad and other rivers empty into Gatun lake; longest rivers are the Tuira-Chucunaque and the Chepo or Bayano; only the Tuira is navigable for about 100 mi.

Climate.—Lowlands have temperatures of. 80" F., with little monthly variation, but with a diurnal range of 15° F. Mean annual temperatures decrease from 74° F. at 3,000 ft. to 60° F. at 5,000 ft., and to 45° F. in the high Sierra de Chiriqui. The Caribbean coast and high mountains, with no distinct dry season, receive from 127 in. to 160 in., or more, precipitation per year. Annual precipitation at Santa Clara, on the coast 60 mi. west of Panamá city, is 51 in., uith January to April almost rainless; western Chiriqui plains receive 96 in. per year; southern Darién more than 100 in., with no distinct dry season. Wind velocities are low; maximum velocities are about 25 mi. per hour. Possible sunshine varies greatly, according to rainy days, which average less than 120 days per year on Pacific coast to more than 260 days on Caribbean coast and mountains.

Vegetation.—Mangroves and palm forests grow in swamps along portions of both coasts. Broadleaf evergreen forests cover about 60% of Panamá. They are in areas with more than 80 in. of rain and no distinct drought season—Caribbean lowlands, hills and mountain slopes up to 6,500 ft., and all of San Blas and Sapo mountains and the upper Bayano, Tuira-Chucunaque and Balsas basins. They contain at least 90 tree families and 1,000 species, of nhich 200 grow to heights of 70 ft. or more, including balsa, brazilwood. Castilla, ceiba, jacaranda, jobo, laurel, lignum vitae, mahogany, rosewood, Spanish cedar, tamarind and Sapota. Above 6,500 ft. in western mountains are deciduous rain forests, dominated by oaks, alder and Loro. On Pacific lowlands and hills, from the western boundary to San Miguel gulf are large savannas interspersed with tropical semideciduous forest, including such species as almbcigo, cedar, ceiba, mora. panama (national tree, from which name of country is derived), roble de Sabana and ronron. Common drug and medicinal plants in Panamá are arnica. copiaba, camomile. lancepod (sources of rotenone), star apple, tamarind, and wormseed.

Animal Life.—Abundant animal life includes: (1) deer, opossum, tapir, ocelot, raccoon and porcupine; (2) reptiles: crocodiles, lizards, snakes and turtles; (3) rodents: agouti, rats, mice; (4) numerous species of aater and land birds, many beautifully adorned; (5) many species of butterflies, moths, beetles, bees, wasps. ants, flies and mosquitoes, many with protective colouration; and (6) numerous species of fresh-water and salt-water fishes (including Mollusca). The chief commercial fish caught are groupers, corbinas, mackerel, snappers and snooks.

II. GEOGRAPHICAL REGIONS

On the basis of physical geography and economic activities the Isthmus of Panamá may be divided into five geographical regions.

Between the Cordilleras Veraguas and San Blas an east-west belt of valleys and high hills, nearly 60 mi. wide, crosses the isthmus. This is a region of interocean routes (canal, railway, highways and airlines) and population concentration, about 34% of the national total. About 40% of the working people of Panamá city and Colón are employed in the Canal Zone. This area, politically and economically the heart of Panama, produces most of the manufactured goods, and large quantities of foodstuffs.

The Pacific plains and hilly lands of the Azuero peninsula, extending from western Chiriqui to the lower Bayano valley, have 46% of the population of the country. With much level land, fertile soils, high temperatures, and marked rainy and dry seasons, they include most of the country's planted pastures and natural savannas (70% of the pastures consist of planted grasses.) Nearly all the bananas exported from Panamá are grown on the western Chiriqui plains.

The whole region produces about 80% of the country's cattle, swine, poultry and animal products. It also produces nearly all the sugar and 75% of the rice, corn, beans, sweet potatoes, yucca and tobacco. Coastal waters supply nearly all the fish caught in

Panamá.

The Cordilleras Chiriquí and Veraguas, rugged, rainy all year and mostly densely forested, are largely uninhabited on their northern slopes, but valleys on their southern slopes have about 13% of the country': population. These valleys produce most of the coffee of Panamá and they also have important citrus fruit, dairy, cacao, tobacco, and lumbering districts, and mountain resorts.

The Caribbean plains and hills west of the Canal Zone, hot, rainy all the year, and mostly densely forested. are sparsely settled, with only 3% of the nation's population. These people are chiefly in Bocas del Toro plains, Panamá's commercial banana region, until late 1920s. This area produces cacao, abacá, rubber, forest products and foodstuffs for local consumption.

Mountains and lowlands of eastern Panami contain one third of the national area. Hot, rainy all year and densely forested, they support only about 4% of the country's population. Widely scattered, this population, without highways. railways and airlines, is engaged principally in subsistence agriculture, hunting, fishing and lumbering. (C. F. J.)

III. HISTORY

Rodrigo de Bastidas explored the northern coast of the Isthmus of Panamá in 1501. It was not until his fourth and last voyage (1502) that Christopher Columbus, sailing along the isthmus, (then known as *Tierra Firme*) came within a few miles of the seas which he sought as the route to the Indies. These were followed in 1509 by Diego de Nicuesa sent by King Ferdinand of Spain to colonize Tierra *Firme*. None of these explorers was successful in establishing a colony, for the hostility of the natives, the lack of provisions, and the presence of disease defeated their efforts.

Colonial Period.—A more successful attempt was made by Martin Fernández de Enciso on the west shore of the Gulf of Darién. Here at Santa Maria, Vasco Nuñez de Balboa (*q.v.*) induced the colonists to plant crops, taught them to befriend the Indians, and introduced many customs of the homeland. But the hope for riches impelled Balboa to seek and find the Pacific ocean (1513), which he called El Mar del *Sur* (South sea), and to claim it for his sovereign.

Cnder Balboa's successor, Gov. Pedro Arias de Avila (Pedrarias), Santa Maria was given a municipal charter and made the seat of a bishopric. In 1519 Pedrarias transferred his headquarters and that of the bishop across the isthmus to a little fishing village, Panamb. In 1531 Francisco Pizarro sailed from this port for Peru, and thereafter the importance of Panamb lay in its location. To it were brought the riches of the Spanish possessions to the south and north for transhipment across the isthmus on the *Camino real* (royal road) to Nombre de Dios and later to Porto Bello (*q.v.*) while in the opposite direction merchandise of the mother country was distributed to the colonies. Each year it was customary for a fleet of galleons to sail from Cádiz, Spain, with the merchandise, for Porto Bello and San Juan de Ulúa (Veracruz), Mexico. Arrival at Porto Bello was the occasion for a great fair at which old and new world produce was exchanged and attracting traders from all of the colonies. Porto Bello became notorious for the prevalence of disease and inflation.

The annual fairs and the fleet system presented targets of concentrated wealth for the famous buccaneers and privateers of the colonial period. Most famous of these was Sir Francis Drake who in 1572 attacked Nombre de Dios successfully, and in 1573 intercepted the mule train bearing the Spanish king's share of treasure to that port from Panamb. One of Drake's lieutenants, John Oxenham, crossed the isthmus in 1575 and contrived to intercept the treasure ship from the Peruvian mines, but his exploit ended in disaster.

Drake returned to the isthmus in 1595 to burn Santa Maria and Nombre de Dios. He failed in an attempt to cross the isthmus for an attack on Old Panami city and died of fever in 1596. He was buried at sea in Porto Bello harbour. In 1602 William Parker captured and sacked Porto Bello. Of the 17th century pirates Sir Henry Morgan was most distinguished for his seizure of this well defended port and for an arduous expedition across the isthmus and capture of Old Panamá city in 1671. Of quite a different character was the scheme of William Paterson (*q.v.*), founder of the Bank of England, to establish a trading post on the isthmus of Darién (*q.v.*), hut the settlement of New Edinburgh succumbed to a variety of hostile forces.

The deterioration of the Spanish conzmercial system was evidcnced by the asiento contract of 1713 which permitted England to trade one ship's cargo annually in the Spanish colonies. This concession encouraged an already vast illicit trade (including the French and Dutch participation), caused Spain to increase its naval patrols, and led to clashes with British sea power. In one of these Adm. Edward Vernon stormed Porto Bello in 1739. Nine years later the port's great fair was discontinued. Political subordination paralleled economic decline. and in 1751 the isthmus was demoted to a dependency of Santa FP de Bogotá, Colombia.

Union with Greater *Colombia.*—Panamá proclaimed its independence from Spain in 1821 after Simón Bolivar (*q.v.*) cleared New Granada (*q.v.*) of loyalist forces, but after a few months it voluntarily joined the Colombian union. The Liberator invited representatives of the Latin American states to Panamá in 1826 where they assembled and passed resolutions for union and confederation. For a time Panamá enjoyed considerable local autonomy under New Granada, but in 1843, under a new constitution, the executive power at Bogota was greatly strengthened, including the appointment of provincial governors. Tomás Cipriano de Mosquera, elected president of Colombia in 1845, negotiated the building of the Panama railroad and concluded a convention with the United States by which that country guaranteed the neutrality of and free transit across the isthmus.

The *Panama* Canal.—The gold rush to California in 1849 provided the impetus for building the railroad which upon completion in 1855 encouraged the canal builders. The Universal Interoceanic Canal company headed by the builder of the Suez canal, Ferdinand de Lesseps. began construction, but legal entanglements, fraudulent financial arrangements and, particularly disease, precipitated the collapse of the company in 1889.

The railroad operation and the canal construction brought a degree of prosperity to the isthmus but failed to bring political stability. For over three decades after mid-19th century. Panamá experienced the effects of a weak and decentralized form of government at Bogotá. In 1886 Rafael Núñez, president of Colombia) reinstituted a highly centralized government and placed a conservative, clerical party in control. But whether it had the status of a state or a department, Panamá was beset by chronic civil strife up to 1903, the year of its independence.

The possibility of the completion and the control of a canal under foreign auspices and the journey of the warship C.S.S. "Oregon" around Cape Horn during the Spanish American War prompted a considerable agitation in the United States for a U.S. controlled canal. On Nov. 6, 1903, three days after Panama's declaration of independence, the Cnited States recognized the new republic and promptly signed a treaty authorizing construction of the canal. (For the construction and history of the Panama canal *see* PANAMA CANAL.)

The *Republic of Panamá* and *U.S.* Relations.—On Feb. 13, 1904, a constitution was adopted which contained a provision authorizing U.S. intervention and which provided for a centralized government with the four provincial governors appointed and dismissed by will of the president. This arrangement was altered in 1917 and 1919 to allow popular election of president, vice-president, and governors. The constitutional convention of 1904 unanimously elected Manuel Amador Guerrero as the first president. Subsequent elections were tumultuous, and in 1908, 1912 and 1918 U.S. military forces intervened to preserve order.

The political history of the republic remained stormy and there were many internal upheavals. At the outbreak of World War II American ministers of foreign affairs met at Panamá city and in the Declaration of Panama announced in Sept. 1939 a 300-mile-wide neutral zone around the Americas. Panamb declared mar on Japan Dec. 8, 1941, and on Germany and Italy Dec. 12. To strengthen defenses. the United States requested from Panama sites outside the canal zone for landing fields, roads and warning

stations. The election of the pro-Fascist Arnulfo Arias to the presidency in June 1940, led to a protracted negotiation in which the Panamanian government demanded conditions and compensations. Among these were a monetary compensation for the sites, cancellation of a road construction debt, the transfer of certain properties of the Panama Railroad company to Panamá, of the water and sewer systems of Panamb and Colbn, of surplus po er from Alhajuela dam and a bridge over the canal.

In addition Panamá requested a short term lease for the sites, Panamanian use of the airfields, and partial criminal jurisdiction in the sites.

Although U.S. army units were authorized to begin operations on one of the sites on March 6, 1941, it was not until May 18, 1942, that the negotiations were terminated. This conclusion was facilitated when Arias was deposed in Oct. 1941 and succeeded by Ricardo Adolfo de la Guardia. Insofar as war circumstances permitted, the Panamanian conditions were met, and the U.S. congress approved legislation in April 1943, providing the necessary funds.

During and after the war the United States returned 98 defense sites to Panamb, and on the remaining 36, the two countries engaged in long negotiations involving joint control, abandonment, length of tenure and U.S. economic benefits for the republic. Agreement was reached, but the Panamanian assembly, influenced by public pressure, rejected the proposals and the sites were abandoned.

Political uncertainties centring around the return from exile in 1949 and the removal in 1951 of Arnulfo Arias, the election of José Antonio Remón as president (assassinated in 1955), and economic recession were factors leading to another general treaty between the United States and Panamá, concluded in 1955.

Panamá resented being excluded from the London conference on the Suez problem in Aug. 1956, and denied the assertion that the United States had sovereign rights in the Canal Zone. In Nov. 1956 Aquilino Boyd, Panamanian foreign minister, declared that Panamá had as much sovereignty over the canal as Egypt had over Suez, and at a round table discussion in March 1957, Latin American legal experts gave considerable support to the doctrine that agreements in perpetuity are invalid because they are inconsistent with sovereignty.

Anti-U.S. demonstrations broke out in Panamá city in Nov. 1959 following demands that the Panamanian flag should be flown as a symbol of authority alongside the U.S. flag in the Canal Zone.

(A. R. W.)

IV. POPULATION

Distribution and Growth. — In 1960 Panamá's population was 1,067,766; the 1950 census gave 805.285. Less than 10% were tribal Indians living in the Darién jungles, on the San Blas archipelago, and in the western mountains. Approximately 11% were white and 13.3% Negro, according to the 1940 census. In 1950 no attempt was made to tabulate racial origin. Panamanians are proud of the relative amity in which people of different races have lived since Negro slaves were first imported by the Spanish settlers in the early 16th century. Negro, Indian, European and oriental strains are so intermingled that such distinctions as those between mestizo and mulatto are often impossible to draw. Because of their cultural differences and fear of their economic competition, however, British West Indian Negroes, whose ancestors provided labour for railroad and canal construction, are no longer freely admitted, although they are physically similar to many Panamanians of old stock.

Panamá's population is growing fast. A high birth rate of 40.4 per 1,000 in 1957. and a low death rate of 9.3 explain its rapid rate of growth which was 29.3 per 1,000 inhabitants annually between 1940 and 1950. Infant mortality was approximately 57 per 1.000 live births. Panamb city has grown especially fast; it numbered 127,874 people in 1950 and 271,425 in 1960. The population of Colbn in 1960 was 59.032; that of David, 22,694; Chorrera, 13,635; Chitré, 9,155; Santiago, 8,634.

The Pacific region south of the mountain range running along the western half of the Isthmus contains most of the population.

Area and Population of Panamá

Provinces	Area (in sq.mi.)	Population			
		1950 census		1960 Census	
		Number	Density per sq.mi.	Number	Density per sq.mi.
Bocas del Toro	3,332	22,392	6.7	32,110	9.6
Chiriqui	3,460	138,136	39.9	186,801	54.0
Coclé	1,931	73,103	37.9	93,406	48.4
Colón	2,861	90,144	31.5	103,738	36.3
Darién	5,996	14,660	2.4	19,594	3.3
Herrera	907	50,095	55.2	61,531	67.8
Los Santos	1,494	61,422	41.1	70,372	47.1
Panamb.	4,436	248,335	56.0	369,280	83.2
Veraguas	4,336	106,998	24.7	130,934	30.2
Total	28,753	805,285	28.0	1,067,766	37.1

Culture. — Spanish is Panamá's national language. Many Indians, however, speak no Spanish, and only recently have Panamanians of West Indian descent mastered the language. English is commonly spoken in the chief cities, and studied in high school and the university.

Almost all Panamanians are at least nominally Catholic. They are, however, very tolerant of other religions. Numerous sects flourish, especially among those of West Indian ancestry.

Panamanian culture exhibits four distinct patterns besides those of the tribal Indians. Spanish colonial culture, with a considerable admixture of Indian elements, is evident in the small towns and villages of the interior. Neighbours and friends gather for working bees called *juntas*. After clearing land, harvesting a crop, or building a house, they feast on *sancocho*, a meat and vegetable stem, and on their favourite food, rice, and drink a corn liquor called *chicha*. Then they sing folk songs and dance such folk dances as the *tamborito*, *cumbia* and *punto* to the music of homemade guitars, violins and drums. On special occasions as the yearly festival of the patron saint many don folk costumes. Women wear *polleras*, voluminous white garments decorated with embroidery or appliqué, or the long, full, brightly flowered skirts called *montunas*, which are still everyday garb in some regions. Men wear the *montuno*, a long straight blouse of white homespun cotton decorated with fringe and painted figures or cross-stitch embroidery, which almost hides the knee-length trousers. Bull-baiting, cock fights, and displays of horsemanship follow Mass and the solemn procession in which the saint's image is carried around the village square.

In gay, cosmopolitan Colón and Panamá city, colonial patterns have been radically altered by foreign influences and urbanization. Their position at "the crossroads of the world" and their economic fluctuations combine to make urban Panamanians tolerant of foreign ways, dependent upon luck and pleasure-loving.

The third cultural pattern, that of the Americans on the Canal Zone, is as nearly American as is possible in a tropical semi-military outpost. Sedate order, routine and regimentation provide a sharp contrast with the colour and bustle across the streets which divide Panamá city from Ancon and Balboa, and Colón from Cristóbal.

The British West Indian Negro immigrants have long been a disunited and largely segregated group at the margin of Canal Zone-American and urban Panamanian culture. As the immigrant generation dies out and no new immigration is permitted, however, the remnants of island culture disappear, and the new generation becomes increasingly Panamanian. They retain English, however, as an economic asset and — along with other young Panamanians — adopt many superficial aspects of American life as presented in the movies and shops.

The Indians. — Prior to the Spanish conquest, Panamá was inhabited by tribes of primitive indigenous Indians of whom the most important were the Cuna or San Blas, Guaymi (qq *v.*) and the Choco groups. Descendants of the Cuna are now divided into two groups: those on the mainland Pacific slope of eastern Panamá, and the San Blas Cuna who live in the archipelago of San Blas. Although Panamanian citizens, the Cuna live by their own tribal lams. The picturesque Chocó Indians are found in the Darién region. (*See* also INDIAN, LATIN AMERICAN; CENTRAL AND NORTH AMERICAN LANGUAGES.)

(Jo. B. B.)

V. ADMINISTRATION AND SOCIAL CONDITIONS

Government.—Panamá is a centralized republic. Its constitution, adopted in March 1946, provided universal suffrage and the secret ballot. The executive is the president (with two vice-presidents) elected for four years, with the power to appoint cabinet ministers. of which there are seven; government and justice. foreign affairs, finance and treasury, education. agriculture, public works, and labour, social welfare and public health. The unicameral national assembly consists of 53 deputies, with alternates, elected for four years, and convenes annually on Oct. 1 for 90 days. Each of the nine provinces is entitled to elect one deputy and two alternates for each 15,000 inhabitants, and one additional for any remaining fraction of not less than 7,500 inhabitants. The judicial organ, the supreme court, consists of five justices appointed by the executive, one every two years for ten-year terms. This court appoints minor magistrates throughout the country.

The constitution recognized Roman Catholicism, but at the same time guaranteed freedom of worship to other religions.

Living and Working Conditions.— In the 1950s Panamá was one of the few countries of the world in which the cost of living had actually dropped. With 1953 figured as 100. the cost of living index in Panamá city stood at 99 in 1958. The gross national product was computed at U.S. $324 per person. Approximately 264,600 Panamanians were gainfully employed. Of this figure, about 60% were engaged in agriculture, 8% in commerce, 8% in services and 7% in manufacturing. Of the gainfully employed less than 1% were members of internationally affiliated labour unions in the mid-1950s. In July 1958 U.S. legislation provided for the establishment of uniform wage scales, retirement benefits and employment opportunities in the Canal Zone for both U.S. and Panamanian employees.

Welfare Services.—Panamá has a social security program providing for maternity benefits, compensation for injuries to workmen and allowances for the aged and indigent. In 1956 the infant mortality rate was 54.7 per 1.000 births; there were 3,300 people per physician and 12,972 people per dentist; and there were 4.2 hospital beds for every 1.000 Panamanians. In coping with these and similar problems, Panamá is among the Latin-American countries participating in the technical assistance programs offered on both a bilateral basis by the Cnited States and a multilateral basis by the United Nations.

Education.—Panamá's educational system, administered by the ministry of education, has the highest single appropriation of funds in the national budget, and consists of public preschool, primary and secondary grades. Higher education is offered by teachers' schools, trade schools, the National Institute, the Conservatory of Music and the advanced university. Primary education is compulsory and free. Efforts to make the Inter-American university a focal point for higher education throughout Latin America had a qualified success. The National university at Panamá city is autonomous but state endowed, with more than 3,000 pupils in the early 1960s. There were more than 1,000 public and private primary schools and 90 postprimary schools with a total of about 200,000 pupils. The illiteracy, about 28.3% (1950 census), excluding tribal Indians, is low for the Caribbean area.

Defense.— Panama has no army, navy or air force. There exists, however, a trained and efficient armed national police force of approximately 3,370 members. (G. I. B.)

VI. THE ECONOMY

Production. — The majority of farm families, constituting about 60% of the total population, live on small holdings in the southern coast region around the city of Panamb and to the west. Rice is the universal staple. maize is also important, and the country is nearly self-sufficient in both. Yucca and beans are grown everywhere; and cattle provide much of the meat supply and some hides for export.

The large plantations of the U S.-owned United Fruit company are in the western area. Bananas are shipped, largely from Puerto Armuelles on the south coast, and abacá from Almirante on the north coast. Cacao and coconuts are also exported. Three large sugar mills maintain plantations supply the domestic demand and export their produce.

The virgin forests east of the Canal Zone contain an abundance of tropical cabinet and dye woods; but these remain largely unexploited. There is a mahogany veneer plant near Panamá city. Softwood exports have become substantial.

The leading mineral products are cement and salt., the latter from the sea flats near Aguadulce in Coclé. The gold and silver mines in Veraguas, known since colonial times, are worked on a small scaie. Pearl fishing is conducted off the Pearl Islands .in the Gulf of Panamá; the shrimp industry is significant.

The cities of Panamá and Colón have numerous retail shops where merchandise and curios from all over the world, brought duty-free, are sold in large volume to tourists passing through the canal. Assorted industries produce leather goods, soap, furniture, clothing, clay products and canned goods such as tomato paste and evaporated milk. A cement plant fills national needs and exports to the neighbouring republics.

Trade and Finance.—The monetary unit is the balboa, which is at par and freely convertible with the U.S. dollar. U.S. currency circulates extensively in the country, but there is no central bank.

Panama's exports were valued in 1959 at approximately 35,000.000 balboas. Imports were valued at 114.000.000 balboas. The traditionally adverse balance of trade is generally offset by invisible exports to the Canal Zone in the form of tourist expenditures, sales to ships and wages of Panamanians employed there. The latter are subject to taxation by Panama. The chief export commodity was bananas. valued at 22,000,000 balboas. In the same year 98% of the exports of the country went to the United States or Canada. Only 55% of the imports, however, came from the same two sources. About 12% of the imports came from continental Europe and 7% from the sterling area.

In 1958 government revenues were approximately 53.000.000 balboas and government expenditures were 64.000.000 balboas. The domestic debt of the government was 35,000,000 alboas and the foreign debt was 28.000.000. National income was estimated in 1956 at 246,000,000 balboas.

Transport and Communications. — The Pan-American highway is complete between Panamb city and the Costa Rican border. There is a good highway between Panamá city and Colón, and also a railway which was built about 1855 by William E. Howland and William H. Aspinwall, Cnited States promoters. This railroad subsequently became the property of the United States government. Important international air services pass through the national airport at Tocumen.

Because of the canal there is an abundance of maritime shipping. Many steamship companies of other countries fly the flag of Panamb to take advantage of the favourable shipping laws. Panamá's ostensible merchant marine is consequently one of the largest in the world. *See* also Index references under "Panamá" in the Index volume. (W. C. GN.)

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PANAMA, a province on the southern coast of the Republic of Panama. Its area of 4.436 sq.mi. is divided by the Panama Canal Zone, three-fourths lying to the east of the latter. Pop. (1960) 369.280. about 35% of the national total who live mostly in urban centres within 25 mi. of the Canal Zone where the leading manufacturing industries of the country are located.

The province produces a variety of agricultural products for domestic consumption. The seat of provincial government is at Panamá city., (C. F. J.)

PANAMA, capital of the Republic of Panamb, located near the Pacific entrance of the Panama canal. Pop. (1950) 127,874.

Panamá city is no longer a port. The harbour facilities lie in Balboa and many of the canal employees live in Ancón. Both are suburbs, located within the Canal Zone and governed by a branch of the United States defense department. Panamá city is linked with Colón by the canal, the Panama railroad and the Trans-

isthmian highway, with David and Chepo by the Pan-American highway, and from the airport at Tecumen with cities of the world.

Originally a native fishing hamlet, the old city (Panamá Viejo) was formally established in 1519 by Pedro Arias de Avila, and made the seat of both secular and ecclesiastical authority. From the Andean countries bullion was shipped by sea to Panama and from there carried across the isthmus by pack animals to Nombre de Dios or Porto Bello where it was loaded on ships of the annual fleet bound for Spain. The city prospered until the depredations of the pirates and privateers curtailed trade. In 1595 Sir Francis Drake tried unsuccessfully to send a force across the isthmus to sack Panamá, and in 1671 Sir Henry Morgan completely destroyed it. The city was rebuilt in 1674 seven miles west of the old site by Alonso Mercado de Villacorta. It was built with a central plaza around which were placed the cathedral, the governor's house and the bishop's palace. Of the modern buildings, most prominent are the Palace of Justice, La Presidencia, the National palace, and the hotel El Panama. The University of Panama is located there. Political decline accompanied economic decay, and in 1751 the area became a province of New Granada (Colombia.)

In the 19th century Panamá city was the tumultuous scene of much political disorder, and in 1903 the standard of revolt from Colombia was successfully raised there. In the Hay-Bunau-Varilla treaty with the United States of 1903, the latter was given the right to keep order and keep the city clean, both rights being yielded in treaties of 1936 and 1955 respectively. The city became the national capital in 1903 and developed rapidly thereafter with the construction of the canal. The title to the water and sewer systems, built by the United States was turned over to the government of the republic in 1942, and in 1953 their management was also transferred. In 1826, 1939, and 1956 representatives of the American republics met there to proclaim their political ideals.

(A. R. W.)

PANAMA CANAL, a high-level artificial interoceanic waterway of the lake and lock type at the Isthmus of Panamá connecting the Atlantic and Pacific oceans, owned, operated and controlled by the United States under treaty, for the transit of vessels of commerce and of mar of all nations on terms of equality, with tolls that are just and equitable. The Canal Zone, through which it was built, is the constitutionally acquired domain of the United States granted in perpetuity by the Republic of Panama, for the construction of the canal, and its perpetual maintenance, operation, sanitation and protection.

By using the canal, vessels plying between the Atlantic and Pacific coasts of the United States can eliminate the Cape Horn route and save a distance of about 8,000 mi., while journeys between the Atlantic and Pacific coasts of the North and South American continents can be reduced by 3,000–4,000 mi.; vessels from Europe to western Asia and Australia can effect a saving of 1,000–2,000 mi. Hence the canal is of the greatest international importance, strategically and economically.

This article is divided into the following sections and subsections:

I. The Waterway
1. Description
2. Navigation
II. Canal Zone
1. Area and Tidewaters
2. Sovereignty
3. Administration
4. Tolls
5. Canal Traffic
6. Defense
III. History
1. Panama Railroad, 1849–55
2. French Project, 1879–1904
3. United States Policy, 1850–81
4. Isthmian Canal Commission, 1899–1901
5. U.S. Diplomacy, 1901–03
6. Building the Canal, 1904–14
7. Principal Engineering and Construction Projects After 1914
8. Reorganization and Policy Determination
9. Panamá-U.S. Relations

I. THE WATERWAY

1. Description. — The Panama canal does not cross the isthmus from east to west as generally supposed, but from northwest to southeast, with the Atlantic entrance 33½ mi. N. and 27 mi. W. of the Pacific entrance. Located in one of the heavier rainfall areas of the world with its lohgest section formed by impounding the waters of the Chagres river valley by a dam at Gatun, its principal features include: twin-flight locks, dams and spillways at both ends of the canal; the summit-level Gatun lake; an excavated gorge across the continental divide, renamed as Gaillard cut, connecting Gatun lake with the Pacific locks; a small Miraflores lake between two sets of Pacific locks; and two terminals.

The Atlantic terminus is at Cristbbal on Limbn bay, a natural harbour protected against northers by east and west breakwaters. The Pacific terminus is at Balboa, a sheltered artificial harbour with its Pacific entrance channel safeguarded from silt-bearing currents by a causeway from the mainland to the fortified islands in the Bay of Panamá.

The canal length from shore line to shore line is 40.27 statute miles; and from deep water to deep water, 50.72 miles. From north to south, its main parts are:

1. Atlantic sea level dredged channel of 500 ft. bottom width from deep water to Gatun locks, about 7.4 mi.
2. Gatun locks in three steps from sea level to Gatun lake, 85 ft. above sea level.
3. Gatun lake section with channels varying in width from 1,000 ft. at Gatun to 500 ft. at Gamboa where Gaillard cut begins, distance about 24 mi.
4. Gaillard cut of 300 ft. minimum bottom width to Pedro Miguel locks at the south end of the cut, distance about 8 mi.
5. Pedro Miguel locks in one step (31 ft.) to the intermediate Miraflores lake, 54 ft. above sea level.
6. Miraflores lake with channel 750 ft. wide to Miraflores locks, distance about 1 mi.
7. Miraflores locks in two steps to Pacific sea level.
8. Pacific sea level dredged section to the Bay of Panamá, distance about 8.5 mi.

The controlling depth for the Atlantic dredged section from deep water to Gatun locks is 42 ft. below mean low water; from Gatun locks to Pedro Miguel, 42 ft. below the minimum Gatun lake level of 82 ft.; from Pedro Miguel locks to Miraflores, 42 ft. below the minimum Miraflores lake level of 54 ft.; and from Miraflores locks to deep water in the Pacific, 42.4 ft. below mean low water spring (maximum) tides.

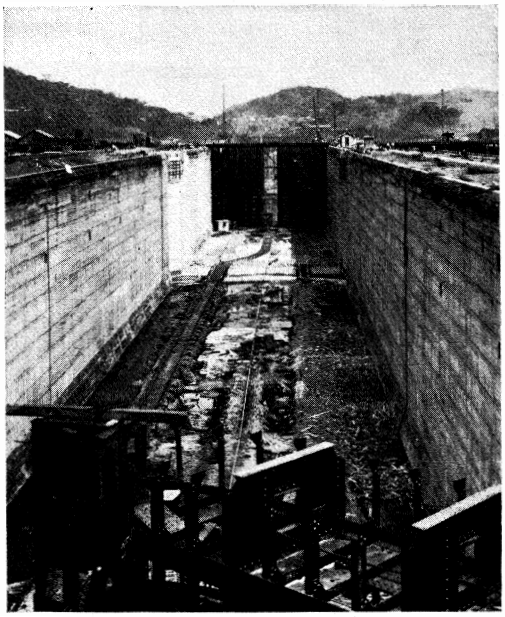
The canal is equipped with modern aids to navigation. The Panama canal has had no major operational improvement since opening to traffic in 1914 with the exception of the Madden Dam and Power project, with its upstream lake to conserve water for lockages and maintenance of channel depths in Gatun lake during dry seasons and to reduce the danger of floods from the upper Chagres in wet seasons, and the enlargement of the Gaillard cut started in 1959.

Locks. — So part of the canal attracts more attention than its massive locks. Constructed in duplicate to enable simultaneous lockages of vessels in the same or opposite direction, all locks have usable dimensions of 1,000 ft. length, 110 ft. width, and a depth to accommodate vessels drawing 40 ft. in salt water. Each lock gate has two leaves, the leaves being floatable structures 65 ft. wide by 7 ft. thick, varying in height from 47 to 82 ft., weighing from 400 to 750 tons, and operated by 25 h.p. motors through gear arrangements.

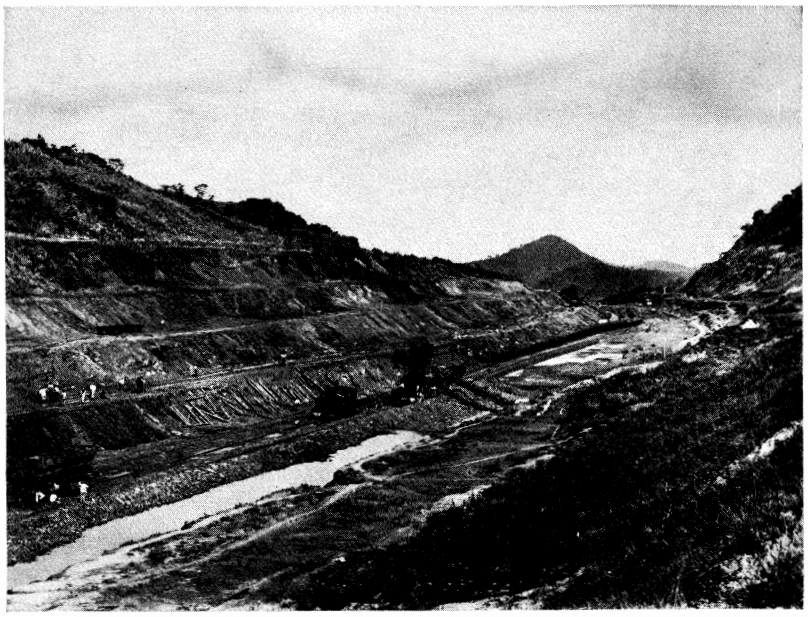
Locks are equipped with unique safety devices, notably hydraulically operated fender chains and electric towing locomotives. The fender chains protect lock gates against vessels that may get out of control when approaching locks, and are dropped into grooves to permit passage. With the exception of small craft, vessels are not permitted to pass through locks under their own power, but are required to be drawn by towing locomotives, varying in number from four to ten, depending on ship characteristics.

The time required for passage through the locks depends upon many factors, including size of vessel and its handling features. Generally, lockage intervals are 80 min. at Gatun, 40 min. at Pedro Miguel, and 60 min. at Miraflores.

Gatun *Dam* and Spillway. — The key structure of the Panama

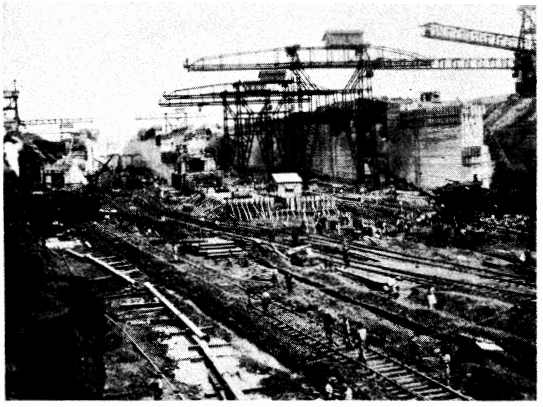


Pedro Miguel locks, March 28, 1912, looking north from lower main gates over west chamber

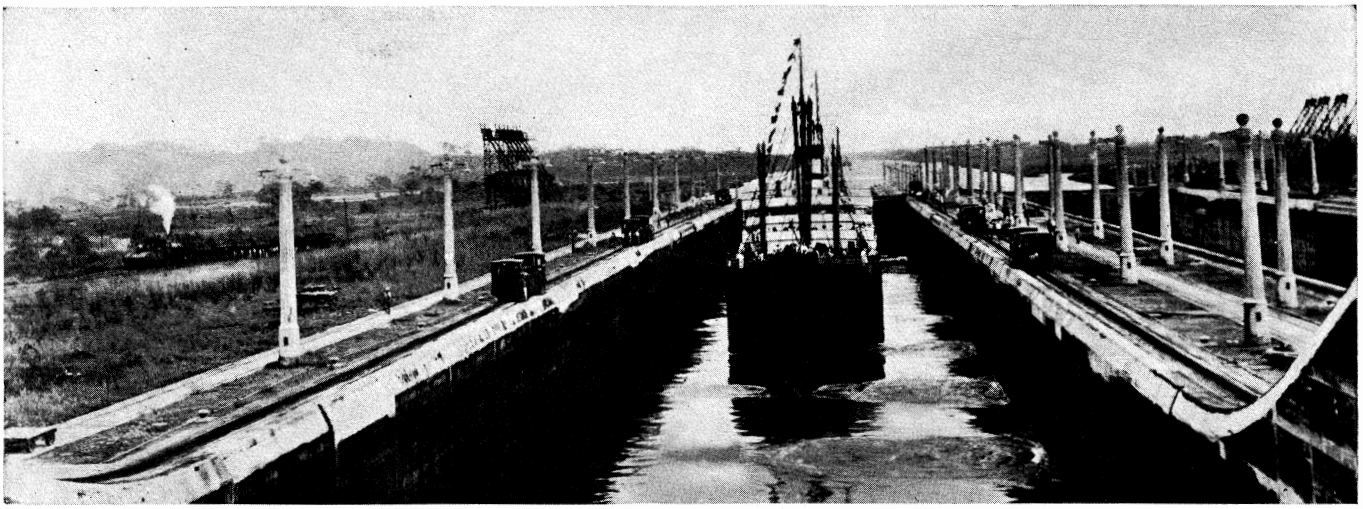


Culebra cut, 1895. looking south from west bank opposite Gold hill and showing French excavation equipment

Culebra cut, 1910, looking south with Gold hill at left



Miraflores locks, Aug. 16, 1912, looking north from west bank toward lower chambers

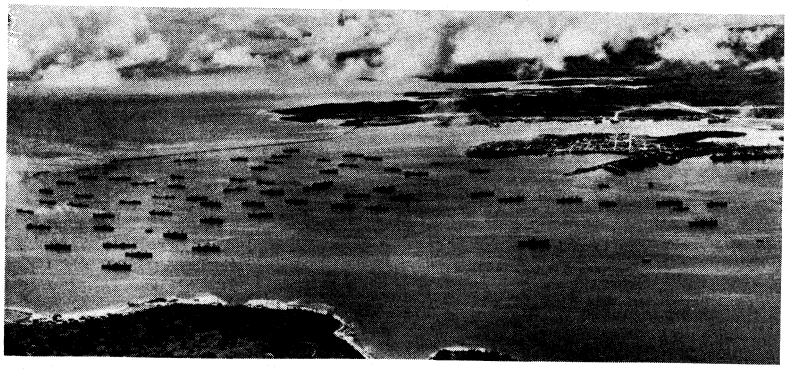


Ship in Gatun lower locks shortly after canal was opened in 1914

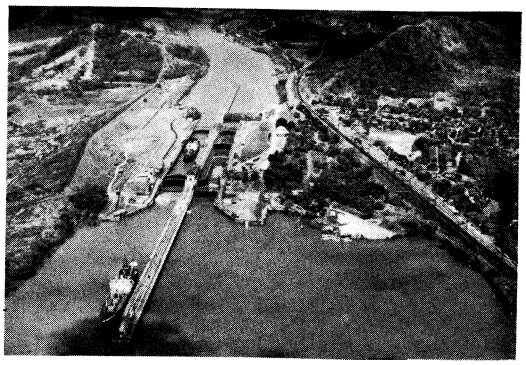
CONSTRUCTION OF THE PANAMA CANAL

BY COURTESY OF PANAMA CANAL COMPANY

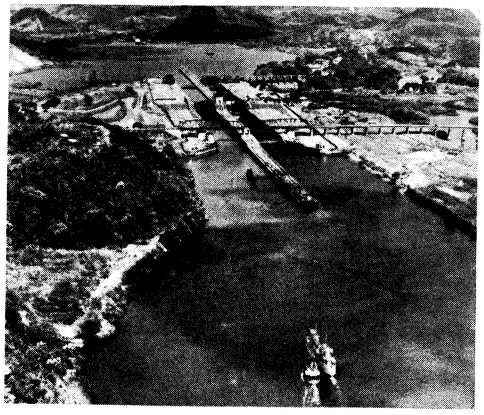
PANAMA CANAL



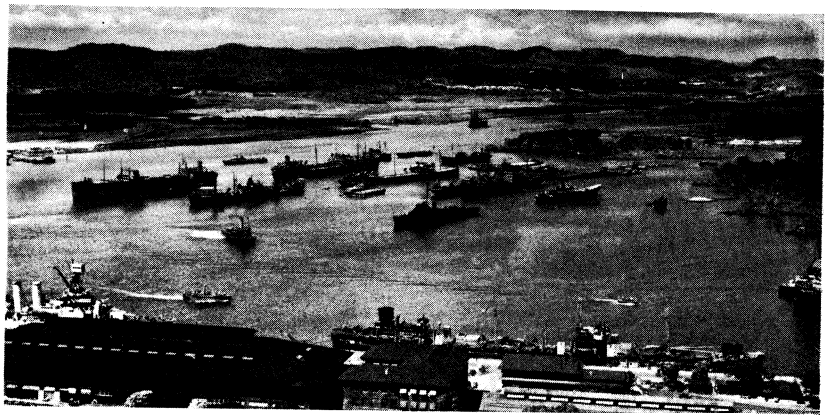
Atlantic terminal Aug. 14, 1945, showing congestion of vessels in Limón bay, protected by breakwaters. Colón and Cristdbal are at upper right



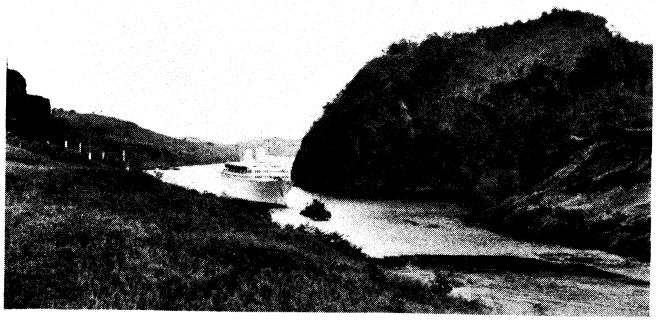
Pedro Miguel locks and dams, looking north into the Gaillard (Culebra) cut. These locks effect a 31 ft. change in water level



Miraflores basin, looking north from the Pacific approach

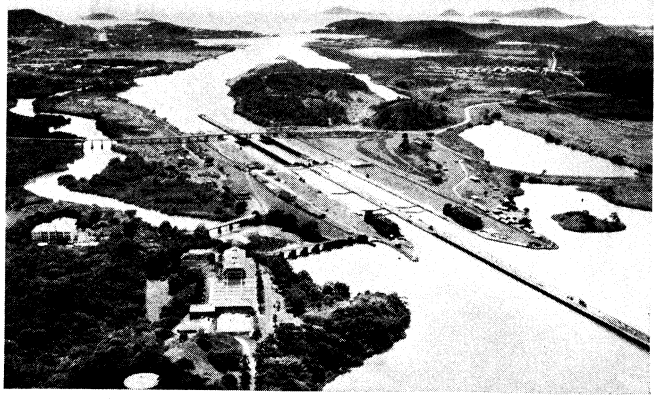


Balboa Inner harbour moorings, Jan. 7, 1944

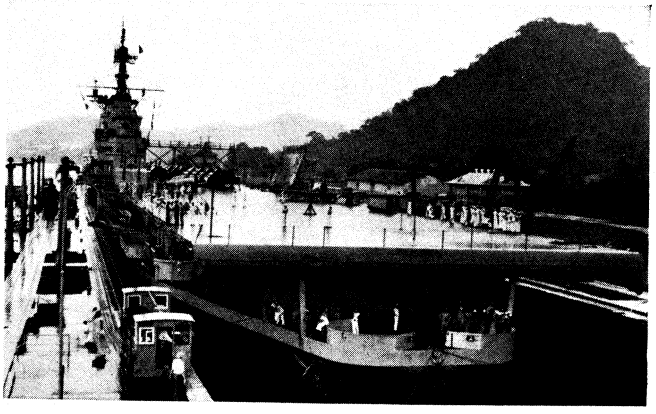


Pacific-bound ship rounding Gold hill in the Gaillard (Culebra) cut. Tow-boats are used in this sector for unwieldy vessels

Gatun locks, looking south from the Atlantic approach



Pacific terminal, looking south toward the Bay of Panamá over Miraflores locks



U.S.S. "Philippine Sea" fitted closely into the east chamber of the Pedro Miguel locks

THE PANAMA CANAL DURING WORLD WAR II AND AFTER

BY COURTESY OF PANAMA CANAL COMPANY

canal is Gatun dam, near the end of the Chagres river valley. It is about 1½ mi. long on its crest, ½ mi. wide at the base, 400 ft. wide at the water surface, 100 ft. wide at the top, and its crest is 105 ft. above sea level. It contains 22,958,069 cu.yd. of material.

Located on a natural hill of rock near the centre of the dam, Gatun spillway was designed to provide adequate control of Gatun lake levels during the maximum known discharge of the Chagres river. The dam and spillway together with Gatun locks form the northern barrier that creates Gatun lake.

Gatun Lake and Gaillard Cut.—Gatun lake, at its normal height of 85 ft., has an area of 163.4 sq.mi. and a shore line of 1,100 mi.; with a watershed of 1,285 sq.mi., which includes territory of the Republic of Panamb. Its designed operating range is 5 ft., between water levels of 87 and 82 ft. above sea level.

Gaillard cut, formerly called Culebra cut, is an artificial extension of Gatun lake across the continental divide to Pedro Miguel locks, with its original bottom at a maximum of 40 ft. above sea level, on an alignment that passes between Gold hill and Contractors hill. Its restricted channel and rocky banks make this cut the most hazardous part of the canal. A steady growth in vessel sizes and number carrying hazardous cargo has increased the frequency of transits requiring one-way navigation in Gaillard cut.

Pacific Dams, *Miraflores* Lake and Spillway.—Across the south end of Gaillard cut, a pair of one-lift (31 ft.) Pedro Miguel locks and two flanking dams to nearby hills form the southern barrier closing the upper valley of the Rio Grande and holding the Gatun lake water level. With crests 105 ft. above sea level, the east dam extends about 300 ft. to Cerro Luisa and the west extends about 1,400 feet to Cerro Paraiso. The east dam is a concrete wall, 260 ft. long, covered with earth; the west is earth and rock, containing 699,518 cu.yd. of material.

At Miraflores, a set of two-lift locks and two dams form a second barrier closing the lower valley of the Rio Grande and creating the intermediate Miraflores lake. This lake, at 54 ft. above sea level. has an area of 1.5 sq.mi. Its watershed is 38 sqmi.

The major part of the east dam at Miraflores is the spillway, designed to handle free flow of water from Gatun lake through one chamber at Pedro Miguel in event of accident. The west dam, with crest 40 ft. wide and 70 ft. above sea level extending 2.700 ft. to Cerro Cocoli. is the second largest dam of the canal, containing about 2,388,423 cu.yd. of material.

Terminal Facilities.—The Atlantic terminus affords safe anchorages in Limón bay and convenient pier berths at Cristóbal. The Pacific terminus has mooring buoy, dock and pier berths at Balboa; also an unprotected outer anchorage in the Bay of Panamá. All piers are modern. 1.000 ft. long by 200 ft. wide, with enclosed sheds and railroad service, ample for storage of consignments and transhipment of cargo.

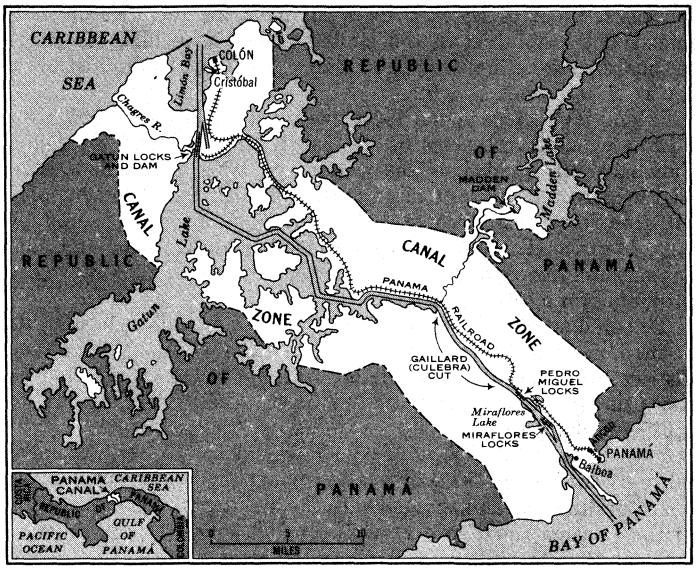
Both terminals are equipped for servicing of vessels, provisioning and repairs. The principal repair installations are on the Atlantic side near Mount Hope. with a 386 ft. dry dock. Larger marine and railway repair shops on the Pacific side are closed, with a 1,044 ft. dry dock in a stand-by status. Salvage tugs and other wrecking equipment are available.

2. Navigation.— All vessels entering or leaving a terminal port, maneuvering in Canal Zone waters, or in transit, in general, are required to take pilots, who, at all times, have charge of navigation and movement. Transits are made under rigid traffic controls. The average time required to transit is from seven to eight hours.

II. CANAL ZONE

1. Area and Tidewaters.— The Canal Zone is a strip of land and land under water 10 mi. wide with boundaries generally 5 mi. from the centre of the canal except for the western salient covering the mouth of the Chagres river. the arms of Gatun lake extending into the Republic of Panamá, and Madden lake. Beginning in the Caribbean, "three marine miles" from mean low water as provided by treaty, the zone extends across the isthmus to a distance of "three marine miles" from mean low water in the Pacific, but excludes the Panamanian cities of Colón and Panamb.

The Canal Zone includes all of Gatun lake and surrounding



MAP OF THE PANAMA CANAL AND CANAL ZONE

shores up to the 100 ft. contour and all of Madden lake and its shores up to the 260 ft. contour. The total area of the Canal Zone is 647.84 sq.mi.—372.32 sq.mi. land, 186.07 sq.mi. fresh water, and 89.45 sq.mi. salt water, including the Atlantic and Pacific coastal waters within the three-mile limit.

The tides at the Atlantic and Pacific terminals differ in both magnitude and character. At Cristóbal on the Atlantic side they are irregular and small, with an extreme range of 3.05 ft. At Balboa on the Pacific side, they are remarkably regular with two highs and two Iows every lunar day of 24 hr. and 50 min., with an extreme range of 22.7 ft.

2. Sovereignty.— Under the authority of the Panama Canal act of 1912 and in conformity with treaty, Pres. William H. Taft, by executive order of Dec. 5, 1912, declared that "all land and land under water within the limits of the Canal Zone are necessary for the construction, maintenance, operation, protection, and sanitation of the Panama Canal." Since title to all such land was acquired by the United States, the Canal Zone, in its entirety, is a United States government reservation.

The only private enterprise activities permitted within the zone are on lands rented under revocable licenses. normally to shipping interests, agriculturists and others directly connected with the canal or its operation. Areas assigned for other government purposes, as of June 30, 1957, include 147.44 sq.mi. for the armed forces. with 114.70 to the army, 18.68 to the navy and 14.06 to the air force; 5.71 to the Smithsonian institution as a wild life preserve on Barro Colorado; and 5.38 as the Madden Forest preserve. Remaining land, largely mountain or jungle, totals 181.70 sq.mi. All areas continue subject to the civil jurisdiction of the Canal Zone government in conformity with the Canal Zone code.

3. Administration.— The Panama canal enterprise, as reorganized July 1, 1931. under public law 841, 81st congress, approved Sept. 29. 1950 (Thompson act), consists of two main units, the Panama Canal company and the Canal Zone government, with the dominant mission of the safe, convenient and economic transit of vessels. The Canal Zone is divided into two districts, the Balboa (or Pacific) subdivision and the Cristóbal (or Atlantic) subdivision.

Balboa and *Cristóbal.*—These subdivisions are coterminous with the Balboa and Cristóbal divisions of the U.S. district court. Their common boundary crosses the Canal Zone at right angles just northwest of Barbacoas Island. The Balboa subdivision includes all Canal Zone area lying southeasterly of this boundary, and the Cristóbal subdivision, all lying northwesterly of it.

Towns, except Gamboa, are clustered near the terminals convenient to canal and shipping activities, in which. directly or indirectly, most of the civilian population in the zone is employed. Gamboa, because it is the headquarters of dredging operations, is located north of Gaillard cut to prevent isolation of equipment from lake

dumps in event of slides. All towns have the facilities of well-managed communities in the United States, with high standards of health, sanitation and education. The canal administrative centre is at Balboa Heights.

A long-felt defect in the 1903 treaty was failure to provide for adequate public crossings of the canal for the Canal Zone and Panama, both divided by the waterway. This condition was initially corrected by the United States through establishment of a toll-free ferry at Balboa in 1932 under legislation sponsored by Rep. Maurice H. Thatcher, former member of the Isthmian Canal commission for whom it was named; and finally, in 1955 by treaty providing for a toll-free bridge.

The civilian population in the 1960 census including dependents of the U.S. armed iorces. nas 42,122, with 11,499 in the Cristobal district and 30.623 in the Balboa district. The population of the principal communities varies from 3,489 for Gamboa to 3,139 for Balboa.

The Panama Canal Company.—This is a corporate instrumentality of the United States, operated under the management of its board of directors and charged with the maintenance and operation of the Panama canal and the conduct of business-type operations incident thereto and to the civil government of the Canal Zone.

The basic law requires that the company be self-sustaining. Its obligations include its own operating expenses. the net cost of civil government, interest and depreciation on Cnited States investment in the enterprise, and $430,000 of the $1,930,000 annuity paid to the Republic of Panamá, the remainder being provided by the department of state, and thereby excluded in fixing tolls

The Canal Zone Government.—This is an independent agency of the United States, administered by a governor of the Canal Zone, under the supervision of the president, or such officer of the United States as may be designated by him (secretary of the army). It performs the functions of city, county and state governments, with certain attributes of diplomatic character in connection with the Republic of Panamá. The governor, who is appointed by the president and confirmed by the senate, is ex-officio a director and president of the Panama Canal company.

The judicial functions of the Canal Zone government are performed by two magistrate's courts, Balboa and Cristóbal, each presided over by a magistrate appointed by the governor; and by a United States district court of the fifth judicial circuit, consisting of two divisions, Balboa and Cristobal, presided over by one judge appointed by the president.

4. Tolls.—The levy of tolls is subject to provisions of the Hay-Pauncefote treaty (1901), the Hay-Bunau-Varilla treaty (1903), and the Thomson-Urrutia treaty proclaimed in 1922. Exempted from transit tolls in accordance with treaty are vessels owned, operated or chartered by the government of the Republic of Panamb and war vessels of the Republic of Colombia; also vessels in transit solely for repairs at Panama canal shops.

Tolls are assessed on the basis of Panama canal net tonnage of actual earning capacity, a net vessel ton being 100 cu.ft. of space. Tolls cover all normal transit charges, including pilot service. Vessels operated by the United States, including warships and auxiliaries, are assessed tolls.

Tolls in 1958 were 90 cents per net ton for merchant vessels, army and navy transports, tankers, hospital and supply ships, and yachts, when carrying passengers or cargo; 72 cents per net ton on such vessels in ballast without passengers or cargo; and 50 cents per ton of displacement for other types. The average measurement per ocean-going commercial vessel in fiscal year 1959 was 5,373 net tons and average tolls per vessel, $4,685.

The Panama Canal company is authorized to prescribe and, from time to time, change rules ior the measurement of vessels and tolls, subject to requirements for six months notice, public hearings and approval by the president of the United States, whose action shall be final and conclusive.

5. Canal Traffic.—Although the Panama canal was conceived and built primarily as an artery oi world trade, its traffic, except during World War II, has had an irregular but sustained growth since 1916 in the number of commercial transits and cargo tonnage.

Fiscal Year	Number of Commercial Transits*	Tolls Revenue	Long Tons of Cargo
1929 . .	6,289	$27,111,125	30,667,768
1933 . .	4,162	19,601,077	
1939 . .	5,903	23,661,021	21,866,627
1944 . .	1,562	5,456,163	7,003,487
1950 . .	5,448	24,430,206	28,872,293
1955 . .	7,997	33,849,477	40,616,301
1956 . .	8,209	36,153,842	45,119,042
1957 . .	8,579	38,444,128	49,702,200
1958 . .	9,187	41,795,095	48,124,809
1959 . .	10,676	45,571,563	48,143,477

*Ocean-going vessels of 300 or more net tons, Panama canal measurement.
Source: ***Annual*** Report. Balboa Heights: Panama Canal Company, Office of the President.

Its traffic volume is extremely sensitive to wars and depressions, and to appreciable political, economic or other upheavals in any part of the world, such as crop failures, strikes, destruction by tropical storms, development of foreign industries and closure of the Suez canal.

A significant ieature of Panama canal traffic is the pattern of its trade routes, of which eight are well defined.

The lowest traffic volume after 1933 occurred in 1944, when there were 1,562 transits by ocean-going commercial vessels with 7,003,487 tons of cargo. A high point in traffic history occurred on Dec. 12, 1956, with the movement of the one-billionth ton (1,000,000,000 tons) of cargo through the canal. Significant of the traffic growth is the fact that one third of this tonnage passed through the waterway between 1947 and 1956.

6. Defense.—The Panama Canal act of 1912 vests responsibility for protection of the Panama canal and Canal Zone in the governor, this protection being the normal exercise of police authority within the Canal Zone. Defense against external aggression is a iunction of the armed iorces, for which the commander in chief, Caribbean, is responsible. These include army, navy and air force units, located in the Canal Zone and elsewhere.

The act iurther provides that "in time of war in which the United States shall be engaged, or when, in the opinion oi the president, war is imminent," the president is authorized to vest exclusive authority and jurisdiction over the Panama canal and Canal Zone government in such officer of the army as the president may designate. During continuance of such condition, the governor of the Canal Zone is subject in all respects to the orders and directions of the designated officer of the army.

During war or emergency, elaborate security precautions are taken by both civil and military authorities, including careful examination oi arriving vessels and use oi specially trained security guards during transits.

III. HISTORY

The advantageous geographical location of the Central American isthmus was recognized by the early Spanish who, within a few years after the visit there by Columbus in 1502, followed with extended explorations iocused on four main route areas: Tehuantepec, Xicaragua, Panamá and the Darién-Atrato. Not finding a strait, they promptly conceived the idea oi constructing one.

Because oi lower continental divides at Panamá and Xicaragua, with penetration by large valleys, these two avenues became rivals for isthmian transit. At Panamb, mountainous terrain and torrential rivers, notably the Chagres, at the time presented insuperable barriers to a canal. Lake Nicaragua, 3,089 sq.mi. in area. with its then navigable San Juan river flowing into the Atlantic, reduced the magnitude of the task to cutting across the narrow strip which separated the lake from the Pacific.

Eventually, control of the Nicaragua route became a focal point oi international conflict, with Great Britain and the United States in a diplomatic deadlock. This situation was prolonged by the Clayton-Bulmer treaty (1850) which deprived the United States of exclusive control over any isthmian canal that it might construct.

1. Panama Railroad, 1849–55.—When United States westward expansion in the late 1840s required better means for transit, three North Americans of vision, John Lloyd Stephens (*q.v.*), William Henry Aspinwall, and Henry Chauncey, organized the Panama Railroad company. Chartered in 1849 by the state of

New York, this company, under enormous difficulties, completed building the Panama railroad in 1855—the first transcontinental railroad of the Americas. Running from Aspinwall (Colón) close to the line of the future canal, this 47.5-mi. strategic rail link was the first concrete step toward construction of the Panama canal, giving it a tremendous advantage over Nicaragua in the choice of route.

In view of the key functions that this celebrated railroad mas later to fill in Panama canal history, it is important to note a treaty of 1846 between the United States and New Granada (Colombia). This treaty was an offensive and defensive alliance aimed primarily toward securing a canal at Panami, even then recognized by Pres. James K. Polk as the most practicable route. It provided that the United States should guarantee the "perfect neutrality" of the isthmus and its free and uninterrupted transit.

2. French Project, 1879–1904.—Meanwhile. French interests under the dynamic leadership of Ferdinand de Lesseps (*q.v.*), hero of the Suez canal. decided to construct a canal across the American isthmus. An International Congress for Consideration of an Interoceanic Canal, consisting of 135 delegates, convened at Paris on May 15. 1879. to decide upon site and type. As president of the congress. De Lesseps applied the full force of his prestige and genius toward securing approval for a sea-level type of canal at Panamá.

Adolphe Godin De Lépinay de Brusly, an engineer, who had studied the American Isthmus protested strongly at this trend. He understood the topography at Nicaragua and how its large natural lake, 105.5 feet high, would contribute toward construction of a canal at that location. He knew- the surface features at Panamb—the continental divide about 10 mi. from the Pacific. the torrential Chagres river flowing into the Atlantic, and the smaller Rio Grande into the Pacific, both through valleys suitable for the formation of lakes. He emphasized the key problems at Panamá as the control of the Chagres river and excavation of Culebra cut, and recognized the lake idea as offering the best solution. he proposed a "practical" plan for building the Panama canal. It called for a dam at Gatun and another at Miraflores, or as close to the seas as the configuration of the land permitted, letting the waters rise to form two lakes about 80 ft. high, joining the lakes by cutting across the continental divide, and connecting them with the oceans by locks. This design, he explained, was not only best for engineering but also most advantageous for navigation.

Unfortunately for the French, De Lépinay's idea was ignored. His conception, however, and its dramatic presentation before the Paris congress of 1879, established him as an architectural and engineering genius and the originator of the plan from which the Panama canal was eventually built.

The French Panama Canal company, despite De Lépinay's timely warning, launched upon its ill-fated undertaking. Ten years later, in 1889, its effort collapsed due to a combination of bankruptcy, lack of planning and disease. In France, it resulted in a sensational financial scandal. Yet, before failing, the company, to save money and time. was forced to change its plans from sea-level to a high-level lock type.

Reorganized in 1894 as the New Panama Canal company, its officers realized that their only chance of assuring any return on the investment was to hold on until the United States could be induced to take control. Thus until 1904 they limited their activities to technical studies and such excavation as were required to protect the concession from Colombia. The total French excavation was 78,146,960 cu.yd. of material, of which 29,908,000 were later useful to the United States.

3. United States Policy, 1850–81.—Kith active canal endeavours temporarily checked by the Clayton-Bulwer treaty and transit facilities met by the Panama railroad, United States efforts were generally restricted to explorations. It was not until Gen. Ulysses S. Grant became president in 1869 that major interest revived. with extensive naval exploring expeditions starting in 1870 and covering the more important canal sites.

With the objective of securing the best type of canal at the best site, and at least expense, the reports of these expeditions were reviewed by the first United States Interoceanic Canal commission, 1872–76, consisting of Brig. Gen. Andrew A. Humphries, chief of U.S. army engineers: C. P. Patterson. US. Coast survey; and Commodore Daniel Ammen, chief of the bureau of navigation of the navy Reporting to President Grant on Feb. 7. 1876. the commission was unanimous in recommending a Nicaragua canal starting on the Atlantic side near Greytonn. following the San Juan river to Lake Nicaragua, through the lake, and thence across the land to Brito. Thus, the United States became definitely committed to the Nicaragua route. then complicated by British control of its eastern terminus through their protectorate over the Mosquito kingdom.

Viewing an isthmian canal as "virtually a-part of the coastline of the United States" and alarmed by the energetic measures taken by French interests at Panamá, United States leaders determined to change American policy. This attitude found expression on Mar. 8, 1880 when the Select Committee on Interoceanic Canals of the house of representatives recommended a resolution by the congress declaring that any form of protectorate on this continent as contrary to the Monroe Doctrine (q *v.*), that the United States asserts and maintains its right to possess and control any artificial means of isthmian transit, and that the president be requested to take steps to abrogate the Clayton-Bulwer treaty. This objective was supported by former President Grant, who, in Feb 1881, publicly commended "an American canal, on American soil, to the American people."

4. Isthmian Canal Commission, 1899–1901.—The French failure in 1889 rendered the canal situation less acute. requiring a new crisis to dramatize the issue. This was supplied by the historic voyage of the U.S S. "Oregon" during the Spanish-American War in 1898, which emphasized the need for an isthmian canal. The result was that Pres. William McKinley, in 1899, appointed an Isthmian Canal commission, nith Rear Admiral John G. Walker, U.S.N. (ret.), as president, to investigate all canal routes. particularly Nicaragua and Panamb, and to recommend the most practicable.

In its first report on Nov. 16, 1901, the commission estimated the cost of a Nicaragua canal at $189,846,062, and Panamá at $144,233,358; and the value of the French holdings at $40,000,000. But as the French company was demanding $109,141,500 for its property, the total estimate for Panamá was $253.374 858. Because of the excess cost for a canal at Panamb, it recommended Nicaragua as the only practicable route.

5. **U.S. Diplomacy, 1901–03.**—Meanwhile, the United States government, under the leadership of Secretary of State John Hay, negotiated with Great Britain the Hay-Pauncefote treaty of Nov. 18, 1901, which superseded the Clayton-Bulwer treaty and recognized the exclusive right of the United States to construct, regulate and manage any Isthmian canal. It further adopted the principal points in the Convention of Constantinople (1888) for the Suez canal as rules for the operation and neutralization of the American canal. These rules provided that the canal should be free and open to vessels of commerce and of war of all nations on terms of entire equality, nith tolls that were just and equitable. The United States was also authorized to protect the canal against lawlessness and disorder.

The New Panama Canal company in Paris, reacting to the commission s recommendation for Nicaragua. on Jan. 9, 1902. cabled Admiral Walker its readiness to accept the United States offer of $10,000,000 for its holdings. Thereupon the commission. in a supplementary report on Jan. 18. 1902. canceled its first recommendation and recommended Panamá as the most practicable and feasible route for an Isthmian canal Describing the previous concessions from Colombia as unsatisfactory and insufficient. the commission emphasized the necessity for obtaining in perpetuity the grant of a sufficient strip of territory across the isthmus for canal purposes. Promptly transmitted to the congress by Pres. Theodore Roosevelt. the new recommendation started a meinorable debate in the congress knonn as the "battle of the routes." Out of it came the basic law for construction of the Panama canal approved June 28. 1903. known as the Spooner act.

This lan authorized the president to acquire all French holdings including its Panama railroad stock at a cost not exceeding $40,-

000,000. to obtain from Colombia perpetual control of a strip of land for the maintenance, operation and protection of the Panama canal and railroad, and then, through the Isthmian canal commission, to construct the Panama canal. The type contemplated by the act was high-level, with Atlantic locks and dams at Bohio to form a Lake Bohio. Provision was also made that in event of failure to obtain an adequate treaty within a reasonable time, the president should proceed with construction of a Nicaragua canal.

In harmony with the act, Tomás Herrán, Colombian chargé d'affaires in Washington, after many months of arduous labour, succeeded in negotiating a most favourable treaty for his country —the Hay-Herrán treaty of Jan. 22, 1903, which was ratified by the United States senate on March 17, 1903.

Unfortunately, this treaty became involved politically in Bogotá. The Colombian senate, called into special session on June 20, 1903, for its ratification, rejected the treaty against urgent pleadings by Herrán in Washington and U.S. Minister Arthur M. Beaupré in Bogotá.

The Panamd Revolution, 1903.—Panamanian leaders, fearing that after all Panamá might still lose the canal to Nicaragua, determined to avert that possibility. A Panamanian agent was then dispatched to Washington to obtain promise of help for a plan of revolt. While no promise was given, the warship U.S.S. "Nashville" appeared at Colón on Nov. 2, 1903. On the following day an uprising occurred, Colombian troops were prevented from crossing the isthmus to put down the rebellion and independence was proclaimed under the leadership of Manuel Amador. It was recognized. first by the United States, second by France, and soon afterward by other countries.

Then followed negotiation of the second basic canal convention, the Hay-Bunau-Varilla treaty of Nov. 18, 1903, with Panamá instead of Colombia. By this treaty, in harmony with the Spooner act, United States was granted in perpetuity exclusive use, occupation and control of the Canal Zone. Significantly the United States could exercise all sovereign powers to the entire exclusion of the exercise of such powers by Panamá. That country was to receive $10,000,000 in cash and a $23'0,000 annuity to begin nine years after ratification of the agreement. The proclamation of this treaty on Feb. 26, 1904, sealed the choice of the Panamá route.

A few days later, on March 8, 1904, President Roosevelt recognized the contributions of Admiral Walker by appointing him as the first chairman of the first Isthmian Canal commission for the construction of the Panama canal. One member, Maj Gen George W. Davis. U.S. army (ret.), was the first governor of the Canal Zone. John F. Wallace, a leading railroad engineer, not experienced in "frontier" work, was chosen as the first chief engineer.

The Canal Zone was formally acquired on May 4, 1904—a day subsequently celebrated annually in the zone as Acquisition day.

6. Building the Canal, 1904–14.—Work under the United States started haltingly. Because of public clamour to "make the dirt fly," the commission weakened in its stand for thorough and comprehensive preparation and started work without proper equipment or plans. Though valuable time was thus lost, the commission made important contributions. It organized the Canal Zone government, started sanitation under the supervision of William Crawford Gorgas (*q.v.*), and recruited the nucleus of an engineering and construction force.

Resigning on March 30, 1905, the Walker commission was succeeded by a new one headed by Theodore P. Shonts, a prominent railroad executive, with Wallace continued as chief engineer. Though for a time conditions improved, Wallace, on June 26,1905, suddenly resigned, throwing the working forces into confusion.

Battle of the Levels, 1904–06.—Of the difficulties of this period the gravest mas increasing uncertainty as to the type of canal that should be built—the high-level lock type contemplated by the Spooner act or a canal at sea level as had been suggested by Wallace in 1904.

Fortunately, President Roosevelt selected a great railroad builder, executive and explorer, John F. Stevens, as the new chief engineer. Stevens' qualifications were unique. He had read everything available on the Panama canal since the time of Phillip II, discovered Marias pass in Montana, built railroads in the Rocky mountains and supervised open mining operations in Minnesota. Thus, he had observed what occurs when the delicate balances of nature are upset, understood the hazards of cutting a ship channel through mountains, and was experienced in personnel and construction problems in undeveloped country.

Arriving on the isthmus on July 25, 1905, at a time of chaos, he rescued the project from possible disaster. He promptly provided housing for employees, established commissaries, adopted sanitation measures, ordered equipment and double-tracked the Panama railroad. Planning the transportation system for Culebra cut excavation and for relocation of the railroad to higher ground on the east side of the canal, moving the Atlantic locks site from Bohio to Gatun to form Gatun lake, recruiting competent leaders, forming the organization for building the Panama canal, he soon found progress hampered because of delay on the decision as to type of canal. then being considered by an International Board of Consulting Engineers, of which General Davis was chairman.

In its report of Jan. 10, 1906. this board split—the majority of eight members headed by General Davis and including five Europeans, voting for sea level; and the minority, five Americans (Alfred Noble, Henry L. Abbot. Frederic P. Stearns, Joseph Ripley and Isham Randolph), voting for the lock type.

The controlling features of the lock plan recommended by the minority were a dam at Gatun creating Gatun lake 85 ft. high as the summit level and Culebra cut. Parallel flight locks were to be provided. three-lifts at Gatun, one-lift at Pedro Miguel, and tno-lifts at Sosa hill, the last two sets being separated by an intermediate Sosa lake. Though of different lock arrangement, this plan was the same type as recommended in 1901 by the Walker commission.

Testifying before congressional committees in Washington in January and June 1906, and using the De Lépinay arguments of 1879, Stevens supported the high-level plan with a conviction that no one could shake. and strongly opposed the sea-level plan recommended by the majority of the International Board of Consulting Engineers. In the end, with the support of President Roosevelt, Secretary of War Taft, and the Isthmian Canal commission, the views of Stevens prevailed against strenuous opposition concerned primarily with questions of "vulnerability." Congress. by act approved June 29, 1906, adopted the high-level lake and lock plan as proposed by the minority. This was the great decision in building the Panama canal.

The transit since 1914. in both peace and war, of thousands of vessels of various types, completely establishes the wisdom of that decision. It secured for Stevens, who was mainly responsible for bringing it about, great fame as the basic architect of the Panama canal.

Pacific Lock Location Question, 1906–08.—Though the high-level plan, as approved by the minority of the International Board of Consulting Engineers, placed all Atlantic locks at Gatun it divided the Pacific locks into two sets. Stevens, early in 1906 before adoption by congress of the minority report, recognized the Pacific lock arrangement as faulty and recommended consolidation as a needed change.

Eventually, on Aug. 3, 1906, Stevens approved a plan placing all Pacific locks in three-lifts south of Miraflores with the terminal dam and locks between two hills, Cerro Aguadulce on the west side of the sea level section of the canal and Cerro de Puente on the east side, a location later recognized by Lieut. Col. George W. Goethals as offering the best site. This arrangement would have enabled lake-level navigation from the Atlantic locks to the Pacific, with a summit level anchorage at the Pacific end of the canal.

Regrettably, Stevens was under great pressure to start active construction Advocates of the sea-level proposal, stung by their defeat in congress, also opponents of any canal at all, mere poised ready to take advantage of any change in the approved program as evidence of weakness in the high-level plan. Together. these two forces represented a political and economic power that could not be ignored.

Stevens' foundation investigations, necessarily made in haste, proved unsatisfactory, and he did not dare to jeopardize the project

by further delay. On Aug. 23, 1906, apparently confident that this important question would rise again, he voided his plan but retained it on file, and proceeded with the approved plan for separating the Pacific locks, which he did not personally favour

Later, after Stevens left canal service, Maj. William L. Sibert, a member of the commission with a keen appreciation of marine needs in the design of navigational works, made more extensive explorations. Finding adequate foundations, he likewise, on Jan. 31, 1908, recommended the consolidation of all Pacific locks in three-lifts at Miraflores to provide a Pacific terminal lake. but his well-reasoned proposal was not approved, and the canal mas completed with two sets of Pacific locks, separated by Miraflores lake.

Construction and Completion, 1907–14.—With canal type decided, construction organization effected, and a greater part of the plant installed by July, 1906, real progress started. Thus, Stevens mas able to assure the press in 1906 that the canal would be completed in 1914 and formally opened by Jan. 1, 1915.

On Jan. 30, 1907, after having brought design and construction to a point where work was in "full swing" and success a certainty, Stevens submitted his resignation to the president. Despite that action, however, Roosevelt, on Mar. 4, 1907, in recognition of his tremendous contributions, appointed him as chairman of the Isthmian Canal commission, making Stevens the first to hold the combined positions of chairman and chief engineer.

Stevens was succeeded by Lieutenant Colonel Goethals, an outstanding army engineer, who, with his associates, civilian as well as military, ably brought the project to completion substantially in accord with the Stevens plan. Such changes as were made, though important, were nonbasic. These included widening the bottom of Culebra cut from 200 ft. to 300 ft., increasing usable lock dimensions to a width of 110 ft. and length of 1.000 ft.. with a depth to permit passage of ships drawing 40 ft. in salt water, rerouting the Panama railroad around Gold hill, relocation of locks from Sosa hill to Miraflores, and redesign of Gatun dam.

Other members of the Isthmian Canal commission on April 1, 1907, were Maj. David D. Gaillard, Major Sibert, naval civil engineer Harry H. Rousseau. Lieut. Col. William C. Gorgas, Jackson Smith and J. C. S. Blackburn. Later changes included Lieut. Col. H. F. Hodges (1908–14) to succeed Smith, Maurice H. Thatcher (1910–13) to succeed Blackburn and Richard L. Metcalfe (1913–14) to succeed Thatcher. Gaillard died on Dec. 5, 1913, without a successor.

The building of the Panama canal, one of the greatest engineering feats in the world was indeed a monumental and unprecedented achievement. Its subsequent success, in both peace and war, entitle all who, in significant manner, participated in its planning, construction, sanitation and civil administration, to highest honour. The canal was opened to traffic on Aug. 15, 1914.

7. Principal Engineering and Construction Projects After 1914.—The Isthmian Canal commission, abolished on April 1, 1914, was succeeded by a highly centralized permanent operating organization authorized by the Panama Canal act of 1912, known simply as The Panama Canal Though free, under the law, to choose the governor from any source. Pres. Woodrow Wilson, in recognition of the services of Colonel Goethals, appointed him as the first governor of The Panama Canal.

The canal was launched into its era of operations under Governor Goethals, who served until late 1916 after the early slide crises. Goethals chose his principal engineer assistant as his successor and established a tradition of succession, by advancement, that lasted until 1952.

Madden Danz and Power Project, 1919–35.—Faced with the problems of an unusually dry season, 1919–20, requiring conservation of water for lockages and maintenance of channel depths, and later by a great flood in 1923, endangering the waterway, together with groning traffic, congress authorized the first important step toward increasing canal capacity, the Madden Dam and Power project. Completed in 1935, it provided more water for lockages, controlled floods, improved navigation and supplied additional power.

Third Locks Project, 1939-42.—The second step toward greater capacity was for a third set of locks. Because of naval needs, in the critical period preceding World War II, congress, on administrative recommendations, authorized the Third Locks project, at a cost not to exceed $277,000.000. The proposed layout contemplated a new set of larger locks, 1,200 ft. long and 140 ft. wide. with 45 ft. navigable depth, near each of the existing locks but at some distance away with the new locks joined with existing channels by means of by-pass channels. At the Atlantic end, the project duplicated existing arrangements. At the Pacific end. however, the proposed channel, in addition to duplicating its faulty layout, contained three sharp bends of 29°, 47° and 37° in succession from north to south.

Work started in 1940 and was pushed vigorously until suspended by the secretary of war in May, 1942, because of shortage of ships and materials more urgently needed elsewhere for war purposes. No excavation was accomplished at Pedro Miguel; that at Gatun and Miraflores was substantially completed. About $75,000,000 was expended.

Terminal Lake—Third Locks Plan, 1942–43.—Fortunately, suspension of work on the Third Locks project occurred while there was still time for canal officials to re-examine it in the light of needs demonstrated by war-operating experience. These studies served to emphasize that the separation of the Pacific locks and failure to provide a summit-level lake at the Pacific terminus were fundamental errors of design. with Pedro Miguel locks as the principal obstruction to optimum canal operating conditions.

Out of the studies, including an evaluation of the sea-level idea, grew what proved to be the first comprehensive proposal for the economic increase of capacity and operational improvement of the Panama canal—the Terminal Lake-Third Locks plan. It proposed the physical removal of Pedro Miguel locks, consolidation of all Pacific locks near Aguadulce, elevation of the intermediate Miraflores lake water level from 54 ft. to that of Gatun lake to create a summit-level anchorage at the Pacific end of the canal to match. as far as possible. that in the Atlantic end. It would also include raising the summit level to its highest feasible height of approximately 92 ft.. enlarging Gaillard cut and constructing a set of larger locks. Essentially, this was the same plan originated by De Lépinay, and later recommended by Stevens and Sibert.

Officially submitted and publicly presented in the Canal Zone, it aroused wide interest among engineers and maritime agencies, including the secretary of the navy, who, on Sept. 7, 1943, submitted it to the president. Soon after. in 1944, it was approved in principle by the governor of The Panama Canal and recommended to the secretary of war for thorough investigation, and later, in 1915, it was approved in general before the congress by a succeeding governor for the major modification of the existing waterway in preference to completing the original Third Lock project. A 1949 congressional investigation reported that it could be accomplished at comparatively low cost.

The Terminal Lake-Third Locks plan, being an enlargement of the existing facilities that does not call for additional land or waters. is covered by current canal treaties and does not require negotiation of a new one. a paramount diplomatic consideration.

Sen Level Plan, 1945–47.—The spectacular advent of the atomic bomb in 1915 injected new elements into the canal picture. At the request of Canal Zone authorities, congress enacted public law 280, 79th congress. approved Dec. 28, 1945. authorizing the governor of The Panama Canal to make a comprehensive investigation of the means for increasing its capacity and security to meet future needs for interoceanic commerce and national defense, including consideration of canals at other locations. This was the first time the terms "security" and "national defense" had been embodied in any Panama Canal statute.

The report of the inquiry with security and national defense as paramount considerations. recommended only the sea-level plan for major canal construction. initially estimated in 1947 to cost $2,483,000,000, a figure later substantially increased. Though the report covered the Terminal Lake-Third Locks plan. which it did not recommend. it offered a relatively minor program for improvement of present installations as a preferred alternative to the major operational improvement of the existing waterway as

recommended in 1943 by the secretary of the navy.

With the exception of the two canal terminals, the 1947 sea-level plan would provide a virtually new Panama canal of 60 ft. minimum depth in navigation lanes and of 600 ft. width between sloping sides at a depth of 40 ft. on a new alignment somewhat removed from the present channel. The plan also provides a tidal lock (200 ft. by 1,500 ft.) and a navigable pass at the Pacific end, many miles of flood control dams on both sides of the projected canal, diversion channels and spillways. Some of its features are not covered by current international conventions and would require a new treaty with Panami, with further concessions, attendant indemnity and increased annuity charges.

The report of the investigation failed to receive presidential approval. Transmitted to the congress on Dec. 1, 1947, without comment or recommendation. its submission, however, led to a recurrence of the 1902 and 1906 debates over route and type with almost identical arguments, but on the basis of the newer term, "security," rather than the old term, "vulnerability."

In voluminous discussions, many leading engineers, nuclear scientists and other experts challenged the assumptions on which the principal 1947 recommendations and estimates rested. The congress took no action until 1957, when an independent inquiry into the entire subject of increased facilities for interoceanic transit was authorized and a special board of consultants appointed.

Its final report of June 1960 included estimates for the Terminal Lake-Third Locks plan ($1,020,900,000) and the Sea-Level plan ($2,537,000) exclusive of any Panamanian indemnity. The board emphasized that the Sea-Level plan would present many constructional problems including interruption to traffic. A plan for a lake and lock canal at Nicaragua ($4,095,000,000) as an alternate route was submitted without definite recommendation. This report, otherwise inconclusive, recommended that the entire canal situation be reviewed in 1970 or earlier if warranted.

Meanwhile. the 1947 report served to focus governmental attention on administrative problems of the Panama canal.

8. Reorganization and Policy Determination. — On June 30, 1945, the Panama Railroad company was reincorporated as a federal corporation and, on Feb. 28. 1949, the house of representatives authorized an investigation into the organizational and financial aspects of the Panama canal enterprise.

All recommendations growing out of this inquiry were implemented except that for transfer of responsibility for canal supervision from the secretary of the army to the secretary of commerce, which the president delayed for further study. The resulting Act of Congress, public law 841, 81st congress, approved Sept. 26, 1950, known as the Thompson act, created the Panama Canal company and the Canal Zone government. Effective July 1, 1951, the act started major administrative changes, including a break in 1952 in the traditional selection for appointment as governor. The law requires that transit tolls be established at rates to place the canal enterprise on a self-sustaining basis. a fundamental principle in canal policy with far-reaching implications for its future. (M. DuV.)

9. Panamá-U.S. Relations. — Because of the previous history of Panami as a land of endemic revolution, the framers of the 1903 treaty, in order to guarantee political stability essential for future efficient operations of the waterway, insisted on its perpetuity, sovereignty and protective clauses. Subsequent events fully substantiated the wisdom of these 1903 treaty provisions, which remain largely unchanged. The canal was no sooner opened to traffic in Aug. 1914, than the United States applied another provision of this treaty, that of obtaining additional lands. During World War I, in which Panamá participated, the United States took possession of several areas of land, and in 1919 acquired a group of islands. Friction over this and other issues led to an attempt in 1926 to revise the convention of 1903, but Panamá refused to sign any agreement. The attempt was renewed in Oct. 1933, when Pres Harmodio Arias conferred in Washington with the U.S president. Their basic agreement mas refined and incorporated in four treaties, signed March 2, 1936. At the insistence of Panamá, the United States was relieved of the obligation to guarantee the independence of the republic and renounced the right to acquire any additional lands and waters outside the Canal Zone. By limiting the use of the zone commissaries to persons employed on the canal and the railroad, the negotiators sought to dissipate a long-standing grievance. It was agreed that Panamá was to operate port facilities at Colón and Panamá city, that equal opportunities between Panamanian and American employees should be observed, and that the United States should increase the annuity from $250,000 to $430,000. Agreement was also reached on constructing a trans-isthmian highway. The weakening of the diplomatic structure was further advanced in the 1955 Eisenhower-Remón treaty, which provided for the annual U.S. payment to Panamá to be increased to $1,930,000, for equal pay for equal work to Panamanians and U.S. citizens (effective 1958), and for Panamanian concerns to be placed on an equal footing with U.S. companies in contract bidding; the U.S. obtained a 15-year lease for a military base at Rio Hato. The effectof these treaties has been the withdrawal of canal activities to the limits of the Canal Zone and the curtailment of activities within the zone.

See PANAMA: *History* for further aspects of Panamá-U.S. relations; *see* also Index references under "Panama Canal" in the Index volume. (A. R. W.; M. DuV.)

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PANAMA CITY, a city of northwest Florida, U.S., and the county seat of Bay county, is 103 mi. E. of Pensacola on the northern shore of St. Andrew bay. The landlocked, deep-water harbour is on the intracoastal waterway. During World War II the city became a major shipbuilding and war industrial centre and the population grew rapidly.

Nearby military installations are Tyndall Air Force base, an air defense command base, and a United States navy mine defense laboratory. Principal products of the area are fish, paper and chemicals, including tall oil. Panama City beach, 10 mi. S. of Panama City, is largely a summer resort.

During the American Revolution the area was settled by Tories, who established indigo plantations and engaged in the lumbering and naval stores industries. Salt works on St. Andrew bay, established to serve the Confederacy, were destroyed by Union raids in 1863. Fisheries in the area were temporarily destroyed in the Civil War.

Panama City was formed in 1909, by merging a village of that

name with hlillville and St. Andrew, which had been a flourishing community as early as 1800. For comparative population figures *see* table in FLORIDA: *Population.* (E. C. Jo.)

PAN-AMERICAN CONFERENCES, a term applied to a wide variety of inter-American meetings attended by representatives of the American states. Of these conferences the most important by the second half of the 20th century were the periodic numbered meetings of the Inter-American conference, which in 1948 succeeded the former International Conferences of American States. the first of which met in 1889–90. After 1948. when the charter of the Organization of American States was adopted at Bogotá, Colombia, the earlier occasional and less formal conferences, dealing chiefly, with technical matters, became known as specialized conferences, and their programs and regulations came under the control and supervision of the Organization of American States itself, acting through one of its organs. Representation at Pan-American conferences was usually restricted to the 21 independent republics of the western hemisphere, although on occasion Canada participated in certain of the specialized conferences.

Inter-American Conferences, *1826–89.—Political Conferences of* 1826–64.—The congress of Panamá of 1826, which met from June 22 to July 15, 1826, on the initiative of Simón Bolivar, was attended by representatives of Colombia. Mexico. Peru and Central America. Colombia at that time embraced the present-day republics of Ecuador, Panamá and Venezuela. as well as Colombia, and Central America included the five republics of Costa Rica. El Salvador, Guatemala, Honduras and Nicaragua, so that 11 of the present-day states were represented. The United States was invited, and after extended debate in congress the invitation was accepted, but the delegates failed to arrive before the meeting adjourned The principal result of the congress was a treaty of union, league and confederation, whereby the signatory states formed a defensive and offensive alliance to preserve their sovereignty and independence against foreign aggression and to be maintained by contingents of troops from each signatory state. At the same time an assembly of plenipotentiaries was provided for, to serve as an organ of the confederation and to regulate the relations between the component states. In spite of the failure uf the signatory states to ratify the treaty it remained as a symbol of continental unity, to be realized more than 100 years later.

The American congress (Congreso Americano) of Lima of 1847 met in the capital of Peru from Dec. 11, 1847, to March 1, 1848, with representatives in attendance from Bolivia. Chile, Ecuador, New Granada (Colombia) and Peru. The principal agreement reached was a treaty of union and confederation by which the contracting states agreed reciprocally to support their sovereignty and independence and to maintain their territorial integrity.

The Continental congress (Congreso Continental) of 1856, held at Santiago, Chile, with delegates representing Chile. Ecuador and Peru in attendance, also approved a treaty of alliance and confederation. The convention of Washington, D.C., in 1856, signed by representatives of Costa Rica, El Salvador, Guatemala. Mexico, New Granada, Peru and Venezuela. also contemplated joint action for mutual protection. This was not strictly speaking a conference but an agreement signed by the diplomatic representatives of the respective countries accredited to Washington. D.C., largely on their own initiative and as a result of informal conversations.

At the American congress (Congreso Americano) of Lima of 1864 (Nov. 14, 1864–March 13. 1865), there were representatives from Bolivia, Chile. Colombia. Ecuador, Guatemala. Peru and Venezuela. In a treaty of union and defensive alliance the parties agreed to defend reciprocally their independence, sovereignty and territorial integrity against foreign aggression. and in a treaty for the maintenance of peace they obligated themselves to resort to pacific means in settling differences.

These early inter-American conferences had as their principal object the common defense and mutual protection of the participating states. Instances of encroachments on the sovereignty of Central and South American states were the European interventions in the Plate river between 1842 and 1850; the Mexican-American War of 1846, which in the eyes of most Central and South Americans was an aggression against Mexico; the filibustering expeditions of William Walker in Central America in 1855–57; the French invasion and the attempted establishment of Maximilian's empire in Mexico in 1863–67; the Spanish occupation of the Dominican Republic from 1860 to 1865; and the attempt of Spain in 1865 to reassert its sovereignty over Peru.

Juridical Congresses.—In the years following, and before the inauguration of the International Conferences of American States, several important juridical conferences were held in South America. The first of these was the American Congress of Jurists of Lima of 1877, which representatives of Argentina. Bolivia, Chile, Costa Rica, Ecuador and Venezuela attended.

The United States was invited. but declined the invitation because of the basic differences between the common law of the United States and the civil law of Central and South America, and also because of the dual nature of the legislative system in the United States. The congress approved a treaty to establish uniform rules in matters of private international law, as well as a convention on extradition.

In 1883, at a congress held in Caracas, Venez.. to commemorate the centenary of the birth of Bolivar, a series of declarations on public international law was signed. This was followed by the South American law congress at Montevideo in 1888–89, at which Argentina. Bolivia. Brazil. Chile. Paraguay, Peru and Uruguay were represented. The congress resulted in the signing of treaties on international civil law; international commercial law; international penal law; the international law of procedure. literary and artistic property, trade-marks and patents; and a convention on the practice of the liberal professions.

First International Conference of American States (1889–90).—The conferences held on the American continent between 1826 and 1888 were inter-American in character but not continental in scope. At none of them were all the nstions represented. It was not until 1889 that the Pan-American conferences and the Pan-American movement in general assumed continental proportions, embracing all the independent nations of the western hemisphere. In that year the first International Conference of American States met in Washington, D.C., on invitation of the Gnited States government.

An attempt to initiate this continental movement had been made in 1881 when the Cnited States government. through Secretary of State James G. Blaine, invited the other nations of rhe continent to be represented at a congress in Washington, D.C., in Nov. 1882, "for the purpose of considering and discussing the methods of preventing war between the nations of America." This invitation was subsequently withdrawn following changes in the administration in Washington and the belief that the unfavourable international situation then prevailing in South America as a result of the war between Chile and Bolivia and Peru made it an unpropitious time to hold the conference. Invitations were again extended on July 13, 1888. this time by Secretary of State T. F. Bayard. It was a coincidence that when the conference actually convened on Oct. 2, 1889, Blaine should again be secretary of state and preside over its deliberations.

All the countries of the western hemisphere were represented except the Dominican Republic. This conference laid the bases of the modern Pan-American movement and created, on April 14, 1890, the International Union of American Republics, operating through a permanent bureau in Washington, later designated as the Pan American union. It approved a series of recommendations relating to rail and ocean transportation, uniformity of commercial documents, port dues, sanitary regulations, establishment of an inter-American bank, patents and trade-marks, freedom of navigation of rivers serving as international boundaries and the submission to arbitration of certain classes of questions arising between the American nations.

Second International Conference of American States.— At this meeting, held at Mexico City; Oct. 22. 1901–Jan. 31, 1902, all the countries were represented. Conventions were drafted on arbitration of pecuniary claims. copyright, patents and trade-marks; extradition of criminals; exchange of official: scientific, literary and industrial publications; codification oi international law: practice of learned professions; rights of aliens: and also a

treaty on compulsory arbitration (signed by only nine delegations). A protocol of adherence to the Hague conventions of 1899 was approved. A resolution on reorganization of the International Bureau of American Republics was also adopted, as were resolutions on measures to facilitate international commerce, sources of production and statistics.

Third International Conference of American States.—At this meeting, held at Rio de Janeiro. Braz.. July 23–Aug. 27, 1906, all the American republics were represented with the exception of Haiti and Venezuela. It approved conventions on the status of naturalized citizens, pecuniary claims, patents, trademarks and copyright and the codification of international law. It recommended that the second Hague conference consider the subject of forcible collection of public debts, and it approved a series of other resolutions dealing with commercial, industrial and financial matters and problems of transportation.

Fourth International Conference of American States.—At Buenos Aires, Arg., July 12–Aug. 30, 1910, all the republics were represented except Bolivia. Conventions were signed on pecuniary claims, copyright, patents and trade-marks. The International Union of American Republics was reorganized and the name of the permanent commercial bureau was changed to the Pan American union. Recommendations were approved dealing with, among other matters, steamship and railroad transportation, consular documents and customs regulations, commercial statistics, establishment of national bibliographical bureaus and the interchange of professors and students.

Fifth International Conference of American States.—Because of World War I the conference originally scheduled for Nov. 1914 was postponed and did not convene until 1923. It was held at Santiago, Chile, from March 25 to May 3. All the countries were represented except Bolivia, Mexico and Peru. A treaty on prevention of conflicts, known as the Gondra treaty, was signed, constituting a first step in the development of inter-American peace machinery; also conventions were signed on trade-marks. publicity of customs documents and uniformity of nomenclature for the classification of merchandise. The Pan American union was reorganized and provision was made for a series of special technical conferences to consider specific problems.

Sixth International Conference of American States.—At Hal-ana. Cuba, Jan. 16–Feb. 20, 1928, all countries were represented at the conference, which gave preferential consideration to the codification of international law and approved conventions on the status of aliens: asylum. consular agents, diplomatic officers. maritime neutrality, rights and duties of states in the event of civil strife, and treaties. It also approved a code of private international law and conventions on commercial aviation, copyright and on the Pan American union.

Seventh International Conference of American States.—At Montevideo, Urug., Dec. 3–26, 1933, all countries with the exception of Costa Rica were represented. The codification of international law was continued by the approval of conventions on extradition, political asylum and nationality. An important convention was signed on rights and duties of states, providing, among other things, that no state had the right to intervene in the internal or external affairs of another. The conference adopted a basic program of economic, commercial and tariff policy, designed to reduce trade barriers and facilitate inter-American commerce.

Inter-American Conference for the Maintenance of Peace.—In 1936 Pres. Franklin D. Roosevelt called the attention of the presidents of the American states to the peace protocols recently signed between Bolivia and Paraguay and proposed that an effort be made by representatives "seated at a common council table" to prevent such hostilities in the future. The conference met at Buenos Aires. Dec. 1–23, 1936. and adopted a treaty for the maintenance. preservation and re-establishment of peace, which embodied an agreement to consult. in the event of a threat to the peace. for the purpose of finding and adopting methods of peaceful co-operation. In spite of the vague terms of the treaty it was regarded as a sort of continentalization of the Monroe Doctrine (*q.v.*), and it became the starting point of closer political collaboration between the American states. The conference also adopted a new treaty on peaceful procedures, bringing into play the plan of consultation, as well as numerous other treaties and resolutions dealing with general principles of inter-American solidarity, the prevention of controversies. codification of international law, equality of treatment in international trade and cultural relations.

Eighth International Conference of American States.—At Lima, Peru. Dec. 9–27, 1938. all countries were represented. The Declaration of Lima, in which American republics reaffirmed their continental solidarity and their determination to defend themselves against all foreign intervention or other activity that might threaten them, was approved. The procedure of consultation among the governments in the event of a threat to the peace or security of the continent was perfected by providing for meetings of the ministers of foreign affairs.

Inter-American Conference on Problems of War and Peace.—Meeting at Chapultepec in Mexico City, Feb. 21–March 8, 1945, all states being represented except Argentina, the conference was called to determine the relations of the inter-American system to the new international organization planned four months earlier at Dumbarton Oaks in Washington, D.C., to replace the League of Nations. An agreement. entitled the Act of Chapultepec, was adopted reaffirming earlier pledges of reciprocal assistance and solidarity, followed by a resolution providing for the reorganization of the inter-American system.

Numerous other resolutions were adopted, one suggesting amendments to the General International organization proposed at Dumbarton Oaks, others dealing with questions of international law. the inter-American peace system, an economic charter of America and a declaration of social principles of America. The conference laid the basis for the work of the two succeeding conferences of 1947 and 1948

Inter-American Conference for the Maintenance of Continental Peace and Security.—**Meeting** at Quitandinha. near Petropolis, Braz., Aug. 15–Sept. 2, 1947, the conference at its close saw the signing at Rio de Janeiro of the important Treaty of Reciprocal Assistance, known as the Rio treaty, which put into effect the principle that an attack upon one American state should be considered as an attack upon all, justified in respect to the obligations of the United Nations charter by the provisions of art. 51 recognizing the inherent right of individual or collective self-defense until the security council of the United Nations might take measures necessary to maintain international peace and, security. A hemisphere defense zone that included Greenland, the Aleutians and Bermuda. but not Hawaii or Iceland, was designated as the area in which the Rio treaty should be operative. The Rio treaty was the model upon which the later North Atlantic treaty, embodying a similar regional defense agreement for the principal North Atlantic and Mediterranean powers, was patterned (see NORTH ATLANTIC TREATY ORGANIZATION).

Ninth International Conference of American States.—Held at Bogota. Colombia. March 30 to May 2, 1948, this conference was attended by representatives of the 21 republics. The assistant secretary-general of the United Nations also participated, but without a vote.

Organization of American States.—The principal work of the conference was the charter of the Organization of American States (*q.v.*), in which the regional system of the Americas. started in 1889. was given its first comprehensive constitution. The charter proclaimed the sovereign equality of the member states and banned intervention by any state in the affairs of another, except in the case of measures for the maintenance of peace and security. Part II of the charter outlined the structure of the organization, renamed the organization of American States. Three representative bodies were created: the Inter-American conference, which was to meet every five years, as the supreme authority of the organization; the Meeting of Consultation of Foreign Ministers, which might be convoked to deal with important emergency problems. especially acts or threats of aggression; and the council of the organization, a permanent body meeting in Washington, D.C. The council was to execute tasks assigned to it by the Inter-American conference or the meeting of foreign ministers and to

supervise the secretariat. It was to be assisted by three technical organs: an economic and social council, a council of jurists and a cultural council.

The central permanent agency and general secretariat of the organization was designated the Pan American union (this name henceforth was restricted to this administrative organ) in Washington. headed by the secretary-general of the organization. Aside from its duties as a general secretariat. the Pan American union was charged with promoting the co-operation of the American states in the fields of economic, social; juridical and cultural affairs. Other principal elements in the Organization of American States were the specialized conferences and, the inter-American specialized organizations, which were to facilitate technical co-operation in economic, social and cultural fields.

Juridico-Political Mutters. — Under the title of "Preservation and Defense of Democracy in America," the conference adopted a resolution strongly condemning international Communism and all other forms of totalitarianism as being incompatible with inter-American principles. The conference also adopted an American Declaration of the Rights and Duties of Man, stating that international protection of the rights of man should be the principal guide of an evolving American law, and specifying the rights and duties in detail (see HUMAN RIGHTS). The subject of European colonies in the Americas was placed on the agenda by Guatemala. Although action on that subject by the conference was opposed by some delegations, including those of Brazil, the Dominican Republic and the United States, the conference adopted a resolution expressing the hope that the occupation of American territories by extracontinental countries might come to an end and establishing the American Committee on Dependent Territories in Havana. Cuba. for the purpose of studying the problem and recommending solutions thereto.

Econontic *Matters.*—The main achievement of the conference in economic matters was the drafting of an agreement on economic co-operation. Pointing to the need for expanding international trade and for general economic development as a means of raising living standards. the agreement emphasized the need for expanding co-operation in fields of technical knowledge and assigned certain responsibilities in that respect to the Inter-American Economic and Social council. The agreement reaffirmed the principles of the International Bank for Reconstruction and Development and of the International Monetary fund as important vehicles for financial co-operation. and supported the extension in appropriate cases of medium- and long-term loans from one government to another.

The agreement recognized the importance of private capital and stated that foreign capital should receive equitable treatment on a nondiscriminatory basis. provided foreign investors observed national laws and refrained from intervening in the political affairs of a country. Other subjects referred to included the improvement of social conditions. maritime transportation. stimulation of inter-American travel and methods for adjusting economic disputes among governments, Although signed by all 21 delegations, the economic agreement was weakened by the attachment of numerous reservations by several governments, leaving its validity and effectiveness in some doubt, and leading to an effort in 1957 to adopt a new agreement.

Peaceful Settlement of Disputes. — The pact of Bogotá, which was signed at the conference, set forth general principles and procedures of good offices and mediation, investigation and conciliation, adjudication and arbitration regarding international disputes. The jurisdiction of the International Court of Justice was recognized as compulsory for a nide variety of cases Few states, however, nere milling to ratify the pact.

Tenth Inter-American Conference. — This conference opened in Caracas. Venez., on March 1, 1954, and closed on March 28. It was the first meeting of that organ of the organization since the adoption of the Bogotá charter of 1948 All of the American republics were represented with the exception of Costa Rica. Subsequently. however. the government of Costa Rica, through its representative on the council of the organization, adhered to the conclusions and signed the final act of the con-

Issue of *Communism.*—After protracted debates, the so-called Caracas resolution was adopted. It repeated in essence the Bogotá resolution, mentioned previously. but omitted all reference to totalitarian regimes other than Communistic. The final vote on the resolution was 17 to 1, with Guatemala opposing. Mexico and Argentina abstained.

Colonialism. — An anticolonial motion was passed by all the Latin-American delegations, with the United States abstaining.

Other Matters. — Conventions were drawn up and signed on territorial asylum, diplomatic asylum and on the promotion of inter-American cultural relations. The Convention for the Promotion of Cultural Relations, dealing with the exchange of students and professors. which was approved at the Buenos Aires conference of 1936, was revised in order to simplify the procedures used.

Special or Technical Conferences. — Because of the variety of topics on the programs of the periodic Inter-American conferences, it was not always possible for the delegates to give detailed consideration to all the subjects placed before them. Furthermore. the delegations at these diplomatic gatherings were not always equipped to deal with technical problems. Accordingly. the practice developed of referring many of these topics to special conferences. with the request either that the projects formulated or conclusions reached be reported back to a subsequent international conference or that they be transmitted directly to the governments. Generally, these specialized meetings consider a particular subject or a group of related topics, and by concentrating on one subject the delegates are in a more advantageous position to give the matter careful study and consideration.

Several of these specialized conferences have a history extending back over a considerable period. The Pan-American sanitary conferences, for example, were inaugurated in 1902 pursuant to a recommendation of the second International Conference of American States. These conferences did important work in the field of public health and sanitation. The numbers of such special or technical conferences increased greatly over the years and the subjects which they were called upon to consider covered virtually every phase of inter-'American activity.

Meetings of the Ministers of Foreign Affairs. — The Declaration of Lima. signed at the eighth International Conference of .American States, made provision for meetings of the ministers of foreign affairs of the American republics — a new type of consultation in the system of Pan-American conferences. Earlier, at the Buenos Aires conference of 1936, the American republics agreed to consult together whenever anything should occur that might threaten the peace of the continent; but the instrumentality by which this consultation was to be undertaken was not specified. At Lima the American republics reaffirmed their continental solidarity and declared that if the peace. security or territorial integrity of any of them should be threatened by acts of any nature. they would consult together through meetings of their ministers of foreign affairs to determine the measures that should be taken.

The first such meeting of ministers of foreign affairs was held at Panama in Sept. 1939, immediately after the outbreak of the war in Europe. It resulted in the adoption of a general declararion of neutrality and the establishment of a security zone to keep the western hemisphere free of belligerent activities. In July 1940, when it appeared that European possessions in America might be transferred from those that possessed them to new occupants, a second meeting was held at Havana. where it was decided that should such a contingency arise the American republics themselves would step in and administer these possessions. In Jan. 1942, following the extension of the war to the Americas, a third meeting of consultation was held at Rio de Janeiro which recommended the severance, of diplomatic and commercial relations by the American republics with the aggressor nations. A majority of the 21 republics had already either declared war on or broken off relations with the axis powers. The recommendation was followed immediately by several other severances of relations; Argentina and Chile remained the only American republics not taking that step.

The fourth Meeting of Consultation of Foreign Ministers was held at the Pan American union in Washington, D.C.. from

March 26 to April 7, 1951. The three topics of the agenda dealt with political and military co-operation, internal security and emergency economic co-operation. The Inter-American Defense board was charged with the preparation of military plans for common defense of the hemisphere. Major consideration was directed to questions of an economic character, and resolutions were adopted on the production and distribution of products in short supply and utilization of necessary services to meet the requirements of the economies of the American republics and on measures to facilitate the carrying out of programs of economic development.

See *International Conferences of Anzerican States, 1889–1928* (first supplement, 193340; second supplement, 1942–54). (C. G. FK.)

PAN-AMERICAN GAMES, a quadrennial sports event for the nations of the western hemisphere, is conducted in almost identical fashion to the Olympic games (*q.v.*).

The birth of these games was at a meeting called the Pan-American congress at Buenos Aires, Arg., Aug. 28–31, 1940, to which invitations were sent to the national Olympic committees of all countries of the western hemisphere. Sixteen of the 21 countries invited were represented.

The idea had been under consideration for several years and became a reality when it was apparent that the 1940 Olympic games, scheduled first for London and then Tokyo, would not be held. After three days of study and deliberation, it was decided to form a Pan-American games organization to conduct the games every four years beginning in 1942, with the support of the International Olympic committee but run solely by the new body. It was formed as an autonomous organization to be governed by a congress, composed of delegates chosen by its members. Regular meetings were to be held every four years.

Buenos Aires was chosen as the site of the first Pan-American games, to be held in the fall of 1942, the 450th anniversary of the discovery of America by Columbus. The organization of these first games was placed in the hands of the Argentine Olympic committee. The tentative list of the sports to be contested in the first set of games included: basketball, boxing, chess, cycling, fencing, polo, rowing, shooting, swimming, tennis, track and field, water polo, weight lifting, wrestling and yachting. However, because of World War II, the first Pan-American games were not held until Feb. 25 to March 9, 1951, at Buenos Aires.

The first Pan-American games were opened at River Plate Athletic stadium, with Pres. Juan D. Perón presiding. One hundred thousand persons were in attendance. Delfo Cabrera, Argentine's 1948 Olympic marathon champion, opened the games by circling the track, carrying the white and blue flag of his country. A severe windstorm, 24 hours before the scheduled opening, did not delay the opening ceremonies, but time spent repairing damaged facilities did postpone the start of competition for a 24-hour period to Feb. 27. A total of 2,000 athletes, representing 20 western hemisphere nations, took part, and the program consisted of 19 sports. Argentina and the United States, which had close to half the entries, dominated the competition.

The second Pan-American games were held in Mexico City, Mex., March 12–26, 1955, with the number of competing athletes dropped to 1,612 and the nations increased to 22. The University of Mexico's excellent facilities were used and the number of sports was increased to 24. The United States, Argentina and Mexico dominated the competition and among them had 55% of the athletes. The site, being close to one mile above sea level, had its effects on many of the visiting athletes, but Lou Jones of the United States eliminated talk of slow performances with a world record of 45.4 sec. in the 400-m. run.

Cleveland, O., was selected (in 1955) to conduct the 1959 Pan-American games, but eventually withdrew in favour of Chicago, Ill., with the dates, Aug. 27–Sept. 7, 1959. Though first refusing to aid Cleveland. the congress of the United States voted $500,000 to Chicago, the money being earmarked to defray the traveling expenses of visiting athletes. The U.S swept the competition, capturing 18 of 22 men's gold medals in track and field.

(ED. F.)

PAN AMERICAN UNION: *see* PAN-AMERICAN CONFERENCES; AMERICAN STATES, ORGANIZATION OF.

PANATHENAEA, an annual festival at Athens of great antiquity and importance. Traditionally begun by Erechtheus and changed from Athenaea (festival of Athena) to Panathenaea (festival of all Athenians, universal festival of Athena) by Theseus, its elaboration seems to date from Peisistratus. In its developed form it was celebrated every fourth year with especial splendour, probably in deliberate rivalry to the Olympic games; its date was the third year of each Olympiad. The annual festival, probably about the middle of August, consisted solely of the sacrifices and rites proper to this season in the cult of Athena. One of these rites originally consisted in carrying a new peplos through the streets to the Acropolis to clothe the ancient carved image of the goddess; but it is probable that this rite was afterward restricted to the great penteteric festival. The peplos was a costly, saffron-coloured garment, embroidered with scenes from the battle between the gods and giants. At least as early as the 3rd century B.C. the custom was introduced of spreading the peplos like a sail on the mast of a ship which was rolled on a machine in the procession.

At the Great (quadrennial) Panathenaea representatives of all the dependencies of Athens were present, bringing victims, and a most brilliant procession resulted. After the presentation of the peplos the hecatomb was sacrificed. The subject of the frieze of the Parthenon is this great procession.

Pericles introduced a regular musical contest in place of the recitations of rhapsodes, which mere an old-standing accompaniment of the festival. This contest took place in the Odeum, originally built for this purpose by Pericles himself. The order of the agones from this time onward was first the musical: then the gymnastic, then the equestrian contest. Many kinds of contest, such as the chariot race of the *apobatai* (said to have been introduced by Erechtheus), which were not in use at Olympia were practised in Athens. Apobates was the name given to the campanion of the charioteer, who showed his skill by leaping out of the chariot and up again while the horses were going at full speed. There were in addition several minor contests: the pyrrhic or war dance; the Euandria or parade of "crack" troops; the lampadedromy or torch race; the naumachia (regatta)! which took place on the last day of the festival. The proceedings were under the superintendence of ten *athlothetai,* one from each tribe, the lesser Panathenaea being managed by *hieropoioi.* In the musical contests, a golden crown was given as first prize; in the sports, a garland of leaves from the sacred olive trees of Athena and vases filled with oil from the same.

The season of the festival was the 24th to the 29th of Hecatombaeon, and the great day was the 28th.

See also ATHENA.

See A. Michaelis, Der *Parthenon,* bibl. *(1871)*; L. R. Farnell, *Cults of Greek States,* vol. i (1896); A. Mommsen, *Feste* d. *Stadt Athen* (1898).

PANAY, westernmost of the Visayan Islands in the central Philippines and sixth in size. Area 4,446 sq.mi., with a mountain range near the west coast: hilly eastern portions, irregular plains along the north coast and a wide lowland on the southeast. The island is divided into four provinces: Antique on the west coast, Iloilo (*q.v.*) in the south, Aklan in the northwest and Capiz (*q.v.*) in the northeast. Pop. (1948) 1,424,102; (est. 1958) 1,711,971. *See* also PHILIPPINES, REPUBLIC OF THE. (J. E. SR.)

PAN CHAO: *see* PAN KU AND PAN CHAO.

PANCH MAHALS, a district in the Ahmedabad division of Bombay state: India. Area 3,497 sq.mi.; pop. (1951) 1,148,432. The tract, which includes Champaner, the old Hindu capital of Gujarat, now a ruin, was transferred to the British by Sindhia in 1861. There are rich mineral deposits, including manganese. The district headquarters are in the municipality of Godhra. From 1933 to 1945 the district was united administratively with the district of Broach (*q.v.*).

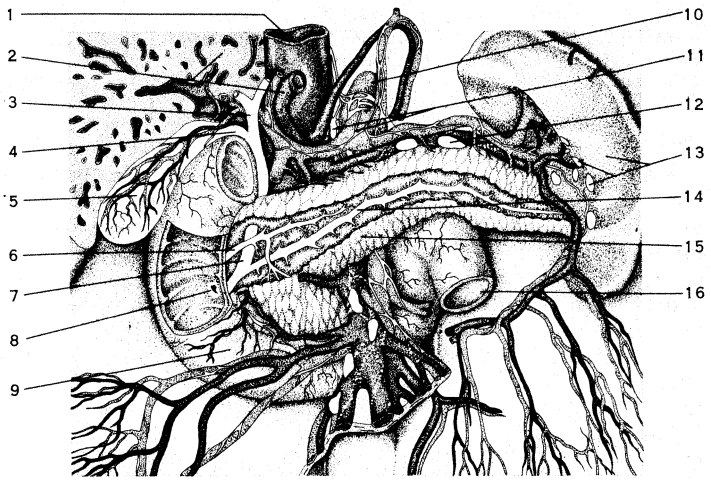
PANCREAS. The pancreas in man is a large digestive gland that lies in the upper part of the abdomen beneath the stomach in the curve of the duodenum to which it is firmly attached. It is behind the peritoneum. The pancreas has an abundant blood

supply and is innervated by nerve fibres from the vagus and sympathetic trunks. A large main duct (the duct of Wirsung) runs the entire length of the gland and empties into the second part of the duodenum, usually in common with the termination of the common bile duct. at what is called the ampulla of Vater. A smaller accessory pancreatic duct (the duct of Santorinij empties separately into the duodenum. These ducts collect the pancreatic juice secreted by the pancreatic glandular epithelium, or parenchyma, and convey it to the duodenum. In addition to the glandular epithelium, there are many thousands of microscopic groups of cells without ducts distributed throughout the pancreas, the islets of Langerhans. The beta cells of these islets are the source of insulin, and it is the removal or destruction of these cells that produces pancreatic diabetes. The alpha cells of the islets are thought to be the source of glucagon, a second pancreatic hormone, which in some respects has an action opposite in effect to that of insulin.

The pancreatic juice is a clear, colourless fluid, alkaline in reaction, and is made up of water in which are dissolved sodium bicarbonate, sodium chloride and three important digestive enzymes: trypsin, pancreatic lipase and pancreatic amylase. Trypsin, when activated by mixture with the intestinal juice. is a vigorous protein-splitting enzyme that facilitates the disintegration of proteins and proteoses into peptones and amino acids. Pancreatic lipase splits the fat of the food into glycerine and fatty acids. the end products of the digestion of fat. The digestive action of pancreatic lipase is greatly facilitated by the emulsifying action of the bile. Pancreatic amylase splits starches and complex sugars into glucose. which can be absorbed and utilized by the body cells. The pancreas secretes pancreatic juice continuously, but the rate of secretion is greatly increased when food is present in the small intestine. The mechanism of this stimulation is partly nervous and partly chemical. Impulses over the vagus nerves cause a secretion of pancreatic juice rich in enzymes. A profuse secretioh of pancreatic juice can occur, however. even if the vagus nerves have been divided. The presence of acid chyme. or partially digested food. in the small intestine causes the elaboration of a specific substance or hormone, pancreatic secretin, in the lining of the small intestine and its absorption into the blood. It is carried through the general circulation eventually to the pancreas and liver. whose cells are then excited to greater secretory activity. Pancreatic juice secreted in response to stimulation by pancreatic secretin is poor in enzyme content. However, a second hormone, pancreozymin. is liberated from the duodenum at the same time and in a rnanner similar to that of pancreatic secretin. This hormone stimulates the pancreas to secrete pancreatic juice rich in enzymes.

The absence of pancreatic juice from the intestinal tract impairs the digestion and absorption of food. This is made evident by the appearance of large amounts of undigested fat and protein in the stools. The impairment. which is most marked in the case of fat digestion and absorption. varies greatly in different persons. Thus in some persons, following removal of the pancreas, there may be little disturbance in digestion or absorption, whereas in others 75% to 80% of the fat in the food appears undigested in the stools, The disturbance in protein digestion is less marked and the digestion of starch is little affected. The pancreas can be successfully removed in experimental animals and also in man. Life can be maintained in a good nutritive state, perhaps indefinitely, if the ensuing diabetes is adequately controlled by the administration of insulin, and if pancreas extracts (lipocaic) are administered in adequate amounts by mouth.

Diseases of the Pancreas.— Diseases of the pancreas are fortunately not common, but when they do occur are often serious. Acute pancreatitis or acute pancreatic necrosis. as it is more accurately called, is a condition in which a large part of the pancreas becomes necrotic or gangrenous, often with extensive hemorrhage and with digestion of the pancreas by the juices of the gland itself. This disease is more likely to occur in persons who have gallstones than in others and often follows the ingestion of large amounts of food and alcoholic beverages. It may cause death within 24 to 48 hours. The cause of death is not certainly known,



FROM AN ILLUSTRATION PREPARED FOR LEDERLE LABORATORIES DIVISION, AMERICAN CYANAMID COMPANY

MACROSCOPY OF THE PANCREAS AND ITS DUCT SYSTEM

Key: 1. Inferior vena cava; 2. Liver and portal vein; 3. Hepatic duct; 4. Cystic duct; 5. Gall bladder; 6. Lesser pancreatic duct; 7. Common bile duct; 8. Ampulla of Vater; 9. Duodenum; 10. Abdominal aorta; 11. Celiac artery and right ganglion of celiac plexus; 12. Superior pancreatic lymph node; 13. Spleen and splenic lymph nodes; 14. Greater pancreatic duct; 15. Pancreas; 16. Jejunum

but is thought to be due in part to the absorption of poisonous chemical substances arising in the disintegrating pancreas. Shock, caused by loss of plasma from the blood vessels, and infection are often contributing factors. The disease is treated by repeated transfusions of blood and plasma, administration of antibiotic drugs and drainage of the common bile duct with removal of gallstones. In some cases an attack of acute pancreatitis that is not fatal may lead to the accumulation of a large amount of pancreatic juice. blood plasma and tissue debris in the pancreas itself or in the overlying tissues, forming a pancreatic pseudocyst. Such pseudocysts may become quite large and are treated by drainage in a surgical operation. Occasionally. nonfatal attacks of acute pancreatitis recur at intervals of weeks or months and produce very severe upper abdominal pain and disability. Many of these cases of relapsing pancreatitis are due to narrowing or obstruction of the pancreatic duct and can be relieved by a surgical operation that provides adequate drainage of the pancreatic juice.

Cystadenoma is a benign cystic tumour that may occur in the pancreas and reach a very large size. The cyst is usually multilocular and contains a mucilaginous fluid. These benign tumours are successfully treated by surgical excision. Cancer of the pancreas is the commonest and also the most serious tumour. When it involves the head of the pancreas, it obstructs the common bile duct and pancreatic duct and causes progressive jaundice, emaciation and impairment in digestion. Advances in surgery have made it possible, in many such cases, to remove the entire pancreas, with survival of the patient, but most of these patients later die of recurrence of the cancer in the liver and other organs.

Benign tumours (adenomas) may arise in the islets of Langerhans and produce symptoms due to the excessive manufacture of insulin and its liberation into the blood stream. Such patients display attacks of weakness or unconsciousness at progressively shorter intervals, and during these attacks examination of the blood reveals an excessively low concentration of blood sugar. The attacks can be relieved temporarily by intravenous injection of glucose; and the patient can be cured if the adenoma can be found and surgically removed. Either benign or malignant tumours arising from the islet tissues, other than beta cells. may cause an excessive secretion of gastric juice in the stomach with progressive ulceration of the mucosa, hemorrhage and perforation. When the pancreatic tumour causing these ulcers is benign and can be removed, the excessive gastric secretion stops and the patient is cured.

The animal pancreas, when used for food, is called sweetbread.

See also DIABETES MELLITUS; DIGESTION; ENDOCRINOLOGY; HORMONES: INSULIN.

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PANCREATIN, pancreatic solution, derived from the pancreas of the hog or ox digested in alcohol, has the power of converting starch into sugar from the presence of the enzyme amylopsin, and albumen and fibrin into peptones from the presence of trypsin. It only acts in a neutral or slightly alkaline medium and at a temperature under 140° F. If used to predigest (peptonize) milk sodium bicarbonate should be added. (F. L. A.)

PANDA (Ailurus fulgens), a mammal of the family Procyonidae (see CARNIVORA). This animal, rather larger than a cat, ranges from the eastern Himalayas to northwest China. It is found among rocks and trees and feeds on fruits and other vegetable substances. Its fur is rich reddish-brown, black below; the face is white, save for a vertical stripe of red from just above the eye to the gape; there are several pale rings on the tail.

H. ARMSTRONG ROBERTS

GIANT PANDA (AILUROPODA MELANOLEUCUS) OF SOUTHEASTERN ASIA

Giant pandas (*Ailuropoda melanoleucus*) of Tibet are the size of a bear, whitish with black limbs, ears and areas around the eyes. On the front foot there is a structure that resembles and functions like a thumb. Giant pandas are playful, clowning, of interest in any zoo fortunate enough to have one. (J. E. HL.)

PANDANUS: *see* SCREW PINE.

PANDAREUS, in Greek mythology, stole a golden dog from the temple of Zeus in Cretan or Ionian Miletus, and gave him to Tantalus for safekeeping. Tantalus swore to Hermes that he knew nothing of the matter, but on the dog's discovery was punished by being crushed under Mt. Sipylus. (For a variation on the story, see TANTALUS.) Pandareus and his wife were killed by Zeus; their orphaned daughters were reared by the Olympian goddesses, but the Harpies stole them and gave them to the Erinyes as servants. (T. V. B.)

PANDARUS, in Greek legend, son of Lycaon, a Lycian. In the Iliad he breaks the truce between the Trojans and the Greeks by treacherously wounding Menelaus with an arrow, and finally he is slain by Diomedes. In the medieval tale of Troilus and Cressida he acted as the lovers' go-between; hence "pander."

PANDEAN PIPE: see SYRINX.

PANDECTS, a name given to a compendium or digest of Roman law compiled by order of the emperor Justinian in the 6th century A.D. (530–533). See JUSTINIAN I; ROMAN LAW.

PANDHARPUR, a municipal town and taluka in the Sholapur district of Bombay state, India. The town stands on the right bank of the Bhima river, 38 mi. W. of Sholapur town. Pop. (1951) 40,514. The taluka covers an area of 498 sq.mi. Pop. (1951) 128,552. Pandharpur is the most popular place of pilgrimage in the Deccan; its temple, dedicated to Vithoba, a form of Vishnu, is visited by large numbers, particularly in July. It is connected by a light railway with Barsi town on the Western railway.

PANDO, a department of northeastern Bolivia, bounded north and east by Brazil, west by Peru and south by the departments of Beni and La Paz. Pop. (1950) 19,804. Area 24,644 sq.mi. The department, formerly called the province of Vaca Diez, was established in 1938 during the administration of Gen. Germán Busch. Puerto Rico, originally designated the capital of the new department, was succeeded by Cobija, pop. (1950) 1,726. because of the latter's accessibility. Pando is largely a forested region, with considerable rain, heat and humidity. The main economic resources are forest products: rubber, quinine, Brazil nuts and hardwoods. Agricultural products include rice, sugar cane, manioc, bananas and corn. Cobija may be reached by air, but otherwise transportation is by rivers: the Abuna, Orton, Madre de Dios. Tahuamanu, Negro and Beni. The isolation, poor communication and sparse population hinder development of the region. The population is chiefly Indian and mestizo. (J. L. TR.)

PANDORA, according to Hesiod (in the Theogony and in Works and Days), the first woman (Gr., the "All-giving"). After Prometheus had stolen fire from heaven and bestowed it upon mortals, Zeus determined to counteract this blessing. He accordingly commissioned Hephaestus to fashion a woman out of earth, upon whom the gods bestowed their choicest gifts. Hephaestus gave her a human voice; Aphrodite, beauty and powers of seduction; Hermes, cunning and the art of flattery. She had or found a jar, the so-called "Pandora's box," containing all kinds of misery and evil. Zeus sent her to Epimetheus, who, forgetting the warning of his brother Prometheus to accept no present from Zeus, made her his wife. Pandora afterward opened the jar, from which all manner of evils flew out over the earth. According to the version given in Hesiod, Hope alone remained inside, the lid having been shut down before she escaped. But in a later story the jar contained not evils but blessings, which would have been preserved for the human race had they not been lost through the opening of the jar out of curiosity by man himself.

In cult Pandora was a title of Earth; at Athens she was associated with the cult of Athena, and the birth of Pandora was depicted on the base of the great statue of Athena by Phidias.

See W. A. Oldfather, "Pandora," in Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft*, which includes a lengthy bibliography; H. J. Rose, *Handbook of Greek Mythology*, p. 55 (1957). (T. V. B.; X.)

PANDROSEUM, a temenos or sacred area, on the north side of the Athenian acropolis, dedicated to Pandrosos, the daughter of Cecrops, legendary first king of Athens. Its position and shape determine the plan of the west side of the erechtheum (*q.v.*).

PANDUA, a ruined city in Malda district, West Bengal, India, once a Mohammedan capital. It is 9 mi. N.E. of Old Malda and about 20 mi. from the other great ruined city of Gaur (*q.v.*). About 1340, Ala ud-Din Ali Shah, king of western Bengal, transferred his capital from Gaur to Pandua; but the time of its prosperity was short, for in 1455 the capital was transferred back to Gaur. Its most celebrated building is the Adina mosque built by Sikandar Shah (1357–89). Other notable buildings are the Ekhlakhi mosque or tomb and the Sona or golden mosque, which, with the Adina mosque, are conserved by the government.

PANDULPH (PANDULF or PANDOLPHO) (d. 1226), Italian ecclesiastic, papal legate to England and bishop of Norwich, was born in Rome. He was first sent to England by Pope Innocent III in 1211 to negotiate with King John over the acceptance of Stephen Langton (*q.v.*) as archbishop of Canterbury. The failure of the negotiations resulted in John's excommunication and Pandulph's return to Italy. He was again in England in 1213 to accept the king's submission, in which John, apparently on his own initiative, surrendered England as a papal fief. Gratified by John's humility, Pandulph used ecclesiastical censures, including excommunication, to avert a threatened French invasion of the country. Temporarily replaced by the cardinal legate Nicholas of Tusculum, Pandulph returned to England in 1215 for the conference at the meadow at Runnimede, where Magna Carta was signed. He was given the see of Norwich by John in gratitude for his services but was eclipsed in 1216 by the arrival of the cardinal legate Gualo. He regained his prominence when Gualo departed in 1218 and as papal representative was entrusted with the care of the child Henry III. He was influential during the regency. Pandulph's paramount influence in the government of England, deriving from the fact that England was a papal fief, lasted until 1220, when Cardinal Langton moved the pope to recall him in the interests of a more national policy. Pandulph retained the see of Norwich but was no longer a factor in English politics. He died at Rome on Sept. 16, 1226, but his body was removed to Norwich for burial.

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John Lackland (1902). (T. L. C.)

PANDURA, an ancient oriental stringed instrument, a member of the lute family, having a long neck, a highly vaulted back and originally two or three strings plucked by the fingers. There were in antiquity at least two distinct varieties of pandura or tanbur: (1) the more or less pear-shaped type used in Assyria and Persia and introduced by way of Asia Minor into Greece, whence it passed to the Roman empire; (2) the oval type, a favourite instrument of the Egyptians. also found in ancient Persia and among the Arabs of north Africa.

PANDYA, the name of a Tamil dynasty of the extreme south of India of unknown antiquity (they are mentioned by Greek authors; *e.g.,* by Megasthenes in the 4th century B C.). The Byzantine emperor Julian received an embassy from a Pandya C. A.D. 361. The dynasty revived under Kadungon in the early 7th century A.D. and ruled from Madura or further south until the 16th century. The small but important (9th–13th century) dynasty of Pandyas of Ucchangi, a hill fort south of the Tungabhadra river, may have originated from the Madura family.

The genealogy and chronology of the family are in hopeless confusion as the kings share very few names, alternately prefixed by Jatavarman or Maravarman (or equivalents), and their numerous records are dated for the most part only in regnal years. From being Jains they became Saivites and are celebrated in the earliest Tamil poetry (the Sangam works). They ruled extensive territories, at times including the Chera (or Kerala) country. the Chola country, and Ceylon through collateral branches subject to Madura. The "Five Pandyas" flourished in the 12th to 13th centuries and after fighting with fluctuating success against neighbouring kingdoms, eventually assumed control of all the plains of the extreme south as far north as Nellore (1257). Family quarrels, however. and the sultan of Delhi's invasions from 1311 onward, culminating in the foundation of the Madura sultanate. about which Ibn Batuta writes horrifying details, weakened Pandya influence Even after the Moslems were evicted c. 1370 by the king of Vijayanagar the Pandyas seldom ruled north of the Cauvery river. By 1312 control over Kerala was lost and by the mid-16th century all their territories had passed into other hands.

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PANEGYRIC, originally a speech composed for delivery at a general assembly (*panegyris*) in ancient Greece, such as the Olympic and Panathenaic festivals. Speakers often took advantage of these occasions. when Greeks of various cities were gathered together, to advocate Hellenic unity. With this end in view, and also to gratify their audience, they tended to expatiate on the former glories of Greek cities: hence came the encomiastic associations that eventually clung to the term "panegyric." The "Olympic" speeches of Gorgias and Lysias (*qq.v.*) have survived only in fragments, but the *Panegyricus* of Isocrates (*q.v.*), composed *c.* 380 B.C.. perhaps for recitation at Olympia, is intact: so also is his *Panathenaicus* (c. 340 B.C.), in which he praised the past achievements of Athens. Akin to panegyric was the *Epitaphius,* or funeral oration, ancient and modern examples of which are to be found in Pericles' funeral speech as recorded by Thucydides. a panegyric both on the war heroes and on Athens itself, and in Abraham Lincoln's Gettysburg Address. In the 2nd century A.D., Aelius Aristides. a Greek rhetorician, combined praise of famous cities with eulogy of the reigning emperor, Marcus Aurelius. By his time the term "panegyric" had probably become specialized in this latter connection. It had been an old Roman custom to celebrate at festivals the glories of famous men of the past and to pronounce laudationes funebres at the funerals of eminent persons.

Another kind of eulogistic speech in Rome was the *gratiarum* actio ("thanksgiving"), delivered by a successful candidate for office. When Pliny the Younger was nominated as consul by Trajan in A.D. 100 he delivered a *gratiarum* actio which he published in considerably expanded form. It later received the title *Panegyricus.* This speech abounds in flattery of a good emperor; later panegyrists flattered good and bad emperors indiscriminately. Their speeches have survived in the collection called *XII Panegyrici Latini,* or Veteres (ed. by W. Baehrens, 1911), containing Pliny's speech and 11 others, in praise of the 3rd- and 4th-century emperors Maximian, Constantius. Constantine. Julian and Theodosius I. Some of the orators are anonymous; the named ones are Eumenius, Nazarius, Mamertinus and Pacatus Drepanius (*qq.v.*). Ausonius and Ennodius (*qq v.*) also wrote Latin panegyrics. not included in this collection, to Gratian and Theodoric respectively. All these orators practise fulsomeness, insincerity and affectation; their virtues are enthusiasm. however misguided, and comparative purity of style in an age of increasing barbarism. Latin verse panegyric is also found from the Augustan age onward; its most celebrated authors were Claudian (c A.D 400) and Sidonius Apollinaris (5th century A D.). Among modem exponents of panegyric may be mentioned Jacques Bossuet, Vaientin Fléchier and Jean Baptiste Massillon, whose funeral orations in the age of Louis XIV are triumphs in this type of literature.

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PANEL, originally a small piece of cloth or parchment; this meaning persists only in certain legal terms, such as jury panel, so called from the original strip of parchment on which the names were written in early days; and in Scotch law in the use of the word for an indictment or for a person or persons named in an indictment; or in the use of the word for the cloth-stuffed lining of a saddle. In architecture and furniture the word signified, originally, a small piece of thin wood enclosed in a surrounding framework. Casts of charred wooden doors taken in Pompeii as well as many ancient classic representations prove that the construction of wooden panels was well understood by the Greeks and Romans. Moreover, numerous Italian Romanesque wooden church doors of the 10th to the 12th centuries, usually of many small, nearly square panels, manifestly continue Roman types.

In much Gothic decorative work tracery forms are frequently used to divide a large surface into small recessed panels of various shapes. This decorative paneling is particularly common on tombs, screens, chancel rails and the like. in which multiplication of cusping frequently gives it great richness, especially in England. In France paneling is used with more restraint and in simpler forms, usually confined to slim, arch-headed shapes. During the late Gothic period of the 15th and 16th centuries, decorative paneling was used more lavishly throughout north Europe, and in the Perpendicular work of England large wall areas were often covered by a series of rectangular or Tudor arch-headed, sunk, tracery panels. Meanwhile, the use of structural wood paneling, at first reserved for doors. cupboards, chests and similar furniture: was spreading to wainscotting; in this development the English led. Occasionally an applied molding is used at the sides and top only of a panel with a chamfer at the bottom. The rich, interior wood paneling of the Tudor and Elizabethan periods in England often combined with linen fold (*q.v.*) decoration and sometimes with crude classic pilasters and entablatures is one of the most beautiful characteristics of those styles.

In the Renaissance of Italy paneling is of importance only in furniture such as choir stalls. etc., and in the rich coffered ceilings which cover many palace halls and church interiors. In France, on the other hand. the use of paneling grew continuously more important as the Renaissance developed and reached a climax in the lavish paneled interiors of the Louis styles (*q.v.*). In this Louis paneling, as in work of the same date in England, the development was toward greater use of large panels made by glueing together smaller pieces of wood. (T. F. H.)

PAN-EUROPEAN MOVEMENT. There have been various attempts to express the cultural unity of Europe since the time of the Renaissance and Reformation. The Roman empire in antiquity, the unity of western Christendom under the pope and the Holy Roman empire in the middle ages created or preserved at least a semblance of unity binding together much of Europe. The Renaissance with its birth of the sovereign absolutist state and the Reformation with its division of Christianity put an end

to the medieval unity of western Christendom. Since then repeated efforts have been made to restore such a unity. They were stimulated in the medieval and early modern periods by the fearful threat of Turkish-Islamic aggressive power, against which the unity of Europe for defense was sought.

Early Projects of European Unity. — Attempts to restore the medieval res *publica Christiana*, or Christian community, were undertaken on a new rational basis, their authors pleading not only for common defense but for universal peace. This was the attitude of Erasmus in his *Querela Pacis* ("Complaint of Peace") (1517) and of the "Grand Dessein." which Maximilien de Béthune, duc de Sully, the minister of Henry IV of France, outlined in his Me'moires. Emeric Crucé proposed in his Le *Nouveau Cynée* (1624) an organization for peace and a court of arbitration with Venice as its seat. In the following century William Penn published his brief Essay Towards *the* Present and Future Pence of *Europe* (1693) which voiced the pacifism of the Society of Friends. The Abbé de Saint-Pierre published in 1713 his *Projet* de paix *perpétuelle* ("Project of Perpetual Peace"), which Jean-Jacques Rousseau republished and condensed in 1761. The enlightened rationalism of these proposals was taken up by Immanuel Kant in his *Zum ewigen Frieden* ("On Perpetual Peace," 1795) and by Jeremy Bentham in his Principles *of International* Law (1789).

In the 19th century, the peace congress which met in Aug. 1849 in Paris with Victor Hugo as its president and Richard Cobden as its vice-president pleaded both for universal peace and for a united states of Europe. After World War I the French statesman Aristide Briand worked on proposals for a union of the European nations. Count Richard Condenhove-Kalergi. an Austrian, founded the Pan-European union. but its activities could not stem the rise of violent nationalism in Europe. The weakened state in which European dei, ocracies emerged from World War II led several private organizations to intensify a campaign for the creation of institutions for European co-operation. Some leading European statesmen, among them Winston Churchill. took an active part in this propaganda. The International Committee for the Co-ordination of European Unity Movements called a congress at The Hague. Neth., in May 1948 which proposed the convening of a European consultative assembly. This time the Pan-European movement was powerfully supported by the U.S.

Organization for European Economic Cooperation. — In the same year practical steps for a closer European integration were taken in two fields. First. a permanent Organization for European Economic Cooperation (O.E.E.C.) came into being in April 1948 as the European co-ordinating agency for the European Recovery program, with the Economic Cooperation administration (ECA) of the U.S. pressing for the fullest use and cooperative development of European resources. Secondly. Great Britain. France. Belgium. the Netherlands and Luxembourg in the same month signed a treaty at Brussels pledging co-operation in the military. economic and cultural fields for a duration of 50 years. It was the need for the defense of Europe and European civilization against the totalitarian system spread from Moscow which helped to overcome at least some of the deep-rooted loyalties to national sovereignty in the various European nations and some of the animosities between them, the result of a long past of feuds and conflicts.

NATO and the Council of Europe. — From the beginning, the Brussels pact was regarded only as a nucleus. On April 29, 1948, Louis St. Laurent, the Canadian minister for external affairs. declared that in view of "the rising tide of totalitarian communism . . . Canada and the U.S. need the assistance of the Western European democracies just as they need ours." On June 11 the U.S. senate passed a resolution. moved by Sen. Arthur H. Vandenberg, which prepared the way for the creation of the North Atlantic Treaty organization (SATO) in Washington, D.C., in April 1949. In the following month 10 European nations (Great Britain, France. Belgium. the Netherlands. Luxembourg, Denmark. Norway, Sweden, Ireland and Italy) signed in London the statute of the Council of Europe. The Council of Europe consists of two bodies: the Committee of Ministers, representing the governments. and the Consultative assembly, representing the peoples and parliaments of Europe, and intended to be a forum of ideas and a place where a stimulus could be given to democratic European initiative. Strasbourg, France, was made the permanent seat of the council.

Any European country which accepted the rule of law and of enjoyment by all persons within its jurisdiction of human rights and fundamental freedoms could join the Council of Europe. Greece. Turkey. Iceland and the German Federal Republic later joined and the Saar was admitted as an observer. The first years of the existence of the Council of Europe were filled with a struggle between the assembly, which wished to develop into a European legislative body, and the European governments which were not willing to establish a supranational authority. Nevertheless. a large number of recommendations and resolutions on the most varied subjects in the economic, political, cultural, social and legal fields were made by the assembly and many of them were fully or partly implemented. Among them was the European Convention for the Protection of Human Rights and Fundamental Freedoms (see HUMAN RIGHTS).

European Coal and Steel Community. — A closer approach to federal instead of purely international co-operation was taken by France. On May 9, 1950, the French foreign minister Robert Schuman suggested the pooling of the coal and steel resources of the European countries and the setting up of a new high authority whose decisions would be binding on the governments concerned. On March 19. 1951. France, Italy, the German Federal Republic. Belgium. the Netherlands and Luxembourg formally initialed in Paris a draft treaty to give legal effect to the Schuman plan. The treaty, valid for 50 years, came into force in June 1952 after the parliaments of the six nations involved had ratified it. The European Coal and Steel Community (E.C.S.C.) established a High Authority, to act as the executive power, and a Court of Justice. both located in Luxembourg, and an assembly, appointed by the various national parliaments or elected by direct suffrage and exercising democratic control over the High Authority. The assembly was located in Strasbourg. In Sept. 1952 British proposals for establishing close organic links between the E.C.S.C. and the nonparticipating members of the Council of Europe were adopted. The six nations forming the E.C.S.C. proceeded with plans for the creation of a European Defense Community (E.D.C.),a European army which would maintain the closest possible liaison with British forces and would be integrated with the NATO system. The six governments signed the treaty instituting the E.D.C. in Paris on May 27, 1952. The treaty also foresaw the constitution of a permanent assembly elected on a democratic basis. The E.D.C. was rejected by France in Aug. 1954 and replaced in 1955 by a Western European union (W.E.U.), including Great Britain in addition to the six E.D.C. countries.

Progress of Federal Integration. — \Tinston Churchill had declared in Strasbourg in Aug. 1949: "The first step has been taken. and it is the first step that counts." In the first decade of the Pan-European movement (1948–58) its realization proceeded on two levels, an organized co-operation of sovereign nations, represented by the Council of Europe, and an approach to federal integration. of which the E.C.S.C. formed the first step. At the end of 1955 Jean Monnet, the former president of E.C.S.C., founded the Action Committee for the United States of Europe. Its purpose was to create a customs union and a common market for the six nations organized in the E.C.S.C. and also a supranational European Atomic Energy Community (EURATOM). Europe is an energy-deficit area. and therefore large-scale industrial application of the energy released by nuclear fission is of great potential importance. By 1958 the six member nations of the E.C.S.C.—Belgium, France, Germany, Italy, Luxembourg, Netherlands — had ratified the two additional treaties establishing the European Economic Community (E.E.C.) and EURATOM. It was planned that the three organizations for the economic federation of the six European nations (E.C.S.C., E.E.C. and EURATOM) should have in common a council of ministers, a European assembly and a European court of justice, supervising the activities of the three economic federations. The E.E.C. treaty also provided for a European investment bank. The single market

(',European common market") without tariffs or other trade barriers foreseen for the E.E.C. was to come into full existence over a period of 12 to 15 years.

Integration v. **Co-operation.**—The six European nations united by iederal institutions were also seeking. however, a wider, though looser, form of co-operation with other European nations. Seventeen western European nations. the participants in the O.E.E.C.. established on Dec. 20, 1957, for example, a European Nuclear Energy agency to promote co-operative undertakings in the peacetime atomic field.

The O.E.E.C.. an instrument of the European Recovery program. was formed. as has been noted, primarily for European recovery. not for European union. It aimed at intensifying European trade without merging national economies. In that direction Great Britain proposed the creation of a free trade area which would embrace the six nations of the common market and other European nations. especially Great Britain and those which, like the Scandinavian countries, tended to follow the British example. Though the iree trade area plan fell short, of federal integration, it nevertheless went much farther than anything that had previously emerged from the O.E.E.C.

It still seemed difficult to reconcile the two different approaches toward a Pan-European movement, the one based on the co-operation of independent governments, the other on the establishment, at least in the economic field. of supranational organizations and authorities. Nevertheless the Pan-European movement had made definite progress. *See* also FEDERAL GOVERNMENT; FOREIGN AID PROGRAMS; WORLD GOVERNMENT MOVEMENTS.

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PANGASINAN, a province of central Luzon. Philippines, occupying the north end of the central plain and fronting on Lingayen gulf on the west coast; it includes the two islands of Santiago and Cabarruyan. Area 2.021 sq.mi.; pop. (1913) 920.191; (1959 est.) 1,127,650. Most of the province consists of the alluvial lowland of the Agno river, which rises in the mountains of northern Luzon. It is one of the richest agricultural regions of the Philippines and has a heavy population of Pangasinan natives and Ilokanos from the northwest Luzon coast settled in the northern section. The chief crop is rice, much of which goes by rail to the Manila markets. Minor crops are maize, mangoes and other fruits, sugar cane, tobacco and coconut: this being the northernmost important coconut growing region. Firewood cutting from the mangrove swamps and salt making are important along the Lingayen gulf coast. The capital is Lingayen. pop. (mun.. 1948) 35,806. (1959 est.) 45.089; during World War II, C.S. forces made reoccupation landings near it. Dagupan, east of Lingayen, is a city chartered in 1947 with an area of 17.1 sq.mi.; pop. (1948) 43.838. (1959 est.) 53.704. It is the chief port and an important rail and road transport centre. There are no other large towns or cities but numerous populous municipalities are located in the northern portion of the Agno river plain. Among these are Binmaley, between Lingayen and Dagupan; Mangaldan, east of Dagupan, a rail transport and cotton textile centre: Calasiao, south of Dagupan, a rice shipping and palm-hat making centre; and the inland municipalities of Manaoag, San Carlos and Bayambang. (J. E. SR.)

PAN-GERMANISM is the name of a movement aiming at the union of all people speaking German or a Germanic tongue into one political body. Sometimes the movement. which was never clearly or authoritatively defined. proclaimed the unity only of the German-speaking population of Germany proper, of the Habsburg monarchy. of Russia (the Baltic provinces), of Switzerland. of France (Alsace) and of the Low Countries (where Dutch and Flemish were regarded as German dialects). With the peculiar position which the Khine river acquired in German nationalism. it was stressed that the source of the Rhine (in Switzerland) and its mouth (in the Low Countries) "belonged" to Germany. Other proponents of Pan-Germanism pointed to the civilizing mission and the colonizing efforts of the medieval German empire in eastern Europe and based upon it claims for German hegemony there. Others again wished to include the Scandinavian nations in the Pan-German unity.

This latter trend was strengthened by "Nordic" racial theories, which regarded the Nordics. as represented by the Teutonic Germans and Scandinavians with their common mythology and saga world, as the most gifted and noble kind of the human species. The close tie between Nordic-Aryanism and Pan-Germanism became even more pronounced after leading German artists and scholars such as Richard Wagner and Heinrich von Treitschke embraced racialism. The famous "Nordic" or Germanic racial theory. which the French writer Comte Joseph Arthur de Gobineau (1816–82) proposed in his *Essai sur l'inegalité des races humuines* (1853–55), made little impression in western Europe but was elaborated into a system by the English-born naturalized German Houston Stewart Chamberlain (1855–1927), Richard Wagner's son-in-law and author of *Die Grundlagen des neunzehnten Jahrhunderts* (1899; Eng. trans.. *The Foundations of the 19th Century,* 1911). He and other German racialists claimed every historical man of genius, including Jesus Christ. as a member of the German race.

Although Emperor William II patronized Chamberlain, official Germany adhered neither to Pan-Germanism nor to racialism until 1933. Pan-Germanism was a movement of German intellectuals, writers and scholars, but did not enter the realm of practical politics before 1914. It was first expressed during the nationalist enthusiasm of the "war of liberation" against Napoleon by such patriotic propagandists as Ernst Moritz Arndt (1769–1860) arid Friedrich Ludwig Jahn (1778–1852), founder of the militant gymnastic organizations (*Turnvereine*).

The ideal Germany which they wished to build had no clearly determined historical, natural or ethnographic frontiers. This encouraged sweeping claims to many territories which had at some time or other been under the vague and ill-defined suzerainty of the Holy Roman empire or to territories where Germans had settled among non-Germanic peoples.

Half a century later, German nationalists such as the political economist Friedrich List (1789–1846). the orientalist Paul Anton de Lagarde (1827–91) and the political publicist Konstantin Frantz (1817–91) advocated the formation of a powerful European confederation in central Europe under German leadership. Such a powerful central European federation from Flanders to the Black sea and from Burgundy to the Vistula. they maintained, would be able to guarantee the peace of the entire continent.

Pan-Germanism was not organized as a movement until 1894, when Ernst Hasse, professor in Leipzig and from 1893 to 1903 a member of the *Reichstag,* reformed the *Allgemeiner Deutscher Verband* (General German league. iounded in 1891) as *Alldeutscher Verband* (Pan-German league). After Hasse's death in 1908 Heinrich Class became his successor. The league inaugurated a dynamic and aggressive policy in Europe and overseas under the slogan "remember that you are Germans." It defined its purpose as follows:

(1) The Pan-German League strives to quicken the national sentiment of Germans and in particular to awaken and foster the racial and cultural homogeneity of all sections of the German people. (2) These aims imply that the League works for: *(a)* preservation of the German *Volkstum* in Europe and overseas and its support whenever it is threatened. (b) Settlement of all cultural, educational and school problems in ways that shall aid the German *Volkstum.* (*c*) The combatting of all iorces which check the German national development. (d) An active policy of furthering German interests in the entire world, in particular the continuation of the German colonial movement.

In his three-volume work *Deutsche Politik* (1905–07), Hasse proposed to protect the German frontiers by a wide military glacis, settled by picked former German soldiers. "We want territory," he wrote, "even if it be inhabited by foreign peoples, so that we may shape their future in accordance with our needs."

Many writers went openly beyond the official program by demanding a close union of Germany with Austria-Hungary, the

Low Countries and Switzerland and the annexation of large parts of western Russia and of the Balkans. Above all, the league was concerned with preserving the German national consciousness and loyalty to Germany of the many millions of German descent settled overseas. Although the league had hardly more than 20.000 members, its propaganda was very active and more or less coloured the thinking of large German circles. Pan-Germanism had also a wide following among the Germans in the Austrian monarchy, where Georg von Schonerer and his disciple Karl Hermann Wolf propagated Pan-German expansionism. German superiority over the Slavs and an anticapitalistic anti-Semitism, doctrines which very much influenced Adolf Hitler when he lived in Austria before World War I.

During World War I Friedrich Yaumann (1860–1919), a Protestant theologian and socialist politician. published *Mitteleuropa* (1915), in which he proposed a vast German-dominated confederation from Antwerp to the Persian gulf. The treaty of Brest-Litovsk in March 191‰seemed to realize much of this Pan-German dream. only to be destroyed a few months'later by the defeat of Germany on the western front. This defeat not only saved the western democracies, but also Communist Russia from the German hegemony foreshadowed in the Brest-Litovsk treaty.

Pan-Germanism did not acknowledge this defeat but strove, even during the days of the Weimar republic, to revive Pan-German nationalism and racialism. Among the various groups which propagated this faith among the masses. the National Socialist German Workers' party (Nazis) under the leadership of Hitler soon became the strongest. While the Pan-Germans before 1914 had regarded England as the main target of their hatred, Hitler turned Pan-German aspirations primarily to the east and singled out Communist Russia as the chief enemy. He propagated Pan-Germanism in its new and extremist form, in which faith in absolute Nordic racial superiority and the cult of force and violence were fused.

One of the schools supporting Pan-Germanism was that of Geopolitik. a "science" establishing a similar mystical tie between geography and history as the racial theory did in maintaining such a tie between biological "science" and man's destiny. Among the geopoliticians Karl Haushofer in Munich and Ewald Banse. the author of *Raum und Volk im Weltkriege* ("Space and Folk in the World War") (1933), were prominent. Writers such as Hans Grimm, *Volk ohne Raum* ("Folk Without Space") (1926). created a favourable moral climate in Germany for the spread of extreme Pan-Germanism. *(See* GEOPOLITICS.) Under these conditions, the feeble efforts of the A'eimar government to resist the rising tide of Pan-Germanism failed, and in Jan. 1933 the government of Adolf Hitler came to power, the first German government avowedly dedicated to the realization of Pan-Germanism. Five years were needed to prepare for the task. They were used not only to arm Germany and to divide public opinion abroad. but to realize the Pan-German principles in the nation itself. In March 1938 the first open steps were taken to carry through the Pan-German program with the annexation of Austria. From then on, step followed step in an almost logical and methodical way to fulfill the whole Pan-German program.

By the beginning of 1942 this realization seemed at hand: the whole of central Europe and the Balkans, western Russia and the Ukraine were under German control—as foreshadowed in the treaty of Brest-Litovsk; but beyond it, Denmark and Norway, France and the Low Countries were occupied by the Germans, and Italy and Spain under the fascist regimes of Benito Mussolini and Francisco Franco were Germany's allies. Again, as in 1918, the German aspirations for a Pan-German empire were destroyed only a short while later by military defeat. This defeat in 1945 had much more devastating consequences for Pan-Germanism in eastern and central Europe than did that of 1918. The German settlements in eastern-central Europe were "liquidated" by forced mass evacuation. Nevertheless, Pan-German sentiments again showed signs of revival in Germany in the second half of the 20th century. *See* also NATIONALISM; NATIONAL SOCIALISM.

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PANGOLIN, the name given to scaly anteaters comprising several genera of the family Manidae of the order Edentata (*q.v.*). These animals are found in tropical Asia and in Africa, ranging from 1 to 3 ft. in length, exclusive of the tail, which may be shorter than. or twice the length of, the rest of the body. The legs are short and the tongue long and wormlike. There are no teeth. Except the under surface of the body and, in two African species, the lower part of the tip of the tail, the whole animal is covered with broad, overlapping. horny scales. The three Asian species are characterized by hairs between the scales and by small external ears. These are wanting in the four African species. The commonest Asian form is *Manis pentadactyla* of China.

WHITE-BELLIED PANGOLIN, OF TROPICAL AFRICA

PANHARD, RENE (1841–1908), French engineer and automobile manufacturer, was born at Paris in 1841 and graduated from the École centrale des arts et manufactures. In 1886 he joined with Émile Levassor, who gained control of the French rights to the Daimler patents. to form Panhard and Levassor. In 1891–92 Panhard and Levassor produced the first vehicle with an internal combustion engine mounted at the front of the chassis. The car, designed by Levassor, had a clutch and transmission to carry the power to the rear wheels. The Panhard and Levassor automobile was put on sale in 1892 and competed successfully in early races. In 1907 the firm adopted the sleeve-valve engine.

Panhard died at La Bourbole in 1908. (M. J. Br.)

PANIC. In the economic sense, panic has usually signified the existence among the public in general of an intense contagious fear that soon the banks would either be unable to repay their depositors on demand, or would not be in a position to lend money, with the result that the normal processes of the money market would be completely upset. The synonym for the first type of panic is the run: of the second, the financial crisis. The first is marked by a demand by the public for legal tender, formerly in extreme cases, by a demand for gold: the second is marked by a demand for bank balances, that is, loans which are hoarded by the borrowers for the same reason that notes or gold are hoarded by the depositor: not because the money is needed at once, but because it map not be available in case it is needed. Examples of the financial panic are the crises of 1847, 1857 and 1866 in Great Britain, each of which led to the suspension of the Bank Charter act: of the run, the state of affairs in New York in the autumn of 1907. Since the depositors do not know which banks really are weak, and since the run is based upon the instinct of self-preservation, it can best be countered by boldness. Claims of the depositors must be met without question because, at the height of the run, any attempt at expostulation will be interpreted as a sign that all is not well, and the run will become intensified. During a run, the commercial banks cannot afford to see any sound concern fail.

It is therefore common practice for neighbouring banks to lend money to any sound bank afflicted by a run. This policy is, however, of no avail in those instances in which numerous bank failures have thoroughly frightened the depositors, for, in such cases, runs on several banks occur at the same time. To meet this sit-

uation, most leading nations have established central banks. These banks customarily exchange circulating notes of their own issues for sound negotiable paper held by the local bank. The local bank pays out to its depositors the central bank notes and thus satisfies their demands. It follows: when local banks really are in sound condition, it is usually easy for the central bank to stop runs.

When, however, the local banks hold a large mass of frozen, or in other words uncollectible, loans, the situation is different. This was the state of affairs prevailing in March 1933, in the United States. On March 4, when Pres. Franklin D. Roosevelt took office, 420 banks had failed since Jan. 1, and every bank was in danger. Therefore, he immediately closed all banks, and no bank was allowed to reopen until examiners had found it to be in sound condition. This procedure stopped the epidemic of runs, for the public now had confidence in the ability of the reopened banks to pay depositors on demand. To prevent runs in the future. the U.S. government enacted a law insuring every national bank deposit up to $5,000. After this, runs disappeared

The two rules by which a central bank ought to be guided in the event of a financial crisis were worked out empirically by the Bank of England between 1825 and 1866, and are set forth in Walter Bagehot's celebrated book, *Lombard Street* (1873).

The first rule is that loans ought to he made freely and on any sound security. The knowledge that loans are obtainable inspires confidence. The second rule is that the loans should be made at a price high enough to discourage borrowing, for otherwise an amount may be demanded which exceeds the power even of a central bank to grant. British experience in the middle part of the 19th century showed very conclusively that the mere existence of a central bank does not of itself allay a financial panic, so long as the ability of a central bank to lend freely is doubted. Because of the provisions of the Bank Charter act of 1844. the ability of the Bank of England to lend was doubted, and confidence was not restored until the issue of the so-called "Government Letter," advising the bank that, in the event of its breaking the law by issuing a volume of notes in excess of the statutory amount, the government would seek to obtain an act of indemnity from parliament. The modern central bank, which is given power to issue notes in excess of any statutory reserve percentage, provided that it is prepared to pay a tax upon the amount so issued in excess, is in a much stronger position. This valuable element of elasticity was provided in Great Britain by the terms of the Currency and Bank Notes acts of 1914–15, by which the bank could increase its fiduciary circulation with the consent of the treasury: an element of safety which is perpetuated by the Currency and Bank Notes act of 1928. In Great Britain, the severity of financial crises and the frequency of runs has diminished greatly. The Baring crisis of 1890 was successfully surmounted without the necessity of having recourse to a suspension of the Bank act of 1844. (T. E. G.; W. I. K.)

United States.—Notable panics witnessed in the United States may be sketched as follows: Black Friday (*q.v.*) occurred on Sept. 24, 1869, the day when the Gould-Fisk clique attempted to corner the gold supply. After forcing the price up from 1jo in the morning to 162½ at noon, the price dropped precipitately to 133, causing many failures and wild panic. The government broke the corner by selling $4,000,000 in gold. Jay Cooke and Co. failed on Sept. 18, 1873. On the following day, Fisk and Hatch suspended. Three large New York banks failed, and panic caused the stock exchange to close until Sept. 30.

Panic as the result of the Baring failure in London began on Nov. 10, 1890. Call money reached 186%; the North River bank suspended; the clearinghouse issued certificates on Nov. 11. On May 3. 1893, panic again set in; call money reached 40% and many banks and brokerage houses failed. Prolonged business depression followed. May 9, 1901, witnessed one of the worst stock market disturbances in history. This panic, known as the Northern Pacific corner, was precipitated by the contest between the Harriman-Kuhn-Loeb interests on one side and the Hill-Morgan on the other, for the control of the Northern Pacific road. From a price of 106 on May 6, quotations on stock of this road jumped to 1,000 on cash sales (May 8). On May 9, the whole list collapsed. Union Pacific dropped from 113 to 76; Southern Pacific from 49 to 29; Atchison from 78¼ to 43; Baltimore and Ohio from 102 to 84; Steel common from 47 to 24; Steel preferred from 98 to 69. Call money went to 75%. The panic of Oct. 1907, followed the collapse of the copper industry. The price of that metal had dropped in six months from 26 cents to 12 cents. The Knickerbocker Trust company closed its doors on Oct. 22; on Oct. 23, a run was started on the Trust Company of America, but the bank withstood it. Call money rose to 125%. The next panic came in 1920 and was accompanied by a heavy fall in commodity prices. The depression which followed lasted about a year. In Oct. 1929, came the first of a series of panic falls in stock prices, culminating in a depression of major intensity and length. No panic caused by inability of the banks to lend has occurred since 1907, despite the fact that the depression of the 1930s was perhaps the most severe on record. Credit for preventing a shortage of loanable funds must be given to the federal reserve system of regional central banks which was established in 1913.

(J. H. B.; W. I. K.)

PANICUM, a genus of grasses (*q.v.*) comprising some 800 species, found chiefly in the warmer regions of both hemispheres, about 150 occurring in the United States. Several are important cereals, as *P. miliaceum* (common millet), cultivated for food in India and Europe; others are valuable forage plants, as P. *maximum* (guinea grass) and P. *barbinode* (Para grass), the only grasses extensively grown for forage in tropical America. Representative North American species are P. *capillare* (old witch grass), P. *virgatum* (switch grass) and *P. texanum* (Texas millet).

PANIN, NIKZTA IVANOVICH, COUNT (1718–1783), Russian statesman, was born at Danzig on Sept. 18, 1718. In 1747 he was accredited to Copenhagen as Russian minister, but a few months later was transferred to Stockholm. where for the next 12 years he played a conspicuous part as the chief opponent of the French party. It is said that during his residence in Sweden, Panin conceived a fondness for constitutional forms of government. Politically he was a pupil of Alexis Bestuzhev; consequently, when in the 1750s Russia suddenly turned Francophil instead of Francophobe, Panin's position became extremely difficult. However, he found a friend in Bestuzhev's supplanter, Michael Vorontsov, and when in 1760 he was unexpectedly appointed the governor of the little grand duke Paul, his influence was assured. He was on Catherine's side during the revolution of 1762, but his jealousy of the influence which the Orlovs seemed likely to obtain over the new empress predisposed him to favour the grand duke Paul as emperor, with Catherine as regent only.

Panin was never chancellor; but he was the political mentor of Catherine during the first 18 gears of her reign. He was the inventor of the famous "Northern Accord," which aimed at opposing a combination of Russia, Prussia, Poland, Sweden and perhaps Great Britain, against the Bourbon-Habsburg league. The idea, though never quite realized, influenced the policy of Russia for many years. It explains, too, Panin's tenderness toward Poland, whom he regarded as an indispensable member of his "Accord," wherein it was to supply the place of Austria, whom circumstances had temporarily detached from the Russian alliance. All the diplomatic questions concerning Russia from 1762 to 1783 are intimately associated with the name of Panin.

After 1772, when Gustavus III upset Panin's plans in Sweden: Panin became more and more subservient to Frederick II of Prussia. As to Poland, his views differed widely from the views of both Frederick and Catherine. He seriously guaranteed the integrity of Polish territory, after placing Stanislaus II on the throne, in order that Poland, undivided and as strong as circumstances would permit, might be drawn wholly within the orbit of Russia. But he did not foresee the complications which were likely to arise from Russia's interference in the domestic affairs of Poland. Thus the confederation of Bar, and the Turkish War thereupon ensuing, took him completely by surprise. He was forced to acquiesce in the first partition of Poland, and when Russia came off third best, Gregory Orlov declared in the council

that the minister who had signed such a partition treaty was worthy of death. Panin further incensed Catherine by meddling with the marriage arrangements of the grand duke Paul and by advocating a closer alliance with Prussia, whereas the empress was beginning to incline more and more toward Austria.

Nevertheless, even after the second marriage of Paul, Panin maintained all his old influence over his pupil, who, like himself, was now a warm admirer of the king of Prussia. There are even traditions from this period of an actual conspiracy of Panin and Paul against the empress. As the Austrian influence increased Panin found a fresh enemy in Joseph II, and the efforts of the old statesman to prevent a matrimonial alliance between the Russian and Austrian courts determined Catherine to get rid of a counsellor of whom, for some mysterious reason, she was secretly afraid. The final rupture seems to have arisen on the question of the declaration of "the armed neutrality of the North"; and in May 1781 Panin was dismissed. He died in Italy on March 31, 1783

Panin was one of the most learned, accomplished and courteous Russians of his day. Catherine called him "her encyclopaedia." The earl of Buckinghamshire declared him to be the most amiable negotiator he had ever met. He was also sf a most humane disposition and a friend of Liberal institutions.

See anonymous *Life of Count N. I. Panin* (1787); *Political correspondence* (Russian and French). Collections of Russian Historical Society, vol ix (1872); V. A. Bilbasov, *Geschichte Katharina II* (1891–93); A. Brückner, *Materials for the Biography of Count Panin* (1888).

(R. N. B.; X.)

PANIPAT, a municipal town and tehsil in the Karnal district of Punjab, India, 53 mi. N. of Delhi'by rail. Population of town (1951) 54,981. Panipat tehsil (area 461 sq.mi.) had a population of 226,638 in 1951. On three occasions the fate of northern India was decided on the plain of Panipat—in 1526, when Baber completely defeated Ibrahim Lodi, the sultan of Delhi; in 1556, when his grandson, Akbar, conquered Hemu, the Hindu general of the Afghan Adil Shah, and re-established Mogul power in northern India; and finally, on Jan. 14, 1761. when Ahmad Shah Durani shattered the Maratha confederacy, thus enabling the British to consolidate their power in Bengal. (C. C. D.)

PANIQUITÁN, a group of tribes oi South American Indians, constituting a linguistic stock or more probably substock. The Paniquitas, from whom the group takes its name, lived in Colombia in the Cordillera Central between the upper Cauca and Magdalena rivers, between 2° and 3° N. latitude. Other tribes of the stock held the region between the rivers as far north as 1° N. latitude together with both banks of the Magdalena as far south as Neiva. The Paniquitan tribes were bitter enemies of the Chibchas (*q.v.*) whom they bordered on the west and south. Unlike the Chibchas and like the peoples to the north and east they used the blowgun and employed poisoned darts and arrows. From some early accounts they appear to have been head-hunters.

See P. de Aguado, *Historia de Santa Marta y Nuevo Reino de Granada, 1575* (1916); H. Pittier de Fabrega, "Ethnographic and Linguistic Notes on the Paez Indians of Tierra Adentro, Cauca, Colombia," *Mem. Amer. Anthropological Assoc.*, vol. i; H. Beuchat and P. Rivet, "Affinités des langues de la sud de la Colombie, etc.," *Museon,* vol. xi.

PAN-ISLAMISM was the ideal embodied in the efforts of Moslem leaders during the 19th century to revive Moslem power and bring about unity. It originated partly by Islam's own realization of its decadence, but mainly as a result of European encroachments in the 19th and 20th centuries on Moslem lands. Islam's own realization of decadence produced the Wahhabi (*q.v.*) movement, which preached going back to primitive Islam, but contact with the west also made possible the rise of such enlightened leaders as the Persian-born reformer Jamal al-Din al-Afghani, who sought to develop Islam to fit modern conditions of life. Above all he sought to achieve the unity of Islam under the aegis of a caliph who could oppose the advance of Christian powers in Moslem lands.

Importance of the Caliphate in Pan-Islamic Doctrine.— Islam. in contrast to Christianity, is both church and state; its political and legal theory are opposed to the submission of Moslem sovereignty to non-Moslem powers. The caliph, head of the Moslem state, is under legal obligation to wage jihad (holy war) should Islam fall under foreign rule. Peace between a Moslem and a non-Moslem ruler should not, in theory, last more than 10 years. Moslem submission to non-Moslem powers is regarded as an anomaly that is tolerated only under force *majeure.* When the Arab caliphate passed to Ottoman sultans in the 16th century (see CALIPHATE: Later Abbasids), the Moslems gradually began to look to the Ottoman sultan-caliph as the defender of the faith, although he lacked the legal qualification of belonging to the tribe of Quraysh. The Shariffian sultans of Morocco and the Mogul rulers of India refused recognition, but the rest of dar al-Islam (world of Islam), except perhaps the Shi'a, accepted the Ottoman caliphate. When Sultan Abdul-Hamid II formally declared himself a sultan-caliph (1876) the Mogul emperor had already submitted to British rule in 1857 and the Shariffian sultan was later to fall under French domination.

Abdul-Hamid II (1876–1909) conducted such an extensive Islamic propaganda that the European powers feared political disturbances among Moslems under their control. In spite of its growing decline. the Ottoman empire through Pan-Islamism enhanced its prestige in Moslem eyes and, as the leading Moslem state. was able to raise its voice on behalf of the Moslem world in the councils of Europe. Although the emissaries of Abdul-Hamid were ill-chosen, and the success of their efforts appeared slight. the Pan-Islamic movement remained as the cherished ideal of many Moslems. Before the rise of nationalism. Pan-Islamism was the dominating ideology throughout the Moslem world. If Abdul-Hamid, as caliph, was its patron, several other public figures posed as its philosophers and preachers. The most outstanding exponent of the movement was Jamal al-Din al-Afghani (1838–97), who preached his doctrine in several Moslem countries and finally resided in Constantinople (Istanbul) until his death. His teachings reached almost every corner of the Islamic world and were echoed in centres set up as far afield as Java, Tunisia and Shanghai. In 1903 Abdullah Suhrawardi founded the Pan-Islamic society of London, whose journal! Pan-Islam, used western concepts such as humanism, liberalism and socialism to characterize Islamic virtues as opposed to European vices. Attempts were made to unify the Sunni and Shi'i sects, but no great progress was achieved when a number of Ottoman and Persian jurists assembled in Najaf early in 1911 and asserted that there was no difference in principle between the two sects. The annual conferences at Mecca during the pilgrimage were cleverly used for Pan-Islamic propaganda, but perhaps the greatest practical project that impressed the Moslems, particularly pilgrims, was the Hejaz railroad, built by private funds, partly provided by Sultan Abdul-Hamid himself, that stood as a monument to the Pan-Islamic ideal.

Nationalism as a Rival Credo.—The fall of Abdul-Hamid in 1909 marked the decline of Pan-Islamism. His failure to achieve Islamic unity and to protect Islam from western encroachment prompted many a Moslem thinker, impatient with the sultan's despotism, to seek a change in the character of Moslem polity. The new generation had been influenced by western constitutionalism (see CONSTITUTION AND CONSTITUTIONAL LAW) and nationalism (*q.v.*) and hoped that the adoption of these concepts might create a strong Ottoman state. But nationalism wrought havoc in Moslem lands; for in so composite a society as dar *al-Islam* under Ottoman rule, nationalism inevitably led to the disintegration of Moslem unity. Although the Committee of Union and Progress formally advocated Pan-Islamism at a conference held in Salonika (1911), the doctrine of nationalism proved to be incompatible with the internationalism of Islam. The Turkish nationalists, who displayed little sympathy with other Moslem countries, made an alliance with Germany that was repudiated by the Moslems in the Arab lands.

The new regimes that mere set up after World War I were in the main organized on the basis of nationalism. The Ottoman empire was broken up, and the caliphial powers were at first reduced to merely spiritual powers (1922) and then the caliphate was abolished in 1924 (see TURKEY: History). The Moslem world protested against the Turkish action, since the status of the caliphate was not a problem for the Turkish nation only but

for the Moslem world at large. The Indian Moslems organized the Khilafat movement, which aimed at the restoration of the caliphial powers to a supreme Moslem authority in Mecca. In 1926 two caliphate congresses were held in Cairo and Mecca in which the need for the caliphate was affirmed, but no agreement was reached as to who should be elected a caliph The Islamic congress held in Jerusalem in 1931 did not even discuss the caliphate question. Between World Wars I and II the Moslem countries tended to concern themselves almost exclusively with practical problems rather than with the larger issues of Islamic unity and the caliphate.

Neo-Pan-Islamism.—After World War II Islam received a certain impetus when Pakistan and Indonesia rose to independent status. A number of Arab countries that had not yet achieved independence. such as Syria. Lebanon (whose population was at least half Moslem) and Jordan, became fully sovereign states. as subsequently did several others in Africa, such as Libya, the Sudan, Tunisia and Morocco. The sudden realization of their influence in international councils induced the Moslem states to co-ordinate their activities. Moslem conferences in Karachi in 1952 and in Mecca in 1954 resulted in establishment of a permanent council and a secretariat for organizing annual meetings to co-ordinate activities for the emancipation of Moslem countries that were still dominated by western imperialism and for raising the cultural, social and economic standards of Moslem people.

This new trend in the revival of Islam, called neo-Pan-Islamism, did not aim at the unity of all Moslem peoples under one central authority, as Jamal al-Din al-Afghani and other Moslem leaders had advocated during the 19th century, but at the co-ordination of the activities of Moslem states within the international community. The Moslem states were quite aware that it was not possible to revive either the traditional Islamic ideal of unity or the religious approach to foreign affairs, because circumstances were not favourable to the association of religion in the relations among nations. If certain religious groups insisted on a more active role for *Shari'a* (religious law) in the domestic affairs of Islam, their active participation in international organizations bore witness to the fact that Moslems not only accepted secular standards in their external relations but also the integration of their countries into the larger world community. Some Moslem jurists who objected to the internal secularization of the state, and who often invoked the jihad against western encroachment on Islam, repudiated any claim that the jihad is aggressive in character. Some Moslem publicists departed so far from traditional concepts as to argue that the law governing Islam's relations with other nations. as originally expounded by Mohammed. was based on the principle of peaceful—not hostile—relations among the nations, and that its humane rules and practices can contribute to the development of the modern law of nations for the mutual benefit of Islamic and non-Islatnic nations.

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PANIZZI, SIR ANTHONY (1797–1879). English librarian, was born at Brescello, in the duchy of Modena, Italy, on Sept. 16, 1797. After taking his degree at the University of Parma, Antonio Panizzi became an advocate. He was implicated in the revolutionary movement of 1821, and escaped arrest by a precipitate flight. He first established himself at Lugano, but was expelled from Switzerland at the joint instance of Austria, France and Sardinia. He came to England in May 1823. in a state bordering upon destitution. His countryman, Ugo Foscolo, provided him with introductions. and he earned a living for some time by giving Italian lessons. By Brougham's influence he was made, in 1828, professor of Italian at University college, London. In 1831 Brougham, then lord chancellor, obtained for him the post of an extra assistant librarian of the printed book department. Panizzi was then working at his edition of Boiardo's *Orlando innamorato.* Boiardo's fame had been eclipsed for three centuries by the adaptation of Berni, and it is highly to the honour of Panizzi to have redeemed him from neglect. His edition of the *Orlando innamorato* and the *Orlando furioso* was published between 1830 and 1833. prefaced by an essay on the influence of Celtic legends on medieval romance. In 1835 he edited Boiardo's catalogue of the lihrary of the Royal society.

To the parliamentary committee (1835–36) to inquire into the management of the British museum, Panizzi contributed an enormous mass of statistics respecting foreign libraries, and evidence on the catalogue of printed books then in contemplation. In 1837 he was appointed keeper of printed books. The entire collection except the kings library had to be removed from Montague house to the new building, the reading-room service had to be reorganized rules for the new printed catalogue had to be prepared, and the catalogue itself undertaken. All these tasks were successfully accomplished, and the rules of cataloguing devised by Panizzi and his assistants became the basis of subsequent work. His report, printed in 1845, upon the museum's extraordinary deficiencies in general literature, ultimately procured the increase of the annual grant for the purchase of books to £10,000. His friendship with Thomas Grenville (1755–1846) led to the nation being enriched by the bequest of the unique Grenville library. In 1847–49 a royal commission sat to inquire into the general state of the museum. and Panizzi was the centre of the proceedings. His administration fiercely attacked from many quarters was triumphantly vindicated in every point. Panizzi did not succeed to the principal librarianship until 1856 It was thus as merely keeper of printed books that he conceived and carried out the achievement by which he is probably best remembered—the erection of the new library and reading room. Purchases had been discouraged from lack of room in which to deposit the books. Panizzi cast his eye on the empty quadrangle enclosed by the museum buildings, and conceived the idea of occupying it with a central cupola too distant, and adjacent galleries too low, to obstruct the inner windows of the original edifice. The cupola nas to cover 300 readers; the galleries were to provide storage for 1,000,000 books. The original design, sketched by Panizzi's own hand on April 1S, 1852, was submitted to the trustees on May 5; in May 1854 the necessary expenditure was sanctioned by parliament, and the building was opened in May 1857.

Many important additions to the collections were made during his administration, especially the Temple bequest of antiquities, and the Halicarnassean sculptures discovered at Budrun (Halicarnassus) by C. T Newton. Panizzi retired in July 1866, but continued to interest himself actively in the affairs of the museum until his death on April 8. 1879. He had been created a knight commander of the Bath in 1369.

His administrative faculty was extraordinary: to the widest grasp he united the minutest attention to matters of detail. His moral character nas the counterpart of his intellectual. he was warmhearted and magnanimous, extreme in love and hate—a formidable enemy, but a devoted friend. His intimate friends included Lord Palmerston, Gladstone. Roscoe, Grenville. Macaulay, Lord Langdale and his family, Rutherford (lord advocate) and Francis Haywood. the translator of Kant. His greatest friendship was with Prosper Mérimée. (R. *G.:* X.)

See Fagan, *Life of Sir Anthony Panizzi* (1880).

PANJABI LANGUAGE (alternatively PUNJABI), the language of the Central Punjab (properly Panjāb). It is spoken by over 17,000 000 people between (approximately) the 77th and 74th degrees of east longitude. The vernacular of this tract was originally an old form of the modern Lahndā, a member of the outer group of Indo-Aryan languages (*q.v.*), but it now belongs to the intermediate group, possessing most of the characteristics of the Midland language, with occasional traces of the old outer basis which became more and more prominent westward. At 74° E. it merges into the modern Lahndā

The vocabulary of Panjabi is very similar to that of western Hindi. Panjabi has no literature to speak of and is free from the burden of words borrowed from Persian or Sanskrit, only the commonest and simplest of such being found in it. Its vocabulary is thus almost entirely *tadbhaza,* and. while capable of expressing all ideas, it has a charming rustic flavour, like the Low-

land Scots of Burns, indicative of the national character of the sturdy peasantry that employs it. The indigenous alphabet of the Punjab is called *Landā* or "clipped." It is related to Nāgarī, but is hardly legible to any one except the original writer, and sometimes not even to him To remedy this defect an improved form of the alphabet was devised in the 16th century by Angad, the fifth Sikh Guru, for the purpose of recording the Sikh scriptures It was named *Gurmukhī*, "proceeding from the mouth of the Guru," and is now generally used for writing the language

See *Linguistic Survey* of *India*, vol. ix gt. 1 p 607, *seq* for a full **accaunt** with specimens of the language and bibliography.

PANJDEH or PENJDEH, a village in the Turkmen S S.R. in the Soviet Cnion, rendered famous by "the Panjdeh scare" of 1885. It is situated on the east side of the Kushk river near its junction with the Murghab at Pul-i-Khishti In March 1885 when the Russo-Afghan Boundary Commission should have been engaged in settling the boundary-line, this portion of it mas in dispute between the Afghans and the Russians. A part of the Afghan force was encamped on the west bank of the Kushk, and on March 29 General Komarov sent an uleimatum demanding their withdrawal On their refusal the Russians attacked them at 3 A M on March 30 and drove them across the Pul-i-Khishti Bridge with a loss of some 600 men. The incident nearly gave rise to war between England and Russia: hut the amir Ȧbdur-Rahman. who was present at the Rawalpindi conference with Lord Dufferin at the time, affected to regard the matter as a mere frontier scuffle. The border-line subsequently laid down gives to Russia the corner between the Kushk and Murghab rivers as far as Maruchak on the Murghab, and the Kushk post has now become the frontier post of the Russian army of occupation.

PANKHURST, **EMMELINE** (1858–1928), British suffragist, the daughter of Robert Goulden, a calico-printer of Manchester, was born July 14, 1858. From 1873 to 1877 she was educated at the École Normale in Paris, where she came under the influence of a daughter of Wenri Rochef ort. In 1879 she married Richard Marsden Pankhurst, a barrister and an advocate of women's suffrage, and served with him on the committee which promoted the Married Women's Property Act. She was at that time a member of the Manchester Women's Suffrage Committee and, during a short residence in London in 1856, took part in the strike of the match girls at Bryant and May's factory. In 1889 she helped to found the Women's Franchise League, and in 1892 left the Liberal Party and became a member of the Independent Labour Party. Returning to Manchester in 1893, she acted for five years as Poor Law guardian, On the death of her husband in 1898 she took the post of registrar of births and deaths at Chorlton-on->ledlo&, but was later obliged to resign on account of her propaganda activities In October 1903, inspired by her daughter Christabel, she was chiefly instrumental in founding the Women's Social and Political Union on a non-party basis.

Having failed to induce the Liberal party to make votes for women a part of their programme she utilized her organization to oppose their candidates, took headquarters in London, held public meetings and organized processions and deputations to the House of Commons. On May 16, 1906, she spoke for her society at a joint deputation of suffrage societies which met Sir H. Campbell-Bannerman at the Foreign Office. But the Liberal party being divided on the question, their leaders refused facilities for the discussion of private bills In Feb. 1908 Mrs. Pankhurst was arrested on her way to the House of Commons with a petition for the Prime Minister, but was released from prison on grounds of ill-health after the expiration of five weeks of her six weeks' sentence. Later in the same year she was imprisoned in Holloway for inciting to a breach of the peace. and once more in 1909 she was arrested for a technical assault. She entered an appeal founded on the Bill of Rights and a statute of Charles II., and pending the hearing undertook a lecturing tour in America and Canada During her absence some unknown person paid her fine. In 1910 there was a short lull in the movement pending the consideration of a moderate measure framed by a nan-party committee of the House, but as the Government opposed the measure the agitation was again resumed. The census was boycotted in 1911, and on her return from a second American visit at the end of the year Mrs. Pankhurst and her daughter directed a window-breaking campaign. Mrs. Pankhurst was sentenced to 9 months' imprisonment for inciting to violence in March 1912.

In 1913–4 arson and the destruction of property were added to the methods of the W.S.P.U. After the bomb outrage at Lloyd George's house at Walton, Mrs. Pankhurst was sentenced at the Old Bailey to three years' penal servitude. After serving at intervals less than three weeks of her sentence she joined her daughter Christabel in Paris and later went to America. In the summer of 1914, when she had again been re-arrested and released several times after her return to England, the remainder of her term was allowed to lapse.

At the outbreak of World War I Mrs. Pankhurst and her eldest daughter, supported by the other militant leaders, lent their organization to the cause of national service. Mrs. Pankhurst, an exceptionally able public speaker, devoted her energies to the encouragement of recruiting in England and America. In 1917 Mrs. Pankhurst visited Russia and subsequently, for the benefit of her health, spent some years in Canada and Bermuda. On her return to England at the end of 1925 she again showed great interest in politics. At the time of her death (London, June 14, 1928) she was the candidate for Whitechapel and. St. George s nominated by the Conservative Party, which she had joined after the passing of the Representation of the People Act, 1918, which included the extension of the suffrage to women.

Mrs. Pankhurst had one son. who died in 1910, and three daughters. Christabel (b. 1880) later abandoned politics. Sylvia (1882–1960) was a pacifist, supported the Russian Revolution and later championed the cause of Ethiopia, where she retired in 1956. See E. Pankhurst, *My Own* Story (1914).

PAN KU (A.D. 32–92) AND PAN CHAO (C. A.D. 45–*c.* 115), brother and sister scholars of the Later Han dynasty (see CHINA: History), were probably born at Ch'ang-an (Sian). he in A.D. 32, she between 45 and 51. Their father. Pan Piao (from Fu-feng, Shensi), had begun a history of the recent Former Han dynasty; after his death in 54, Pan Ku undertook to revise and amplify it, but was imprisoned at Loyang. the capital, for tampering with the dynastic records. His twin brother, Pan Ch'ao (not to be confused with their sister), obtained an imperial audience, and after reading the writings in question the emperor gave Pan Ku an official post, eventually ordering him to complete the history.

In the following decades Pan Ku revised the sections planned by his father, the imperial annals and the biographies, and added between them a section of tables and one of treatises. The resulting *Han* Sku (literally "Han Documents"), conceived as a supplement to the Shih *Chi* of Ssu-ma Ch'ien (see CHINESE LITERATURE: Historical Writings), differs from the latter work not only in chronological scope but in approach and style, its comments being more impersonal, its judgments more strictly Confucian, its prose more regular.

Among Pan Ku's shorter works, his "Rhymeprose on the Two Capitals" is notable as the model for later fu compositions on this subject. In 89 he accompanied the ambitious Tou Hsien on a campaign into Mongolia, where his victory inscription was carved in rock. Tou Hsien's fall from favour after returning to China involved Pan Ku, who died in prison in the year 92.

Pan Chao meantime had gained a reputation as a lady scholar and exemplary widow. Wed at 14. she never remarried after the early death of her husband, Ts'ao Shou, devoting herself to literature and educating her son. After her brother's death the emperor commissioned Pan Chao to finish his work. which she did, with some assistants, by completing the tables and the treatise on astronomy. "Aunt Ts'ao" (Ts'ao Ta-ku), as she was called. was made a lady-in-waiting to the empress and was respected as a teacher at court. Her skill in verse is seen in the "Rhymeprose on the Great Bird," prompted by an ornithological tribute sent to court in 101 by her brother Pan Ch'ao, after nearly 30 years of extraordinary military and colonial service in central Asia. In the same year her memorial to the throne enabled him at last to return to the capital. Pan Chao produced her best-known uork Lessons

for Women in 106. She died at about 70 years of age.

Biographies of the Pan family appear in the Hou *Han Shu* or "History of the Later Han," ior which their own labours set the pattern, as for subsequent Chinese dynastic histories.

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PANLOGISM, in philosophy, is the metaphysical theory that thought or reason is the ultimate reality, or that the universe is completely rational or intelligible (Greek *pan,* all, *logos,* reason). The term is sometimes applied to the absolute idealism of Hegel. *See* IDEALISM: HEGEL, GEORG WILHELM FRIEDRICH.

PANNAGE, an English legal term for the feeding of swine a wood or forest, hence used of a right or privilege to do this.

PANNONIA, a country bounded north and east by the Danube, conterminous westward with Noricum and upper Italy. and southward with Dalmatia and upper Moesia. Its original inhabitants were probably of Illyrian race. From the 4th century B.C. it was invaded by various Celtic tribes. probably survivors of the hosts of Brennus. Little is heard of Pannonia until 35 B.C., when its inhabitants. having taken up arms in support of the Dalmatians. were attacked by Augustus, who conquered and occupied Siscia (Sissek). The country was not, however, definitely subdued until 9 B.C.. when it was incorporated with Illyria, the frontier oi which was thus extended as far as the Danube. In A.D. 7 the Pannonians, with the Dalmatians and other Illyrian tribes, revolted, and were overcome by Tiberius and Germanicus, after a hard-fought campaign which lasted for two years. In A.D. 10 Pannonia was organized as a separate province. The proximity of dangerous barbarian tribes (Quadi, Marcomanni) necessitated the presence of a large number of troops (seven legions in later times). and numerous fortresses were built on the bank of the Danube. Some time between the years 102 and 107, which marked the termination of the first and second Dacian wars. Trajan divided the province into Pannonia superior, the western, and inferior, the eastern portion.

Under Diocletian a iouriold division of the country was made. In the middle of the jth century Pannonia was ceded to the Huns by Theodosius II. and after the death of Attila passed into the hands of the Ostrogoths. Longobards (Lombards) and Avars.

The inhabitants of Pannonia are described as brave and warlike, but cruel and treacherous. Except in the mountainous districts. the country mas iairly productive, especially after the great forests had been cleared by Probus and Galerius. Before that time timber had been one of its most important exports. Its chief agricultural products were oats and barley, from which the inhabitants brewed a kind of beer.

The native settlements consisted of *pagi* (cantons) containing a number of *vici* (villages), the majority of the large towns being of Roman origin. In Upper Pannonia were Vindobona (Vienna). probably founded by Vespasian; Arrabona (Raab), a considerable military station; Savaria or Sabaria (Stein-am-Anger), founded by Claudius, a frequent residence oi the later emperors. and capital of Pannonia *prima.* In Lower Pannonia were Sirmium (first mentioned in A.D. 6. also a frequent residence of the later emperors), and Sopianae (Fünfkirchen), an important place at the meeting of five roads.

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PANOAN, an independent linguistic stock of South American Indians. so called from the Pano, one of its important tribes. The Indians of this stock occupy a large area in northeastern Peru and the adjacent parts of Brazil and Bolivia. The region may be roughly described as covering the territory south of the Amazon between the mouths of the Huallaga and Yaruri rivers, and including the region along the Huallaga. Ucayali, upper Yurua and Purus rivers extending south to the lower Beni and Mamore in about 12° S. latitude. The better known tribes are the Cashibos, Chacobos, Conibos, and Shipibos.

See P. Rivet, "Sur quelques dialectes Panos peu connus," with bibliography, *J. Soc. Américanistes de Paris* (new series), vol. vii, pp. 221–242; D. G. Brinton, *The American Race* (1891).

PANOFSKY, ERWIN (1892–), German-U.S. art historian. was born in Hanover, Ger., March 30, 1892. He received the degree of doctor of philosophy from the University of Freiburg in Breisgau and was professor at the University of Hamburg from 1926–33. He first went to the United States in 1931 as visiting professor at New York university, New York, and in 1935 became professor of art history at The Institute for Advanced Study, Princeton, N.J.

Cast in a lucid and entertaining prose style. his writings are distinguished for their variety of subject, critical penetration, erudition and rich allusiveness to literature, philosophy and history. Panofsky was the historian of many iconographic. stylistic and theoretical aspects of medieval and Renaissance art; he also wrote the classic account of Albrecht Durer and a definitive history of early Netherlandish painting. Central to all his writings is the profoundly humanistic view that form and content in a work of art are indissoluble; thus art has more than mere visual meaning and is always charged with the basic attitude toward life of the civilization that produced it.

Among Panofsky's major works in English are *Studies in Iconology: Humanistic Themes in the Art of the Renaissance* (1939); *The Codex Huygens and Leonardo da Vinci's Art Theory,* Studies of the Warburg Institute, vol. xiii (1940); *Albrecht Dürer,* 2 vol. (1943), 3d ed. (1948), also republished. with full text and illustrations but without the handlizt of Durer's works. as *The Life and Art of Albrecht Dürer* (1955): (ed. and trans.) *Abbot Suger on the Abbey Church of St. Denis and Its Art Treasures* (1946); *Gothic Architecture and Scholasticism* (1951); *Early Netherlandish Painting, Its Origin and Character,* 2 vol. (1953): *Meaning in the Visual Arts* (1955), a collection of nine of Panofsky's most important articles and essays on a wide variety of subjects and, with Dora Panofsky. *Pandora's Box: the Changing Aspects of a Mythical Symbol* (1956). (RR. W. L.)

PANORAMA, the name given originally to a pictorial representation of the whole view visible from one point by an observer who in turning around looks successively to all points of the horizon. In this sense it is synonymous with cyclorama. In an ordinary landscape picture only a small part of the objects visible from one point is included. If a greater part of a landscape has to be represented, it becomes more convenient for the artist to suppose himself surrounded by a cylinder in whose centre he stands. and to project the landscape from this position onto the walls of the cylinder. In a panorama such a cylinder (the first of which were about 60 ft., but later ones as large as 130 ft. in diameter) is covered with an accurate representation in colours of a landscape. so that an observer standing in the centre of the cylinder sees the picture like an actual landscape in nature completely surround him. This gives an effect of great reality to the picture. which is skillfully aided in various ways. The observer stands on a platiorm representing, say. the flat roof of a house, and the space between this platform and the picture is covered with real objects .which gradually blend into the picture itself. The picture is lighted from above, but a roof is spread over the central platiorm so that no light but that reflected from the picture reaches the eye. To make this light appear more brilliant, the passages and staircase that lead the spectator to the platform are kept nearly dark. Such panoramas, suggested by a German architectural painter named Breisig, were first executed by Robert Barker, an Edinburgh artist, who exhibited one in Edinburgh in 1788 representing a view of that city. A view of London and views of sea fights and battles of the Napoleonic wars followed. Panoramas gained less favour on the continent of Europe, until. after the Franco-German War. a panorama of the siege of Paris was exhibited in Paris. This panorama. executed by Henri Philippoteoux. French painter, included plastic objects in the foreground which strengthened the optical illusion. Paul Philippoteoux. the son of the above painter, was noted for his "Battle of Gettysburg" (1883)

which was exhibited in several U.S. cities before being put on permanent exhibit at Gettysburg, Pa. Other distinguished painters of panoramas were Ludwig Braun and Anton von Werner in German>- and De Neuville and Detaille in France.

The name panorama. or panoramic view, is also given to drawings of views from mountain peaks or other points of view. In photography a panoramic camera is one which enables a wide picture to be taken.

The term diorama (*q v.*) refers to a comparable kind of painting in which the viewer looks through an opening at a partly translucent painting some distance away.

PAN-PIPES: *see* SYRINX.

PANPSYCHISM, a philosophical term applied to any theory of nature which recognizes the kxistence of a psychical element throughout the objective world (Gr. πᾶν, all; ψυχή, soul). In such theories not only animals and plants but even the smallest particles of matter are regarded as having some rudimentary kind of sensation or "soul" which plays the same part in relation to their objective activities or modifications as the soul does in the case of human beings Such theories are the modern scientific or semi-scientific counterparts of the primitive animism of savage races, and may be compared with the hylozoism of the Greek physicists. In modern times the chief exponents of panpsychist views are Thomas Carlyle. Fechner and Paulsen: a similar idea lay at the root of the physical theories of the Stoics.

PAN-SLAVISM. Various movements for a closer union of the peoples spesking a Slavic language were known from the beginning of the 19th century under the name of Pan-Slavism. It was generally overlooked that the affinity of language implies neither a common descent nor an affinity of cultural traditions or ways oi life. Though the Slavic languages are closely related, the various peoples speaking them have been shaped by historical and religious influences in such a way that there is more similarity between some of them and their non-Slavic speaking neighbours than there is among them. One great division of the Slavs is based upon the thousand-year-old impact of religion: Russians. Serbs and Bulgarians have been Greek Orthodox; Poles. Czechs and Croats Roman Catholic. The Russians and the Balkan Slavs remained for many centuries without any close contact with the European community, while the western Slavs had their cultural and political life integrated into the general central European pattern. Only in the first half of the 19th century, under the influence of the French Revolution and of German romanticism, did Pan-Slavism start as a movement among intellectuals, scholars and poets. It had rarely any influence on practical politics, however. The various Slavic nationalities conducted their policies in accordance with nhat they regarded their national interests, and these policies were frequently bitterly hostile to other Slavic peoples while friendly and co-operative toward non-Slavs.

An early forerunner of Pan-Slavism was a Catholic Croat priest, Yuri Krizanitch (1618–83), who in 1659 travelled to Moscow, to the "tsar of my race". to propagate Pan-Slavism and the union of the Greek and Roman Churches. He stressed the need for Slavs to emancipate themselves from the cultural and political dominion of foreigners, especially the Germans; at the same time he demanded the Europeanization of Russia and deplored its grievous oriental backwardness. Yet he was haunted by the vision of the future greatness of the Slavs. His ideas found hardly any echo at the Russian court. The great Russian rulers of the 18th century, Peter I and Catherine II, were much more interested in Europeanizing the court of St. Petersburg and the administration of their empire than in contacts with the smaller Slavic nationalities, which they used only as far as it seemed expedient for their imperial policy and expansion. In the 18th century Russia annexed the Slavic Ukraine and was the prime mover in the destruction of Slavic Poland.

Pan-Slavism in its modem form started among the Czechs, Slovaks and Croats. The interest in folk songs and folk lore, in the vernacular of the peasants and in national traditions, aroused by Johann Gottfried Herder and the German romanticists, stimulated the interest of Slavic intellectuals in their own people and their past. Through men like Joseph Dobrovsky (1753–1829) and Pavel Josef Safarik (1795–1861), Prague became a centre of research in Slavic antiquities and philology. A Slovak Lutheran pastor Jan Kollar (1793–1852), who was decisively influenced by German nationalism during his student years in Jena, became famous for his cycle of poems *Slavy Dcera* (The Daughter of Slava), in which he expressed his bitter grief over the disappearance of the Slavs in the lands east of the Elbe and Saale through German aggression; he exhorted the Slavs to restore their ancient glory and to assure an even greater future by a close union of all Slavs. He regarded the Slavic languages as mere dialects of one Slavic language and pleaded for the closest cultural co-operation among the Slavs in his *Über die literarische Wechselseitigkeit zwischen den Stämmen und Mundarten der slawischen Nation* (On the Literary Mutuality of the Tribes and Dialects of the Slav Nation, 1837).

The first public manifestation of Pan-Slavism was a congress of the Slavic nationalities of the Habsburg monarchy held in Prague in June 1848. Under the chairmanship of the Czech patriotic leader and historian Frantisek Palacky (1798–1876), the Austrian Slavs demanded the transformation of the Habsburg monarchy into a federation of equal peoples under democratic Habsburg rule and declared the need of a strong Austrian state as protection for all the smaller nationalities of central Europe against German aggression and against the trends of Russia to establish a universal empire. These Pan-Slavs rejected Russian autocracy and looked to the West and its liberal democracy for guidance.

Their hopes for a federal transformation of the Habsburg monarchy were shattered by the concessions which Francis Joseph made in 1867 to Magyar nationalism at the expense of the Hungarian Slavs who became subject to a ruthless Magyarization policy. The Austrian Slavs now turned for protection against German and Magyar superiority to Moscow. But other Slavic peoples, the Poles and Ukrainians, suffered bitterly under Moscow's oppression. Thus, although many Russian writers and politicians were willing to propagate a Pan-Slavism under Russian leadership, Pan-Slavism suffered from the beginning from the fact that Russia itself was an oppressor of Slavs, much more cruel than Austria, and that Russia envisaged not a Slavic collaboration in freedom and equality but Russian domination over the Slavs. Some Russians even wished to impose the Russian Orthodox religion and the Russian language and culture upon the other Slavs.

While these Russian Pan-Slavs used Pan-Slavism as a vehicle for Russian expansion, another school of Russian thinkers, the Slavophiles. proclaimed the superiority of Orthodox Russian civilization over the West. Alexei Stepanovich Khomyakov (1804–60) and Ivan Vasilyevich Kireyevsky (1806–56), much influenced by German romantic philosophy, believed that the Russian religion and the Russian people had developed a system of spiritual values and social relations which was being undermined by Western influences. Europe, they taught, was the creation of Roman and Teuton conquests. of Catholic rationalism and will to domination and Protestant individualism and anarchy. These elements led to racial and class war. to the disintegration of society, to the decay of faith. Russia, on the other hand, represented an organic community, alien to the European spirit of violence and competition; Russia alone harboured the promise of social justice and of a perfect order.

These ideas were sufficiently vague and flattering to Russian *amour-propre* to be widely accepted by various currents and put into the service of Pan-Slavism. Some of the greatest Russian writers like the novelist Fyodor Mikhailovich Dostoievrky (1821–81) and the poet Fyodor Ivanovich Tyuchev (1803–73) enthusiastically supported the wildest Pan-Slavic dreams and the most excessive glorification of Russia's mission for the leadership of mankind. Historians like Mikhail Petrovich Pogodin (1800–75) and scientists like Nikolai Yakovlevich Danilevsky (1822–85) foresaw a Slavic federation under Russian leadership comprising the whole of central Europe east from a line connecting Stettin on the Baltic and Trieste on the Adriatic sea, the Balkans and Constantinople; and thus creating the geographic and economic fountlation for Russia's world leadership. A Pan-Slavic congress called to Moscow in 1867 expressed many of these plans and hopes.

The Russian government. however, was on the whole cool toward these expansionist claims, although it sometimes made use of the underlying sentiments in its anti-Turkish policy. After the Russian revolution of 1905 and the beginnings of constitutional life in Russia, a new start was made with a liberal Pan-Slavic program under the leadership of the Czech statesman Karel Kramar (1860–1937). Pan-Slavic congresses met in Prague and in Sofia, Hulgaria, hut they led nowhere except to pious declarations. The reality of a bitter hostility among Poles, Ukrainians and Russians; Serbs and Bulgarians; Serbs and Croats; Czechs and Slovaks, hindered then as later any effective Slavic collaboration. In World War I Poles and Russians, Serbs and Bulgarians faced each other as deadly enemies. World War I brought the simultaneous weakening of Russia and Germany, and thereby the chance for the western Slavs, the Poles, the Czechs and the Yugoslavs to create their independent and much enlarged states. They did it in co-opcration with the western democracies, but outside of Czechoslovakia democracy was not firmly rooted among the other Slavs and was soon replaced by dictatorial regimes. Nor was there any unity among the Slavs or within the new Slavic states. In Poland the Ukrainian minority felt itseli oppressed by the Poles; in Czechoslovakia the Slovaks accused the Czechs of lust for domination; in Yugoslavia Serbs, Croats and Slovenes faced each other in open hostility. In Russia the new government established in Nov. 1917 when Lenin overthrew the short-lived Russian democracy regarded Pan-Slavism as a reactionary imperialist movement. With the prevailing emphasis on internationalism and on class solidarity, a union based on common racial descent or on an affinity of language was unthinkable. Pan-Slavism seemed dead. Nobody then would have predicted its revival and intensification two decades later and the realization of most of its far-reaching aspirations.

Soon aiter the German attack upon Soviet Russia in June 1941, a Pan-Slavic committee was iounded in Moscow under Communist sponsorship, which in frequent proclamations summoned all Slavs to fight against the Germans and stressed the racial and cultural community of the Slavs as opposed to Germanism. For the first time the international class ideology was supplemented by a doctrine of racial brotherhood and solidarity. Vyacheslav Molotov, the Soviet foreign minister, justified on Sept. 17, 1939, the Soviet annexation of eastern Poland by blood ties with its inhabitants. Similarly the racial theory was used by the Soviet government for the annexation oi Czechoslovakia's Carpatho-Ukraine on June 29. 1945.

As the war between Germany and the U.S.S.R. progressed, Pan-Slavism was used more and more for establishing a peace according to Soviet Russia's plans through the close integration oi all Slavic nations under Moscow's leadership. Repeating the ideology of earlier Russian Pan-Slavic and Slavophile thinkers, the Communists proclaimed the Slavs as by nature inclined to "true democracy" and a perfect social order and predestined for world leadership toward an ideal peace. After the war the Communist parties in the various Slavic nations became the foremost propagandists of this new Pan-Slavism under the leadership of the U.S.S.R., the mother country of Communism and the "older brother" among the Slavic nations.

For the first time, people of Slavic descent living outside the Slavic countries as citizens of non-Slavic nations—especially Slavic immigrants in the U.S., Canada, and Latin America—were organized for the support of their Slavic "motherlands" now dominated by Communist parties. Therein, as in so many other respects. Stalinism followed the lead given by Hitlerism, when the latter organized the *Auslandsdeutsche* (people of German descent but citizens of non-German lands), to impress upon them the conviction that their primary loyalty belonged to Germany, and to transform them into agents oi German national socialism. In the U.S. a Slavic congress was created to mobilize the Anericans oi Slavic descent for the support of the policies of the Slavic "motherland." But once the nature of Communism and Pan-Slavism was understood, these subversive activities abroad on behali of Slavic solidarity quickly lost importance.

The Pan-Slavic committee in Moscow, under the chairmanship of Lt. Gen. Alexander Gundorov, called a meeting of all the various Pan-Slavic committees at Belgrade. I'ugoslavia, in July 1946. It decided to convene a Pan-Slavic congress in Belgrade, which mas opened on Dee. 8, 1946, with an address by Marshal Tito, the Communist dictator of Yugoslavia, A central Pan-Slavic committee mas elected and the Yugoslav capital was chosen as its permanent seat. At that time Tito's Yugoslavia appeared as the most promising and most faithful supporter of Stalin's Communism and Stalin's Pan-Slavism. But 18 months later, in June 1948, the open break between Tito and Stalin changed the whole situation. As the Pan-Slavism of the 19th century was frustrated by Polish opposition to Moscow's imperialism. so Yugoslav opposition to the new and more ruthless imperialism of Moscow weakened the U.S.S.R.'s Pan-Slavic propaganda, of which less and less was heard after 1948.

Danilevsky had foreseen in 1869 a confederation under Russian leadership which would include all the lands controlled by Stalin east of the Elbe and the Adriatic sea in 1946 In addition, Danilevsky expected the Straits of Constantinople and Greece also to fall under Russian control. In 1947 only British and U.S. opposition prevented this latter expectation from realization. Danilevsky also explained the necessity of including the non-Slavic speaking Magyars and Rumanians in this Slavic empire. Dostoievsky in 1881 stressed the need ior Russia to control, in addition to the Slavic lands, Asia; only then would it be able to confront the sea powers. The Communist control of China was achieved by 1949. But while the most daring dreams of 19th century Russian Pan-Slavism were thus realized in the middle of the 20th century: Pan-Slavism itself receded into the background and was replaced by a theory of Russian predominance over Slavic and non-Slavic peoples alike. Beginning in 1945. and in an ever increasing degree, all Moscow-controlled litrrnture glorified the Russian people as the fountainhcad of all cultural creativeness and the only undisputed leader in the political and social field ior all peoples—for the Slavic Ukrainians and Bulgarians as well as for the non-Slavic Uzbeks and Rumanians. Larer Pan-Slavism gave way to Pan-Russianism, anti Stalin seemed determined that the Russian language and culture should supplant the various languages and cultures of the non-Russian Slavic peoples.

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PANSY or HEARTSEASE, a favourite garden flower. one of the oldest in cultivation, belonging to the genus *Viola* of the violet family (Violaceae). It has been grown for so long a period under such diverse conditions and in such a variety of forms that its origin is uncertain. The numerous handsome forms. with their striking variations of size and colour, are purely an artificial production of the gardeners and differ in a marked degree from any related wild plant now known. The pansy is generally supposed to be merely a cultivated form of *Viola tricolor* (*see* VIOLET). a weed of European grain fields, the garden pansy hence being designated as *V. tricolor hortensis.*

The tufted or bedding pansy, called also horned violet. is a cultivated form of *Viola cornuta,* a native of Spain and the Pyrenees mountains. It difiers from the true pansy in its tufted habit of growth and in the shape and position of its flower parts. The petals. which are obovate in form, do not overlap as in the true pansy. but stand distinctly apart. The spur on the lower petal, instead oi being short and rounded, is long, slender and sharp-pointed, whence the name horned violet. There are numerous garden forms varying greatly in colour, ranging from violet to white.

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GIANT PANSY (VIOLA)

The modern varieties of the pansy consist of the show varieties and the fancy varieties, obtained from Belgium and now much improved. Show varieties are subdivided according to the colour of rhe flowers into selfs, white grounds and yellow grounds. The fancy or Belgian pansies have various colours blended, and the petals are blotched, streaked or edged. The bedding varieties, known as violas or tufted pansies, have been raised by crossing the pale-blue *Viola cornuta,* and also *V. lutea,* with the show pansies.

The tufted pansies are hardier than the true pansies and are free-blooming sorts marked by effectiveness of colour in the mass.

The garden pansy is a short-lived perennial which must constantly be renewed. It does not like summer heat and is best raised from seed in a greenhouse or frame and used for spring-bedding effects. The tufted pansies. which stand the heat better, can be grown as garden perennials. preferably in partial shade. (N. TR.)

PANTALOON (Ital. *pantalone*), a character in the old Italian popular comedy, said to represent a Venetian, from the favourite Venetian saint San Pantaleone, and transferred from it to pantomime (*q.v.*). The Italian pantaloon was always a silly

old man with spectacles and nearing slippers and his character was maintained in pantomime and also made his name a synonym for a tottering dotard. as in Shakespeare's As *You* Like It (II, vii, 158) From the Venetian usage the nord "pantaloon" (whence "pants") was also given to certain garments for the legs, the exact meaning varying at difierent times.

PANTELLERIA, an island in the Mediterranean (ancient Cossyra), 62 mi. S.W. of the southwestern extremity of Sicily and 44 mi. E. of the African coast, belonging to the Sicilian province of Trapani. Pop, (1951) 10,306. It is entirely of volcanic origin and 32 sq.mi. in area; the highest point, an extinct crater. is 2,743 it. above sea level. Hot mineral springs and ebullitions of steam still testify to the presence of volcanic activity. The island is fertile but lacks fresh water. The chief town (2,294 in 1951) is on the northwest, upon the sole harbour (fit only for small steamers), which is fortified. There is also a penal colony there. Sweet wine and raisins are exported. On the west coast, 2 mi. S.E. of the harbour, a neolithic village was situated. with a rampart of small blocks of obsidian upon the east. Within it remains of huts were found. with pottery, tools of obsidian, etc. To the southeast are tombs. known as *sesi*, similar to the *naraghi* of Sardinia. consisting of round or elliptical towers with sepulchral chambers in them, built of rough blocks of lava. Fifty-seven of them can still be traced. The largest is an ellipse of about 60 by 66 ft., but most of the *sesi* have a diameter of 20–25 ft. only. After a considerable interval, during which the island probably remained uninhabited, the Carthaginians took possession of it, occupying as their acropolis the twin hill of San Marco and Sta. Teresa, 1 mi. S. of the town of Pantelleria.

The Romans occupied the island in 255 B.C., lost it again the next year and recovered it in 217 E.C. Under the empire it served as a place of banishment for prominent persons and members of the imperial family. About 700 the Christian population was annihilated by the Arabs, from whom the island was taken in 1123 by Roger of Sicily. In 1311 a Spanish fleet, under the command of Requesens, won a considerable victory there, and his family became princes of Pantelleria until 1553, when the town was sacked by the Turks.

The strategic situation of the island in the narrow passage dividing the eastern and the western Mediterranean induced the Italian government of Mussolini to fortify the island, using its rocks and caverns for the purpose. The rocky island did not offer sufficient land for air bases; so Lampedusa (*q.v.*) was made a complementary air base. In June 1943 these installations were subjected to the most intensive air assault of World War II to that dale, when Allied bombers rained tons of bombs on the island. All buildings and fortifications were practically levelled when Pantelleria surrendered to the Allies June 11, 1943. It became the first metropolitan Italian territory occupied in World War II by the British and American forces. (T. A.; X.)

PANTHEISM (Greek ἂνπ, "all," "everything," *θεός*, "God"), thst system of philosophy which identifies God with the total universe. The term "Pantheist" was introduced by John Toland (*Socinianism Truly Stated*, 1705), who also gives its essential tenets: "All things in the world are one. What's all in all things is God" (*Pantheisticon*, 1720, part ii). This formula is wide enough to cover a number of divergent systems and historians of thought have used the term "pantheism" in different senses so that it is often difficult to determine whether a given system should be called pantheistic or not. The essential doctrines of pantheism are here taken to be: (1) monism. the assertion that the universe is one single whole of closely interconnected parts, with nothing beyond it. from which follows the denial of a transcendent deity and of creation: and (2) the assertion that this whole is either itself divine and the proper object of worship or contains some divine indwelling principle. The second alternative in this second doctrine makes it possible for a system to be pantheistic and yet, in a sense. dualistic, as for instance was Stoicism. Doubt concerning the application of the term arises in connection with such systems as Neoplatonism, in which the world is regarded as an emanation from God; or again in connection with those systems of absolute idealism which allow for a development of the Absolute, for instance Hegelianism.

It is useful to distinguish pantheism from allied systems into which it easily passes. A pantheist nho stresses the uniqueness of God and the inadequacy of phenomena to express his nature may come to regard the natural world as mere appearance (maya) and God as the only reality; this has been called acosmism. On the other hand. one may stress the self-sufficient character of the natural world and so come to deny its divinity; this is naturalism or atheism. In the following historical sketch allied as well as strictly pantheistic systems will be mentioned. The critical discussion will be concerned with pantheism in the strict sense, taking Spinozism, its most complete and logical form, as typical.

Historical Outline. — Pantheism occurs in the context of almost all religious systems. even of those which are logically inconsistent with it, as are Buddhism, tvhich is atheistic, and Judaism, Christianity and Mohammedanism, which are theistic. Two reasons for this may be suggested. In the first place, pantheism is often an attempt to intellectualize an existing religious system (*i.e.*, while preserving the religious attitude, to redirect it toward an intellectually satisfying object). The pantheist is in revolt against the crudities of polytheism or the anthropomorphic tendencies of monotheism and may be unconscious of the break with transcendentalist theology. Second, the mystic's sense of the nearness of God is expressed naturally in pantheistic terms, which thus often occur in writers who would repudiate pantheism as a system. Pantheism was officially condemned by the Roman Catholic Church in 1870.

There is a strong pantheistic strain in Indian religious thought, which reaches its full expression in the Upanishads. Brahman, the underlying principle of the universe, is identified with *atman*, the conscious mind. This single reality is known not by discursive thought but by intuition.

In China Taoism tends to pantheism, being monistic, but it is doubtful whether the Tao can be regarded as a deity. Neo-Confucianism. a conflation of Taoism and Confucianism, with some Buddhist influence, is predominantly pantheistic. Special mention may be made of Chu Hsi (1130–1200), who developed a dualistic pantheism similar to Stoicism; and of Wang Shou-jen (1472–1529), who was an absolute idealist.

Mahayana Buddhism has also had pantheistic thinkers, for instance Asvaghosa (c. A.D. 80) in India and Chih-h'ai (538–579) in China.

The religion of ancient Egypt appears to have approached pantheism via syncretism, all the gods being identified with one god, Ra, Osiris or Isis. Similarly in Babylon, the other gods were said to be names of Marduk.

The Ionian philosophers approached pantheism in seeking for one underlying principle. and Xenophanes' rejection of polytheism paved the way for Parmenides. whose pantheism is close to acosmism, since his One is immutable and particular things in some sense illusory.

The most complete system of pantheism in the ancient world is Stoicism. The Stoics were materialists but they regarded the material universe as governed by the indwelling divine λόγος (reason). In religious utterances, as in Cleanthes' famous hymn, this is identified with Zeus. The Stoics stressed the determinism that is characteristic of pantheism. Neoplatonism, as has been said, is only doubtfully pantheistic, but it had great influence on later pantheistic writers.

In the middle ages all three monotheistic religions produced pantheistic writers. Particular mention may be made of the Jewish Kabbalists, who developed the doctrine of the microcosm (important for pantheism); three Christians, Johannes Scotus Erigena (c. 815–*c.* 877), Johannes Eckhart (c. 1260–1327) and Nicolaus Cusanus (1401–64); and the Mohammedan Averroes (1126–98).

The Renaissance saw a great revival of pantheism under Neoplatonic influence. The leading figures are Pietro Pomponazzi (1462–1525), Giordano Bruno (c. 1548–1600) and L. Vanini (1581 Pantheism received its most complete expression at the hands of Spinoza (1632–77). Early in the 18th century it was professed and named by John Toland (see above), but by the

orthodox it was generally equated with atheism. It was later revived by Lessing and by Goethe, nho developed a literary cult of Spinoza. Pantheism indeed came to have a great influence on literature. Goethe and Wordsworth especially gave notable poetic expression to it.

In the 19th century nearly all German and, therefore, a great part of European philosophical thought was affected by pantheism. Friedrich Schleiermacher; the father of modern theology, was himself a speculative pantheist; and the idealist systems of Fichte, Schelling and Hegel were at least close to pantheism. Hegel influenced F. H. Bradley and Bernard Bosanquet in England and Benedetto Croce and Giovanni Gentile in Italy.

In the first half of the 20th century A. N. Whitehead and Samuel Alexander constructed philosophical systems which may be regarded as pantheistic in a loose sense. but philosophy as a whole was dominated by empiricism and positivism which are hostile to all system building. Theology developed on Thomist or extreme transcendentalist lines; and although some thinkers. for example N. Berdyaev, wrote in pantheistic terms, they would have repudiated the designation.

Critical Evaluation. — If the world is identified with God, it must be perfect. This leads to determinism on the one hand and to panpsychism on the other: to determinism, because the single perfect system allows for no alternatives and because the close interrelation of parts is itself a perfection of the whole; to panpsychism, because if any part lacked a quality that it might have, the whole would fall short of perfection. In Spinoza's system, every mode falls under all the attributes, including thought; everything is alive.

These two doctrines are themselves involved in the single theory that the parts of the whole are microcosmic; *i.e.*, that they reproduce or reflect in some degree the nature of the whole. This is the easiest way to understand Spinoza's "finite modes." The mental side of every part consists in its representation of the whole, so that a change in any one necessarily involves a change in all the others.

Objections to pantheism may be divided into philosophical and religious. The most radical philosophical objections are those of the positivists and empiricists; but as these reject the possibility of metaphysics altogether we shall not concern ourselves with them but rather consider objections peculiar to pantheism.

A strict, as distinct from an evolutionary, pantheism has great difficulty in accounting for time and change. The strict pantheist appears to be right in insisting that the whole, if it is to be called God, must be eternal (*i.e.*, complete at any time); but at the same time he cannot deny the reality of change without falling into acosmism. Spinoza maintains that Substance (God) does not change. although its parts do. It is difficult to interpret this.

It has been objected that the pantheist has a peculiar difficulty in accounting for evil. for all things being manifestations of God, all should be equally admirable. But the pantheist is in no worse position than the theist on this point. Both must take refuge in the view that, although the distinction of good and evil holds within the whole, the whole itself is good, whether because it is God or because it is the creation of God. Alternatively the pantheist may maintain more logically that the whole is beyond the distinction of good and evil. It would be inappropriate to commend it; the proper attitude is worship.

It has been said that pantheism makes nonsense of moral distinctions and the idea of duty. This has been maintained on two grounds: first, that pantheism is deterministic; and second, that it makes the distinction between good and evil illusory. The first difficulty, which is not peculiar to pantheism, will not be treated here. To the second point, the pantheist might reply that moral distinctions are in fact subjective or at any rate relative to human needs. Spinoza is at times content with this reply and gives a frankly subjectivist definition of "good"; but the outline of another answer, which makes morality intrinsic to his pantheism and objective, can be found in his writings. He defines "blessedness" as "the knowledge which the mind has of its union with the whole of nature" (*De Emendatione intellectus*). This is the highest human state in the sense that a man in this state resembles God as closely as it is possible for a mode to do. Moreover: Spinoza claims to show that blessedness is causally connected with the ordinarily recognized human virtues (prudence: temperance, benevolence) so that a purified common-sense morality can be based on his metaphysical system.

Religious objections to pantheism are summed up in the charge that it denies personality to God. The religious consciousness, it is said, can be satisfied only by a personal object. Spinoza frankly admits that his God is impersonal. The *amor intellectualis Dei* is quite different from the emotion felt toward a person, and it is irrational to ask that God should love us in return.

In summing up. it may be said that pantheism as a mood is something recurrent in human nature which will always find poetical and other expression. As an intellectual system, it suffers from the defects of extreme monism. As a religion, it will appeal to the very few who combine strong religious feeling with a high degree of intellectual austerity.

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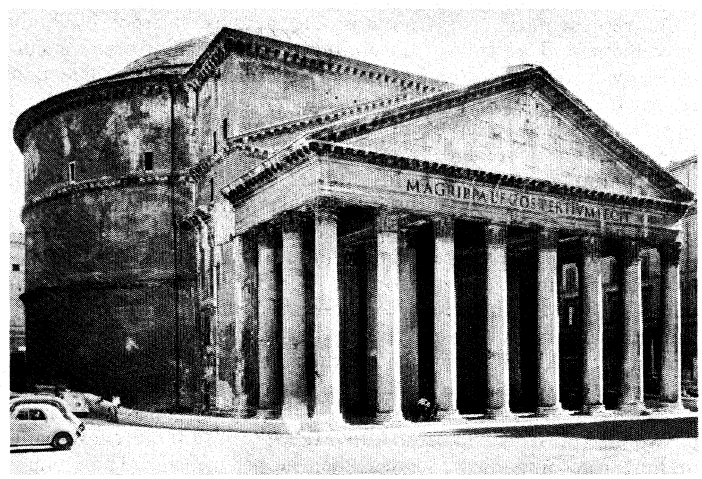
PANTHEON, a building for the worship of all the gods revered in a certain locality: hence a building where famous men are buried, or a structure built to commemorate a number of national heroes.

Specifically, pantheon is the name of three famous buildings, one of which is in Athens, one in Rome and one in I'aris. The Athenian pantheon, less well known than the other two, was constructed by the Roman emperor Hadrian. The Roman pantheon nas begun by Agrippa in 27 B.C., probably as a rectangular building of ordinary temple type. It was completely rebuilt by Hadrian. in its present circular form (*c.* 120), the columns of the present front porch being probably those of the earlier building. Under Septimus Severus repairs and alterations were made: it is likely that at this time the rectangular coffers were cut on the inside face of the dome. The Roman pantheon is remarkable not only for its size, the dome being 141 ft. in diameter. and for its elaborate brick construction: hut also for its perfect preservation and the fact that for almost 2.000 years it has served continuously as a place of worship, having been dedicated in A.D. 609 as the church of Sta. Maria Rotunda. The gilt bronze tiles that once covered the dome were stripped off and carried to Constantinople at an early date, and in the 17th century the bronze trusses and girders which carried the portico roof were melted and used to



FEDERICO ARBORIO MELLA

PANTHEON IN ROME. BEGUN BY AGRIPPA (27 B.C.) AND COMPLETELY REBUILT BY HADRIAN (*c.* A.D 120). IT IS NOW KNOWN AS THE CHURCH OF STA MARIA ROTUNDA

make Bernini's baldachin in S. Peter's at Rome. The present stucco panels and pilasters that circle the interior above the order cornice and below the spring of the dome are of late Renaissance date, and the bronze rosettes and moldings that once decorated the coffers have disappeared. Otherwise, the interior of the building exists in its exquisite original form.

The pantheon at Paris was begun in 1764 by J. G. Soufflot as the church of Ste. Geneviève. This was secularized under the Revolution and then received its present name—*panthéon*. It served as a church, also, in 1828–30 and in 1851–70. The *panthéon* at Paris bears little resemblance to the Roman example. It is a cruciform building with a high triple dome over the crossing and the four arms vaulted with lower saucer domes on pendentives.

PANTHER, another name for the leopard (*q.v.*), also used in America as the name of the puma (*q.v.*). The panther was formerly supposed to be a distinct animal from the *pardus,* pard, the leopard. In modern times a distinction has been unscientifically drawn between a larger type of leopard, to which the name panther was given, and a smaller and more graceful specimen.

PANTODONTA. The first archaic ungulates to attain large size belong to this extinct order of hoofed mammals. *Pantolambda* of the mid-Palaeocene attained the dimensions of a sheep, and late Palaeocene genera, such as *Barylambda,* ranged up to eight feet in length. Representatives are known from North America, Europe and Asia. The history of the group extends from the mid-Palaeocene to mid-Oligocene. During this time, three families were diiferentiated to produce a highly varied array of ancient herbivores. Primitively?as in *Pantolambda,* molar teeth were triangular. but in more advanced forms, as *Coryphodon* of the Eocene, a unique pattern of cross-lophs had developed. Most genera possessed stout limbs terminated by hoofed feet. *Sparactolambda*, of the late Palaeocene, however, had developed claws, presumably associated with a root-eating mode of life. Although a trend toward large size was universal within the order, strong structural diversity is found in the different families.

Pantodonts, uintatheres and periptychids have been variously grouped together in orders termed Amblypoda and Taligrada. Such relationships, however: have been shown to be spurious. Periptychids are closely related to condylarths, and the pantodonts and uintatheres have only a remote common ancestry, probably among the protoungulata. (E. C. O.)

PANTOMIME. The primary meaning of *pantomimus* is "he who plays every role" or "imitator of all persons and of all things." During the Roman empire the term referred to a theatrical entertainer who by means of gestures and body movements alone acted out a mythological story while successively portraying each character in the plot. The entertainment itself was also called a pantomime. Early in the 18th century the word pantomime began to be used in England to designate dramatic ballets on mythological themes or outright harlequinades.

As representation of emotions and actions entirely by body movement and gestures, pantomime occurs in all primitive cultures (war dances, animal mimicry, sacrificial rites). The first recorded pantomimist was the legendary dancer Telestes, whom Aeschylus is said to have employed in his production of the *Seven Against Thebes (467* B.C.).

In Rome, pantomime came into its own during the Augustan age. In *22* B.C. two pantomimists won public acclaim, Pylades of Cilicia, who specialized in tragic subjects, and Bathyllus of Alexandria, who traded in lighter fare. Both artists were *pantomimi* in the original sense of the word; *i.e.,* they acted out in dumb show a continuous fable and played all the parts in it. By changing his masks several times during a performance Pylades played the roles of Dionysus, Pentheus, Cadmus and Agaue when he recreated the story of Dionysus' coming to Thebes. On another occasion he would now be Atalanta, and a moment later he would transform himself into Meleager. 4 large chorus and orchestra accompanied Pylades when he performed. The Roman pantomimist also needed the services of a writer who furnished him with a scenario; Lucan and Statius were among the authors of such *fabulae salticae.* Most Roman emperors became involved in the affairs of the leading pantomimists of the day. Later in the Christian era patristic denunciations of these dance spectacles offer ample proof of the continued thriving existence of pantomime shows.

In the meantime, the strongest defense of pantomime had come from Lucian of Samosata *(c.* A.D. *125–c.* 190), whose dialogue *De saltatione* contains a dithyrambic praise of dumb shows. Lucian stated the qualifications expected of a first-rate pantomimist: the prerequisites were a sound knowledge of music and mythology. a prodigious memory, extraordinary sensibility and a perfectly proportioned body that combined athletic strength and suppleness of limb. Lucian gave a long list of pantomime subjects, ranging from the origin of the world to the times of Cleopatra. Aside from Lucian there were other champions of pantomime, but no other treatise had the influence Lucian's dialogue was to have on future dancing masters, and it mas the *De saltatione* that provided the inspiration for the introduction of pantomime into England. Another impetus, however, must also be considered, that of the Italian *comnzedia dell' arte* (*q.v.*). The strolling players of improvised comedy developed a body language that had universal significance and could be understood outside Italy, in France as well as in Poland, in Vienna as well as in St. Petersburg. Their comedies abounded in situations that had to be explained and exploited in terms of dumb show.

John Weaver, dancing master of Drury Lane, must be credited with having taken to England the idea of staging pantomimes after the manner of the Italians as well as of the ancients. According to Weaver,

> . . . the first Entertainment that appeared on the English Stage, where the Representation and Story was carried on by Dancing, Action and Motion only, was performed in Grotesque Characters. after the Manner of the Modern Italians, such as Harlequin, Scaramouch &c. and was called The ***Tavern*** Bilkers.

This pantomime was invented by Weaver and first performed in Drury Lane in *1702.* Weaver's second attempt at reviving pantomime was made at the same theatre in 1716 when he produced *The Loves of Mars and Venus* "in imitation of the ancient Pantomimes." However. what Weaver was reviving was not the art of Pylades or Bathyllus: his Drury Lane spectacles were actual ballets in which several performers were featured, in contrast to the one-man shows of the Roman pantomimists. Yet the term pantomime persisted! and Londoners were seized by a mania for these mute entertainments, especially when they were staged by John Rich (*q.v.*) at the Lincoln's Inn Fields theatre. Rich, unable to compete with Drury Lane in the field of legitimate drama, staked his fortune on pantomime. He selected a serious classical fable and combined it with a grotesque *commedia* story about Harlequin and his beloved Columbine. Rich himself, under the stage name of Lun, danced the role of Harlequin and executed with his magic wand as many transformation scenes as the budget would allow. Later, the mythological pretext was discarded, and the pantomimes became pure harlequinades. In the 19th century Harlequin went out of fashion; and Joseph Grimaldi's (*q.v.*) clown stepped in. These pantomimes became elaborate fairy-tale fantasies that still delight English audiences at Christmas.

In France, Jean Georges Noverre (*q.v.*) is often cited in connection with pantomime, and, to be sure, in his *Lettres sur la danse* (first edition, Lyon, 1760), echoes of Lucian may be heard. But actually Noverre belongs not to the history of pantomime but rather to the history of the ballet. He reached his apogee as a choreographer when he staged his *ballets d'action* for the court of Wiirttemberg (1760–67) on such themes as Alceste, the death of Hercules, and Medea. Lucian would have approved of these subjects but would have been disappointed by the fact that the various characters in any given myth were danced by a host of solo dancers rather than by one man. In the 19th century Parisians made pilgrimages to the obscure Théâtre des Funambules where Jean Gaspard Deburau (1796–1846) had created the character of the white-faced, white-robed, melancholy Pierrot. Deburau founded a tradition that is still alive in France: Marcel Marceau, the great pantomimist of modern times, is a true "imitator of all persons and of all things." In the hands of Marceau, pantomime again became a one-man show, Marceau being David at one moment and Goliath the next.

See also BALLET; CLOWN; HARLEQUIN; MIME.

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PANTOPODA, an alternative name for Pycnogonida (*q.v.*), an aberrant group of spiderlike marine arthropods.

PANTUN, a Malay verse form, usually a quatrain, rhyming abab, as in the following example:

Dari mana punai mēlayang;
Dari paya turun kē-padi.
Dari mana datang-lah sayang;
Dari mata turun kē-hati.

The pantun, like all traditional Malay verse, is essentially a word verse, not to be divided into feet or scanned; each line contains four (rarely three) "full" words (*i.e.,* not counting particles or affixes). The first two lines (the "skin") have little or no connection in meaning with the last two lines (the "fruit" or "contents"). There is, however, a close connection in sound: just as the skin suggests, yet hides, the fruit, so do the first two lines of a pantun suggest, in sound, the content of the last two lines. As in the example quoted, there should be not only end rhyme (*"mēlayang"* with "sayang," *"padi"* with *"hati"*) but as much sound correspondence between the two halves of the pantun as possible (*e.g.,* vowel correspondence between *"paya"* (line 2) and "mata" (line 4), often resulting in repetition (*e.g.,* "Dari mana" in lines 1 and 3). R. J. Wilkinson's free translation of the above pantun:

The fate of the dove is to fly;
he flies to his nest on the knoll.
The gate of true love is the eye;
the prize of his quest is the soul.

reproduces well the internal rhymes characteristic of a good pantun.

The pantun first occurs in Malayan literature of the 16th century, but is probably much older. In view of the theory that the Austronesian (Malayo-Polynesian) racial group came from Yunnan (in southern China), it is interesting that some of the earliest Chinese poetry, in the Shi-King ("The Book of Odes"), resembles the pantun Again, as the Malays have been strongly influenced by the civilization of India, the pantun may have been influenced by the *çloka*—one of the most popular of the Sanskrit quantitative metres. However, the existence of pantunlike verse forms in Tibet (the *gtang-thung-bzhad*), Turkey (the mani), Norway (the *gamlestev*), Latvia (the *daina*) and Spain (the copla)—all, like the pantun, types of folk verse—shous that similarity of form need not indicate derivation. In fact, as a pantun-type verse is to be found not only in Malay but in many other branches of the western or Indonesian division of the Austronesian linguistic group (*e.g.,* the Batak *umpama,* the Javanese *parikan,* the Malagasi *hain-teny*), there seems no reason to suppose that the pantun is not an indigenous form.

Although considered somewhat old-fashioned (partly in reaction against the traditional Malay appreciation of a pantun more for the number of sound-correspondences between the two halves than for depth of feeling). the pantun is by no means dead. Informal parties often end with the singing of literary pantuns to a guitar, and literary pantuns appear in newspapers and periodicals.

Pantuns are sometimes linked together, with the second and fourth lines of the first verse becoming the first and third lines of the second verse, and so on. It seems to have been these linked pantuns which inspired Victor Hugo to produce a chain verse nhich he called *"un pantoum ou* chant *malais,* d'une *délicieuse originalité."* His example was followed by Theodore de Bainville and Leconte de Lisle. In English. Austin Dobson's poem "In Town" is a pantunlike chain verse that completes the circle by making the last line of the last verse identical with the first line of the first verse,

See W. A. Braasem, *Pantuns* (1950); *R.* J. Wilkinson and R. O. Winstedt, *Pantun Melayu,* and ed. (1955). (CL. S.)

PAN-TURANIANISM, a movement to unite in a political and cultural union all the Turco-Tatar peoples living in Turkey, southeastern Russia, Transcaucasia, Siberia and Turkestan. The last-named area is called in Persian Turan, the land to the north of Iran. The name Turanian for the Turco-Tatar family of languages was first used by the Magyars of Hungary. The Hungarian language belongs to the Finno-Ugric group of languages which are related to the Turkish languages, and in the half-century before World War I some Magyars wished to base upon this affinity of languages a common front of the Turks and Magyars against the Slavs and Pan-Slavism (*q.v.*).

Of greater importance was a similar 19th- and 20th-century trend to oppose a unity of the Turks in Turkey and of the Turco-Tatar peoples of the Russian empire against the growing Russian tsarist and communist domination. In 1878 Ismail Gasprinski (1841–1914), a Crimean Turk, proclaiming the "unity in language, thought and action" of all the Turkish-speaking peoples in the Russian and Ottoman empires, started in the Russian Crimea the Turkish newspaper *Tercüman.* In 1911 Yussuf Aktshura Oghlu founded in Constantinople (Istanbul) a similar paper. *Türk Yurdu* ("The Turkish Homeland" j. At the same time prominent Turkish writers such as Ziya Gokalp (1875–1924) and Halidé Edib Adivar (1883–), author of the novel *Yeni Turan* ("The New Turan." 1912). glorified the common legendary past and the future of the Turkish race. For Gokalp, "the Fatherland of the Turks is not Turkey, it is not Turkestan, it is the far-flung and everlasting land — Turan." The Pan-Turanian writers hoped for the rebirth of heroic types of Attila and Jenghiz Khan evolved into civilized men. Their symbol was a she-wolf (*Bozkurt,* or gray wolf) regarded as the mother of the race and worshiped before the conversion to Islam.

During the years 1913–18 when Turkey was involved in a bitter struggle with Russia, Pan-Turanian propaganda was officially promoted by the Ottoman government. In the 1920s and 1930s Kemal Attatiirk's realism de-emphasized the movement and confined Turkish nationalism to Turkey itself. World War II, with its revival of Pan-Slavism under Stalin and its Russian threat to Turkey, brought a renewed, though slight, interest in Pan-Turanianism among some Turks. The demand for a federation of Turanian states continued after World War II among the Turkish-speaking Islamic peoples in the U.S.S.R. Emigré groups of these peoples living in Turkey, Germany and Pakistan carried on an active propaganda for the realization. in some form; of the Pan-Turanian ideal. See also TURKS OR TURKIC PEOPLES; TURKEY: KAZAKHSTAN; UZBEKISTAN and other articles concerning the Turkish-speaking areas of the U.S.S.R.; NATIONALISM.

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PANYASIS (more correctly, PANYASSIS j, of Halicarnassus, Greek epic poet, uncle or cousin of Herodotus, flourished about 470 B.C. He was put to death by the tyrant Lygdamis (*c.* 454). His chief poems were the *Heracleias* in 14 books, describing the adventures of Heracles in various parts of the world, and the Ionica in elegiacs, giving an account of the founding and settlement of the Ionic colonies in Asia Minor. Although not much esteemed in his own time, some later critics assigned him the next place to Homer (see Quintilian, *Inst. orat.* xi, 54).

Fragments in G. Kinkel, *Epic. poet, fragmenta* (1877). ed. separately by J. P. Tzschirner (1842); F. P. Funcke, *De Panyasidis vita* (1837); *R.* Krausse, *De Panyassidé* (1891).

PANZINI, ALFREDO (1863–1939), Italian novelist and essayist, was born in Senigallia, Marche. Italy, Dec. 31, 1863. He was educated at Venice and at the University of Bologna,

where he studied under the poet Giosue Carducci. He contributed frequently to magazines in the next years, particularly to the *Corriere della Sera* and the *Nuova Antologia*. In 1893 he published his first book, *Il Libro dei Morti*, and was thus launched in earnest on his career as a writer. He wrote prolifically from that time until his death: his works including chiefly novels, essays and short stories.

His two most popular novels were La *Laterna di Diogene*, an autobiographical account of some of his travels, and *Santippe*, a story oi Socrates from the point of view of his wife. He also achieved some success with *Viaggio di un Povero Letterato*, *Il diavolo nella mia libreria* (1920) and *Io cerco moglie*, the last of which was the only one of his works translated into English. He also compiled a *Dizionario moderno*, which became widely known and used. In addition to his writing, Panzini taught for many years, first at Milan and later at Rome. When the Italian Royal academy was founded, he was chosen one of the first members. He died April 10, 1939.

PAOLI, PASQUALE (1725–1807), Corsican general and patriot, was born at Stretta in the parish of Rostino. He was the son of Giacinto Paoli, who had led the Corsican rebels against Genoese tyranny. Pasquale followed his father into exile, studied at Naples under the reformer Genovese and entered the Neapolitan army, serving with distinction as a cavalry officer; on his return to Corsica in 1755 he was chosen commander-in-chief of the rebellion against Genoese rule. After a series of brilliant actions he drove the Genoese from the whole island except a few coast towns.

From 1757 to 1768 he was the head of the Corsican government; he completely reorganized the administration, introduced many useful reforms and founded a university at Corte. In 1764 Genoa concluded a treaty with France, whereby 3,000 French soldiers were sent to assist the Genoese to hold the fortresses, but only for defensive purposes. Paoli continued the struggle, wrested the island of Capraia from the Genoese and captured the towns where there were no French troops, since the Corsican revolutionaries did not consider themselves at war with France. But in May 1768 Genoa, despairing of ever being able to subjugate the island, sold it to France, and the French forces in the island were at once greatly increased.

Paoli now fought against the French, whom he defeated in many hard-fought battles. But with the further increase of the French forces the Corsican resistance gradually broke down, until in May 1769 Paoli had to abandon Corte, the capital, and take refuge in England. During his sojourn in London he enjoyed wide popularity and was the friend of many celebrities, including Dr. Johnson. On the outbreak of the French Revolution the government allowed the Corsican exiles to return, and after visiting Paris, Paoli landed at Bastia in Jan. 1791, with the rank of lieutenant-general and governor of Corsica. He resumed his work of reform and development, enjoying wide popularity, and when the republic replaced the monarchy in France he was confirmed in his appointment.

But he had enemies in Corsica itself, who accused him of reactionary sentiments and of responsibility for the defeat of the French expedition to Sardinia. He was deprived of his command by the convention, and a commission was sent to the island to hold an enquiry on his conduct. The commissioners set up a government of their own, side by side with that of Paoli, who was supported by the majority of the islanders. Anarchy ensued, and in July 1793, Paoli was outlawed. A civil war broke out between Paoli and his followers, assisted by British forces, and the Republicans, assisted by the French. The latter were finally defeated and the French forced to surrender; a *consulta* at Corte decided to place the island under British protection and drew up a constitution, and although Paoli was not too favourable to the British protectorate, he ended by accepting it.

The British government, instead of appointing Paoli viceroy, as had been expected, appointed Gen. Sir Gilbert Elliot, who relied upon another Corsican, Pozzo di Borgo, rather than on Paoli, and eventually got Paoli out of Corsica by having him summoned to London, where he went in 1795. This created a good deal of ill feeling, and rebellions broke out all over the island; the movement received support from the French, and the British were driven out. Paoli again had a very cordial reception in London and was awarded a pension from the British government. He died in London on Feb. 5, 1807.

See Boswell's *Life of Johnson* and his *Account of Corsica and Memoirs of P. Paoli* (1768); N. Tommaseo, "Lettere di Pasquale de Paoli" (in *Archivio storico italiano*, 1st series, vol. xi), and *Della Corsica*, etc. (*ibid.*, nuova serie, vol. xi, parte ii); Pompei, *De l'état de la Corse* (1821); Comte de Buttafuoco, *Fragments pour servir à l'histoire de la Corse de 1764 à 1769* (Bastia, 1859); Giovanni Livi, "Lettere inedite di Pasquale Paoli" (in *Arch. stor. ital.*, 5th series, vol. v and vi); and Lencisa, P. *Paoli e la guerra d'indipendenza della Corsica* (1890); Bartoli, *Historia di Pascal Paoli* (Bastia, 1891).

PAOLINI, PIETRO (1603–*c.* 1682), Italian painter, was born at Lucca, Italy, in 1603. He studied under Angelo Caroselli in Rome, where he spent most of the rest of his life. After his return to Lucca, however, he painted for the Church of San Michele there one of his best-known works, "The Martyrdom of St. Andrew." He also founded an academy at Lucca. He may have been the inventor of the camera lucida, an instrument for projecting views scaled to proportion on paper, so that they may be traced.

PAOLO, GIOVANNI DI: *see* GIOVANNI DI PAOLO.

PAOLO VERONESE: *see* VERONESE, PAOLO.

PAO-T'OU (PAOTOW), industrial city of the Inner Mongolian Autonomous Region, China, on the Yellow river, 230 mi. west of Peking. Pao-t'ou owed its initial importance as a trade centre to the construction of the Peking–Pao-t'ou railroad in the 1920s. The city became a collecting and distributing centre of a large part of Suiyuan province, shipping wool and hides to processing plants on the coast, and importing tea, cloth and other necessities. Pao-t'ou was occupied by the Japanese from 1937 to 1945.

Under the Communist regime, after 1949, Pao-t'ou was selected as the site of one of China's three huge steel plants, the two others being at An-shan and Wu-han. Construction on the steel plant and associated industries began in the mid-1950s and soon transformed the former placid caravan centre into a bustling industrial site. Railroad lines were laid to the Pai-yün-o-po iron mine, 90 mi. to the north, and the coking-coal mines of Shih-kuai-kou (Shihkwaikow), just northeast of Pao-t'ou. The main Peking–Pao-t'ou railroad was extended to Lan-chou (Lanchow) in 1958. In 1954, the city, together with all Suiyuan province, passed to Inner Mongolia. Pao-t'ou's population was 149,000 by the 1953 census, but spurred by industrial construction and expansion had considerably increased by the early 1960s. (T. SD.)

PAPACY, the headship of the Roman Catholic Church as represented in the persons of the successive popes, or bishops of Rome. The papacy is the only institution that has existed continuously from the early Roman empire. Its activities, its influence and its claims have varied and developed and have been challenged and combated; its fortunes and prestige have waxed and waned many times. Local yet world-wide, it has always based its pronouncements upon tradition while it has taken its colour from the Present; flexible in choice of means, in all the changes of social and political sentiment it has remained uncompromisingly monarchical. There have been many great and saintly popes; many nonentities and not a few worthless or bad; but the office has always been greater than the man, and it survives. In addition to the historical survey below, *see* VATICAN, THE and the biographies of individual popes under their names throughout the encyclopaedia. (M. D. K.)

This article is divided into the following sections, at the end of most of which there is a bibliography (for the bibliography of sections VIII and IX *see* section X):

I. The First Six Centuries
II. The Rise of the Medieval Papacy
III. The Papacy in Avignon, Till 1378
IV. The Great Schism, 1378–1417
V. The Early Renaissance Papacy, 1417–92
VI. The 16th Century
VII. The 17th and 18th Centuries
VIII. The Restoration
IX. The Rise of Democracy and Rationalism
X. The Papacy in the International Crisis, From 1914

I. THE FIRST SIX CENTURIES

St. Peter.—The history of the papacy begins at the point when Jesus left his apostles. St. Peter, by virtue of the words spoken to him by Christ (*Tu es Petrus* . . ., "Thou art I'eter," etc., Matthew xvi. 18–19; *cf.* John xxi, 1 j) and as a natural consequence of the role that he had already begun to play among his colleagues, can be seen to occupy a pre-eminent place from the beginning. Peter, James "the brother of the Lord" and John "the beloved disciple" are called "the pillars of the Church" in the Acts of the Apostles. But if James, as "brother" of Jesus, appears to be the leader of the Jerusalem Christians, it is nevertheless Peter whose influence predominates in the newborn church; Peter is the head of the church.

Peter is seen as taking the initiative and as the person to whom all questions that arise are addressed. It was Peter who introduced the first uncircumcised member into the Christian community, namely the centurion Cornelius. Though subsequently Peter's temporary abstention from sitting down at table with the gentile Christians at Antioch showed him less resolute than St. Paul, he soon let Paul reconvince him of Christian freedom; and Paul's very anxiety to persuade Peter shows that he recognized the weight of Peter's authority in the government of the church.

Further, Peter's first journey to Xntioch, the details of which are unknown. is evidence of a missionary activity far beyond the original Palestinian limits of Christianity; and we are entitled to infer from his letters to the faithful of Pontus, of Bithynia, of Cappadocia and of Macedonia (as interpreted by Origen, whose observations have been preserved in Eusebius) that his apostolate took him not only to Antioch but into these regions as well. There is even better evidence for his having visited Corinth. Dionysius, bishop of Corinth in the 2nd century, states expressly that his see owed its origin to the apostles Peter and Paul.

Both apostles died as martyrs in Rome, during the persecution under Nero. There is no reason, however, to suppose that they had been working there together or that their martyrdoms took place at precisely the same time.

Though his having been in Rome is in Peter's case even less explicitly attested than in Paul's, the evidence is nevertheless such as cannot seriously be called in question. That the Prince of the Apostles was in fact in Rome seems to be established beyond all reasonable doubt (1) by indications in the writings of the Roman priest Gaius (late in the 2nd century); (2) by the lists of bishops of the Roman church; (3) by the evidence of Irenaeus of Lyons (*c.* A.D. 180) and of Dionysius of Corinth; (4) by the invaluable testimony of the Asiatic bishop Papias (early in the 2nd century); (j) by a letter from St. Ignatius of Antioch to the Christians of Rome under the emperor Trajan and by one from St. Clement of Rome to the Christians of Corinth *c.* A.D. 9*j*; (6) by a passage in the First Epistle of St. Peter, if we interpret it according to its natural sense; and (7) by archaeological evidence, in particular by the discoveries made under the *confessio* in the basilica of St. Peter, in Rome, in the 1940s. Peter's stay in Rome may not have been very long, if he arrived there only at the close of his career; but it was enough to fix the centre of the Christian church in what was then the capital of the Roman empire.

We cannot say how long Peter had been in Rome when the first persecution of the young church broke out. In A.D. 64, when several quarters of the city were destroyed in a great fire, public opinion almost unanimously (and perhaps rightly) suspected the emperor Nero of having started the conflagration in order to clear the ground for an extension of his palace. To divert this suspicion. Nero formed the idea of blaming the Christians. who could be represented as the enemies of humanity because of their austere way of life. All who could be found ("a vast multitude") were put to death with atrocious tortures, and Peter was one of the victims.

The Early Successors of St. Peter.—Of Peter's first two successors only the names are known, Linus and Anacletus. The third, however, stands out more clearly. This was St. Clement, whose letter to the Christians of Corinth, written to settle a controversy among them, is still extant. While its tone is one of charity rather than of authority, this letter shows that the bishop of Rome considered himself empowered to intervene in the affairs of another community; and the fact that his letter was soon regarded as having almost canonical status is evidence of the Roman bishop's prestige throughout the whole of Christendom.

*TABLE I.— Popes of the rst and 2nd Centuries**

?–?	Peter (d. between A.D. 64 and 67)	125–136	Telesphorus
67– 76 or 67– 79	Linus	136–140	Hyginus
76– 88 or 79– 91	Anacletus	140–155	Pius I
88– 97 or 92–101	Clement I	155–166	Anicetus
97–105 or 101–105	Evaristus	166–175	Soter
105–115 or 109–119	Alexander I	175 189	Eleutherius
115–125	Sixtus I (Xystus)	189–199	Victor I

*The dates given in this table are not entirely certain.

Little is known of the first successors of St. Clement, though we are better informed on the series of bishops of the Roman church than on that of any other. In Rome alone is the episcopal succession traceable without interruption back to its apostolic founder. While their dates remain uncertain, we know that Clement was followed in turn by Evaristus, by Alexander I, by Xystus (Sixtus I) and by Telesphorus (all bearing names of Greek origin), during the reigns of the emperors Nerva, Trajan and Hadrian. Telesphorus is rather better known than the others because of his martyrdom, which took place either in Hadrian's reign or under Xntoninus Pius. The next bishop, Hyginus, and his successor Pius I were put to death under Antoninus. Xnicetus, who succeeded Pius, received the visit of St. Polycarp, the famous bishop of Smyrna, who made a point of visiting the city recognized as the see of the apostle Peter (A.D. 154). It was during the next pontificate, that of Soter, in Marcus Xurelius' time, that the story of the miracle of the thundering legion (alleged to have been saved from annihilation at the hands of the Quadi by a storm sent in answer to the prayers of Christian soldiers) began to obtain currency. Eleutherius, who had been deacon under Anicetus, became pope in succession to Soter before the death of the emperor Marcus Aurelius (180). It was he who received the letter from Dionysius of Corinth, already cited as a link in the chain of evidence for St. Peter's having been to Rome. It was likewise during this pontificate that St. Irenaeus came to Rome as the delegate of the church of Lyons, which in this period was much respected for the number of its martyrs; and Eleutherius was requested to give a ruling on the question of Montanism, with regard to which the Lyons Christians asked him to show mercy to the erring while not compromising with error. His pontificate lasted until 189, nine years after the accession of the emperor Commodus; but it was only after Victor I (189–199) had succeeded Eleutherius as pope that Commodus granted a pardon to the Christian convicts in the Sardinian mines. This was the beginning of an improvement. precarious but nevertheless undeniable, in the church's relations with the state under the last of the Xntonine emperors. (See Table I.)

Victor I.—Under Victor the activity of the Roman see became prominent to an extent hitherto apparently unprecedented but for St. Clement's intervention in the affairs of Corinth. His pontificate, indeed, may be regarded as typical of certain aspects of papal history. Greek ceased to be the single official language of the Roman church, and Latin began gradually to take its place. Victor himself, who seems to have been of African origin, wrote in Latin; and this shows the progress made by Latin in the Roman Christian community, which had previously been Greek or oriental rather than Latin in complexion. The spread of Latin influence, moreover, is to be discerned also both in the development of ecclesiastical organization (a number of synods met in Rome to deal with the problem of the heretic Theodotus and with the controversy about Easter) and in that of the Roman church's relations with other churches (several of these merged at the request of the bishop of Rome). In short, this pontificate constitutes an epoch. and it is true to say that with Victor I. far more than with any of his predecessors, the actions of the bishop of Rome were the actions of a pope.

The Schism of Hippolytus.—The next pope, Zephyrinus (*c.* 199–21;), and his successor Calixtus I (Callistus. 21; or 218–222), who is thought to have formerly been his chief deacon. were confronted with the opposition of the priest St. Hippolytus. the first member of the Roman clergy to produce a theologicophilosophical

work on dogma. Hippolytus was a passionate champion of the doctrine of the Logos, emphasizing the distinction of the Persons of the Trinity in contrast with the "modalist" view, which stressed the unity of the Godhead. Blaming Zephyrinus for not declaring himself in favour of the Logos doctrine as then formulated, Hippolytus started a schism; and on the death of Zephyrinus he and Calixtus were rival candidates for the succession. Hippolytus, unwilling to submit to Calixtus, found himself with no choice but to set himself up as an antipope. His reputation as a scholar and his literary talent were assets to his cause, yet the church preferred Calixtus, a mere freedman of far less education, but a good spokesman of the faith, a strong character and an able administrator. It was Calixtus who moved the official burial ground of the Roman Christians from the vicinity of the Via Salaria to that of the Via Appia, to the site known subsequently as "the Cemetery of Calixtus" (though he was himself not buried there) and eventually as "the Cemetery" without further epithet.

The schism of Hippolytus lasted for several years, but came to an end when persecution brought the opposing leaders together. Under an edict of the emperor Maximinus Thrax (Gaius Julius Verus Maximinus), both Hippolytus and the second successor of Calixtus, namely Pontianus (230–235), were deported to Sardinia. There a reconciliation took place, and Hippolytus was honoured as a martyr.

Calixtus, however, had previously had to face another charge, on the ground of his alleged laxity, insofar as he had mitigated the rigour of penitential discipline. On this point Hippolytus had the support of Tertullian; but the Roman inclination to mercy eventually prevailed throughout the church. Arguments have been advanced to indicate that it was in the course of this controversy that the bishop of Rome first claimed primacy of jurisdiction over the other bishops, the claim having been suggested to Calixtus by Tertullian's protest against his use of the words *Tu es Petrus* as a justification for assuming authority over the church. These arguments, however, are quite arbitrary, as the memory of the apostle Peter had been kept continuously alive in Rome, and the Roman see would not have needed an African theologian to apprise it of the special Petrine authority which it enjoyed because of the *Tu es Petrus*.

Anyhow, the fact that men such as Hippolytus and Tertullian made such forceful attacks on Roman bishops accused of laxity in the defense of doctrine or of morality constitutes a tribute to the authority which those bishops exercised and which, in the opinion of some critics, they were jeopardizing. A further tribute, contemporary with the formulation of these protests, was Origen's journey to Rome to visit Pope Zephyrinus. He was one of the many who could not resist the attraction of the centre of ecclesiastical life in the Christian world.

In Rome, Origen of course made the acquaintance of Hippolytus and even heard him deliver a homily. This was before Hippolytus went into schism, which did not happen till the pontificate of Calixtus. Calixtus died in 222, in the reign of the emperor Alexander Severus, during a period of peace between church and state (though he is reckoned among the martyr popes). He was buried on the Via Aurelia, far from the official cemetery, perhaps near the spot where he lost his life in some riot.

Calixtus was succeeded by Urban I, who was pope from 222 to 230. According to the *Liber Pontificalis* this pontificate was marked by the institution of the 25 presbyteral ***tituli,*** that is, of the 25 principal churches in Rome; but since there is no corroboration of this statement from any other source, it remains open to doubt.

Urban's successor Pontianus, as has been said, was swallowed up, together with Hippolytus (still in his role of antipope), in the persecution under Maximinus Thrax, which brought about their reconciliation. Condemned to the mines of Sardinia, they both died there after making their peace, Hippolytus exhorting his supporters to unite with the rest of the faithful. Their bodies were brought to Rome and buried there: Pontianus' in the Cemetery of Calixtus, in the popes' crypt; Hippolytus' on the Via Tiburtina.

Anteros, elected to the papacy while the deported Pontianus was still alive (235), was himself soon prosecuted and sentenced to death; Pontianus survived him for a time before succumbing to the strain of work in the Sardinian mines. *(See* Table II.)

TABLE 11.— The Papacy From Zephyrinus to Miltiades

c. 199–217	Zephyrinus	254–257	Stephen I
217/218–222	Calixtus I	257–258	Sixtus II
217/218–235	*Hippolytus, antipope*	259–268	Dionysius
222–230	Urban I	269–274	Felix I
230–235	Pontianus (d. in exile)	275–283*	Eutychianus
235–236	Anteros	283–296*	Gaius
236–250	Fabian	296–304*	Marcellinus
251–253	Cornelius	*c.* 308–*c.* 309	Marcellus I
251	*Novatian, antipope, expelled* (d. *c.* 258)	309 (310?)	Eusebius
253–254	Lucius I	311–314	Miltiades

*Dates uncertain

Papal Authority in the Last Years of Persecution. — The next pope, Fabian, had a longer pontificate, which lasted until his martyrdom in 250 in the course of the persecution under the emperor Decius. He too is important in the early history of the papacy. Now that there was no longer any trace of the Hippolytan schism, the second successor of Pontianus was free to work undisturbed at the development of Roman Christianity as an organic body. The *Liber Pontificalis* credits him with the institution of the seven diaconates between which the ecclesiastical administration of the city was divided, together with the seven subdiaconates auxiliary to them. Two events, moreover, which took place under Fabian provide further evidence of the Roman see's pre-eminent authority in the church: (1) when the bishop of Lambaese, in Africa, professed doctrines which an African council found to be heretical, his teachings were censured not only by his metropolitan, the bishop of Carthage, but also by Pope Fabian, in a stern letter; and (2) when Origen was accused of heterodoxy and found guilty by his bishop, Demetrius of Alexandria, he sent a memorandum on his doctrine to Fabian in order to clear himself.

The election of a successor to Fabian was delayed for 14 months because of the Decian persecution; and when it took place the election gave rise to a schism. While the majority of the votes were for the priest Cornelius, a minority of the faithful declared itself in favour of another priest, Novatian. This Novatian had a high reputation as a learned theologian and was an uncompromising champion of rigorism in church discipline who refused to admit the *lapsi* (*i.e.,* those who had lapsed from Christian practice during the persecution) to the sacrament of penance.

In his struggle with the extremists Cornelius had the support of St. Cyprian, the famous bishop of Carthage, himself confronted with an analogous but converse problem in his own diocese, where he had to resist a movement toward extreme laxism. Their mutual support enabled Cornelius and Cyprian to prevail over their opponents (though the Novatianists remained for a long time in schism). Their friendship is still remembered, despite a temporary misunderstanding; and the church has joined them liturgically in a single feast.

The opposition that he encountered provided Cornelius with an opportunity of evaluating the moral authority at the command of the Roman pontiff. The synod convened by him in 251 was attended by about 60 bishops, and sentence of excommunication was passed on Novatian and his adherents. The Roman church at that time numbered 46 priests and about 40 other clerics. But troubles soon began again. The emperor Gallus inaugurated a new persecution, which went on for several months; and Cornelius had to spend the end of his life in exile, dying in 253.

The next pontificate, that of Lucius I, did not last long, and this pope also had to go into exile. His successor was a former priest, Stephen I (254–257). Under him there occurred some important differences between Rome and Carthage, not without dramatic incident. Two Spanish bishops had lapsed, during the Decian persecution, to the extent of pbtaining certificates of having made sacrifice to the pagan gods and had therefore been deposed by their colleagues; but when they appealed to Stephen (a step which seems to indicate that such a procedure of appeal was recognized as normal), the pope acquitted them. The rest of the Spanish episcopate, however, was not ready to yield its point and raised the matter at the council of Africa, at which St. Cyprian was presiding. Cyprian, who exercised considerable influence

throughout the church in the west, confirmed the sentence of deposition. We must assume that Stephen subsequently received information that shed new light on the case and caused him to see the justice of the sentence, since he does not appear to have persisted in the difficult task of upholding the accused.

Shortly afterward, Martianus, bishop of Arles, who shared Novatian's rigorist opinions, was denounced as a schismatic by the Gallic bishops. who addressed their charges to Rome and to Carthage simultaneously. Cyprian wrote at once to Stephen. inviting him to instruct the Gallic bishops to depose Martianus and at the same time asking the pope to inform him of the name of the new bishop of Arles, so that the African bishops might know with whom they were to have relations. This implies that the only lawful bishop was he who was in communion with the *ecclesia principalis,* as Cyprian calls Rome *(Letter* lix).

A serious difference of opinion, however, was soon to arise between Pope Stephen on the one hand and the African episcopate and several Asiatic churches on the other. Rome and the majority of the other churches held that it was not necessary for converted heretics to be rebaptized and that all that was required for them was confirmation by the laying on of hands and anointing with chrism, whereas the Africans and the Syrians rebaptized. Cyprian having solemnly affirmed the rightness of this practice in a letter to the pope, Stephen replied that the Roman usage was the only lawful one and that all the churches should conform to it if they wished to remain in communion with Rome. Cyprian and with him Firmilian of Caesarea in Cappadocia took the view that unity of faith did not preclude diversity of usage and insisted on their own view of the matter in question! declaring at the same time that they did not want to sever relations with Rome. The dilemma was resolved by Stephen's death, in Xug. a57.

His successor, Sixtus II, was of a more conciliatory disposition. Encouraged by a letter sent to Stephen a short time previously by Dionysius of Corinth ("the Irenaeus of this second Victor"), he resumed relations with Cyprian and with Firmilian. His pontificate came to a sudden end with his martyrdom under the emperor Valerian in 258, and the next pope, whose name was Dionysius also, sent a friendly message, together with a charitable contribution from Rome, to the Cappadocian Christians when their country was suffering from the effects of a Persian invasion (259).

The Roman church's claim to governing in matters of faith received a further strengthening during Dionysius' pontificate (259–268). The bishop of Alexandria, whose name was likewise Dionysius, wrote a letter stressing the distinctness of the Persons of the Trinity to such an extent as almost to give the appearance of tritheism and unmistakably subordinating the Son to the Father. Protests and appeals against this doctrine were addressed to the bishop of Rome, and Pope Dionysius took immediate cognizance of the matter, which became known as "the affair of the two Dionysii." He condemned both the modalists. who denied that there was any real distinction between the Persons, and those n-ho acknowledged three separate hypostases and considered the Logos to be a creature. The Roman bishop spoke here as arbiter in matters of faith, and the bishop of what was then the most important eastern church accepted his decision without questioning his competence to pronounce judgment.

Pope Dionysius died in Dec. 268. His successor Felix I (269–274) received an acknowledgment of his authority from the emperor himself. The occasion was the claim of Paul of Samosata, bishop of the important see of Antioch, to retain his bishopric even though he had been deposed by a council in view of his anti-Trinitarian heresy. The emperor Aurelian, having been asked to decide the question of legal ownership, gave his verdict that the rightful bishop and legal proprietor of the bishop's residence was the one recognized by the bishops of Rome and of Italy (272).

The immediate successor of Felix was Eutychianus, whose successor was Gaius; but very little is known of these two popes, even the dates of their pontificates being uncertain. The next pope. Marcellinus, became bishop of Rome in 291 or in 296 and witnessed the end of a long period of tranquillity in a renewal of bloodshed under the emperor Diocletian. This was the last official persecution of the Christians in Rome; and its aftermath was a long crisis in the government of fhe church. Marcellinus did in fact die a martyr's death in Oct. 304, but may have shown some temporary weakness beforehand! with the result that the church felt ill at ease after his death. Moreover, the persecution delayed the election of his successor till *c.* 308, when Marcellus became pope. Consciences however were still troubled, agitation spread and Marcellus had to go into exile. The appointment of Eusebius (c. 309–310) as pope failed to restore tranquillity and he too was soon exiled. Only with the election of Miltiades (Melchiades) in July 311 was peace restored.

Throughout this early period, now drawing to its close, the bishop of Rome, despite trouble from within and from outside the church, had consistently exercised the role of principal representative of the Christian church. Whenever persecution had broken out, the first blows had been aimed at him; and on the other hand he had also received impressive marks of recognition, for instance from Aurelian.

Furthermore, the fact that the leaders of Christianity, men such as Polycarp, Irenaeus and Origen, paid him visits and conversely that the Roman church sent letters on doctrinal or disciplinary matters to the other churches bears witness to the special authority of the Roman see as acknowledged by Christendom in its entirety, an authority experienced rather than formulated, actual rather than theoretical, unaffected, moreover, by the individual character of those in whom it was personified.

The Christian Empire and the Arian **Crisis.**—Two months before the accession of Miltiades, an edict of the emperor Galerius had put an end to the persecution of the Christians; next, Maxentius restored to Miltiades the church property that had been confiscated in the course of the persecution; and these measures were soon confirmed and amplified by the emperor Constantine, in the measure known traditionally, though inaccurately, as the edict of Milan. Constantine: indeed, promptly changed the whole imperial policy toward the church from one of toleration to one of positive favour. At the same time, however, internal dissension broke out again within the church. The Donatists, so named after their leader the African bishop Donatus, adopted an attitude of intransigence like that of Novatian and his followers and refused to absolve the *lapsi* of the late persecution. Schism resulted; and to put an end to it Constantine called on Miltiades to settle the question. Miltiades held a council in the Lateran palace, which the empress had just presented to him; and the Donatists were condemned. On their refusal to submit, Constantine summoned a larger assembly of churchmen to Arles. This council also failed to end the dispute; its concluding letter to the pope, however, is yet another striking proof of the authority that he was felt to exercise. This pope was not bliltiades but his successor Silvester I (314–335), whose long pontificate saw the beginnings of the Christian Roman empire as Constantine showered favour after favour upon the church. This meant, however: that the church's independence was often endangered. Thus neither Constantine nor his immediate successors gave any official recognition to the Roman bishop's primacy of authority over the whole church; and during the Xrian crisis the popes were only rarely accorded a pre-eminent role in affairs. There were, however, a few incidents of some significance.

Silvester sent two legates to the council of Nicaea, where they were treated with great honour and respect, though they did not preside at its debates. The next pope, Marcus, reigned for less than a year (Jan.–Oct. 336); but his successor Julius I (337–352) made his personality felt. During the prosecution of Athanasius by the Xrians, he acted decisively. At the council of Rome (340) he insisted that the bishop of Alexandria was still in communion with him; and subsequently he maintained the same view in a letter to the eastern churches, in which, moreover, he showed himself well aware of his primacy of jurisdiction.

Two years later! at the council of Sardica (343), the western bishops, with whom the eastern bishops had just broken off relations, recognized the supreme authority of the bishop of Rome. The canons of the council acknowledged that it was within his power to annul any decision of the entire Catholic episcopate. These canons, it is true, were rarely applied in practice, as the

eastern bishops, even when the schism was over, were reluctant to submit to Roman authority in matters of discipline. In the west, however. the popes did not confine themselves to declaring that a verdict ought to be reconsidered but exercised positive jurisdiction. as in the past. For instance. when the two Arian bishops Ursacius of Singidunum and Valens of Mursa retracted their errors, the pope received them back into communion, thus abrogating. on his own authority, the sentence of deposition that the council of Sardica had passed against them.

The glory of the papacy was somewhat diminished under the next pope, Liberius (352–366). It is true that Liberius persisted for a long time in the defense of Athanasius against the emperor Constantius, who wanted him to .condemn the Alexandrian bishop. But after being exiled to a place far distant from Rome. where Felix was made bishop instead, Liberius lost heart and agreed to sign certain formulas which, without disavowing the Nicene formula, nevertheless emasculated it; and he also agreed to sever relations with Athanasius (for which he was to incur the reproaches both of Athanasius and of St. Hilary). Nonetheless: he was joyfully received by the Christian community on his return to Rome, while Felix had to flee to Porto, outside the city boundaries. Constantius, however, decreed that the two bishops should rule the Roman community jointly; but his orders were disregarded. The prestige of Liberius was nevertheless impaired, and he was not invited to the great council which met at Rimini in 359 to put an end to the Arian crisis; but this temporary humiliation served to prevent the papacy's being involved in the council's rather shameful capitulation to imperial despotism and in its compromise with heresy. In 362, with his authority strengthened anew, Liberius received a delegation of eastern bishops and prevailed upon them to profess the Nicene faith and to anathematize the formulary of Rimini. The letters that he gave to them for 64 other eastern bishops were entirely in accord with the program of reconciliation that Athanasius was advocating. The eclipse of the papacy was over! but the curious phenomenon of the simultaneous occupation of the Roman see by two bishops lasted until 365, when Felix. who moreover had never returned to the city, died. Liberius did not long survive him, dying in 366.

Damasus and His Successors, to 422.—The confusion arising from these years of crisis was not at once allayed. The successor to Liberius was the deacon Damasus, who had rejoined his party after a period of allegiance to Felix; but a party of extremists objected to him and nominated another deacon, Ursinus. The result was another schism in the Roman church, which continued for several years. Only after the secular power had intervened, in the person of the emperor Valentinian I, did Ursinus give up the struggle.

Nonetheless, despite these disorders, the organic development of the Roman church continued. More places of worship were opened, and the number of priests rose from 46 in the middle of the 3rd century to 70 at the end of the 4th (the number of deacons remained limited to 7, though the patrimony of the church, of which they had charge. had been very much increased). Damasus, who took a particular interest in the upkeep of religious buildings, made himself responsible for the restoration of the catacombs (to which pilgrimages were then beginning to be made) and had metrical inscriptions put up in them. The words were of his own composition and not of very high poetic quality; but the workmanship of the engraving was excellent, so that. the Damasian inscriptions have become famous. His intellectual preoccupations found further expression in the interest that he took in the pontifical archives and in St. Jerome's exegetical work. In many respects, he was a great pope, reviving the traditions of Miltiades and of Julius I; and in the termination of the Arian crisis he played a very important part. St. Basil, the most eminent of contemporary eastern bishops, was at pains to reach agreement with him, even though they did not see eye to eye on the subject of individuals; and though the personal authority of St. Ambrose and his rank as bishop of Milan (at that time the seat of the imperial government in the west) seemed sometimes to overshadow the influence of the Apostolic See or "Seat" (sedes *apostolica,* as he himself called it), Damasus nevertheless secured Rome's position in the church—particularly, however, in the western half of the empire. The synodal letter of the council of Rome of 378 shows how Rome's jurisdiction extended over the whole of the western church, as based on an established tradition of authority.

Siricius. who succeeded Damasus, was pope for 15 years (384–399). He does not seem to have been so great a man as his predecessor, but this makes the extent of his administrative activity all the more notable. He conferred on the bishop of Thessalonica powers which made him virtually papal vicar in eastern Illyricum; he intervened at the council of Toledo to arrange for the reconciliation of the penitent Priscillianist heretics of Spain with the church; he wrote likewise to the bishop of Tarragona on the reconciliation of converted Arians; and he stated the rules of church discipline on accession to holy orders when the Gallic bishops asked for his advice on the subject. The documents relevant to this activity are of great significance. The papal decisions are accompanied by the threat of sanctions against those who contravene them; and the letters of Siricius constitute the first decretals, whereby the Roman bishop made lams, as a sovereign, for the whole church in the west.

If he did not do the same for the church in the east, he nevertheless believed himself to be entitled to intervene in its affairs. For instance, it was his instructions to Theophilus, bishop of Alexandria, and to the council of Caesarea (393) that made possible the termination of the long-standing schism of Antioch (a product of the Arian controversy). Likewise. his arbitration was invoked, in 394, in a dispute within the Arabian church, on the subject of the bishopric of Bostra. It is well worth emphasizing here that it was to the pope that Syria and Arabia looked for a final judgment, despite the misunderstandings that were already dividing Rome and the east. It is equally important to note that the pope did not owe his primacy, as some writers have suggested, to the well-known rescript of the emperor Gratian. Gratian in fact proclaimed the authority of the Roman bishop in reply to a letter from the synod of 378; but the misnamed *Decretum Gelasianum* or "Gelasian decree," which really represents a motion of the council of Rome of 382, proves that the church, less than five years after Gratian's rescript, held the primacy of Rome to be of divine, not of imperial, institution.

The following pontificate, that of Anastasius I, from 399 to the end of 401 was short and uneventful.

Pope Innocent I (402–417) saw the sack of Rome by the Goths under Alaric; yet he maintained a firm hold on the church despite public calamities. He gave untroubled answers to the questions on matters of discipline that the Italian, Gallic and Spanish bishops addressed to him; he confirmed the privileges that his predecessor Siricius had bestowed on the bishop of Thessalonica, through whom papal control was thus exercised over the churches of Dacia and of Achaea; and when the emperor Arcadius, by an abuse of his power, deposed John Chrysostom from the see of Constantinople, he announced that he would remain in communion with the wrongfully deposed patriarch and, in fact, refused communion to his successor throughout John's lifetime. Finally, when the Pelagian heresy began to spread in Africa, the pope, notified by the councils of Carthage and of Milevum, condemned its sponsors, Pelagius and Coelestius. On the reception of the letters from the Apostolic See, St. Augustine preached a sermon in which he used the words: "The rescripts have arrived. The case is closed *[Causa finita est].*"

The church was less fortunate in the pontificate of Innocent's successor, Zosimus (417–418). Entranced with his own prerogatives and confused in his thinking and in his action, the new pope allowed himself to encourage the ambitions of an intriguing megalomaniac, Patroclus, bishop of Arles, to the extent of appointing him as his vicar in Gaul on the ground of an alleged historical primacy of his see. This unforeseen and ill-inspired decision provoked a crisis in which all the churches of southern Gaul were shaken; and Proculus. the highly respected bishop of Marseilles, was pronounced deposed from his see. This sentence, however, was not carried out, Zosimus dying in Dec. 418. Furthermore, when the Pelagians appealed to him to reverse Innocent I's decision, Zosimus seemed for a time to be ready to reconsider the matter;

eventually, however, he confirmed the existing judgment. Even so, he disturbed the African episcopate by espousing the cause of a disreputable priest called Xpiarius. who had been excommunicated by his bishop. This case too was unsettled when Zosimus died—to the great relief of Africa and of Gaul alike.

His death, however. was followed by the troubles of a double election. Boniface I (418–422), a saintly man, prevailed eventually over his rival Eulalius, with the support of the imperial court at Ravenna. He had then (1) to settle the affair of Xpiarius, who was cleared of the sentence of excommunication but obliged to leave his diocese; (2) to deal with another African case, that of the bishop of Fessala, who was appealing against a sentence of the synod of Hippo (after inclining somewhat in the opposite direction, Rome seems eventually to have confirmed the sentence); and (3) to curb the pretensions of the bishop of Arles, who considered that the decision of Zosimus authorized him to ordain a bishop outside his on-n province. What was perhaps more important. he had also to stand up against the eastern emperor Theodosius II, who, in a rescript of July 421, had tried to deprive the bishop of Thessalonica of his privileges as papal vicar in Illyricum. Boniface's forceful protest. addressed to the western emperor Honorius, promptly secured the withdrawal of this measure. Not long after this the pope died.

The **Nestorian** Question. — Boniface was succeeded by Celestine I (422–432), formerly a deacon, to whom belongs the credit for sending St. Patrick to spread the Christian faith in Ireland. His pontificate began with a repercussion of the Apiarius affair. Apiarius, having made himself objectionable in the city to which he had been transferred, had been forthwith excommunicated; he had then appealed again to Rome. Celestine agreed to hear his case, but the pope's intervention was markedly resented by the African bishops. Order was restored in the west when Apiarius frankly admitted his own unworthiness. In the east, however, the stage was being set for a tragedy in which the pope. in the interests of doctrine no less than of discipline, was bound to take an active role.

The recently elected patriarch of Constantinople, Nestorius, had advanced the doctrine that Mary ought not to be called "Mother of God" *(Theotdkos)* but only "Mother of the Christ." This appeared, at least, to imply a denial of the truly divine nature of Jesus; and an impassioned outcry was raised in consequence. Celestine convened a council in Rome in 430, and this council instructed Cyril, the patriarch of Alexandria, to draw up an indictment of Nestorius and, in the event of his refusing to retract his doctrine. to depose him. This! under Cyril's influence, was what the council of Ephesus (431) in fact proceeded to do; and its work received the approbation of the pope, whose legate proclaimed his primacy over the universal church in terms that were to be echoed, 14 centuries later, at the Vatican council. Celestine's letters to the bishops of the council, to the emperor Theodosius II and to the successor of Nestorius serve to emphasize the fact that the measures against Nestorius had received pontifical approbation.

Unfortunately, however: the council had opened without waiting for the arrival of certain eastern bishops, the most important of them being John of Antioch. whose see was ranked next after that of Alexandria in the east; and these bishops, whose attitude toward the rather ambiguous teaching of Nestorius was less severe than Cyril's, refused to associate themselves with the sentence passed against Nestorius in their absence and claimed, instead, to depose Cyril, on the ground that his condemnation of Nestorian doctrine amounted to a denial of the human nature of Christ, which, they said, was reduced by Cyril to a mere appearance of human nature. Cyril therefore excommunicated John of Antioch. This gave rise to a new schism. which was still unhealed when Celestme died (July 432). In 433, however, a reconciliation was effected between the Antiochene bishop and the Alexandrian, as a result of negotiations in which the tribune Aristolaus, representing the emperor, and Xcacius of Berea, the senior eastern bishop, had mingled persuasion with threats of force.

Under Celestine's successor, Sixtus III (432–440), relations between Rome and the east were on the whole undisturbed, though a minor incident took place in 437, when a Constantinopolitan synod tried to encroach on the rights of the Holy See in Illyricum and on those of the patriarch of Antioch in the east. Sixtus had to remind the lllyrian bishops of their obligations toward his vicar in Thessalonica and drew the attention of Proclus of Constantinople to established precedents.

Leo I, the Early **Monophysites** and **Chalcedon.**—The successor of Sixtus was Leo I (440–461), rightly called the Great, whose pontificate saw the primatial authority of the Roman see even more strikingly reinforced in consequence of a new doctrinal crisis. This crisis had its roots in the preceding one; its solution was a fitting culmination to the new pope's manifold achievement, which left a lasting mark on the church.

The range of Leo's activity in the west can be indicated by the following summary. In Rome itself he denounced the Manichaean heresy, which a number of secret adherents were maintaining. In the field of practical politics he persuaded Attila, who was terrorizing northern Italy, to halt his march on Rome at the Mincio; and when Gaiseric, king of the Vandals, occupied the Eternal City, Leo's intercession saved it from sack. In Gaul he restored the organization of the church on its proper basis, checking the ambitious but otherwise meritorious Bishop Hilary's attempt to revive the primacy of his see of Arles, but recognizing his successor Ravennius as pontifical vicar. In Spain he took measures against the Priscillianist heresy. For want of a council. the bishops of the provinces of Tarraconensis, Lusitania. Baetica and Cartaginiensis were required to sign a formulary of Catholic belief. He also sent messages to the African bishops, who were undergoing a savage persecution at the hands of the Vandals. In Illyricum, the vicarial powers of the bishop of Thessalonica were reaffirmed. But the great victory of the papacy under Leo consisted in his exercising his *magisterium* ("teaching. authority") in matters of faith not merely with the consent of the eastern bishops but at their invitation.

Eutyches, an archimandrite of Constantinople, in extreme reaction against Nestorianism, had maintained that Christ as God incarnate had not two natures but only a single nature (hence the name, "Monophysitism," given to this heresy). When Flavian, bishop of Constantinople, took action against Eutyches, controversy ensued, and the emperor Theodosius II summoned a council to meet at Ephesus (449) to settle the question. Leo sent representatives to this council and also wrote a statement of Catholic Christological doctrine in a letter, known as the *Tome of Leo*, which he addressed to Flavian. The council, however. fell under the influence of Dioscorus, patriarch of Alexandria, who supported the Monophysites; and it deposed Flavian and other bishops for refusing to come to terms with the heresy. This conduct earned the council the name of "robber synod" or *latrocinium* of Ephesus. On the appeal of the deposed bishops, Leo procured the annulment of the acts of the *latrocinium* by the council of Chalcedon (451), where the *Tome* was triumphantly received. The eastern bishops, though they were often quite ready to do without the Holy See so long as they had no positive need of it, yet had prompt recourse to it whenever adverse circumstances reminded them of the advantages to be gained from its intervention. They did not, however, regard questions of discipline and questions of dogma in the same light. The 28th canon of Chalcedon, in fact, on the basis of a canon of the council of Constantinople of 381, departed from ancient tradition so far as to accord to the bishop of Constantinople, as bishop of the new capital of the empire, a rank immediately after the pope and a status nearly equal to his. Leo refused to give his approval to this canon.

The monophysite heresy was to raise its head again not long after Chalcedon. causing relations between Rome and the eastern patriarchates once again to deteriorate. For 20 years, however, there was to be no urgent call for Roman intervention in the east. Thus Leo's successor Hilarius (461–468) had a peaceful pontificate, occupied only with the further co-ordination of ecclesiastical affairs in Gaul. His aim was to revive (without actually using that expression) the primacy of the see of Arles, the bishops of which had already been made pontifical vicars by his predecessors; but the bishop of the time: Leontius, showed himself to be in no hurry to assume the role designed for him, which, more-

over, the prevailing quiet seemed to render somewhat supererogatory. (*See* Table III.)

TABLE 111.—The *Papacy From 314 to 590*

314–335	Silvester I	483–492	Felix III
336 (Jan.–Oct.)	Marcus	492–496	Gelasius I
337–352	Julius I	496–498	Anastasius II
352–366	Liberius	498–514	Symmachus
355–365	Felix *II, antipope*	*498–c 505*	*Laurentius, antipope*
366–384	Damasus I	514–523	Hormisdas
366–367	*Ursinus, antipope*	523–526	John I
384–399	Siricius	526–530	Felix IV
399–401	Anastasius *I*	530–532	Boniface II
401–417	Innocent I	*530 (autumn)*	*Dioscorus, rival pope*
417–418	Zosimus	533–535	John II
418–422	Boniface I	535–536	Agapetus I
418–419	*Eulalius, antipope*	536–537	Silverius (deposed)
422–432	Celeitine *I*	537–555	Vigilius
432–440	Sixtus III	555–561	Pelagius I
440–461	Leo I	561–574	John III
461–468	Hilarius	574–579	Benedict I
468–483	Simplicius	579–590	Pelagius II

The End of **the** Western Empire.— The next pope, Simplicius (468–483), had to turn his attention to the east again. The bishopric of Antioch was disputed between partisans and opponents of the council of Chalcedon, and the Monophysite Peter Mongus managed to make himself bishop of Alexandria. Simplicius wrote to the emperor Zeno and to Acacius, bishop of Constantinople, demanding the removal of Peter, but without success. In the west, meanwhile! he pursued the co-ordinating policy of his predecessors by extending the regime of the vicariate to Spain; the bishop of Seville became the pope's representative in the Iberian peninsula. At the same time his pontificate saw the disappearance of the western Roman empire. The boy emperor Romulus Augustulus was deposed in 476; no successor to him was nominated; and when the barbarian *patricius* ("patrician") Odovacar (Odoacer), the real master of Italy, sent the imperial insignia to Constantinople, the eastern emperor seemed to have became the sole rightful sovereign of the Roman world. This elimination of the imperial power in the west served perforce to enhance the prestige of the papacy throughout that half of the world, where it had begun to emerge as the focus of authority ever since Constantine had left Rome for Constantinople.

This development made the choice of every new pope a matter of even greater importance than it had been in the past, when rivalries, conflicts and even schisms calling for imperial intervention had sufficiently demonstrated how much was at stake. Simplicius then had desired to see the procedure of election regulated; and after that pope's death Odovacar's representative announced to the assembly of Roman senators and clergy that his master should be consulted about the choice of the next pontiff, who moreover should be required to pledge himself not to alienate any part of the church's patrimony (now grown to a considerable amount of property), of which the pope was to be regarded as administrator. Such were the circumstances of the election of the new pope, Felix III, who came of an old Roman family. The east, however, was still the field in which the strength of the papacy was to be most severely tested.

The Acacian Schism and **Theodoric.**—Reaction against the legislation of Chalcedon had come to a head, and the patriarch Acacius of Constantinople and the emperor Zeno could together find no better means of allaying the agitation than to promulgate an "edict of unification," the so-called *Henoticon,* which, without explicitly abandoning the canons of Chalcedon, reverted to the Cyrillian theological formulas, omitted all reference to the two natures of Christ and, by implication, made the *Tome of Leo* a thing of the past. The pope could not allow the patriarch of Constantinople, supported by the emperor. to arrogate to himself the right of superseding the council of Chalcedon. He therefore demanded an explanation of these proceedings and, when Acacius failed to provide one: pronounced sentence of deposition and excommunication against him. This meant another schism, which was to last nearly 3½ years (484–518).

Felix III died in 492, leaving unchanged the situation that had arisen from his condemnation of Acacius. His successor Gelasius I, who was of African origin, likewise failed to restore the union of Rome and the east but yet has an honoured place in the history of the papacy. He had an exalted idea of his mission and of the authority with which he was invested by it; and his tone, in his correspondence with the emperors, anticipates that of the medieval popes in their contest with the heads of the Holy Roman empire. He wrote, in fact, on several occasions to Zeno's successor Anastasius I in the hope of persuading him to disavow Acacius and the *Henoticon,* reinforcing his letters with treatises on points of doctrine; but all to no avail. He showed himself no less energetic in his resistance to the Roman aristocracy, a number of whom still clung to the old pagan traditions. When some of these Romans tried to revive the licentious festivity of the Lupercalia, the pope expressly forbade Christians to take part in it. Gelasius, who died in 496, is remembered as a strong man whose personality enhanced the prestige of the Apostolic See.

The following pope, Anastasius II, used conciliatory language in the letter that he sent to the emperor—his namesake—to notify him of his accession. Indeed the tension between Rome and Constantinople appeared for a moment to have been eased to such a degree that some of the Roman clergy became alarmed at what they took to be a weakness on the part of the pope. Barely two years later the pope died (498), before any new development had taken place in Rome's relations with the east.

Suspicion, however, had been aroused in Rome, and the consequences were serious. On the pope's death two parties forthwith confronted one another: the one under the archpriest Laurentius, who favoured Anastasius' policy of conciliation; the other, which was the larger, under the deacon Symmachus. The latter was upheld as the rightful pope by the Ostrogothic king Theodoric, who was then master of Italy; but the partisans of Laurentius would not abandon their case and brought charges of moral indignity against Symmachus. Theodpric, who was moreover an Xrian, claimed the right of judging the issue, but Symmachus would not acknowledge this right. The result was that the Roman church was troubled by schismatic division for about ten years, though Symmachus was never dispossessed of his see; and these circumstances did nothing to promote reunion with the east. Though the last years of his pontificate were calmer, peace had still not been wholly restored in Rome when Symmachus died (514). The lamentable schism between the two halves of the universal church likewise remained.

Symmachus was succeeded by one of his deacons, Hormisdas, who had the double satisfaction of seeing both the remnant of schism eliminated in Rome and the reunion of eastern and western Christendom brought about.

The pope's first approach to the emperor met with no success; but when Justin I had taken the place of Anastasius I on the imperial throne, the situation changed altogether. Justin was personally in favour of accepting the canons of Chalcedon explicitly; and Christian opinion in Constantinople, weary of the prolonged schism, supported him in this view. He therefore welcomed the formulas drawn up by Hormisdas, which contained the words: "We desire in all things to adhere to the communion of the Apostolic See, wherein the whole and true solidity of the Christian faith resides, wherein religion is ever preserved immaculate." The pontifical enactment condemned Nestorius, Eutyches and Acacius and reaffirmed the faith as professed .in the *Tome of Leo.* Thus ended the Acacian schism.

The reunion of Rome and the east and the restoration of peace between pope and emperor was a great achievement, but it had an unfortunate repercussion in the west: it put an end to friendly relations between the pope and the Ostrogothic king Theodoric, who was now no longer needed by the pope to support him against the emperor and who was bound to regard with mistrust the *rapprochement* between Rome and Constantinople.

Theodoric's hostility was made clear when Justin decided to deprive his Arian subjects of the use of their churches. On the death of Hormisdas (523), Theodoric iorced the new pope, John I, to go to Constantinople to persuade the emperor to withdraw his edict. This was the first visit of a pope to Constantinople; John received a splendid welcome; and the edict was withdrawn at his request. The pope, however, of course refrained from asking that persons newly converted from Arianism should be sent back into

heresy, as Theodoric had desired; and on his return to Rome he was thrown into prison, where he died on May 18, 526. Within four months the Arian king died also.

Theodoric's support may have helped to bring about the election of John's successor, Felix IV; but the election received general approbation, and Felix' short pontificate (526–530) was a peaceful one. The next two pontificates, that of Boniface II (530–532) and that of John II (the first pope to take a new name on his accession; 533–535), were likewise short and for the most part uneventful, though Boniface was at first confronted with a rival pope. Dioscorus. The aftermath of the Monophysite crisis was however still to be felt. In Constantinople some of the Acoemetae, a group of monks who were reacting against tendencies represented by the so-called "Scythian" group, took up a Nestorian position and refused to accept the term *Theotókos* ("Mother of God"). Justin's successor, the emperor Justinian, whose lasting concern with theology arose from personal interest on the one hand and from recognition of its political importance on the other, accordingly invited the pope to condemn these Acoemetae (534). John had no choice but to comply with his demand.

The Affair of the "Three Chapters". — Yet more trouble was to arise from the persistence of Monophysitism. The emperor was anxious to win the adhesion of the Monophysites at any price; his wife the empress Theodora had the interests of the Monophysites at heart; and in the resultant crisis the papacy was to undergo one of its most exacting trials. In the short pontificate of Agapetus I (535–536), it is true, good relations were maintained between papacy and empire. Sent to Constantinople by the Ostrogothic king Theodat to dissuade Justinian from attempting the reconquest of Italy. the pope refused to enter into communion with the newly elected patriarch Anthemius, who had entered into communion with Severus, the notoriously Monophysite patriarch of Antioch; and on the withdrawal of Anthemius another patriarch was installed in his place. A council assembled in Constantinople then declared both Xnthemius and Severus officially deposed. By this time, however, Agapetus was dead; and the two following popes had to face the terrible difficulties that almost immediately ensued.

Silverius (536–537), who spent only a short time on the pontifical throne, seems to have been the victim of Theodora's resentment. Refusing her request to reinstate Anthemius as patriarch of Constantinople, he was accused of having collaborated with the Goths against Belisarius, who had just reconquered Italy for the emperor. Brutally driven from his see, Silverius was deported first to Asia, then to the island of Palmaria; and the deacon Vigilius, whom the Byzantine court expected to be more accommodating, was made pope in his place.

Vigilius (537–55j) had to sustain an attack that was pressed hard against him. At the instigation of Theodore Ascidas, bishop of Caesarea in Cappadocia, and in pursuance of his desire to satisfy the Monophysites, Justinian demanded the condemnation (1) of the writings and of the person of Theodore of Mopsuestia; (2) of Theodoret's writings against Cyril of Alexandria; and (3) of the *Letter to Maris* of Ibas, bishop of Edessa. All three of these writers were suspected of Nestorianism, and there was indeed ground for the suspicion; but it was open to question whether it was right to anathematize men who had died at peace with the church and whose writings had not been condemned by the council of Chalcedon. The ensuing controversy is known as that of the "Three Chapters," a name that may originally have referred to Justinian's three condemnatory propositions but is here taken as applying to the three groups of writings condemned. The eastern bishops, then, agreed to the anathematization proposed; and Vigilius, summoned to Constantinople, published a *judicatum* ("verdict") censuring the "Three Chapters." This. however, caused such an outcry in the west, where some bishops actually broke away from communion with the pope, that Justinian decided to convene a general council and that meanwhile things should remain as they had been before. Nevertheless, without waiting for the council to assemble. Justinian repeated his condemnation of the "Three Chapters": whereupon Vigilius decided to sever relations with him. For his personal safety Vigilius took refuge first in a sanctuary in Constantinople, then at Chalcedon; and from Chalcedon he issued censures against Theodore Ascidas, against the patriarch Mennas and against certain other bishops who shared their views. The council, however, opened without the pope and confirmed the sentence passed against the "Three Chapters."? The pope's *constitutum* ("resolution") of May 14, j53, withheld ratification of this measure, but that was not his last word. Comforting himself with the thought that neither Theodore of Mopsuestia, Theodoret nor Ibas had been altogether beyond reproach, Vigilius succumbed to lassitude, to homesickness, to the appeals of the Romans for his return and to the ill-treatment meted out to him by Justinian. He signed a second *constitutum* (Feb. 23, 554) which revoked the first and gave pontifical approbation to the council's verdict.

This act of weakness, extorted in circumstances that might be held to invalidate it, in fact did no more to impair the purity of the faith than the weakness of Liberius had done 200 years before; but its consequences were no less serious. A number of western bishops felt that a blow had been dealt against the council of Chalcedon and, in Africa and in Illyricum especially, broke away from communion with Rome, grouping themselves round the metropolitan of Aquileia, to whom they gave the title of patriarch. This "schism of Aquileia" was to last well into the following century.

Temporal Power and the Protection of Italy. — The moral authority of the papacy, then, had suffered a considerable setback? and Justinian's "pragmatic sanction" of 554 map have been intended as a measure of compensation for it. By this act the emperor acknowledged, confirmed and increased the temporal power of the pope, who was henceforth to have a voice in the nomination of the governors of the Italian provinces of the empire and to participate in the control of their finances. The pope became the official protector of the civil population against the depredations of the military, against extortion by the tax collectors and against abuse of power by the administration.

The successor of Vigilius was Pelagius I (555–561), who made resolute use of the pope's new rights, organizing the temporal government of the territory over which he was actually sovereign and setting the papacy on the road to real political power. This power was to grow so rapidly that Gregory the Great could write, a few years later: "I should like to know whether the pope: in this world, is a spiritual leader or a temporal king."

The papacy was thus faced with new problems. Conditions were no longer the same as they had been while the pope and the Constantinopolitan emperor were opponents. In this latter part of the 6th century the pope was to be concerned more with vigilance against the danger of barbarian invasion and with the protection of the peoples of Italy than with his function as spiritual head of the universal church.

The pontificate of Pelagius' successor John III (561–574) saw the invasion of the Lombards, who overran the northern half of the Italian peninsula, captured Ravenna and threatened both Rome and Naples. In the face of such a danger, it was doubtful whether much real help could be expected from Constantinople, distant as it was and now weak itself. Yet the emperors persisted in their claim to be the guardians of the papacy. When John III died, Rome had to wait for ten months before the emperor ratified the election of the new pope, Benedict I, whose consecration had therefore to be deferred all that time.

Pelagius II succeeded Benedict in 579. Under him the papacy began to look in a new direction for a safeguard against the new danger that was threatening both the Holy See and the Italian peoples, for whom the popes now felt themselves more than ever responsible.

The Supreme Shepherd of the Church in the latter half of the 6th century could hardly have hoped for anything more fortunate than'the conversion of the Visigothic rulers of Spain from Arianism to Catholicism, which in fact took place during Pelagius' pontificate. But Pelagius also saw that the Lombard danger was assuming ever more threatening proportions. He decided? therefore, to turn to the Franks, who had been Catholics since the time of Clovis. In a letter to the bishop of Auxerre he declared that it

was the duty of the Franks, as true believers, to defend Rome and Italy against the "deathly race" of the Lombards. The emperor, himself of little use as a protector, was persuaded by Gregory, the pope's *apocrisiarius* (nuncio) at Constantinople, to give his consent to Rome's appeal to the Franks, to whom, moreover, subsidies were granted. Halted in their advance, the Lombards took up a defensive position.

When the Franks withdrew and the Lombards became threatening again, Pelagius made another appeal to the emperor. The exarch Smaragdus. imperial representative in Italy. then set himself to renew the understanding with the Franks, whose support now seemed essential to the independence of the papacy. This understanding was afterward to be even closer than it had ever been.

The papacy, however, had undergone many changes of fortune, faced many external dangers, experienced several schisms, felt the abuse of imperial power and been subjected to frustration, to coercion, to acts of war and to the effects of desertion; and its prestige had not escaped unimpaired. In Pelagius' time, though the reigning emperor Maurice was himself well disposed and reasonable in his attitude toward Rome, a dispute arose with regard to the claim of the bishop of Constantinople to the title of ecumenical patriarch, which his predecessors had assumed at the time of the schism of Acacius and which seemed to make him the equal of the pope, if not more, since the pope had never claimed that title. Pelagius protested, but Maurice did nothing to make the patriarch John the Faster drop the title, and the pope died without getting satisfaction on the matter.

Gregory, his *apocrisiarius* at Constantinople, was elected to succeed him (590). As Leo I in the 5th century, so likewise was Gregory to win the title of "the Great," as one who had not only restored the ancient authority of Peter's see but added new splendour to it. His election constitutes an epoch in the history of the church.

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II. THE RISE OF THE MEDIEVAL PAPACY

Gregory I and the 7th Century.—With the pontificate of Gregory I (590–604) the papacy entered its medieval phase, in the course of which the primacy of the Roman church was eventually to be realized to its fullest possible extent.

In the preceding six centuries, as has been seen. some remarkable successes had been achieved in establishing the doctrinal and theoretical foundations of the primatial and monarchical position of the pope. In Gregory's pontificate, however, signs of a new application of this doctrine can be discerned: The pope's denial of the Byzantine emperor's claim to fix doctrine and dogma had hitherto been a source of danger to the papacy insofar as it exposed the pope to a charge of high treason whenever he overrode any imperial decree on such matters; and Gregory found an original means of circumventing this danger. This he did by the intensification of the Roman church's interest in western Europe in those countries, that is to say, which lay outside the direct jurisdiction of Byzantium. The initiation of the English mission under St. Augustine (of Canterbury) not only marks a decisive step toward freeing the papacy from encroachments by the imperial government in precisely those matters which mere of vital concern to the popes but also constitutes the beginning of the "Romanization" (in the religious sense) of Europe. By this turning of the papacy to the west a firm foothold for Roman doctrine, liturgy, law and customs was secured.

A number of factors combined to make this undertaking propitious. The large estates of the Roman church in Gaul (the patrimonies) were, so to speak, islands radiating Roman secular and ecclesiastical influence; the clergy everywhere lived according to Roman law; the Gallic provinces, having long been subject to Roman administration, were receptive of Roman forms of life and so of the influence of the papacy; the fairly well-developed Roman liturgy naturally enough gained a commanding position of superiority; the lucidity and unambiguous language of papal letters and decrees issuing forth from the papacy (the great bequest of ancient pagan Rome) could not but help to produce the desired result; the eastern empire, itself hardly ever united, could not, in any case, object to the extension of papal influence over Germanic nations; and the help provided by the rapidly advancing Benedictine monachism was yet another factor in the spread of Roman ecclesiastical rule. In an assessment of the enduring achievements of Gregory's pontificate recognition should also be accorded to the influential character of the pope's own writings, which, attuned as they were to a more or less uncritical reading public, served to popularize a good deal of patristic lore.

It was also Gregory I who introduced the official title by which the pope was thereafter to designate himself, namely servus *servorum* Dei ("the servant of the servants of God"), an ingenious and succinct conflation of scriptural, Leonine and Justinianean expressions. Illoreover, the registers of this pontificate (comprising altogether 848 lengthy letters) are the oldest extant papal registers and of permanent value to the papacy. They reflect Gregory's own experience as prefect of the city of Rome and are an excellent testimony of his legal training—a feature characteristic of most medieval popes.

In the history of the medieval papacy the 7th century marks a period in which progress neither in its European standing nor in its own institutions can be recorded (see Table IV for the successors of Gregory down to 752). The reasons for this stagnation are manifold, one of the most potent being the heavy hand that the imperial regime in Constantinople laid upon the Roman church, which consequently found itself deprived of the necessary freedom of deployment of its forces. Nevertheless, while Rome itself could do little, the seeds which Gregory I had planted were to bear fruit. The especial attachment of England to the papacy in this century is perhaps the most striking feature; and Spain, before it succumbed to the Islamic onslaught, supplied, in such writers as Isidore of Seville and in the decrees of the numerous Spanish councils and synods, a reservoir of doctrine and legislation upon which later papal legislators and lawyers were to draw freely. Relations with the imperial regime in Constantinople steadily worsened. After the scandalous treatment of Martin I, who, supported by some very able writers, opposed a Christological pronouncement by the emperor and was subsequently arrested, charged with high treason and exiled, there came the legislation of the "Trullan" council of Constantinople (692), which, convoked by the imperial government and therefore held to be universal, adopted in its 102 decrees an openly hostile attitude toward the papacy, the doctrinal points that the popes had always opposed being here made into law. This synodal legislation was bound to increase resentment at Greek rule in Italy, where alienation from

TABLE IV.—*The Papacy From 590 to 752*

590–604	Gregory I	678–681	Agatho
604–606	Sabinian	682–683	Leu II†
607 (Feb.–Nov.)	Boniface III	684–685	Benedict II‡
608–611	Boniface IV	685–686	John V
615–618	Deusdedit (otherwise called Adeodatus I)	686–687	Conon
		687 (*Sept.*)	*Theodore* and Paschal, *rival antipopes*
619–625	Boniface V		
625–638	Honorius I	687–701	Sergius I
640	Severinus*	701–705	John VI
640–642	John IV	705–707	John VII
642–649	Theodore I	708 (Jan.–Feb.)	Sisinnius
649–655	Martin I (d. in exile)	708–715	Constantine
654–657	Eugenius I	715–731	Gregory II
657–672	Vitalian	731–741	Gregory III
672–676	Adeodatus (II)	741–752	Zacharias
676–678	Donus	752 (March)	Stephen II (d. unconsecrated)

*Elected in 638; consecrated 640. †Elected in 681. ‡Elected in 683.

the east had already been making rapid progress during the preceding decades. Culturally, socially. politically, ritually and, above all, in religious matters, east and west spoke quite different languages; the easterners were contemptuously referred to as Greeks; and it was in the 7th and early in the 8th century that *Romanitas* acquired that peculiar suggestion of antithesis to Byzantinism or Graecism which was to become such a vital element in the making of Latin Christendom. *Latinitas* and *Romanitas* came to signify the same thing, denoting on the one hand a religious attachment to the Church of Rome and on the other a kind of self-imputed historic superiority to Constantinople, an upstart city without historic roots. At the same time, the frequent pilgrimages to Rome of young and virile western potentates (especially of the English), the missionary work undertaken by the Anglo-Saxons and the genuine veneration of the deeply religious Germanic nations for St. Peter and for his vicar could not but help to demonstrate by very palpable means to the papacy that, while the east exhibited all the characteristic features of Caesaropapism and hence hostility toward the Roman church, the west was demonstrative in its manifestation of loyalty to the see of Peter.

The task therefore of extricating the Roman church from the constitutional framework of the empire was considerably facilitated by prevailing circumstances. Harsh and unjust taxes levied by the imperial regime in Italy, a corrupt officialdom, an effeminate army and an ineffective administration only increased the popular resentment. As a result of the moribund regime in Italy the popes had steadily assumed a leading role in the affairs of the peninsula. Rome as a historic and ecclesiastical centre came more and more to the fore; it became the rallying focal point. The iconoclastic policy that had been pursued by the emperor Leo III the Isaurian from 726, together with a renewed increase in taxes, finally determined the papacy to enlist the help of the Franks; and the renewed advance of the Lombard forces toward the centre of Italy made this step appear as a matter of practical politics.

The Franks, the "Donation" and the Coronation of 800.—Largely as a consequence of the missionary work of St. Boniface, the youthful Frankish kingdom had ecclesiastically come under the doctrinal and disciplinary influence of the Roman church. This orientation toward Rome proved to be of crucial importance in the decades to come. Although nominally the ruler was still a Merovingian, effective governing power had for some time been in the hands of the mayors of the palace, who held their power from the king; and Pippin, the astute mayor, saw the incongruity of a situation in which the king was a mere puppet without power and the mayor in fact the actual ruler. Pippin's deposition of the Merovingian Childeric III mas cautiously sanctioned by the papacy, which duly appreciated Pippin's submission of his request as a concrete confirmation of papal views. In contrast with the eastern Roman emperors, the primitive Franks paid so much respect to the pope that he was even approached in so delicate and serious a matter as that of substituting one ruling house for another. The answer which Pope Zacharias gave was, however, dictated by the papal doctrine that only he should be a king who was useful. Childeric had proved himself useless and thus had no right to rule—a point of view which suited Pippin's designs admirably, but one which mas not without danger to the future German monarchy. Pippin was soon given an opportunity to show his appreciation of the papal reply by deeds.

In the 8th century the Lomhards. under their king Aistulf, resumed their policy of conquest, attempting to subdue the whole Italian peninsula to their rule. Ravenna. the seat of the imperial exarch, fell in 751, and the Lombard armies directed their attacks southward. toward Rome. The pope, Stephen II (III), appealed to I'ippin; in person he went to see the Frank: crossing the Alps in the winter of 753–754, and met him at Ponthion at Epiphany. Pippin promised military help to the pope, taking an oath to the effect that he would restore districts stolen from the Roman church by the Lombards. The pope anointed him again—he had already been anointed by St. Boniface two years earlier—and made him "patrician of the Romans." After some negotiations Pippin agreed to issue a iormal document in which the earlier promises were solemnly embodied; in particular he promised to restore the exarthate jthe district round Ravenna) and some other more or less defined regions to the Roman church.

Two years later, in 7j6. after a military campaign, Pippin implemented these promises; and the so-called papal state came into being. comprising large districts in central Italy. This district was. so to speak, carved out of the body of imperial Italy and belonged juridically to St. Peter, the pope being its temporal administrator. It lasted until 1870.

Few episodes in history have given rise to more discussion than the action of Pippin; and few episodes can have been of more momentous consequence than the creation of this state. What was the basis of the pope's demands ior the "restoration" of these (and other) districts? To mention but one esample: how could the pope demand that the exarchate of Ravenna, which was imperial territory, be returned to the Roman church? It is difficult not to believe that the basis of the pope's demands was the "Donation of Constantine" (*q.v.*), and we here take the view that this forgery was made not later than the autumn of 753, before the pope set out for his journey to the Frankish king. According to this forgery the emperor Constantine the Great had, as a token of his gratitude for receiving baptism and recovering from leprosy, not only donated the Lateran palace to St. Peter, through the medium of the pope, Silvester I, but also conceded to the pope the dominion of the city of Rome and all other provinces, cities and regions of Italy and the occident; the pope was also given the imperial insignia, ali imperial power and dignity; and the pope kept all the garments and emblems of imperial power except the imperial crown. This document formed the title deed in the negotiations with Pippin. because territory that was "given" to the pope by Constantine was now said to have been stolen by the Lombards; and as a loyal son of the church Pippin did what was expected of him, driving the Lombards out and handing the territories "back" to the "rightful" owner, St. Peter. With the establishment of the papal state, the papacy had effectively emancipated itself, constitutionally, from the shackles of the imperial regime at Constantinople.

This emergence of the papacy as an independent entity was accompanied by the introduction of a number of institutional changes in the second half of the 8th century. The decree oi the Lateran council of 769, by which an attempt was made to regulate the election of the pope by confining it to the Roman clergy and excluding the laity, was to be the model for the later and more permanent procedure (*see* below); the election of a new pope, moreover, was no longer announced to the imperial court. but to the Frankish king. The dating of papal documents according to imperial years, as enjoined by the constitution, was abandoned. The popes began to strike their own coins. These and other significant changes permit of one conclusion only. namely that the papacy had in fact extricated itself from the imperial domination and had assumed the status of an independent power.

The coronation as "emperor of the Romans" of Charlemagne, the son and successor of Pippin, by Pope Leo 111 on Christmas day. 800. can be regarded as the final and calculated step in this process. Charlemagne had not only vastly increased the Frankish territory by military conquest but had also crushed all further resistance on the part of the Lombards by incorporating their kingdom into his own. He was one of those medieval rulers to whom Christianity

was a motivating force in all his governmental actions; and hand in hand with this went his profound devotion to the Roman church as the see of St. Peter in matters of doctrine. Severtheless. while the coronation can be regarded as concluding the process of papal emancipation, the papal interpretation of it, according to which, since there was only one emperor of the Romans, the eastern empire could no longer be in legitimate existence, did not meet with Charlemagne's approval, as it would have involved him in a serious conflict with Byzantium, with which he wished to live in amity. Charlemagne therefore gave the coronation a meaning to which. indeed, the pope could not object: namely a purely religious one. He came to hold himself as an emperor of the Roman Christians, since to him *imperium Romanum* and *imperium Christianum* were the same thing. Although from a practical standpoint this Christmas episode had little effect on the contemporary scene: it nevertheless set a porverful historical precedent which later was endowed with an importance quite out of proportion to the actual result. (See Table V for the popes from 752 to 900.)

TABLE V.—*The Papacy From 752 to 900*

752–757	Stephen III (II)	*855*	*Anastasius Bibliothecarius of San Marcello, antipope*
757–767	Paul I	858–867	Nicholas I
767–768	*Constantine II, antipope*	867–872	Adrian II
768 (July)	*Philip, antipope*	872–882	John VIII
768–772	Stephen IV (III)	882–884	Marinus I (miscalled Martin II)
772–795	Adrian I	884–885	Adrian III
795–816	Leo III	885–891	Stephen VI (V)
816–817	Stephen V (IV)	891–896	Formosus
817–824	Paschal I	896 (April)	Boniiace VI
824–827	Eugenius II	896–897	Stephen VII (VI)
827 (Aug.–Sept.)	Valentinus	897 (Aug.–Nov.)	Romanus
827–844	Gregory IV	897 (Nov.–Dec.)	Theodore II
844 (Jan.)	*John, antipope*	898–900	John IX
844–847	Sergius II		
847–855	Len IV		
855–858	Benedict III		

The 9th Century.— Throughout the 8th century the papacy had firmly kept the initiative in its hands, and this also is the key to the understanding of its overwhelming success in the 9th. Leo III's successor, Stephen IV (V), traveled again across the Alps, this time not to make a Frank a king, as in the case of Pippin, but to make a Frank unambiguously an emperor. The coronation of Charlemagne's son Louis I. performed by Stephen at Reims in Oct. 816, begins the long line or' medieval coronations combining Byzantine features (the act of crowning) and Frankish elements (anointing). Moreover, the ceremony in 800, if ceremony the coronation be called, did not make any explicit reference to the "Donation of Constantine," though hard to explain without taking the forgery into account; but in 816 the pope brought with him the (alleged) crown of Constantine and declared that what he in fact put on Louis' head was Constantine's crown. Thereby the whole act was given its historical and political meaning: Louis was crowned as the sole Roman emperor and became, in theory at least. the legitimate successor of the ancient Caesars, with the further consequence that the legitimate standing of the eastern Roman emperor became a matter of speculation.

The role of the papacy as the agency which made emperors became one of its most treasured prerogatives, and it was a role that suited the western kings very well. The title of Roman emperor not only gave these kings an immeasurably enhanced standing but also kindled political and historical imagination to the fullest possible extent. The Franks as successors of the Roman Caesars was a theme that conveniently bridged the gulf between religious Romanism (adherence and loyalty to the Roman church) and political Romanism (the resuscitation, rebirth and continuation of the ancient Roman empire). Much of the grandiose papal edifice was erected upon this fertile ground, as the making of a Roman emperor provided the papacy with a unique opportunity to apply its principles in practice. The emperor made by the pope was, according to the papal theory of government, a lieutenant, an assistant, the secular arm in the execution of the papal plan.

Naturally enough. the papal role in the making of emperors could never be acknowledged by the Byzantines, who, crowned as they were by their own patriarchs considered the pope merely a somewhat exalted higher ecclesiastic; but. as later conflicts between papacy and western empire were to show, the corollaries of the papal claim were not always acceptable to the western emperors either. The western emperors, indeed. in contrast with the Byzantines, found themselves in an inescapable dilemma. On the one hand, it was axiomatic ior them that only the pope could validly confer universal (Roman) imperial power; on the other hand. they disputed the implicit superiority of the popes. maintaining a theory of the papacy which greatly resembled that upheld by the Byzantines. One of the strongest motives for western kings to become emperors of the Romans was the position that they thereby gained of universal lordship of the world; and this made them the natural opponents of the Byzantines. who, for historical reasons, considered themselves as the only rightful heirs to the ancient Roman emperors. It was precisely this universal aspect of the Roman imperial title that made Charlemagne reject the terms of coronation as contrived by the pope; but the allurement was apparently too strong for later imperial generations.

The papacy was not slow in developing and applying its own theme. When Louis' son Lothair I was invited by Paschal I in 823 to come to Rome to he crowned emperor. he immediately accepted the invitation; and this was the first fully fledged imperial coronation held at St. Peter's (henceforward the proper place for these ceremonies) and also the first occasion on which a sword was handed to the emperor by the pope during the ceremony as a symbol of that physical power which was to suppress evil, the underlying idea being that the emperor symbolically received physical strength from the pope for the specific purpose of exterminating evil (cf. Rom. xiii. 4). On the very next occasion, in 850, it was no longer necessary for the pope to issue an invitation, for it was now the father. Lothair I. who requested the pope. Leo IV, to crown his son Louis II as emperor. It is a measure of the success of the papal theme that 25 years later, that is, 75 years after the abortive coronation of the first Charles, it was the papacy under John VIII (872–882) which "selected and nominated" the emperor Charles the Bald. Within this short span, the papacy had risen to be able to choose. from among a number of claimants. the one who was to be its prolonged arm in the furtherance of its aims. There can be no doubt that the invasions and raids of the Saracens made the creation of a secular arm more than a mere theoretical or nominal issue. Yet it is equally true that the medieval Roman emperor—whose specifically Roman universal nature (as distinct from his Frankish or German kingship) was for all practical purposes that of a phantom—was an offspring of the Roman church. Without the latter not even the idea of a Roman empire in the middle ages would have come about. The pope's right to create a Roman emperor was based "historically" on the "Donation of Constantine" and doctrinally on the axiom that, since all power came irom God. the pope, as Peter's vicar: acted in a mediatory role in creating the emperor.

There was. also, a development in a different sphere. The higher clergy in the Frankish domain had greatly profited from the ecclesiastical legislation of Charlemagne and from his educational policy. which produced not only far larger numbers of clerics with an infinitely better educational background. but also a critical spirit of inquiry. This inquiring spirit, then, focused its attention on the right of the king or emperor to legislate in matters of ecclesiastical discipline, doctrine and administration. By what authority could the emperor be said to issue laws in these matters? Moreover, the legitimacy of the old Germanic proprietary church system, according to which the owner of the land not only owned the church built on it but could also appoint and dismiss the cleric serving the church, came to be seriously questioned. The decrees of the numerous councils of the 9th century hear witness to an openly hostile attitude toward the system of lay patronage; this conciliar legislation not only weakened the basis of the existing regime but also. what is more important for the present purpose, indirectly strengthened the influence of the papacy. The three great forgeries concocted in the middle of this century in or near Reims—the works of the pseudo-Isidore (see DECRETALS: The False *Decretals*) and of Benedictus Levita and the *Capitula Angilramni*—are an eloquent reflection of the highly advanced state of clerical education produced by Charlemagne's educational

policy. These forgeries, by incorporating spurious papal decretals and synodal decrees as well as royal and imperial rescripts, attempted to set forth the laws for a true Christian commonwealth and, in so doing, quite naturally adopted an .antagonistic attitude toward lay domination in the church; it was for this reason that the primatial position of the Roman church came to be buttressed. Although in origin quite independent of the papacy, the forgeries became a powerful prop to papal designs, not so much because of their contents but rather because of their character as handy reference books. The first identifiable use of them was made by Nicholas I (858–867), and thenceforward they proved themselves very useful source books for the papal chancery.

Further factors which considerably strengthened papal influence in the 9th century were the internecine conflicts of the Frankish rulers and the general unrest within their kingdoms, in themselves merely symptoms of a deeper-lying ideological crisis; in particular, marriage affairs, attempted invasions and internal rebellions were spheres in which the moral-religious nature of the papacy could be brought into full play. The presupposition for this influence was that the papacy was credited with this moral-religious status. When everyone believed that life on earth was a mere preparation for life in the next world, the Roman church. with its hallowed prestige, tradition and experience, could without undue difficulty drive home unquestioned tenets.

The circumstances were such that the papacy had every opportunity to state, to restate, to formulate and to elaborate its own fundamental theme in numerous letters. Under Nicholas I, Adrian II and John VIII the papacy, with a wealth of scriptural, patristic, conciliar and papal material, insisted on its leadership of the whole body of Christians (east and west); emphatically proclaimed that the true monarch of this body was the pope as vicar of St. Peter; insistently asserted the freedom of the clerical body from lay and royal control; and vigorously reasserted the primacy of the Roman church vis-à-vis the government in Constantinople, with which, as a result of the steps taken by the patriarch Photius, relations entered into a very delicate stage. Lastly, due recognition should be given to the exceptionally rich scholarship both in theology and in liturgy which had grown up in the 9th century in Frankish lands and which exercised great influence on the papacy in the next century, when Latin and Teutonic elements were inextricably fused together. Unction at a priestly ordination, till then unknown in Italy, became an element of ordination as a result of the Germanic influence on the papacy. The liturgical contribution from the north in the 10th century may he compared with the juridical contribution made by the forgeries in the gth, with the difference that the one was to remain valid whereas the other was eventually proved spurious.

The Popes and the Emperors, 918–1073.—The intimate connection between the papacy and the Saxon dynasty established in Germany in 918 had two notable results: in the first place the Roman empire in the west received a new lease of life; and secondly the Germanic influence became preponderant. During the 10th century and much of the 11th the papacy became merely a part of the governmental machinery of the Roman empire.

But despite this setback the papacy, even in this period, contrived to develop some of its themes, particularly in the imperial coronation rites. Medieval rites expressed at all times a program, an idea, by symbolic means and gestures. The papacy on the occasion of these coronations devised a number of symbolic measures in the ritual which were to bring out clearly the ancient papal ideology. For example, while the anointing was left to the three cardinals, the act of crowning was performed by the pope alone, so as to demonstrate that he was the sole agent in conferring imperial dignity; the oil with which the emperor was anointed mas no longer the chrism, but an oil of an inferior kind; nor was he any longer anointed on the vertex of the head, but between the shoulder blades and on the right forearm, so as to designate the sacring of the seat of physical strength and the actual part of the body that wields the sword. The conferring of the typical imperial emblems, crown, sceptre, sword and ring, was moreover left entirely to the pope; the emperor had to take an oath of obedience to the pope and to kiss his feet; it was in his function as "father"

TABLE VI.—*The Papacy in the 10th Century*

900–903	Benedict IV	946–955	Agapetus II
903 (July–Sept)	Leo V	955–964	John XII (deposed Dec. 963)
903–904	*Christopher, antipope*	963–965	Leo VIII*
904–911	Sergius III	964–965 or 966	Benedict V*
911–913	Anastasius III	965–972	John XIII
913–914	Lando	973–974	Benedict VI
914–928	John X	974 (June–July)	*Boniface VII, antipope (expelled)*
928 (May–Dec)	Leo VI	974–983	Benedict VII
928–931	Stephen VIII (VII)	983–984	John XIV [deposed]
931 935	John XI	*984–985*	*Boniface VII (returned)*
936–939	Leo VII	985–996	John XV
939–942	Stephen IX (VIII)	996–999	Gregory V
942–946	Marinus II (miscalled Martin III)	*997–998*	John *XVI, antipope*

*Rival popes, one or other of whom may be regarded as an antipope

that the pope adopted the emperor as "son" of the Roman church; and so forth. All this ritual was to show that the conferring of imperial power was entirely at the discretion of the pope. The title of emperor was not something which the German king had a right to demand, but rather a privilege (*beneficium*), as the popes were never weary of telling the emperors. (See Table VI for the 10th-century papacy.)

There is little doubt that a certain incongruity can be seen between the subordinate position of the emperor. so clearly manifested on the occasion of his coronation, and the actual government exercised by him, for in the first half of the 11th century popes were made and unmade according to the requirements of the imperial government. The explanation is, not that the papacy lacked a program or the necessary institutions, but that the time was not yet ripe for a frontal attack on the existing bases of the imperial government (bishops and abbots and all higher clergy were appointed by the emperors and by the kings. just as the popes themselves were) and that the papacy lacked the men to transform mere theory into fact. It was the emperor Henry III (1039–56) who, by deposing and installing a number of popes, unwittingly provided the papacy with the kind of men to make that frontal attack and to realize that transformation. The popes appointed by Henry III surrounded themselves with extremely learned, talented and energetic men who clearly saw the incongruity of the situation. Moreover, through these new arrivals in the Roman church fresh blood was infused. They were cosmopolitan in their outlook, coming as they did from places far away, particularly from Lorraine and from the Low Countries, where a considerable opposition to the regal-sacerdotal regime of the emperors had grown up. As long as the making of the popes gave the emperors a means of exercising their influence (this imperial right was based on a harmless document originally issued by Otto I in Feb. 962 and reissued by him in a falsified version in Dec. 963), there was little opportunity of maintaining independence from the imperial government. Hence, the combination of the premature death of Henry III with the fact that his successor, Henry IV, was but a minor and with the ascendancy in the Roman curia of highly gifted men resulted in the first concrete legislative steps directed against the imperial domination of the church. The very important decree issued by the Lateran council of 1059 under Nicholas II expressly forbade lay investiture of bishops and of abbots, stipulated that the election of the pope must proceed "canonically" (*i.e.*, with imperial influence excluded') and established the composition of the electoral body. This electoral body was subsequently to become the College of Cardinals. in whose hands alone the choice of the vicar of St. Peter lay. There were three groups of cardinals—cardinal bishops (7), cardinal priests (28) and cardinal deacons (18)—who in one way or another were connected with the local Roman churches and who, since the 6th century, had performed auxiliary functions in the pope's cathedral, the Lateran church. Not unlike the old Roman senate, the College of Cardinals performed the function of an advisory body to the pope; hence was formed the Roman curia. It was also from this body that the papal legates were drawn who represented the pope's authority in distant lands. But the constitutional rights of the cardinals had never been clearly defined, and this defect led later to serious friction between them and the popes.

The year 1059 also witnessed the first papal coronation (as

distinct from consecration). This ceremony. though performed on all subsequent popes, was never regarded as of the same importance as an imperial coronation, because it was never considered an element essential to the constitutional position of the pope. Immediately after accepting the election, the candidate was pope, although in theory at least he might still be a mere layman (who would then have to seek episcopal consecration as soon as possible). The object of the papal coronation was merely to show by contemporary and suitable means the regal-sacerdotal, that is, the truly monarchic character of the pope elected. *(See* Table VII for the popes of the 11th century.)

TABLE VII.—*Popes of the 11th* Century

999–1003	Silvester II	1047–48	Benedict IX (restored)
1003 (June–Dec.)	John XVII	1048 (July–Aug.)	Damasus II
1004–09	John XVIII	1049–54	Leo IX
1009–12	Sergius IV	1055–57	Victor II
1012–24	Benedict VIII	1057–58	Stephen X (IX)
1012 (May–Dec.)	*Gregory, antipope*	*1058–59*	*Benedict X, antipope*
1024–32	John XIX	1059–61	Nicholas II
1032–11	Renerlict IX (resigned)	1061–73	Alexander II
1045 (Jan.–March)	Silvester III	*1061–72*	*Honorius II (Peter Cadalus), antipope*
1045 (April–May)	Benedict IX (deposed)	1073–85	Gregory VII
1045–46	Gregory VI	*1080, 1084–1100*	*Clement III (Guibert of Ravenna), antipope*
1046–47	Clement II	1086–87	Victor III
		1088–99	Urban II

Many other changes took place in the Roman curia during the 1050s and 1060s. The residence of the popes, the Lateran palace, was reconstituted: old offices merged into new ones or decayed altogether; the chancery (the pope's secretariatj with its numerous special officers, the financial departments, the judicial tribunals. etc.. were put on a new footing. A feature hitherto reserved to royal courts now also entered into the service of the curia, namely feudalism. Nicholas II's enfeoffment of the Normans in 1059 was the beginning of a long line of feudal contracts concluded between the curia and kings. princes. etc.. so that by the end of the 12th century the papacy had more feudal vassals than any other European power. In these contracts St. Peter. acting through the pope, was envisaged in the role of a feudal lord giving protection to his vassals, who enjoyed certain privileges in return for military services or money payments.

It was also at this time that the breach with Constantinople (1054) became final. as a result of the abortive mission of Cardinal Humhert. Himself one of the great driving spirits in the Roman curia, Humbert was also the author of an influential collection of decrees, the first collection of canon law in the later medieval sense. Its characteristic feature: as also that of the subsequent collections, was its orientation on the primacy of the Roman church. The attention given to law in this same period is noteworthy. Hildebrand as a member of the curia, long before he became pope as Gregory VII, appreciated the vital importance for governmental and constitutional purposes of a fixed body of law; for how else, if not by law, was the whole church, the *societas Christiana*, to be governed? To be sure, there had been collections of law before this time, but what they had lacked was a deliberate orientation on the primacy of the Roman church; these earlier collections exhibited an episcopalist rather than a papal bias. The new movement, necessitated as it was by the ascendancy of the papacy itself, reached its preliminary conclusion in the middle years of the 12th century with the publication of Gratian's *Decretum*, in itself a masterpiece of the. handling of the vast papal, patristic and synodal material with the help of Roman law and the fashionable dialectical method. Gratian's was a private work and remained so, never receiving official sanction. Since, basically, medieval canon law was doctrine made into an enforceable rule and since, furthermore, only the pope as a universal authority was credited with the power of turning doctrine into law, the medieval canon law was considered a universal law binding all Christinns. It dealt with all matters of importance to the medieval Christian commonwealth. *(See* CANON LAW.)

Gregory VII **and** the Investiture Contest.— Gregory VII (1073–85) vigorously asserted the primatial position of the papacy within Latin Christendom and in doing so precipitated the investiture contest *(see* INVESTITURE). In the course of that gigantic struggle with the German kingdom under Henry IV the popes with a ruthless logic applied old papal tenets. While the ideas were by no means new. their application on a vast scale was, and it was this novelty which caused so much stir, bewilderment and consternation in Europe. This conflict stands out as a great watershed in European history. The position of the pope as the supreme leader of the whole of Christendom was summed up in Gregory VII's pithily formulated 27 "sentences," the *Dictatus papae* (1075): all matters affecting the well-being of the Christian commonwealth are to be finally decided by the pope, who himself cannot be judged by anyone *(papa a nemine judicatur)*; a council is ecumenical (*i.e.*, universal) only if the pope has summoned it or authorized its decrees; the pope alone may wear the imperial emblems and alone has the right to demand the *osculatio pedum* (kissing of the feet); he may depose kings and emperors and princes and create new kingdoms; he alone is the universal bishop; and so forth. The 27 "sentences" contained the basic pronouncement of the papal-monarchic principle. The application of this principle, resulting in the centralization of the papal government and in a number of consequential measures (the excommunication and deposition of Henry IV; the exaction of an oath of obedience from the bishops; the gradual enforcement of the bishops' periodical visits to the pope, the so-called *visitatio liminum apostolorum;* the requiring of papal approval for the translation of a bishop to another see; the prohibition of simony and of clerical marriage; the renewed prohibition of lay investitures; etc.) produced a convulsion in Europe and quite especially in Germany. which was the country primarily affected by these and other measures, finding itself deprived of all stable foundations. The humiliation of Henry IV at Canossa barred the way to a return of the German king to full monarchic status. hitherto unquestionably enjoyed. Naturally, this great conflict had its inevitable repercussions in England and in France. though never reaching the same dimensions as in Germany. Moreover, the investiture contest provided not only the stimulus for the so-called humanistic Renaissance of the 11th and 12th centuries but also for an unprecedented literary activity of a polemical nature. This is one of the earliest occasions on which a very successful attempt was made at creating a public opinion by means of books, pamphlets, speeches, etc.; and publicistic literature was from now onward an indispensable accompaniment of all ideological conflicts.

One more novel feature could be detected during the conflict. For the first time the papacy revolutionized the lay masses against married and simoniacal priests. Little historical imagination is needed to appreciate the dangerous effects of this legalized and sanctioned strike. The rapidity with which the papacy could achieve its purposes was a result of its ideological preparedness. The imperial side had at its disposal history, tradition and custom, but these carried little weight in a Christocentric world when counterbalanced by papal arguments derived from Scripture and by the undisputed function of the pope as vicar of St. Peter. It was indeed a resounding victory of ideas over hard facts.

The 12th Century.— Though Calixtus II made some temporary concessions to the empire in the concordat of Worms in 1122 (in England and in France the issues had been settled earlier), the monarchic authority of the pope over the west came largely to be realized. The following 100 years saw the papacy rise to the zenith of its power. Moreover, despite numerous protestations on the part of the emperors, particularly of the new Staufen dynasty, their desire to be crowned by the pope as emperors implicitly forced them into acceptance of fundamental papal themes. No appeal to the "sacred" Roman laws could alter their position. Imperial protagonists evolved, as a reply to the ever-advancing papal claims, a dualistic theory of government, whereby both emperor and pope were to be supreme heads in their respective spheres, though the demarcation of these spheres was never and could never be established. This dualistic theory was, naturally enough, roundly condemned by the papacy. With unparalleled logical insistence the papacy proclaimed the monarchic form of government to be exercised over the Christian body politic by those who alone were qualified. The combination of royal and sacerdotal powers

in one person was in medieval times the hallmark of a monarch, and the popes now openly asserted this double function. Moreover, a distinction came to be drawn between the office of the pope and the person occupying this office; and this separation of office and officeholder proved itself of considerable value to the institution itself. The change of the pope's function from "vicar of St. Peter" to "vicar of Christ" (a designation that came gradually into use during the 12th century until it was firmly established under Innocent III) suitably expressed the increase in papal authority. Since Christ was held to have been both King and Priest from Whom all power stemmed (an axiom to which without exception everyone adheredj. His vicar too asserted the same combination of offices in his person, with the consequence that he, like Christ. claimed plenitude of power. This claim was of immeasurable value to the pope not only in his dealings with kings and emperors, but also in his relations with the episcopate. The vicar no longer merely of an apostle—albeit the prince of the apostles—but of Christ, the pope, again like Christ, could institute bishops, the successors of the apostles. Recalcitrant bishops who might maintain that they were the equals of the pope and that he therefore could not give them orders were thus reduced to silence. Basing their function on the vicariate of Christ, the popes could henceforward dispense with the Donation of Constantine, in which hitherto their claim to the royal part of their position was grounded. (*See* Table VIII for the 12th-century papacy.)

TABLE VIII.—*Popes of the 12th* Century

1099–1118	Paschal II	1144–45	Lucius II
1100	*Theoderic of Santa Rufina, aniipope*	1145–53	Eugenius III
		1153–54	Anastasius IV
1102 (Feb.–March)	*Albert of Sabina, aniipope*	1154–59	Adrian 11'
1105–11	*Silvester IV (Maginulf), antipope*	1159–81	Alexander III
		1159–64	*Victor IV (Octavian of Monticelli), antipope*
1118–19	Gelasius I1	*1164–68*	*Paschal III (Guido of Crema), antipope*
1118–21	*Gregory VIII (Maurice oj Braga), antipope*	*1168–78*	*Calixtus III (John oj Struma), antipope*
1119–24	Calixtus II	*1179–80*	*Innocent III (Lando of Sezza), antipope*
1124–30	Honorius II	1181–85	Lurius III
1124 (Dec.)	*Celestine II (Theobald), antipope*	1185–87	Urban III
		1187 (Oct.–Dec.)	Gregory VIII
1130–43	Innocent II	1187–91	Clement III
1130–38	*Anacletus II (Pierleone), aniipope*	1191–98	Celeitine III
		1198–1216	Innocent III
1138 (March–May)	*Victor 1V (Gregory), antipope*		
1143–44	Celestine II		

Hand in hand with the emergence of the papacy in the 12th century as a monarchic power on a universal scale went a number of institutional and constitutional reforms necessitated by the growth of papal go ernment. The chancery, as the central organ, with its scope greatly increased, underwent further modifications not only in personnel but also in the kind of documents issued (it must be emphasized here that the papal decretals were often in themselves first-class juristic documents, endowed with universal validity and enforceability by virtue of the pope's function as supreme legislator and judge); the legatine system was consolidated; the papal election procedure was regulated insofar as a two-thirds majority became necessary for a successful candidature; the older papal synods came to be supplanted by the Lateran councils, which the popes claimed to be universal councils because they convened them (a right previously asserted by the emperors); regular meetings of the popes and cardinals were held (consistories) in which papal policy was discussed and also decided; through the succession of a number of able chamberlains the finances of the papacy were put on a solid basis; liturgy came more and more into the orbit of papal legislation; and so forth. For obvious reasons the papacy took the initiative in the summoning of the crusades (*q.v.*). The first three were partly a manifestation of genuine religious zeal by the masses; partly the realization of royal ambitions; partly an attempt to re-establish the primacy of the Roman church in the east; and partly, through the immunities conferred on the crusaders, a means of escape from pressing civil burdens. Resistance to the papal scheme of government catne not only from the imperial side but also from other kings. As they seemed of little consequence at the time, the papacy did not heed the warnings implicit in schemes such as those advanced by Henry II of England, ominous though they were and destined to come to fruition later.

Innocent 111.—Under Innocent III (1198–1216j the papacy reached the high-water mark of its European influence. Innocent had been thoroughly trained in law at the University of Bologna. and was only 37 years old when he succeeded the nonagenarian Celestine III. He was endowed with great intellectual gifts and with an extraordinary capacity for work. In him the vision of the far-seeing statesman was happily wedded to the subtlety and perspicacity of the scholar; and his unsurpassable command of language and diction was coupled with a profound sense of a religious humanism. More than 6,000 letters, the most important of which he personally dictated, are a testimonial to his talents. Incisive. lucid, well-shaped. they deal with a multitude of tasks affecting Christendom in one way or another. With his pontificate, moreover, begins the long series of extant papal registers.

The religious complexion of the 13th century would have been radically different but for the discerning mind of Innocent III. Itinerant preaching and apostolic poverty, hitherto regarded as sure signs of heresy, were given a legitimate standing—a policy that later led to the recognition of the mendicant orders, notably the Franciscans and the Dominicans. Some successful attempts were made to bring heretical sects back into the church; but severe measures were taken against those sects (for example the Albigenses) which the pope was unable to bring back. The Lateran council of 1215 enjoined annual oral confession to the parish priest. The episcopate, always the cause of some anxiety, was firmly controlled, as the papacy intervened more and more in the filling of vacant sees; and bishops came to be styled *episcopi apostolicae sedis gratia,* "bishops by the grace of the apostolic see."

Papal legislation reached unprecedented heights, giving a great impetus to canonistic scholarship; and litigation at the papal tribunal was encouraged. Masters and students of Bologna flocked to hear the pope as judge, the issues tried ranging from a boundary dispute in a parish to the contested eiection of a king or of an archbishop. The pope intervened on several occasions in the, affairs oi kings (notably in the matrimonial affairs of Philip II Augustus of France, of Peter II of Aragon and of Alphonso IX of Leon); and the case of John of England provides an example of the use of interdict over a whole country together with personal excommunication in order to bring pressure on a recalcitrant prince. The tottering papal state. meanwhile?had been re-established; and the relations between the papacy and Sicily were clarified. Furthermore, Bulgaria (1204) and England (1213) were made feudal dependencies of the papacy. and papal suzerainty over Portugal was reaffirmed. Important constitutional laws, such as Magna Carta, were declared null and void.

In the complicated conflict between the Innocentian papacy and the two claimants to the imperial throne the pope showed his diplomatic superiority in a masterly manner. His correspondence in this struggle, spanning a period of more than ten years. superbly marshals the arguments for the papal-hierocratic standpoint: the pope as king and priest selects the future emperor; the relations between the former and the latter are that of sun and moon; the pope as vicar of Christ, the true Priest-King. confers imperial power to which no claimant has a right, for it is only through the exercise or' the papal favour that a king can be promoted to be emperor. The idea of papal universal monarchy had never been so trenchantly exposed and applied as in these and similar pronouncements oi Innocent III. That the outcome of the conflict was not commensurate wirh Innocent's strategic ability was due partly to deceitful machinations by those on whom he primarily relied for information (especially the German bishops. such as Adolf of Colognej and partly to circumstances over which he had no control. In the midst of the conflict the fourth crusade was launched. When the crusaders captured Constantinople (1204), a Latin patriarchate was erected and ior a short time the Roman primacy over Constantinople became a reality. In his correspondence with the Greek emperor Innocent had had further opportunity to state his views on the secular power, for to the pope had been given not only the government of the church, but also that of the world (a statement

which originally came from St. Bernard).

The summoning of a general council was a fitting conclusion to this eventful pontiiicate. This council, the fourth ecumenical council of the Lateran, which met in 1215, was to demonstrate the ascendancy of the papacy. The pope purposely adopted the method of the ancient Roman emperors in his edict of convocation and thus palpably showed the place which the papacy had attained. This moreover was the first genuine "general council." since both clerics and laymen were summoned; participants numbered more than 1.200. Many of its decrees remained the law until 1918.

The 13th Century, After Innocent III.—In the post-Innocentian period the papacy reached its greatest measure of concrete success (*see* Table IX for the 13th-century popes). In its hitter conflict with the emperor Frederick II, who from the middle years of the pontificate of Honorius III. throughout that of Gregory IX till his death during that of Innocent IV proved himself a most determined adversary. the papacy was Iorced to spend most of its energy on defeating Frederick to its own detriment and to the advantage of national kings. especially those of England and of France. Both sides were powerfully assisted by an army of highly gifted publicists. In increasing quantity and quality the two contestant: tried to influence public opinion: and the manifestoes, encyclicals, pamphlets. etc., testify both to the depth of feeling engendered and to the range of scholarship attained. However, Frederick's appeal to all the European nations to form a league against the pope fell as flat as his stigmatization by the pope as the Antichrist. Although the validity of the sentence of the general council under Innocent IV which deposed and excommunicated Frederick in 1245 was not free from doubt, it nevertheless gave rise to a long period of anarchy in the empire. This lasted until 1272, when Rudolph of Habsburg (the first of his family to become German king) won control of the situation. Subsequent emperors were mere shadows of their predecessors.

TABLE IX.—*Popes of the 13th Century*

1198–1216	Innocent III	1276 (Jan.–June)	Innocent V
1216–27	Honorius III	1276 (July–Aug.)	Adrian V
1227–41	Gregory IX	1276–77	John XXI
1241 (Oct.–Nov.)	Celestine IV	1277–80	Nicholas III
1243–54	Innocent IV	1281–85	Martin IV
1254–61	Alexander IV	1285–87	Honorius IV
1261–64	Urban IV	1288–92	Nicholas IV
1265–68	Clement IV	1294 (July–Dec.)	Celestine V (resigned)
1271–76	Gregory X	1294–1303	Boniface VIII

As a universal authority the papacy in the 13th century was able to develop, to apply and to enforce a number of principles which have since become part of modern international Ian.. These included the protection of legates and the safe conduct of ambassadors; respect for the sanctity of treaties; the humane treatment of prisoners and hostages; the protection of exiles; etc. By the same authority the papacy also ordered the free passage of troops engaged in a just campaign; instructed kings to enter into alliances; allotted occupied territory to a victorious belligerent; deposed rulers; and so forth. In the field of legislation great strider were made. Gregory IX in 1234 issued the first comprehensive official statute book; and most of the papal and conciliar legislation that had accrued between this date and 1298 was published in a further lawbook. the *Liber Sextus* or *Sext,* by Boniface VIII !these codes, together with the supplement issued by John XXII in 1317, remained canon law until 1918). Of particular importance in this century were also the two general councils held at Lyons (1245 and 1274); the earlier one was largely occupied with the action taken against Frederick II. though a number of important disciplinary decrees were also promulgated; the second achieved a temporary union of the eastern and western churches and, among its decrees, passed the constitution *Ubi periculum,* which turned the customary conclave into an obligatory prerequisite for the validity of a papal election.

Nevertheless, the papal-hierocratic government began, as the century wore on, to produce inevitable reactions. The heretical movements. still largely disunited and diversified and for this reason unable to present a united front, gained considerable momentum. Instead of being channeled back into the church, as was Innocent III's avowed aim, these movements could easily join forces with anticlerical parties which themselves had very little in common with heretics. The establishment of the Inquisition under Gregory IX could do little except stiffen the resistance. Even within the Roman Curia serious tensions arose in the College of Cardinals, naturally affecting the pope most directly. Resentment moreover was bound to be felt not only at the increasing taxation but also at the exercise oi papal control over appointments to benefices: in connection. for instance, with provision or collation (the exclusive right of conferring benefices), with reservation (whereby the pope reserved collation to himself) and with expectancies (anticipatory grants of provisions before the benefice had in fact become vacant). The papal standpoint could be said to be perfectly logical and consistent; yet in the practical application of the basic tenet. namely the papal plenitude of power, the necessary wisdom and restraint were missing. The papal plenitude of power was never a problem of law or of theology, but one of simple human psychology.

Nor did the universities, which the papacy (itself the founder of several seats of learning) had done so much to promote, always produce the kind of scholar expected. On the contrary, the necessarily liberal spirit induced a critical approach to axiomatic tenets—a feature that is almost the exact counterpart to the 9th-century one noted above. While on the one hand the 13th century represents the heyday of medieval scholasticism with its fine achievements in philosophy and theology. on the other it saw the release of intellectual forces which. when fully matured, were to make a not inconsiderable contribution to the decline of papal authority in the 14th. In particular. the influence of the Aristotelian doctrine of the state as a natural entity struck at the very roots of papal monarchy. Hitherto Augustinian ideology had been dominant, according to which the church stood alone as a visible! organic, corporate union, embracing as it did both clergy and laity, itself a divine foundation governed by the pope on the monarchic principle; but now, through the influence of Aristotle, the concept of the state as a self-sufficing and autonomous entity following mere natural or human laws began to take its place beside the concept of the church. The church then, from being an organic and juristic body, receded to become more and more a merely mystical body, for which neither law nor tribunal nor any other attribute of government was considered necessary. The living organism of the church as a legal institute evaporated, so to speak. into the vague, purely spiritual and mystical union of Christians; and the governing authority of the papacy thereby received a serious setback. As a result of this advance in thought the papacy could no longer command men's minds. Moreover, when it was held, again on Aristotelian premisses, that supreme authority rested with the body of citizens (and at least conceptually they were sharply distinct from Christians), the pope's position was changed, radically, from that of the divinely appointed monarch handing power downward into that of one who could be said to receive his power from below, that is, from the Christians; so that his function. which had been that of directing, was now no more than that of representing the Christian body politic. The monarchic position of the pope was severely challenged.

It is noteworthy in this connection that it was not until the closing years of the 13th century that the concept and term "political" became current in the west. Once this step had been taken, the further atomization of human activity into moral. religious, social, etc., naturally followed, with the consequence that for each of them a separate set of rules was developed; the wholeness of man and therefore of society was denied. Thenceforward, matters pertaining to the realm of "politics" could be said to belong exclusively to the political organization, namely to the state; and the papacy, by virtue of this reorientation. was relegated to the decision of merely religious, that is, nonpolitical. issues.

This doctrinal revolution in the closing years of the 13th century, together with the steadily mounting criticism of the working of the papal system of government itself, accounts for the rapidity with which the papacy lost ground. Boniface VIII (1294–1303), in the desperate battle which, fighting with totally inadequate weapons, he lost to Philip IV of France, could do little more than

fix papal doctrine in a number of notable pronouncements, without any more concrete results. Against the doctrine of state sovereignty, so ably propounded by the French jurists, the tools of the papacy proved themselves hopelessly out of date. The pope was allotted a function in the purely religious field and denied the right to issue binding laws or decrees affecting the citizens of a kingdom. It was the citizens—and no longer the governors of a divine society—who by their insight into ordinary human needs were alone qualified to direct their own human and natural society. Life in this world began to assume its own purposeful and autonomous meaning; and a further vital element in the papal ideology had lost its appeal. Boniface VIII's pontificate marks the end of a long period which saw the rise of the papacy from still rather insignificant beginnings to at times dazzling heights.

This growth of the papacy can be explained only by the Christocentric character of medieval society, which the papal standpoint held to be indivisible. The individual as well as society at large was considered one indivisible whole which could not be carved up into different compartments. Only under this presupposition could the papacy with its insistence on the directing force of its divinely instituted monarchy govern the undivided whole of western Christendom. It is unhistoric to stigmatize as "political!' the numerous efforts of the medieval papacy in virtually all spheres of human activity. Considering man and society, that is, the church, as one whole, the papacy was bound to act as it did and to direct man and society along the path to the eventual goal. It is historic, on the other hand, to acknowledge the debt which medieval Europe owed to the papacy, which, in the middle ages at any rate, was the only highly developed and stable institution and as such gave to the world, by virtue of its government, a sense of unity, order and purpose.

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III. THE PAPACY IN AVIGNON, TILL 1378

Boniface VIII had died broken by the brutal attack of the Colonna upon the Gaetani palace in Anagni. He had not had time to excommunicate Philip IV of France for his resistance to the bull *Unam sanctam* (1302); but the threat of the French monarchy to denounce him to a general council was hanging over him and may have influenced the conclave of 1303 into electing Benedict XI, who had been absent from the Curia during the later stages of the dispute between Boniface and Philip. Henedict. however, died within a year; and the conclave that met at Perugia in 1304 let nearly 11 months pass before electing Bertrand de Got, archbishop of Bordeaux, who took the name of Clement V (1305–14). Bordeaux was in the territory held by the English king, and a considerable number of the cardinals created by Clement were to be Aquitanians; but the pope chose Lyons to be the place of his coronation (Nov. 1305), with a view to conciliating Philip IV, who was still pressing for the condemnation of Boniface. Then, as Philip, from 1307 onward, persisted in his determination to destroy the Templars (*q.v.*), Clement in 1308 decided to hold a council. This council was summoned for Oct. 1310 and was to be at Vienne, though in fact it did not open till Oct. 1311; and it was the prospect of this council that prompted Clement to select Aviguon for his residence. He arrived in Xvignon on March g, 1309.

Avignon, a possession of the Angevin counts of Provence and kings of Naples, stood on the Rhône adjacent to the Comtat Venaissin (which had been in possession of the popes since 1274). Midway between France and Italy, on a great trade route, the town guarded the southernmost of the rare bridges over the Rhône; and it was reasonably near to the sea. Avignon, indeed. was a more suitable centre for church administration than Rome, if history was forgotten and the existing balance of power in Europe taken principally into account; for neither Rome nor Italy was safe for prolonged sojourn, and politically France now bulked largest.

In view of this French predominance Clement V had at first supported the election of Henry of Luxembourg as German king (Henry VII) in 1308; but as the result of the council of Vienne and of French pressure in favour of Robert, the Angevin king of Naples, he came round to the anti-imperial side, of which the main organizer was Florence. Thus when, in 1313, Henry prepared ior war against Robert, Clement threatened Henry with excommunication. With his ally Frederick of Sicily, Henry might have conquered the Angevin had he not succumbed to fever (Aug. 1313j; whereupon Clement, claiming to rule while the empire was vacant, gave Robert the title of imperial vicar in Italy. Robert, however, spent his treasure and forces upon assaults on Sicily, lost control of the Romagna and never made much impression in Lombardy, where the Visconti and the Scaligeri lorded it in Milan and Verona respectively.

Clement died in April 1314. An adroit but timid and physically ailing pontiff, he had been obliged to consent to the destruction of the Templars (whom he himself dissolved, so as not to leave their extinction to Philip IV) and to erase from the papal registers all apostolic letters against Philip IV and his agents. Only in the war of Ferrara (1309) against the Venetians had he had any success.

He had moreover falsified Dante's highest hopes, turning upon his earlier welcome to the emperor and yielding to France; yet he left a notable memorial of himself by adding the Clementines to the existing body of canon law. He was a confirmed nepotist and appears to have had a large secret treasure. His private resources and the funds of the apostolic camera he treated as a single unit,

which he kept under the control of his family and on which he drew in order to make substantial presents to his relatives.

John XXII (1316–34).—Clement's successor, elected after an interval of two years and three months, was John XXII, who left a permanent mark upon the later medieval papacy. A vigorous and passionate Cahorsin of 72, formerly chancellor of the Angevin Charles II of Naples, John XXII touched the political and intellectual life of Europe at many points. He presented a firm and insensitive front to the Franciscan zealots who mingled poetry and prophesying with their determination to follow the naked Christ and to make the moderates of the order follow their example. In this. as in his doctrine of the Beatific Vision, John aroused a great deal of theological ,antagonism and was unfortunate in having as his opponents such men as Michael of Cesena and William of Occam. In 1322 he revoked the bull Exiit qui *seminat* (1279) of Nicholas III, which, by declaring the possessions of the Franciscans to be the property of the papacy, had enabled the order to claim total poverty while its "use" of the papal property was sanctioned; and by the bull *Cum* inter *nonnullos* (1323) he declared the Franciscan doctrine that Christ and his apostles lived in absolute poverty to be heretical. As a result Michael of Cesena, Occam and others took refuge with John's enemy Louis the Bavarian (see Louis IV or V, Roman emperor); and at Munich a new factory of antipapal argument and propaganda came into being: encouraged by the revolutionary thinking of Marsilius of Padua, the doctor who looked upon the church as the pars sacerdotalis ("priestly department") of the state. The intellectual attack on John was pressed by Occam, whose polemical works are dominated by the thought that the papacy under John did not possess the *magisterium* in Christian teaching, but was emitting views that were plainly heretical.

John entered into a fierce quarrel with the empire and began a long series of military and diplomatic actions in Italy to uproot Ghibellinism and prepare the way for a return to Rome. At the imperial election of Oct. 1314 five electors had chosen the Wittelsbach candidate Louis of Bavaria, while the remaining four voted ior Frederick of Habsburg, duke of Austria. John, on becoming pope, viewed with alarm the possibility of a new imperial intervention in Italy and thought it safest to keep the empire vacant (as Clement had done) until he should have decided the issue between the two claimants; meanwhile he maintained Robert of Naples as imperial vicar in Italy. Louis the Bavarian's victory over Frederick of Habsburg at Miihldorf (1322) was alarming to John. and his suspicions were confirmed by the fact that Louis sent a vicar to Italy to help the Ghibellines in Milan and in Verona. In Oct. 1323 he declared Louis guilty of acting as king of the Romans before his election was confirmed by the pope and of helping heretics by aiding the Visconti of Milan. Louis was ordered within three months to surrender his title, and his subjects were to renounce him under pain of excommunication and forfeiture. The German ruler retorted (Jan. 1324) by declaring the independence of the empire and the sufficiency of his election and coronation to make him king of the Romans without papal approval. On March 23, 1324, John excommunicated Louis. In the course of his Italian expedition (1327–30) Louis reached Rome and was crowned emperor by four laymen syndics of the Roman people; and an antipope, Nicholas V (Pietro Rainalducci) was elected in May 1328; but the expedition achieved little else, since John continued to insist on the nullity of an election unconfirmed by the papacy. There could be no settlement of the quarrel while John was alive; and after his death indignation with his policy provoked the German princes to declare at Rense that the chosen of the electors was king of the Romans without need of papal confirmation (1337).

The pope found the Ghibellines of northern Italy no less intractable. The Visconti and the Scaligeri remained unmoved by excommunication, and John had to send the warrior legate Bertrand du Pouget to retrieve the situation. He also appealed to Philip V of France, who authorized Philip of Valois (the future Philip VI of France) to descend into Italy (1320); but Philip, instead of fighting Galeazzo Visconti, parleyed with him. Later, Philip excused himself to the French king on the ground that neither John nor Robert of Anjou, who was pledged to help him, had sent him any money. The Visconti seized both Vercelli (1321) and Cremona (1322); and the pope tried, without success, to tempt Frederick of Austria to rescue the position. Despite the Ghibelline recovery, the legate was successful in forming a Guelph nucleus in Parma, Modena, Reggio and Bologna; and it was suggested that a new North Italian kingdom might be constituted for John of Bohemia, Henry VII's son, who in 1330 came to Italy to help the Brescians against Mastino della Scala. But the Italian powers took fright. Guelph and Ghibelline alike formed, in 1332, the league of Ferrara to expel the invader, and the papal and legatine forces were twice defeated in 1333, at Ferrara and at Argenta. John of Bohemia left Italy and the legate, against whom Bologna revolted in 1334, had to make his escape to Avignon. The 14 years of warfare had cost John XXII 2,480,000 florins, more than half the revenues of his pontificate. He had at least asserted the power of the church in northern Italy, even if unsuccessfully. His general administration contributed substantially to the development of the papal bureaucracy. Under his rule the court of Rome became permanently fixed at Avignon. The episcopal palace where John lived was a powerfully defended place; the atmosphere of security guaranteed the untroubled working of the monarchical centralization.

Administration, Finance and Development at Avignon.—The Avignonese system, complicated as it grew to be, was founded upon two simple administrative acts: a petition to the pope and the papal reply, in the form of a grant of some licence, dispensation, or favour in the shape of office or benefice. The recipient was willing (and obliged) to pay the fees laid down, both to the chancery (for its share in the process and in the issue of the necessary documents) and to other authorized agents. The most common form of petition was for the papal collation of a benefice, whether a canonry with or without a prebend or a "church" (*i.e.*, parish church) or other emolument. But the issue of letters of provision did not necessarily imply that the petitioner got the benefice for which he asked. The executors of the provisions (generally clerks of the diocese named) might find that the benefice was already filled or that obstacles were encountered against which litigation had to be commenced. Hence the growth and volume of lawsuits in the curia; hence, perhaps, the increasing vogue of expectatives (grants of benefices sooner or later to fall vacant) and the increasing reliance of the curia on the chief owners of ecclesiastical patronage, the diocesans and the religious houses, to provide for papal nominees when benefices in their gift fell vacant. At the same time the popes steadily increased the categories of reservations, from those benefices which fell vacant by their holders' dying within a given distance of the Roman curia right up to the bishoprics and archbishoprics in all parts of the church reserved by a constitution of Urban V. John XXIE saw the need of advance by stages. In the constitution Ex debito of 1316 he extended reservation to several categories of benefices over and above those which were vacantes in curia (*i.e.*, those of which the holder had died in Rome); and the constitution *Execrabilis* (1317), forbidding a clerk to hold more than one living with the cure of souls, placed the collation of the benefice that the pluralist clerk was forced to resign in the hands of the Roman curia. At Avignon the plenitude of power was asserted not so much politically as administratively, and petitioning became a skilled technique, for the system of granting benefices was regulated by the delicately adjusted rules of the apostolic chancery.

The livings or offices, whether conferred in consistory (appointments in collegiate churches) or by ordinary process of assented petition, involved, in addition to the fees just mentioned, payments to the apostolic camera and to the camera cardinalium, called servitia ("services") and annates respectively. The latter were paid on simple benefices; the higher benefices involved both the "great" and the "little" servztia. Gathered locally by papal collectors, the payments, which in the case of prelates included visitationes ad *limina* or sums in lieu thereof, were frequently advanced by papal merchants who satisfied the needs of the pope and cardinals for ready money and retained the papal grant until they had secured from the grantee binding agreements to pay (*obligationes*), approved by the curia. This development of papal finance and, in particular, the help of the mercatores *domini Papae*

(papal merchants) enabled John XXII to finance his military enterprises in Italy. The chamberlain Gasbert de Laval (1319–47) acted both as administrator and as a diplomatic counselor and was responsible for many of these developments. The system of collectories, areas into which Christendom was divided for the collection of papal duties, was promoted by him; it did not. however, function till the middle of the 14th century. In addition to the expansion of the chancery and of the fisc and the growth of the papal *palatium* or law court, the papal penitentiary dealt with those ecclesiastical offenses the absolution of which was reserved to the Holy See and, through its local penitentiars, exercised the power of binding and loosing vested in the pope. The whole edifice was kept together by the collaboration of the cardinals. who had come to be the pope's sole counselors when seated with him in consistory, and during the Avignonese period the aristocratic theory of their necessary co-operation and consent in all major papal acts undoubtedly developed.

On his death John XXII was succeeded by Benedict XII (1334–42), a theologian devoted to the reform of the religious orders. The bull *Summi magistri* (1336) dealt in its 39 chapters with all the main aspects of the religious life of the Order of St. Benedict, its government, the regime of the convents, its temporal possessions and its studies. The pope was also much concerned to remedy abuses in the secular clergy, especially those connected with commends and the payment of procurations. In view of his reforming activity it is not surprising that Benedict was the object of calumny. He was accused of avarice, of egoism, of prejudice, of dislike of the cardinals and of hatred of the mendicants.

Strangely enough, the rigorous Benedict began the erection of a papal palace separate from the bishop's residence at Avignon. No longer was the see of Avignon kept vacant and administered by the bishop of Marseilles. Round the court of the old episcopal palace he constructed a building that resembled both a monastery and a fortress, yet one suitable for the expanding curia; and in 1339 he transferred to it the papal archives which had been at Assisi since the pontificate of Benedict XI.

It was the Limousin Clement VI (1342–52) who in June 1348 took the step of purchasing Avignon for 80,000 florins from Joanna I of Naples, countess of Provence and granddaughter of Robert of Anjou. He also built on to Benedict's palace a second, less austere, more fitted to his grandiose conception of the papacy. Already in Benedict's time Sienese artists, in particular Simone Martini, had been brought to decorate the churches at Avignon. Clement charged Matteo Giovannelli of Viterbo and Lippo Memmi with the decoration of chapels in the new palace and had his own apartments lined with tapestries from the north. The galleries and halls were filled with ornaments and rich furniture; new plants and strange animals appeared in the gardens; and Hebrew manuscripts and translations from the Arabic mere added to the library. Already with Petrarch the influence of humanism was making itself felt.

Clement VI and Innocent VI.—Clement VI, a clearheaded, Renaissance type of pontiff, was confronted by three problems: the crusade; the failure of the Florentine bankers; and the state of the Italian possessions of the Holy See. The Anglo-French struggle was likely to be long and to hamper attempts to relieve the last Christian states left in the east. namely the kingdom of Armenia Minor and the kingdom of Cyprus. Clement thought of the crusade as the pope's first duty and made himself responsible for an expedition that was successful in taking Smyrna (1345); but later, to Clement's indignation, the Latins of the east traded the place for a precarious peace with the Turks and for guarantees against piracy. Finance, because of the Florentine bankruptcies. was an acute problem. Clement had to look outside Florence for his bankers, but the Malabayla of Asti were hardly a big enough concern to handle all the camera1 revenues, and Clement on certain occasions had to employ 11 banks to send his military commanders in Italy sums varying from 20,000 to 40,000 florins. But these were failures of mechanism rather than of revenue itself, for a pontiff who could lend to the king of France no less than 600,000 florins from the secret account mas not doing badly. All that could be got was needed to meet the situation in Italy. The papal territories in Romagna and the Marches were disputed by the Visconti, by the Pepoli, by the Ordelaffi and by the Malatesta; while the patrimony was menaced by Giovanni di Vico, the prefect of Rome. Clement's nephew Astorge de Durfort was sent to re-establish the authority of the Holy See in the Romagna.

Clement was also concerned with Naples and with affairs in Rome itself. In Naples he strove to ensure that justice was done to Queen Joanna, who was suspected of the murder of her husband, Andrew of Hungary. In Rome he at first supported (1343) the popular leader Cola di Rienzi in his attempt to create an orderly bourgeois state based upon the ancient Roman republic: but when after 1347 Cola's plans went beyond the establishment of order and the suppression of the nobles and displayed a dangerous revivalism embodying a federation of Italy in which all Italians must be Roman citizens, Clement became alarmed and refused any more support.

The next pontificate, that of Innocent VI (1352–62), saw the Italian campaigns of Gil Alvarez de Albornoz. the fighting cardinal who revived the papal state and made possible the return of the pope to Rome. Sent as legate to the Romagna and to the march of Ancona, he quickly dealt with Giovanni di Vico (1354) and reduced the whole patrimony and Umbria to order; and in 1355 the Malatesta family surrendered and received back some of their dominions as papal vicars. The duchy of Spoleto and the march of Ancona were both recovered in 1355. In 1357 Cesena was captured from the Ordelaffi, but further success was for the time undermined by the intrigues at Avignon of Bernabb Visconti. who was trying to secure Bologna; and Albornoz was replaced for a year by the abbot of Cluny, Androin de la Roche. In 1358, however, Innocent sent Albornoz back to confront Bernabò. In 1363 Bernabb was defeated, but Urban V decided not to break up the Visconti state. Had he done so, the later threat of Visconti domination over the city-states of Tuscany and central Italy might have been avoided.

The Return to Rome.—The last two pontiffs in the undisputed Avignon line, Urban V (1362–70) and Gregory XI (1370–78), were neither politicians nor administrators but intellectuals. Both were men of great piety, and Urban was generally accounted an austere saint. It was he who took the decision: in 136j, to bring the curia back to Rome. He was greatly concerned to reunite the eastern and western churches and hoped to enter into conversations with the patriarch of Constantinople. He could not do this so well from Avignon as from Rome. Leaving Avignon on April 30, 1367, and reaching Rome on Oct. 16, Urban installed himself in the Vatican; but he was not to remain long there. When the Anglo-French war flared up again (1369 and 1370). the pope thought it best to return to Avignon, where negotiations could be more easily undertaken with Charles V and Edward III. On Sept. 27, 1370, Urban was back at Avignon.

Gregory XI was a Limousin, the Sacred College at the time of his election being balanced between Limousin and non-Limousin cardinals, with Gregory the senior in the former group. He had reached the conclusion that. in order to conduct negotiations with the eastern church and to maintain the papal territories. consolidation by Albornoz and residence at Rome was necessary. But by proposing to go at a time when the apostolic treasury was almost empty, while also a large proportion of the personnel of the papal civil service was southern French by origin: Gregory aroused a good deal of criticism.

He delayed his departure, however, while he tried to bring about a truce in the Anglo-French struggle and then to convert the one-year truce of 137j into a definite peace. But events in the east, particularly the conquest of Armenia Minor by the Egyptians, were pressing, and on top of these happenings came the attempt of Florence to organize a league against the pope and at the expense of papal territory. In the War of the Eight Saints (1375; called after the magistrates deputed by Florence to conduct the campaign) Florence secured the revolt of Bologna and other papal towns; and the ecclesiastical territories would have been lost had it not been for the vigorous action of Gregory XI and the activity of his legate, Robert of Geneva (later Clement VII). The move to Rome, where Gregory arrived in Jan. 1377, was essentially sound and can even be said to have saved the papal state. Gregory,

however, did not live to see the result. (Table X shows the succession of the popes from 1303 to 1378.)

TABLE X.—*Popes of the 14th Century, to 1378*

1303–04	Benedict XI, in Rome	1334–42	Benedict XII } in Avignon
1305–14	Clement V, to Avignon 1309	1342–52	Clement VI } in Avignon
1316–34	John XXII, in Avignon	1352–62	Innocent VI } in Avignon
1328–30	*Nicholas V (Pietro Rainalducci), antipope in Italy (resigned)*	1362–70	Urban V, in Rome 1367–70
		1370–78	Gregory XI, to Rome 1377

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IV. THE GREAT SCHISM, 1378-1417

The double election of 1378 and the consequent schism had disastrous efiects upon the church. Historians now regard Urban VI's election as canonical, in spite of the rude and threatening behaviour of the Roman populace demanding "a Roman or at least an Italian." It was only when Urban showed himself bitter and hostile to the cardinals and to the bishops at the curia that 13 French cardinals, fearing that the majority in the Sacred College would be turned against them by a new promotion of Italians to the purple, left Rome and retired to Anagni. There they denounced the election of Crban as "null, because it was not made freely, but under fear." At Fondi on Sept. 20, 1378, they elected Robert of Geneva to be pope as Clement VII. For 39 years after these events there were to be two (and later, for a time, three) rival popes, each with his own following, his own college of cardinals and his own administrative offices.

Keither France nor England decided immediately with whom to sympathize. By the end of 1378, however: France had declared in favour of Clement VII; and England took the opposite side. Scotland, Savoy and, for a time, Portugal followed the French example; and after further delays Castile, Aragon and eventually Navarre also declared for Clement VII. Urban VI, on the other hand, was supported by the house of Luxembourg (kings of Bohemia and Holy Roman emperors), by Poland, by Hungary, by the county of Flanders, by northern and central Italy and, from 1381, by Portugal. Clement hoped to dislodge Urban from the Vatican with the help of the French mercenaries who were occupying the castle of Sant' Angelo; but the castle fell in April 1379, and Clement had to retire to Naples. There Queen Joanna I was willing to recognize him, but the populace supported the pope born in their own city, Urban. Clement left Naples in May and entered Avignon on June 20, 1379.

With the divided papacy the church entered upon a prolonged crisis. The confusion, particularly in territories uncertain which pope to obey, was profound, and the dual nature of the papacy gave opportunity, both to England and to France, to prolong the antagonism and the party divisions of the Hundred Years' War. To France especially the schism offered the opportunity of intervening in Italian politics and, in particular, of gaining a foothold in the kingdom of Naples, where the younger Angevin line of France opposed the claims of the Hungarian branch of the family; and there were two great expeditions (1382–84, 1390) by French armies to conquer and hold the kingdom. In 1392–93 the Avignonese papacy put forward, in the interest of Louis, duke of Orléans, brother of Charles VI of France and son-in-law of Gian Galeazzo Visconti, the project of a kingdom of Adria, on the lines of the kingdom formerly suggested by John XXII for John of Bohemia. Such active Italian intervention cost money and involved both pontiffs, the Avignonese most of all, in continuous efforts to apply the fiscal and revenue-collecting methods of earlier Avignonese popes. It aas undoubtedly the sharp financial practice of Boniface IX, who succeeded Urban in 1389, that alienated English opinion from the Roman pontiff. Yet neither pope could afford an estrangement with the kingdoms of his obedience, and royal propaganda was met, at any rate as far as Urban VI was concerned. by papal compliance.

On the other hand the Avignonese pope was less ready for concession. Benedict XIII, the successor of Clement VII, had promised before his election, in 1394, to resign the papacy if in the interests of the unity of the church this became necessary. When the French king demanded this, Benedict demurred and fell back upon a theory of the plenitude much like that of Boniface VIII. He denied to the University of Paris, which was then advocating "the way of cession," to the court or to the cardinals sympathetic with the French king any sort of right to demand his resignation; and this attitude was at the root of the two withdrawals of obedience by the French. On their first withdrawal of obedience (1398), the French besieged Benedict in Avignon; but after his escape to Provence they reacknowledged him as pope (1403).

Later, the collapse of the plan for negotiations between him and the Roman pope in 1408 was followed by a second French declaration of neutrality toward the rivals. Benedict, however, who mas eventually driven to take refuge in the island of Peñíscola, off the coast of Valencia, never abandoned his claim. Finally deposed by the council of Constance he lived on, fiercely maintaining his own status. until 1424.

Boniface left the papal state in Italy even stronger than it had been under Albornoz, but his successor, Innocent VII, was less qualified to deal with an enemy such as Ladislas of Durazzo. Even before the conclave had elected the new pope, Ladislas entered Rome, forced the pope to receive a popular government under a treaty highly advantageous to himself and made him accept the sinister condition that he would not end the schism until Ladislas' right to the crown of Naples was conceded. In Aug. 1406 Ladislas made peace and was created papal vicar of Campania and Maritima, in return for which he undertook to pay Innocent 20,000 florins.

Innocent died in Nov. 1406 and Gregory XII was elected. This nervous, greedy man who thought only of his relations and took no heed of spiritual duties or his temporal responsibilities may be judged by the bull which he addressed to the cardinals (Aug. 29, 1407), asking them to approve the donation of various lands of the church to his brother and to his nephews, not in vicariate but in fee. He was intending to give up Faenza, Forli and Orvieto, and the proposal suggests that he had no hope of keeping the temporal power in existence. In 1408, when Ladislas moved on Rome and thence to Viterbo and to Orvieto, there was nobody to stop him. He could be temporarily pacified, but not bought off, by grants of church lands; and Gregory made him extensive concessions with little hope of stemming the tide. By the autumn of 1408 Gregory's pathetic position in Italy and his failure to concert resignation with Benedict XIII (who was consistently intransigent) had convinced the cardinals that the "way of the council" was the only hope for the church. Their efforts were strongly supported by the Gallican church and by the rulers of France, of England, of Bohemia and of Hungary. The result was the council of Pisa, which assembled in 1409. Unity and reform were its two objects. Keither was secured. Determination to make a speedy end of the schism soon led to the election of Alexander V; but since the council merely declared the two existing pontiffs schismatic without persuading them to resign, the result was a condominium of three representatives of St. Peter. Nor was reform in the church brought any nearer.

For nearly five years after the council of Pisa there was—with the exception of the abortive council of Rome (1413)—a pause in the activity of general councils. In 1410 Alexander died and was succeeded by a most unspiritual figure of great ability. John XXIII, who, as Baldassare Cossa, cardinal legate in Bologna, had been a most successful opponent of rebellious *condottièri* and had

organized the fighting strength of the best mercenary captains against Ladislas of Durazzo. The league against Ladislas reached its high-water mark in 1410; but the departure of Louis of Anjou for Provence after the successful action of Roccasecca (May 1411) left John inadequately protected. His only possible resort was King Sigismund of Hungary, whom, after the death of Rupert of the Palatinate (May 1410), he had recognized as king of the Romans. Ladislas not long afterward lost one of his best captains to the pope and was then willing to make peace, which was signed at San Felice in June 1412. Ladislas promised to repudiate Gregory in favour of John, while the pope abandoned the Angevins and Sigismund. The pope took Ladislas and his *condottière* Muzio Attendolo Sforza into his service and promised them large territorial concessions and extremely large sums of money. In May 1413, however, the perfidious Ladislas moved against Rome. John had to seek refuge in the suburbs of Florence.

The Council of Constance. — The protection of Sigismund, for what it was worth, meant for John XXIII agreement to appear at the general council. on which Sigismund had set his heart; and John's position grew weaker as Ladislas deployed his forces northward and threatened Tuscany. But in Aug. 1414 the king died. John. seeing the chance of escape from the council, immediately attempted to form a league with Florence and Venice to keep the representatives out of Italy. To the cardinals he protested that, rather than go to the council, he must go to Rome and recover the states of the church. The cardinals told him that he could do this by legates or deputies; the council he was bound to attend. The assembly, fixed for Constance, opened in the late autumn of 1414.

Representation at the council was almost universal, and its composition was very heterogeneous. With many different purposes and cross-purposes seeking fulfillment. questions of internal organization, particularly the order of business and the method of voting. assumed immediate and fundamental importance. If heads nere counted, the reactionary party might win and John XXIII might simply remove his opponents and ignore the question of reform. Such an outcome was hardly in keeping with the plans of the French leaders Pierre d'Ailly and Guillaume Fillastre. Their program was essentially that expressed in Pierre d'Ailly's *Capita agendorum*, nhich called for a complete reformation in head and in members of the church: and they were not to be satisfied with the restoration of unity in the person of a suspected libertine. Hence, when the English delegation, led by Robert Hallum (Hallam) and supported by the Germans, suggested that the system in vogue in the universities should be adopted and that voting should be by nations, the French fell in with the plan and the papalist Italians were outnumbered. This deprived the cardinals of effective influence. Envisaging the result. John XXIII publicly professed his willingness, on conditions, to quit the papal chair; but in March 1415 he secretly escaped from Constance.

The unequal battle between the cardinals, anxious to preserve their right of election, and the conciliar liberals, determined to procure John's abdication, continued until John was finally deposed. More of a layman than a clerk. John had yet made brilliant promotions to the cardinalate. and the charges against him at his trial were, in the main, fantastic. Shortly afterward Gregory XII resigned; and in July 1417, after prolonged efforts to secure his voluntary abdication, Benedict XIII was at length pronounced schismatic and heretical. Unity was eventually achieved by the election of Martin V in Nov. 1417. (Table XI shows the state of the papacy during the Great Schism.)

TABLE XI.—The *Great Schism*

Years	Roman line	Avignonese and Aragonese schismatics	Conciliar opposition (Pisa and Bologna)
1378–89	Urban VI	*Clement VII (Robert of Geneva)*	
1378–94			
1389–1404	Boniface IX	*Benedicl XIII (Pedro de Luna)*	
1394–1423			
1404–06	Innocent VII		
1406–15	Gregory XII (resigned)		
1409–10			Alexander V
1410–15			John XXIII (deposed)
1417–31	Martin V		
1423–29		*Clement VIII (Gil Sánchez Muñoz) (resigned)*	
		Benedict XIV (Bernard Garnier), counter-antipope	

By a majority in the council, reform was left to the new pope, and certain specified recommendations were made to him. Martin V, however, was content to pass the inadequate decrees of March 1418 and to make a series of concordats with the principal powers, involving for the most part his recognition of the actual status of papal finance in the various countries, together with certain modifications in favour of national demands for the reform of abuses in the central bureaucracy. The fact was that in their relations with the Avignonese papacy the principal countries oi Europe had evolved a technique of mutual agreement and compromise which their rulers did not wish to upset.

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V. THE EARLY RENAISSANCE PAPACY, 1417–92

Martin V's chief problem was to assert his authority over the *condottieri* who, under pretext of serving the church. were making free with its lands in Italy. His proposal (Jan. 1418) that the rule of the lands and cities of the church should in future be given to cardinals or to other ecclesiastics and that the papal vicariate of such lands should not be granted for more than three years was accepted by the council of Constance; but in these territories he had to establish himself by diplomacy rather than by force, and places like Bologna made stiff bargains. His chief difficulty was the *condottière* Braccio da Montone; and it was only after Braccio had been defeated in the battle of Aquila (June 1424) that Martin could make headway in central Italy.

In non-Italian affairs likewise the pope, strongly supported by his cardinals. set himself to advance the interests of the Holy See and to retrieve the authority of the curia in the church as a whole. He did his utmost to render abortive the council of Siena (1423–24), which he refused to attend in person and which he was able ultimately to get dissolved on the ground of its insufficiently representative character and because churchmen present had no security from attack by the townsfolk and others.

Against the English government, however, he asserted to the full his determination to get rid of the Statute of Provisors of 1390 (see PROVISION), even to the extent of suspending (1427) Archbishop Henry Chichele (Chicheley) from his office as legate. In the Spanish kingdoms he similarly emphasized the rights of the church against the crown. He was a' restorer of the papal supremacy in all matters ecclesiastical; M. Creighton's view that Martin reduced his cardinals to insignificance is. however, contradicted by many appointments and acts in Martin's government of the papal state.

Eugenius IV, **Basel** and **Ferrara-Florence.**—Eugenius IV succeeded Martin in 1431. Devout but of no international experience and often of faulty judgment, Eugenius had to steer the papacy through the crisis of the council of Basel; and his pontificate also saw the reconciliation of France and Burgundy (Arras, 1435) and the Pragmatic Sanction of Bourges (1438). He was also the pope under whom the union of the Greek and Latin churches took place at the council of Ferrara-Florence (1439). Eugenius had none of the gifts to guide difficult business to a successful issue; but he had a certain obstinate dignity, and if he

could be swayed by disingenous persons, his own character was simple enough. Above all, he was well served by his cardinals, particularly by the great Niccolò Albergati (1375–1443), on whom Martin V had much relied. His chief victory was over the council of Basel (1431–48) which he first allowed to be summoned, then, on hearing that his legate Giuliano Cesarini was proposing to invite the Hussites and Bohemian religious radicals to state their case, dissolved. Eugenius was forced, through the desertion of the cardinals, to recognize the assembly once more (1433), but he made use of its blunders. Important among these were the determination of the French radicals to secure upon French soil a meeting place for the prospective council which was to seek unity of the Greek and Latin churches and the council's assertion of its right to grant indulgences. But even more serious was the council's interference in matters with which it had no concern. These considerations led Eugenius in 1437 to break with the fathers at Basel, to repudiate the decrees of the assembly and finally, in September, to order its removal to Ferrara. In 1439 the fathers, still at Basel, replied by the citation and "deposition" of the pope and the election of Amadeus VIII of Savoy as Felix V. Meanwhile in 1438 Eugenius secured the holding of his new council at Ferrara, attended by the Greek emperor John Palaeologus and many Orthodox prelates; and in 1439, at Florence, whither this council had been transferred, the Greeks accepted the Catholic doctrine of the procession of the Holy Spirit, the use of either leavened or unleavened bread in the Eucharist and the headship over all Christendom of the Roman pontiff. This resounding victory, though it never became a generally accepted fact, enabled Eugenius to defy the Basel assembly during its last phase (1439–48). But some work of value had already been effected. A compromise, involving the Compacts of Prague (1433), had been arranged with the Bohemians at Jihlava (Iglau) in 1436; and reforming decrees had been passed which forbade reservations as unauthorized by canon law and which abolished annates and limited the number of cardinals (some of the more important of these recommendations were accepted by Charles VII of France and embodied in the highly Gallican Pragmatic Sanction of Bourges).

Humanism **and** Italian **Politics.**—Eugenius died in Feb. 1447. It has been observed that he was outside the chief interests, intellectual and moral, which were moving Italy. His successor, however, was the humanist Nicholas V. A man of peace and moderate views, strong in the desire for reform while maintaining the prestige of the Holy See, Nicholas concluded the concordat of Vienna with the German king Frederick III in 1448, extending the basis of Martin V's concordat of Constance to regulate the relations of the pope with the German church; and he also dealt reasonably with Felix V when he abdicated (1449), restored Louis Aleman to the cardinalate of which Eugenius had deprived him as a partisan of Felix and recognized three of Felix's creations. His chief concern was the restoration of the buildings of Rome and the increase of the books and treasures in the Vatican. The jubilee of 1450 provided the funds to carry out the proposed restorations; but the visit of Frederick III and his imperial coronation in 1452 gave the pope the best opportunity for his aesthetic antiquarianism, and he used the occasion to the full.

The political league between pope and emperor proved, however, a failure, nor would Frederick give any help with the crusade which the pope was preparing. The diet of Frankfurt (1454) was more occupied in reforming the empire than with crusading. Amid these disappointments Nicholas V died in 1455. His claim to distinction rests on his building in Rome, on his virtual foundation of the Vatican library, on the welcome he gave to scholars from Constantinople and on his patronage of Italian humanists.

The short pontificate of the first Borgia pontiff, Calixtus III (1455–58), is notable mainly for the pope's abortive crusade against the Turks. The papal fleet, dispatched from Ostia, won a few islands in the Aegean from the Turks and brought help to the Hospitallers in Rhodes. One promotion of great importance was made: Aeneas Silvius Piccolomini, who had consistently fought the electoral opposition to the emperor in Germany, was raised to the purple in 1456. Aeneas had always appreciated that the strength of the electors' opposition lay in their ability to use the decrees of Constance and of Basel and the concordat of 1448 as weapons against any close *rapprochement* of Frederick III with Rome. He therefore had an answer to all complaints from Germany; and it was perhaps his arguments and promises, together with the legation of Nicholas of Cues (Nicolaus Cusanus) in Germany, that prevented the empire from sliding into a quasi-independence of Rome.

An orator and a humanist, Aeneas had done so much for the papacy in Germany through his letters and his personality and had so many contacts with the influential of Europe that at the conclave of 1458 he received the majority of votes. To Pius II (as he called himself) it was left to abolish all traces of the conciliar regime. The bull *Execrabilis et in pristinis temporibus inauditus* (1460) condemned any appeals to a future general council (though for the time being it did not stop people from making them); Louis XI was urged to abolish the Pragmatic Sanction and did so; and in 1462 the Compacts of Prague were annulled by the pope. Into the crusade Pius flung himself with all the ardour of his incomparable pen and, in the end, by personal example that led to his death. Yet his more important work had been done in Germany, and it was his knowledge of the German (highly separatist) mind that showed him how to support Nicholas of Cues, when bishop of Brixen, against Sigismund of the Tirol, how to bribe the electors and how to win Frederick III for the papacy. His eloquence and his love of pageantry should not obscure the fact that he was invariably in earnest; and he had an astonishing flair for publicity and the manipulation of opinion. Yet at the end of his time it was clear that the papacy, if it had great prestige and high diplomatic ability and had the money to build and to decorate, was now being grouped as one of the European concert of powers having *auctoritas* ("authority") rather than *potentia* ("power"). More than that, it was as an Italian principate that the world of diplomacy saw it.

The cardinals at any rate showed suspicion of a *princeps* or actual potentate. Before electing a successor to Pius II (1464), they framed a series of regulations for the guidance of the college and for the control of papal policy, including the provision that they were to be consulted on appointments to the more important posts. The new pope, Paul II, would have none of these restrictions; and while he was prepared to take advice on necessary reforms, he followed his own judgment in making changes within the papal court. In 1464 he ordered a drastic purge of the College of Abbreviators; and when the humanist Platina (one of them) objected, he imprisoned him till he came to a better mind. Deeply concerned with the well-being of Rome, he lived in the palace of San Marco, where he could see and enjoy the Roman carnival. Not isolated in the Vatican, he dwelt among the people of Rome, a friend to the magistrates and a patron of artists and scholars. In external relations he was as suspicious of Bohemian utraquism as Eugenius IV had been *(see* HUSSITES). He condemned George of Podiebrad, the king of Bohemia, as a heretic (Dec. 1466); and further, diverting possible forces from the crusade against the Turks, he turned Matthias Hunyadi (Corvinus) of Hungary against the Bohemian king. This was not to the taste of Frederick III, who, if he did not like George of Podiebrad, disliked and feared Matthias of Hungary even more strongly; but the last visit which a Holy Roman emperor ever paid to Rome was not successful in changing Paul's determination to ally himself with the Hungarian king and to crush the Bohemian. Paul and George died both in the same year, 1471. Paul II promulgated, with the consent of the citizens, new statutes for the city of Rome. A churchman and a disciplinarian, he fell out with the Roman academy, which, after the dissolution of the College of Abbreviators, had become the national resort of aggrieved scholars and humanists; and by condemning them and subjecting Platina to torture, he prepared the way for a denigratory biography of himself, in which he was represented as hating literature and literary men. Paul was in fact medieval in his literary sympathies, had little time for elegant frivolity and disliked panegyrics. Literature apart, he was a magnificent builder and art collector. Implication in Italian wars he was determined to avoid.

Wholly different was the aim of his successor Sixtus IV (1471–

84), never a man of the crusade nor a curial politician. Though he sent a papal force against the Turks, at heart he had the aggrandisement of the papal state and the embellishment of its capital as his objectives. His agents were the members of his own family (he was Francesco della Rovere, from Savona in Liguria), whom he enriched on a scale hitherto unknown. If Pietro Riario was all glitter and extravagance, Giuliano della Rovere and Girolamo Riario were men of demonic energy who involved him, sometimes outwardly protesting, in the disputes and turmoils of Italian politics—most acutely of all in the conspiracy formed with their help by the Pazzi against Lorenzo de' Medici (1478). Here Girolamo's agents did not stop at murder (Giuliano de' Medici was killed), yet the pope found reason to justify his censure of Lorenzo. War followed, and Lorenzo had to seek a peace through the papacy's ally, Naples, in 1480. Apart from plunging into the feuds of the great Roman families, Savelli, Colonna and Orsini, the pope committed himself, more scandalously, to the aggression of Venice against Ercole I of Feirara (1482). Venice. however, soon appeared to be a dangerous rival to the papal state and was laid under an interdict by Sixtus (1483). In Rome, Girolamo Riario was openly on the side of the Orsini, but victory over the Colonna was hard to achieve. and before he had won it Sixtus died.

Sixtus IV was a superb patron of architects, painters. sculptors and scholars and a great builder and a restorer of churches. His principal monument is the Sistine chapel in the Vatican; but he also built the fine hospital of Santo Spirito. Under him the papacy became an Italian principality, observing the rules and conduct that were to find favour with Niccolb Machiavelli and acting upon "reason of state" backed by clerical censure as well as by force; but the example had been set by Boniface VIII and Martin V.

Such popes, while not devoid of nepotism, were free from the weakness and pliability that marred the pontificate of Innocent VIII (1484–92). Giovanni Battista Cibb, cardinal of Santa Cecilia and bishop of Molfetta, emerged as pope from a simoniacal election, managed by Cardinal Giuliano della Rovere, under whose domination he remained continuously. The diarist J. Burchard reports that Cibb non his election by signing petitions for favours which were brought to him in his cell the night before. In earlier years, before he entered the priesthood, Cibb had had two illegitimate children, one of whom, Franceschetto. was now to appear publicly at papal functions. Cardinal Giuliano, who hated the Aragonese dynasty, was not slow to support Innocent in his quarrel with Ferdinand I (Don Ferrante) of Naples; but the war that followed Innocent's demand for tribute from his fief and Ferdinand's counterdemand for Benevento, Terracina and the territory of his father cost the papacy Aquila and subjected it to extreme insults and to the loss of most of its remaining political prestige. The only offset for Innocent was his gaining possession of the Turkish prince Jem, brother of the sultan Bayezid II, from his custodians, the Knights of St. John. Jem was an important hostage for the good behaviour of the sultan, affording the pope time to hold the congress of Rome (June 3, 1490) and to plan the organization of the crusade, which was to be a five-year affair. This might have been carried through but for the death of Matthias Corvinus and the ensuing civil war in Hungary. (Table XII shows the succession of the popes from 1431 to 1492).

TABLE XII.—*The Papacy From 1431 to 1492*

1431–47	Eugenius IV	1455–58	Calixtus III
1439–49	*Felix V (Amadeus of Savoy), antipope*	1458–64	Pius II
1447–55	Nicholas V	1464–71	Paul II
		1471–84	Sixtus IV
		1484–92	Innocent VIII

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VI. THE 16TH CENTURY

The Papacy and Reform, 1492–1534.—Alexander VI (1492–1503), Julius II (1503–13), Leo X (1513–21) and Clement VII (1523–34) appeared to their contemporaries primarily as Renaissance princes preoccupied with Italian politics, the patronage and enjoyment of Renaissance culture and the advancement of their families. Julius II alone performed a creative work. By reconstituting the papal states through the recovery of territories seized by the Venetians and through the reabsorption of the conquests of Alexander VI's son Cesare Borgia, he assured a firm territorial and economic basis for the papacy in the new age of nationalism. It was he who inaugurated the construction of the modern city of Rome and began the long-contemplated erection of a new St. Peter's, entrusting this to Bramante and the decoration of the Vatican to Michelangelo and to Raphael. But, though a greater personality in every way than his successors. he was no more capable than Leo X or Clement VII of giving Catholicism a much-needed spiritual and intellectual lead. Julius' military successes and Leo's spendthrift magnificence, together with their liberal but superficial patronage of the scholars, artists and philosophers of Renaissance humanism, might give temporary splendour and an appearance of enlightened tolerance to the papacy but were no adequate substitutes for a serious attempt to meet the moral and doctrinal needs of Christendom. The easy lives of the popes and their lavish affection for their relatives caused grievous scandal, and it is ironic that it should have fallen to an Alexander VI to condemn the excesses of a Savonarola.

Moreover, the existence of the papal states inevitably involved the papacy in the chronic warfare which ravaged Italy from the French invasion of 1494 to the peace of Câteau-Cambrésis in 1559 and which formed part of the wider European struggle between the Habsburg and the Valois dynasties. Anxious. as ever, to prevent Milan and Naples from falling together into the hands of a single power—especially Germanic hands—the papacy was constrained to see both fall to the Habsburgs, masters also in Spain and seated on the imperial throne. Alexander VI cultivated mostly the French alliance, but Julius II contrived the expulsion of the French from Milan. With France again temporarily victorious in Italy after the battle of Marignan (1515), Leo X decided to make his peace. Meeting Francis I at Bologna, he began the negotiations that resulted in the concordat (1516). But Clement VII's alliance with the French against the emperor Charles V after the latter's victory over Francis at Pavia in 1525 led to the barbarous sack of Rome by Spanish and Lutheran troops in 1527.

This event marked the end of an era in Rome and opened the way for the reassessment of values and the reform of the papal curia, for which the ground had been prepared by the founding of new religious orders and the influence of the members of the Roman Oratory of Divine Love. The numerous organs of the curia formed a centrally controlled bureaucracy unparalleled in size, now almost completely Italian in personnel and a prey to all the abuses—ranging from mere obstructive delay to widespread corruption—that 16th-century social and economic conditions made almost inevitable in such a system. The curia was also a great financial centre whither monies came from all parts and were handled by up-to-date Italian banking methods. This gave scandal in that, though much curial business was purely administrative or legal. much also came close to the substance of religion, such as the traffic in ecclesiastical benefices, the management of offerings for indulgences and, above all. the countless dispensations which continually hindered reform and frustrated the good purposes of the provisions of canon law. Furthermore. the taxation of churches throughout Europe and the enormous fees in-

volved in ecclesiastical promotions generated bitter resentment, especially in Germany. Nevertheless the popes, like other contemporary potentates, were unsystematic and extravagant in finance and lived largely from hand to mouth on borrowings and pawnings.

Except perhaps for the Dutchman Adrian VI (1522–23), whose good intentions had little time to develop their potentialities, the popes gravely underestimated the depth and the dangers of their unpopularity in Germany, though they continued to fear the less dangerous bogey of a new conciliar movement. But Julius II not only met the feeble challenge of the schismatic council of Pisa (1511–12) but trumped it with the fifth general council of the Lateran (1512–17; completed by Leo X), a mainly Italian assembly whose good intentions produced little positive result. Roman theologians like Cajetan (Tommaso de Vio) meanwhile restated the loftiest theories of papal supremacy both in church and in state, and the popes themselves remained fully conscious of a leading function in Christendom. All continually urged the union of warring Christian princes against the advancing Turks. Alexander VI in 1493 drew a line to demarcate the Atlantic conquests of Spain from those of Portugal; and Paul III (1534–49) was soon to pronounce that American Indians had souls. Popes still ratified treaties and received the "obedience" of new sovereigns.

The Protestant revolution (see REFORMATION), first set in motion by Luther and Zwingli in Germany and Switzerland, found the papacy psychologically unprepared for a radical and permanent rejection of its authority. The combined results of dissolvent Renaissance criticism, of exasperation with the Roman curia and with the lives of the popes, of the successful action of German and Swiss towns and princes in taking independent control of refashioned ecclesiastical organizations and, above all, of the attraction of the new religious outlook turning around justification by faith alone produced a situation which left the papacy expostulating but impotent. Yet all over Europe much control over the church had recently been passing, either tacitly or explicitly by specific agreement with, or privilege from, the papacy, into the hands of the secular power. But the actions of German, Swiss and Scandinavian authorities in setting up new state-controlled churches with Protestant beliefs overstepped the limits of possible papal toleration and grievously disappointed whatever trust in princes the popes had inherited from the middle ages. It was probably decisive that in the 1 jzos, while events were still fluid in Germany, both emperor and popes were preoccupied with Italian politics. By 1530, when Charles V, after his coronation by Clement VII, again gave his attention to Germany, it was too late. The German and Swiss Protestant organizations had become vested spiritual and political interests too strong for easy upset. Then came the Reformation parliament in England, with legislation in restraint of appeals to Rome and of the payment of annates. In 1534, shortly before his death, Clement VII accelerated the English schism by finally pronouncing Henry VIII's marriage with Catherine of Aragon to be valid. The Act of Supremacy followed, making the king of England head of the English church.

The Council of Trent. — In the ensuing years the pressure of the Catholic reformers and the rapid advance of Protestantism in its various forms forced the papacy to devote more serious attention to church affairs. Paul III, Julius III (1550–55), Paul IV (1555–59) and Pius IV (1559–65) all worked, with varying intensity, toward the restoration of the primacy of the spiritual in the activities of their office, though with all of them the marks of the Renaissance papacy persisted in different ways. Paul III excommunicated Henry VIII (1538) but aimed at political neutrality between Habsburg and Valois. He introduced into the College of Cardinals the leaven of a group of zealous and virtuous reformers and set up a series of coinmissions to inquire into abuses. These reported with great frankness, and the slow, difficult process of curial reform was inaugurated. It was Paul who in 1540 approved the foundation of the Society of Jesus (*q.v.*), destined to be uf inestimable value to the papacy; and in 1542 he refounded the Roman Inquisition with a jurisdiction theoretically universal, though in practice confined to Italy. He also convened the Council of Trent (*q.v.*), which had ten sessions (1545–47; including two at Bologna) during his pontificate, six (1551–52) under Julius III and ten (1562–63) under Pius IV.

This council was of prime importance in papal history. It was not the universal, uncommitted, general council of all Christians desired by Protestants, but an assembly of those continuing to acknowledge the papal headship, in which there was always a large Italian majority and only relatively small representations of other nations. Within these terms, however, it was a great co-operative achievement that clarified the whole field of Catholic doctrine, rejecting all the principal Protestant theses, and established fresh norms of discipline regulating every aspect of church life. This achievement was largely due to the supervisory control of the papacy, which emerged stronger, reinvigorated and much more self-assured from a hazardous enterprise on which it had embarked with considerable apprehension. Though the council made no pronouncement on the papal power, the challenge of the innumerable problems involved in its assembly, program and management drew new strengths and initiatives out of the papacy which served to restore and to push to even greater lengths its ecclesiastical leadership and control.

No effective revival of 15th-century conciliar principles occurred. A declaration that each bishop's diocesan jurisdiction came immediately from Christ, rather than mediately through the pope, was avoided. The reform of the curia was not forcibly taken out of Rome's own hands. Reforms were not permitted to be made indiscriminately without reference to relevant doctrine. Proposals, disliked in Rome, for radical changes in liturgy and discipline put forward by more liberal Catholic reformers or urged by Catholic princes for the appeasement of overmighty Protestant subjects whose existence created novel and harassing political difficulties were successfully resisted.

The Council of Trent witnessed a crisis in the problem of the nature and extent of the powers of the state in matters of Catholic reform. The emperor and other Catholic rulers desired to control the program and policy of the council according to what was politically convenient to themselves and to do so not only through their accredited ambassadors but also through the bishops of their territories, whom they tended to regard as forming national delegations which should press the views of their political superior. Thus the political background to the sessions under Paul and Julius was occupied by the rise and fall of Charles V's hopes of achieving the submission of the German Protestants either by force or by concessions or by a mixture of both; the French, on the other hand, desired only the maintenance of the concordat of 1516 and the maximum harrassing of Charles by his Protestant vassals. During the sessions under Pius IV, Charles's imperial successor Ferdinand wished only to safeguard the hard-won, if unsatisfactory, stalemate of the peace of Augsburg (1555), which had legitimized the Lutheran states on the principle *Cujus* regio, ejus *religio* ("the ruler's own religion determines the religion of the state"). It was the French who, worried in their turn by the Calvinist movement, then chiefly pressed for the wide concessions and changes after which many Germans, too, still hankered; while the Spaniards opposed concession of any kind. It was a remarkable and far-reaching achievement of papal diplomacy to have preserved not only unity but uniformity and to have prevented the establishment of differing, quasi-autonomous, national Catholic settlements which would perhaps have involved, in Germany and in France, such points as a married clergy, lay communion under both kinds and altered and vernacular liturgies.

Paul IV alone in this series of popes deliberately rejected the conciliar method — though Marcellus II (1555) would probably have done so too had he lived. A man of deep personal piety, Paul believed that he could effect reform in Rome better without a council; and indeed his thunderbolts, though sometimes overcharged and occasionally misdirected (as when aimed at the cardinals Reginald Pole and Giovanni Morone), had a permanent effect on ecclesiastical conditions in Rome. But his excessive violence in orthodoxy and in reform was carried over into politics. He succumbed disastrously to the evil counsels of his unworthy nephews and to his consuming hatred of Spain and of the Habsburgs, for which he would have jeopardized even the Marian

restoration of Catholicism in England. His attempt to drive the Spaniards from Naples in 1557 collapsed in a humiliating disaster when his French ally withdrew. Only Spanish restraint averted another sack of Rome like that of 1527. Paul even refused to recognize the abdication of the emperor Charles V and the election of Ferdinand as his imperial successor, as having been effected without papal approval; and the following pope, the diplomatic, conciliatory and easygoing Pius IV, had tacitly to withdraw from this unrealistic position. In Paul IV's violent politics, as in the nepotism, the ease of life and the self-indulgent cultivated tastes of Paul III, Julius III and Pius IV. the papacy had still not wholly cast itself free from its immediate past.

The Counter-Reformation Papacy, 1566–1605.—The 40 years following Pius IV's death mere the zenith of the reformed papacy. With the Tridentine achievement behind them and peace restored to Europe and to Italy at Câteau-Cambrésis in 1559, a succession of energetic pontiffs of blameless lives devoted their whole attention to the spiritual restoration of Catholicism, to the reform of the church's administration and to the fight against Protestantism. Pius V (1566–72), a former inquisitor of great severity, inaugurated and typified this period (he was canonized in 1712). Of its three other important popes—Gregory XIII (1572–85), Sixtus V (158j–go) and Clement VIII (1592–1605)—Sixtus, a remarkable and forceful man, is the outstanding figure. Rome was again a centre of holiness. The spiritual influence of the Jesuits and of St. Philip Neri was deeply felt throughout the city; and there were few in the Roman court who did not make at least some show of conformity with the new piety.

The papacy was now setting the pace throughout the church of its obedience. Its active, central control had been renewed through the Council of Trent and on this now depended the completion and enforcement of the council's work. In the hurry of its termination the council had entrusted to Rome a number of unfinished matters. Roman commissions drew up and published the Tridentine creed (1564) and catechism (1566), a new breviary (1568), a new missal (1570), the Sixtine and Clementine editions of the Vulgate (1590 and 1592) and a new version (1564) of the *Index* of prohibited books (of which the *Index* of 1596 was a revised edition). The successful enforcement of the rule that diocesan bishops should visit Rome periodically to submit reports strengthened the ties binding them to the pope. National seminaries in Rome made for the spread of Roman influences and ways. The Roman Inquisition was sharpened, and its activities ensured the practical disappearance of Protestantism and of open scepticism from Italy. The Counter-Reformation papacy recognized no necessity either to understand (save for purposes of confutation) or to tolerate beliefs incompatible with the Tridentine creed. It censured both individuals and governments who tried to do either. The censorship of new publications and the control of reading were strictly applied, wherever practicable, in the Catholic world in the interests of rigid orthodoxy. Yet within the limits allowed by orthodoxy and within the scope of current ecclesiastical-philosophic ideas, the papacy genuinely strove to further learning and to improve the educational level of the clergy; in this it was much assisted by the Jesuits in their many universities and colleges. The Vatican library and press mere liberally promoted. In 1578 the Roman catacombs began to be rediscovered; and this, together with the historical work of the Oratorian C. Baronius replying to the Lutheran "Magdeburg Centuriators," stimulated research into early Christian history. Gregory XIII's reform of the Julian calendar (1582) was in time accepted throughout most of the world; and the Copernican thesis was apparently not yet suspect. There was still room, however, for controversies on divine grace. In 1567 and 1579 Rome censured the theories of the Louvain theologian Michael Baius; but the more serious conflict that arose in the 1590s between Jesuits represented by Luis Molina and Dominicans represented by Domingo Bañez much harassed Clement VIII and was eventually suppressed without solution by Paul V. The papacy was also much concerned at the continuance in France of Gallican views on ecclesiastical authority and church history. In the forms of art and literature a new Tridentine puritanism imposed itself; nevertheless, a flourishing artistic and musical life was maintained in Rome, and much of the humanistic spirit retained a permanent foothold within the church.

In church government, while the medieval inheritance of the old curial organs still survived, unchanged essentially though somewhat reformed, the papacy now perfected for its wider and more intensive tasks a new equipment of a more modem character. First, the cardinals, who in 1500 had formed a smallish body, predominantly aristocratic. potentially turbulent and fitfully asserting claims to a real participation in the papal authority. had by 1600 much increased both in numbers and in moral quality; and those resident in Rome had been transformed into a body of ecclesiastical civil servants performing in organized boards known as congregations (in addition to the full weekly consistory) a mass of varied ecclesiastical business. Sixtus V in 1586 established the numbers of the college at 70 and in 1588 set up the organization of 15 permanent congregations. thus reducing to a system that still prevails in principle *(see* CURIA ROMANA) the practice of special cardinalitial committees that had been growing throughout the century. This new bureaucracy further buttressed the papal supremacy; the cardinals might still elect the pope, but they were now much more completely his servants. Secondly, there mas the rise of the papal secretary of state. This new official bypassed and eventually atrophied the older secretariates of the curia in all important affairs. By the second half of the century the secretary was almost always a papal nephew with whom the existing pontiff could have relations of trust and intimacy. This new and more justifiable form of nepotism—of which St. Charles (Carlo) Borromeo, nephew of Pius IV, was neither the first nor perhaps the most influential example—lasted until late into the 17th century and produced many able and upright papal first ministers. Third, the diplomatic representation of the papacy by nuncios at the courts of the Catholic secular powers was systematized by Gregory XIII and the scope of their concern widened to include religious as well as political matters. Important factors in the Counter-Reformation, their main task was to promote acceptance and implementation of the reform decrees of Trent by political and ecclesiastical authorities alike. Gregory XIII was also the first pope to see the world-wide missionary activity of the Roman communion, both inside and outside Europe, as a whole (though the special missionary congregation *de Propaganda Fide* ["for the propagation of the faith"] was not founded until 1622). This period also saw some successful Uniate movements, the largest being the submission to Rome, by the union of Brześć (Brest-Litovsk) in 1596, of a number of Ruthenian dioceses in Poland; while Cniate colleges (Maronite and others) appeared in Rome.

Despite the slow turn of the tide in Germany from the pontificate of Gregory XIII onward and despite all the intensification of Catholic propaganda methods (both of suasion and of force, whether concealed or open), the Counter-Reformation papacy failed to win back England or Scotland, Russia or Scandinavia or the bulk of Protestant Germany and Switzerland. It failed also to prevent either the Calvinizing of the United Provinces of the northern Netherlands after their break from Spain or the privileged toleration finally accorded to French Calvinism by the Edict of Nantes in 1598. The papacy still regarded the capture of the monarch as the trump card in the technique of national conversion and maintained its full political claims in respect of heretical rulers. Pius V's bull of 1570 denying the right of the excommunicated Elizabeth I to rule in England and the successive papal denunciations of the validity of Henry of Navarre's claim to the French throne were eventually recognized to have been mistakes, but not to have been *ultra vires;* and the Jesuit Robert Bellarmine's theory of indirect papal power in teinporal matters led to the inclusion of his book *De controversiis* in the *Index* of 1590 (which however was revised after Sixtus V's death). English Catholics were forbidden to take an oath of allegiance declaring the papal deposing power to be heretical. Political theories which justified armed revolt against declared heretical "tyrants" (or even the violent removal of them) found support in Rome, where the taking of human life in the right cause and in approved circumstances caused no uncomfortable humanitarian feelings, as witness Gregory XIII's reception of the news—inaccurately con-

veyed—of the massacre of St. Bartholomew's day in France.

The Council of Trent did not end friction between pope and Catholic sovereigns. The co-operation of the latter was essential to the Counter-Reformation, but they still claimed a considerable and unwelcome independence in church affairs. Neither Valois nor Bourbon sovereign in France would withdraw toleration from Calvinism; and their concern to defend the "Gallican liberties" of the crown made them unwilling to "receive" the new ecclesiastical discipline of Trent officially as the law of the land. Philip II of Spain, though he was the right arm of the Counter-Reformation, was a constant irritant by his overbearing claims and pretensions; and Clement VIII welcomed the revival of an independent counterbalancing Catholic France under the former heretic Henry IV. This enabled him to modify the Spanish ascendancy among the cardinals and was to have a corresponding effect in future conclaves.

By 1605 the papal states, enlarged by Clement VIII's incorporation of the duchy of Ferrara in 1598, had become more firmly consolidated and now formed the economic support of the papacy. The peace of Câteau-Cambrésis had led to some economic revival in Italy. The exploitation of the resources of the states (customs, duties, alum profits and direct taxation), together with a developed system of public loans, known as *moati di pietà*, had replaced the older sources of papal revenue drawn from all over Christendom. The papal states were squeezed to supply the finances required for the multifarious needs of the Counter-Reformation popes, including the great building activities of Sixtus V. Sixtus' energetic action freed Rome and the Campagna only temporarily from endemic banditry, but his provision of a new water supply was more permanent, and his employment of Domenico Fontana to complete the dome of St. Peter's, his many other new buildings, his obelisks, his fountains and his adornment of Rome in general accelerated the transformation of the medieval into the baroque city.

In 1605 the papacy had neither dropped out of European public life nor had yet fully resigned itself to the loss of northern and much of central Europe. Its spirit and its organization had been notably renewed, in some ways even modernized. The naval league that defeated the Turks at Lepanto in 1571 had been organized by Pius V. But the counterattack on Protestantism, except for the coming Thirty Years' War, had all but reached its limits, and the 17th century was to bring fresh problems.

Rome was now increasingly remote from the intellectual and material forces at work in nations such as England and Holland that were to influence so deeply the future course of history; and the papacy's attitude even toward Catholic France was not always understanding. Coming to move more and more in a closed world, the popes were losing the universal role that they had once been acknowledged to hold in Christendom. Yet with the geographically vast American accessions to Catholicism and the spread of Catholic missions throughout the globe the papacy was beginning again, in a new sense, to become a world power. (Table XIII shows the succession of 16th-century popes.)

TABLE XIII.—*The 16th-Century Popes*

1492–1503	Alexander VI	1555–59	Paul IV
1503 (Sept.-Oct.)	Pius III	1559–65	Pius IV
1503–13	Julius II	1566–72	Pius V
1513–21	Leo X	1572–85	Gregory XIII
1522–23	Adrian VI	1585–90	Sixtus V
1523–34	Clement VII	1590 (Sept.)	Urban VII
1534–49	Paul III	1590–91	Gregory XIV
1550–55	Julius III	1591 (Oct.-Dec.)	Innocent IX
1555 (April)	Marcellus II	1592–1605	Clement VIII

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VII. THE 17TH AND 18TH CENTURIES

Paul V.—During the pontificate of Clement VIII, who died in 1605, the secular authorities of the kingdom of Naples and of the Venetian republic had constantly violated ecclesiastical rights, without provoking retaliation from Rome. For the sake of Christian peace, Clement, who was a statesman, had held his hand while remonstrating vigorously and even issuing a few threats, but the French ambassador to Venice, Philippe Canaye, who felt that the doge and senate were trading on the pope's forbearance, had surmised that under a *pape* plus, *brusque* there might be serious trouble. The utterance was prophetic. One of the first public acts of Paul V (1605–21), who succeeded after the 26-day reign of Leo XI, was to excommunicate the recalcitrant minister of Naples for his breach of the *privilegium fori* (the right of ecclesiastics to be judged in criminal cases by their own order). After some months of protest against even worse offenses by the proud republic of the north, Paul launched an interdict against the whole Venetian territory, with little effect except to stiffen the resistance. A compromise peace was eventually patched up, but it had become plain to the Holy See that the day for interdicts and depositions had passed, and they were never again used as a weapon of compulsion against a sovereign state. When Paul forbade the Catholics of England to take the new oath of allegiance which James I imposed on them after the Gunpowder plot, many Catholics accepted the dire consequences of refusal, but a small vociferous party maintained that the oath did not contravene any doctrine of the faith and might safely be taken. That, however, was hardly the point when an express order had been issued by the supreme spiritual authority of the church. The one real blot on this good and zealous pope's administration was his excessive fondness for display, which wasted funds that could have been better employed on the objects dearest to his heart; viz., a crusade against the aggressive Turks in eastern Europe and the salvaging of the faith in Austria, Poland, Hungary and the German states. His contention with Venice had taught him caution, and he feared nothing more than an open breach of the peace of Augsburg, though that measure had been so little favourable to Catholic claims. He endeavoured with all his might to maintain peace between the dedicated rivals, France and the Habsburg powers, and his closing days were rendered happy by the news of the emperor Ferdinand II's victory over the Calvinists of Bohemia in the battle of the White Mountain.

The Thirty Years' War and the Peace of Westphalia.—The pontificate of Paul's successor Gregory XV (1621–23) was made memorable by the foundation in 1622 of the congregation *de Propaganda Fide,* for the spreading of the Catholic faith in heathen lands and other missionary countries such as England. Through this congregation the church was enabled to recover in distant lands much of the ground that had been lost through the Protestant and Calvinist revolution in Europe.

Under Gregory also the church won some notable successes in Bohemia, in Moravia and in Hungary through the tireless diplomatic and apostolic efforts of such men as the nuncio Carlo Carafa, the cardinal archbishop Péter Pázmány and the members of religious orders, especially the Capuchins and Jesuits.

The College of the Propaganda, distinct from the congregation, was founded in 1627 by the next pope, Urban VIII (1623–44), to

train missionaries of all nationalities for all parts of the world and is still known as the Urbanum. It was possibly the best thing that he did in the whole of his long and ineffective reign. As Maffeo Barberini, nuncio in Paris, he had been extremely successful, acquiring the full confidence of the French court; but as pope he added little except a profusion of baroque art to the dignity and prestige of the Holy See. He squandered on his arrogant and worthless nephews vast wealth that should have gone to the support of the poor, of hardly tried missionaries beyond the seas and of the Catholic cause in Europe, imperiled by the diplomatic unscrupulousness of Cardinal Richelieu and by the military genius of Gustavus II Adolphus of Sweden. He tried to maintain an uneasy neutrality between the two mighty contenders of the Thirty Years' War, France and its Protestant allies on the one side and the house of Habsburg in Spain and in Germany on the other, on the ground that he must not endanger his common fatherhood of the warring parties, so as no longer to be able to heal their differences. The result of his refusal to align himself unequivocally with the devoutly Catholic emperor Ferdinand II was that the French under Richelieu and his successor Mazarin eventually prevailed, without having any reason to be grateful to the papacy. The chief reason for the pope's hesitation was the presence of Spanish power north and south of the papal states, whereby the Holy See's independence was constantly menaced. This situation explains and, on the whole. justifies papal policy during the period now being considered, for the Holy See had a long memory and was determined, as far as in it lay, not to be again the mere puppet or chaplain of Caesar. If Urban VIII and his successors clung covetously to every square yard of their hereditary states. even to the extent of going to war for their integrity. it was because, in those times of aggressive nationalism and absolutism. they could never be sure where Caesar, in the shape of a Spanish or a French king, or a Holy Roman emperor, would be content to stop, unless barred on a frontier by troops as sturdy as his own. That Catholic France should be allied with the Protestant princes and acting in collusion with the Turks does not seem as shocking to us as it necessarily was to the popes of that period; and Richelieu also demonstrated, by his tolerance of the defeated Huguenots as a religious minority, that unity of faith was no longer to be considered a necessity of national power and prosperity—a lesson which England took very much longer to learn. The concern of the popes to prevent a permanent Spanish occupation of the Valtellina mas actuated by the fear that it would serve as a channel of reinforcement for the Spanish Habsburgs in Milan by the Austrian Habsburgs in the Tirol north of the Alps. Under Gregory XV papal troops had taken possession of the valley, but Urban VIII was not able to maintain the position, and the Calvinist Grisons eventually assumed control.

By the peace of Westphalia, signed in 1648, the Catholic Church in the empire lost a great deal of territory through the cession of ecclesiastical estates to the Protestants. For this policy the new emperor, Ferdinand III, was responsible. It was plain that Austria had lost the war, and Ferdinand, advised by his able minister Maximilian von Trauttmannsdorf, a paler version of Richelieu, determined to save what he could of his hereditary dominions by sacrificing those of the church. The new pope, Innocent X (1644–55), protested in the most vigorous terms against the clauses of the peace which alienated Catholic lands, but nothing that he could say or do had the least effect. This was symptomatic of the great change which had come over the political scene. Until then the Holy See had maintained, in spite of the Protestant revolution. some measure of its medieval prestige as a unifying centre of the nations; but Richelieu. Mazarin and Trauttmannsdorf. all three Catholics, had destroyed that precious office of mediatorship, and the popes were no longer to be consulted by the nations in the making of war or peace.

Apart from the fact that he was dominated by his rich sister-in-lan, the extraordinary and most objectionable Olimpia Maidalchini. Innocent X gave evidence of every quality of a good ruler and showed, in spite of his advanced age. a remarkable determination to see that his states were justly and wisely administered and that crime, even in high places, did not go unpunished. When the bishop of Castro was assassinated at the instigation of the duke of Parma, the pope sent his troops to raze that town to the ground. After the most careful consideration he condemned five propositions extracted from the *Augustinus* of Cornelius Jansen, whose followers in France, led by the abbé de Saint-Cyran, strenuously contended that the book did not contain them. There followed a century of acrid controversy which did much harm to the church in France and other countries. Before the rise of communism in the 20th century, the world had known no more determined and resourceful propagandists than the Jansenists.

The secularization of politics brought to a head by the peace of Westphalia had the result of increasing the spiritual power of the papacy within the church. The tendency toward centralization of all the church's activities in Rome, observable for centuries past, was given a new impetus by the claims of the secular states, Catholic as well as Protestant, to regulate all ecclesiastical affairs within their dominions. The establishment of the various congregations in Rome to help the Holy See in the government of the universal church, the gradual supersession of cardinal nephews by officially appointed secretaries of state, the overhauling and increasing of the nunciature service and the closer linking of the universal episcopate with Rome by means of the compulsory visits ad *limina* apostolorum—all these measures gave new vitality and strength to the papacy, precisely at the time when its importance in world affairs seemed to have been finally eclipsed.

Even a pope such as the vigorous Innocent X's indolent successor, Alexander VII (1655–67), who was personally a fine character and had been an excellent nuncio, contributed to the process by leaving more and more of the administration to the congregations, with the result that the secretariate, so often in the past the perquisite of self-seeking, avaricious cardinal nephews, became increasingly important. Two well-loved popes of deeply spiritual mind, Clement IX (1667–69) and Clement X (1670–76), did their best to rouse Europe to the menace of the Turks, again on the march, but could achieve very little because of Louis XIV's understanding with the Sublime Porte.

Innocent XI, the Turks and Louis XIV.—In 1676 a pope succeeded who was also a saint and a statesman, the incomparable Innocent XI (1676–89). "In manner gentle, in temper tolerant, in mood humane, in outlook broad and comprehending, he nevertheless possessed and exercised an inflexible will and an imperturbable daring" (Sir Winston Churchill, A History oj *the* English-Speaking Peoples, vol. ii, *The New World,* Cassell, London, 1956). Innocent needed all his qualities to deal with the pretensions of the absolutist Louis XIV, who could command the most powerful army in the western world to support his claims. The pope was not in the least hostile to France and bent all his energies to persuade Louis to put the interests of the Christian west above his national ambitions by entering into an alliance with the emperor Leopold I against the Turks. But his pleadings fell on deaf ears; Louis had already assured the Porte of his benevolent neutrality should the sultan decide to attack the emperor. French influence was also very strong in Poland and caused John III Sobieski to hesitate before throwing in his lot with the sorely pressed Leopold, who had to contend, not only with the Turks, already in possession of part of Hungary, but with the insurgent Hungarian Calvinists. In fact, it was the Calvinists, under their brilliant leader Imre Thokoly, who appealed to the grand vizier, Kara Mustafa, to launch his hordes against the Habsburg power. Soon they were under the walls of Vienna, where one of the most famous sieges in history began in July 1683. By dint of constant appeals and immense subsidies, Innocent, through his indefatigable nuncio in Warsaw, Obizzo Pallavicini, persuaded the reluctant Sobieski to move to the rescue. Sobieski was slow in coming and, but for the intervention of Charles of Lorraine, Vienna must have fallen. When the siege was raised (Sept. 12), Sobieski claimed all the glory for himself; but the real architect of the Christian victory was Innocent XI.

Innocent, who came of a banking family, inherited an insolvent papal treasury but, by dint of the most rigid economies, wise taxation and complete avoidance of the ostentation to which some of his predecessors had been addicted, not only balanced his

budgets but also accumulated, by appeals to the Catholic powers and to the episcopate, vast sums for the common good of Christendom, including 7,000,000 gold florins contributed to the prosecution of the war against the Turks. His stand against the pretensions of Louis XIV mas no less staunch and admirable, even if he had to leave it to his successors Alexander VIII (1689–91) and Innocent XII (1691–1700) to make peace with the Grand Monarque, who helped by withdrawing from Avignon in 1689 and by abrogating. in 1693. the Gallican articles of 1682. Only then did the Holy See consent to institute canonically the 35 French bishops appointed irregularly and as a defiant measure by the king. Innocent XI saw more clearly than any of his predecessors that Protestantism had to be tolerated for the sake of general peace, and he expostulated strongly against the persecution of the Huguenots by Louis XIV after the revocation, in 1685, of the Edict of Nantes.

Innocent XII, the last pope of the 17th century, is notable as having put an end to the nepotism which had spoiled the good intentions of so many of his predecessors. In 1692 he issued a bull making it unlawful for any subsequent pope to bestow the cardinalate on more than one of his relatives or to give any of them a benefice bringing in more than a modest revenue. For himself, he said, his nephews were the poor and distressed people of Rome.

Clement XI.—The long reign of Clement XI (1700–21), a pope worthy of a better fate. was made wretched by the War of the Spanish Succession. When the dying Charles II, last of the Spanish Habsburgs, nominated Louis XIV's grandson Philip of Anjou as his successor, the pope was in no position to repudiate this creation of a Bourbon dynasty in Spain, but his recognition of Philip as king inevitably antagonized the emperor Leopold I, who accused him of having gone over to the French side in the endless contest between Bourbon and Habsburg. This accusation was not true, for Clement's only desire was to avert war by peaceful mediation or, if he could not do so, to save Italy from the calamity. He failed in both aims disastrously. French troops occupied Mantua, the key to upper Italy, but were ousted from that strong position by the genius of the imperial general Prince Eugène of Savoy. After that, the struggle between the emperor, who fought to make his son, the archduke Charles! king of Spain and Naples, and Louis XIV turned into a great coalition war. almost a world war. Leopold I died in 1705 and was succeeded by his son Joseph I, who proved even more hostile to the unfortunate pope, crushed between the upper and the nether millstones. In Vienna there was no forgiveness for his recognition of the Bourbon king in Spain, though he determinedly refused to invest Philip as king of Naples. Imperial troops invaded the papal states, conquered Naples and compelled the holy father, who feared another sack of Rome, to promise recognition of the archduke Charles as king of Spain. Thereupon Philip V expelled the papal nuncio from Madrid and broke off diplomatic relations with the pope. The peace of Utrecht (1713) and the peace of Rastatt (1714) resulted in heavy diplomatic defeat for the Holy See, whose age-old rights of suzerainty in Naples, in Sicily, in Parma and in Piacenza were completely disregarded.

Perhaps the most important of the unhappy Clement's acts was his bull *Unigenitus* (Sept. 8, 1713) against the Jansenists, whose resistance to it was, however, much encouraged by the example of opposition set by the cardinal archbishop of Paris, Louis Antoine de Noailles. Much less wise was his condemnation of the Chinese and Malabar rites in 1704, a measure which, through the bungling of his legate in China? C. T. Maillard de Tournon (whom he created cardinal in 1707), led to a persecution of the Chinese Christians and to the ruin of many flourishing missions. The pope himself was a noble character, dogged by misfortune but never despairing, a tireless worker, abounding in charity, who heard ,confessions in St. Peter's like an ordinary priest and did not disdain to go into the pulpit.

The Papacy and 18th-Century Secularism.—Innocent XIII (1721–24) was handicapped by ill-health and showed very little of the quality of his great predecessor Innocent III, whose name he took and to whose family, the Conti, he belonged. Under French pressure he raised to the cardinalate that morally questionable person Guillaume Dubois, archbishop of Cambrai and prime minister of the French crown. In 1723 the Jansenists in Holland went into open schism by electing Cornelius Steenoven to be archbishop of Utrecht without the authority of the Holy See.

Innocent's successor, very much against his will: was the devout, unworldly Dominican archbishop of Benevento, Pietro Francesco Orsini, who took the name of Benedict XIII (1724–30). In spite of his exemplary personal qualities and his zeal for reform, Benedict's reign was disgraced by the venal conduct of his principal confidant, the rapacious cardinal Niccolb Coscia; and Benedict's inexperience in secular affairs led him to make concessions which were promptly exploited in the sphere of politics. The sensitiveness of professedly Catholic governments at that period of ever-expanding scepticism and irreligion was well illustrated by the ludicrous outcry that they made when the pope, in 1728, extended the feast of Gregory VII (whom Paul V had canonized) to the universal church, as though the mild, conciliatory Benedict were thereby reasserting the claims to depose monarchs and deprive them of their kingdoms which seven centuries earlier Hildebrand had successfully maintained! The perfectly objective account of Gregory's struggle with the emperor Henry IV, in the second nocturn of the new office. was regarded as an attempt against the sovereignty of princes and an incitement of their subjects to rebellion. The *signoria* of Venice and the *parlements* and Jansenists of France protested in violent terms. The viceroy of Naples proposed to the emperor that the printers of the offending nocturn should be cast into prison. and the senate of Palermo forbade the office under a penalty of 1,000 scudi. Not to be outdone, the Dutch government, "in order to safeguard the reformed religion," forbade Catholic priests within its jurisdiction to recite the office of St. Gregory under a penalty of 1,000 florins. The pope declared all the arrogant decrees of the secular powers against the office to be null and void. The happiest event of his reign was the restoration of Comacchio (1725). This fortified commune, 30 mi. S.E. of Ferrara, had been retained by the emperor after the War of the Spanish Succession and was considered by the popes to be very necessary for the defense of their states. After Benedict XIII's death in 1730 there were riots in Kome directed against his favourite Cardinal Coscia and that man's followers, who had seriously depleted the papal treasury by their depredations. The debt of the Holy See amounted to 60,000,000 scudi.

The next pope, Clement XII (1730–40), whose parents had belonged to two of the wealthiest families in Florence, partially restored the situation by contributions from his own ample funds. by making Coscia disgorge his ill-gotten booty and by various financial measures, including a public lottery and the issue of paper money. The new pope was an extremely affable man of spotless reputation, but his age (he was 78 years old at his election), his gout and a weakness of the eyes resulting in total blindness shortly after his election all militated against his being able to do much for the church in that age of spreading rationalism and scepticism. From the outset of his pontificate, the pope had to struggle with the regalian pretensions of Charles Emmanuel of Sardinia and with serious trouble over those ill-omened duchies Parma and Piacenza, which, though held as fiefs of the Holy See since 1545, became bones of contention between Bourbon Spain and Habsburg Austria on the extinction of the male line of the Farnese dukes in 1731. With England as mediator, the rival Catholic powers composed their differences without resort to war, but the protests of the pope were completely ignored in the arrangement. The Gallicanism of France had crossed the Pyrenees to Spain with the Bourbon king—to become in its new home, under the leadership of Gaspar Molina, bishop of Malaga, even more affronting to the papacy than in the land of its origin. In the kingdom of Naples, which Don Carlos (the future Charles III of Spain) had seized from the Habsburgs in 1734, the ruling power behind the throne was the violently anticlerical Bernardo Tanucci. The best-remembered act of Clement XII was his constitution of April 28, 1738, condemning Freemasonry under heavy ecclesiastical penalties; and his most endearing act was restoration of complete independence to the little republic of San Marino, which the cardinal Giulio Alberoni, of his

own initiative, had in 1739 annexed to the papal states.

It was at this nadir of the Holy See's political influence that Prospero Lambertini became pope as Benedict XIV (1740–58). He was the most genial, witty and learned of all occupants of the papacy, as well as one of the kindest and most compassionate. Before his election he had played a decisive part in settling the manifold differences of the Holy See with the encroaching Catholic powers, and as pope he directed all his great ability and energy to the restoration and maintenance of peace with those same suspicious and aggressive governments. Even the courts of Turin and Naples, which had defied his predecessor and grievously afflicted the church, came, however sulkily. to some kind of understanding with the new pope, who showed himself conciliatory almost to a fault. In Spain the difficulties were even greater, because of the baleful influence of Molina, the bishop of Málaga, whom Clement XII had made a cardinal in a pathetic attempt to mitigate his anti-papal hostility. Still stranger was it to find a strong Gallican in Philip V's Jesuit confessor. an impetuous Frenchman who had convinced himself that Benedict was meditating some drastic coup against his order. The coup was being prepared, surely enough, but not by Benedict XIV. The concordat which the pope eventually signed with Spain (1753) has been heavily criticized as giving away far too much and as greatly encouraging the caesaro-papism of the Spanish court. but it may well have been his only way of preventing a complete schism. During the War of the Austrian Succession, Benedict had to endure the devastation of his defenseless states by the armies of both contending parties because he tried to remain neutral. He said that he could write a treatise on "The Martyrdom of Neutrality." The pope had the defects of his shining qualities. His love of literature and learning and his charming geniality and broad-mindedness led him into a friendly correspondence with the leader of the anti-Christian movement, Voltaire, on whom he bestowed two gold medals. to the surprise and grief of all good Catholics. He promoted schemers such as the cardinal Domenico Passionei whose dearest object in life, assisted enthusiastically by a group of hidden or open Jansenists. was the destruction of the Society of Jesus. The bull Ex *quo singulari* (1742) put an end to the century-old controversy on the Chinese rites by forbidding to Christian converts certain observances which the Jesuits, on the testimony of the Chinese emperor, had maintained to be of purely social significance. That spelled the eclipse of many bright hopes for the conversion of China; and it was followed in 1744 by another bull, *Omnium sollicitudinum,* dealing similarly with the Malabar rites. On the other hand, oriental Catholics nearer home received great support from the Holy Father, who encouraged them to maintain their own rites: "We desire most intensely." he declared, "that all should be Catholics, but not that all should be Latins." As proof that the church in that age of rampant secularism and scepticism retained its indestructible vitality, there arose two new religious families. the Passionists and the Redemptorists, which the pope had the happiness of approving. But almost his last act on earth, the appointment of the cardinal Francisco de Saldanha, a creature of the marquis of Pombal, to report on the Jesuits of Portugal, played straight into the hands of the Jesuits' swarming enemies.

The Suppression of the Jesuits.—Clement XIII (1758–69) spent his pontificate in an almost unbroken fight against the godless forces of the times and did everything in his power to save the doomed Society of Jesus from its confederated foes, Bourbon absolutists. Jansenists, *philosophes,* Freemasons. During his reign, the Jesuits were expelled successively from Portugal (1759), from France and the French dominions (1764), from Spain and the Spanish dominions (1767), from Naples (also 1767) and from Parma (1768). All their property was confiscated and their flourishing missions in India and in the far east and in North and South America were ruined. The pope received the destitute exiles into his states, but their enemies had not finished with them. In Jan. 1769 the ambassadors of Spain, of Naples and of France appeared in turn before the Holy Father and demanded the complete suppression of the Society of Jesus throughout the world. At that point the tormented pope had a stroke and died.

The conclave from which the gentle, peaceable Franciscan friar Lorenzo Ganganelli emerged as Clement XIV (1769–74) was subjected to pressure and interference such as had not been paralleled for ages; and the unfortunate man, who by an irony of history had been created cardinal by Clement XIII because he was supposed to be friendly toward the Jesuits, never had a chance of proving his friendship. Terrified lest France and Spain should resort to open schism, he issued on Aug. 16, 1773, a brief, *Dominus* ac *Redemptor* (dated July 21), dissolving the one order which from its beginnings had dedicated itself wholeheartedly to the service and defense of the Holy See.

Pius VI.—Clement survived the destroyed society by less than 14 months and was succeeded by Pius VI (1775–99), a throwback to some of the ostentatious and irresponsible Renaissance popes, who might be charged with having fiddled while Rome burned. He was not the man to deal with the Febronianism (*q.v.*) of the emperor Joseph II nor with the cataclysm that ensued from the French Revolution of 1789; but the destruction of his temporal authority by the armies of the Revolution in 1798 and his death in captivity in the following year presaged a new epoch for the papacy. (Table XIV shows the succession of popes from 1605 to 1800.)

TABLE XIV.—*The Papacy From 1605 to 1800*

1605 **(April)**	Leo XI	1691–1700	Innocent XII
1605–21	Paul V	1700–21	Clement XI
1621–23	Gregory XV	1721–24	Innocent XIII
1623–44	Urban VIII	1724–30	Benedict XIII
1644–55	Innocent X	1730–40	Clement XII
1655–67	Alexander VII	1740–58	Benedict XIV
1667–69	Clement IX	1758–69	Clement XIII
1670–76	Clement X	1769–74	Clement XIV
1676–89	Innocent XI	1775–99	Pius VI (d in exile)
1689–91	Alexander VIII		

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(J. P. BK.)

VIII. THE RESTORATION

Pius VII (1800–23).—When the Benedictine bishop Luigi Barnabh Chiaramonti emerged as pope from the prolonged and rather undignified conclave at Venice, his election could be interpreted as a reaction against the pressure of political elements (mainly pro-Austrian) in favour of a candidate whose major interest was known to be in the religious aspect of contemporary problems. With a mental acuteness that enabled him to cling tenaciously to the essential points while sacrificing matters of detail Pius VII, notwithstanding his respect for tradition, promptly showed his readiness to reach a compromise with the Revolution insofar as was compatible with the church's principles. Overriding the shocked opposition of some members of his entourage, he made a bold decision and negotiated the celebrated concordat of 1801 with the first consul of the French republic, Napoleon Bonaparte. In the belief that it was of vital importance for Rome to come to terms with the republic, both for religion's sake and because of the international significance of such a reconciliation, Pius not only stood sponsor, in a moral sense, for the child of the Revolution but also, in return for certain substantial advantages, waived the claim that Catholicism should be recognized as the state religion. Giving his official blessing to the liquidation of the pre-Revolutionary church in France, he renounced the ecclesiastical property that had been secularized, set himself to a far-reaching reorganization of the provincial and diocesan structure of the church and called on the surviving bishops to resign their sees.

This last concession was altogether without canonical precedents; and by inducing Pius to agree to it Napoleon struck a heavy blow at the Gallican tradition, since the pope, however well aware he may have been of the extent of his powers over the bishops, had never previously dared to assert them so drastically in practice. Moreover, the fact that a concordat was signed was by itself a victory for the papacy. Whereas in the 18th century it had been either disregarded or treated as a foreign power against which the national episcopate could be brought into play, the papacy now became an ally whose influence over the clergy of the Catholic world mas acknowledged by the several governments and whose co-operation would be sought in settling the religious questions that the state had formerly tried to settle by unilateral action.

The prestige accruing to the papacy from the concordat was to be augmented when Pius and Napoleon (whom he had consecrated as emperor in 1804) came into conflict. The cause of the quarrel was political rather than religious; viz., the pope's refusal to incorporate the papal states within Napoleon's continental system of blockade against England. The emperor thereupon annexed what was left of the states of the church (1809). When Pius retorted by excommunicating him, he had him arrested and tried to reduce his position to that of a high ecclesiastical official of the empire. These rough measures, which at one moment came very near to success, had two results: in the first place, they aroused a deep feeling of esteem and respect for the victim among Catholics, particularly among Catholics north of the Alps, where for centuries few had cared much about a pontiff who never left the vicinity of Rome; and secondly. they served to align the pope with the powers that were eventually to be victorious against Napoleon, even though at the time of the pope's arrest these powers showed little concern for him.

On the one hand, then, Pius VII and his secretary of state, Ercole Consalvi, who was a man of genius, had adopted an understanding attitude toward the France of the Revolution and so had been able to re-establish, within a few months of the beginning of this pontificate, a power that had been seriously threatened; on the other, the moral authority of the papacy, enhanced as it was by the pope's subsequent resistance to Napoleon, was to be seconded in the work of restoring the church by the counterrevolutionary dispositions of the cabinets of Europe, after Waterloo.

In reaction against Napoleon, numbers of European statesmen came to think that an independent spiritual power vested in the person of the pope constituted a valuable guarantee. This view, together with the principle of legitimism, caused the papal states to be restored by the congress of Vienna; and Consalvi's diplomatic ability succeeded in securing complete restoration except for Avignon and the Comtat Venaissin. Yet this success carried nith it the germs of trouble for the popes. Their subjects, particularly those in the Legations (Bologna, Ferrara, Ravenna and Forli) which had been annexed to France for 20 years, had acquired a taste for modern administrative methods and now felt misgivings at the re-establishment. even in part only. of the archaic procedure of pre-Revolutionary times. Consalvi, who had moreover to struggle against opposition within the curia, tried to modernize the administration, the judicial procedure and the financial system of the states by means of the constitution of 1816. The progressives, however, were disappointed in their hopes.

While it was principally Consalvi who was responsible for the reorganization of the papal states, Pius VII concerned himself with the ecclesiastical and religious aspects of the restoration. In the period following 1815 it was generally accepted that the church was the best safeguard of monarchy; and Pius took advantage of this opinion and of his own personal ascendancy to continue his policy of concordats. This policy enabled him, at the cost of a few concessions to the spirit of the age, to counteract the tendency toward state control of the church (to which all contemporary governments were inclined) and to get himself implicitly recognized as the real head of the universal church. Further, in view of what had happened in France, he could insist on more favourable conditions in his concordats. In other respects, he showed himself capable of profiting from circumstances. In France and in Spain he co-operated with the counterrevolution; in Austria and in Germany, however, where the spirit of the emperor Joseph II was still vigorous, he did not scruple to appeal to new ideas of liberty; and in the Protestant countries he called for toleration.

With papal encouragement, the religious orders took up the task of reorganizing themselves; and in 1814 Pius restored the Society of Jesus, which in later years was to be one of the papacy's most active partners in the work of ecclesiastical centralization. Different from many of his predecessors of the 18th century. whose interest was principally in administration and in politics, Pius VII showed a great concern for doctrine and issued stern condemnations of the enemies of the church, especially against Freemasonry, in which he saw the embodiment of the revolutionary and anti-Christian philosophy of the 18th century. He remained true to the tradition of the humanist popes, however, in his interest in educational reform, in the improvements that he introduced into' the Vatican library and into the pontifical museums and in his desire to make Rome a centre of the arts.

Leo XII (1823–29).—In their efforts to adapt the papacy to the political, intellectual and social conditions of the modern world? Pius VII and Consalvi had come up against the opposition of the *zelanti; i.e.,* those churchmen who stood for political reaction and objected to any concession that might be made to modern aspirations. This party was well represented in the higher clergy and in the curia, and the election of Annibale Sermattei della Genga as pope, under the name of Leo XII, constituted a victory for it.

Their next success was the abandonment, in the papal states, of the reforming policy of Consalvi. Authoritarianism was reinstated. This reaction, however, provoked in the *bourgeoisie* a strong resentment against "government by priests"; and though Leo's financial policy, by reducing expenditure, made it possible to reduce taxation: the precarious economic situation of the state remained unchanged, while the pope forfeited the affection of those who had profited from the abuses that he removed.

In matters of doctrine Leo took a number of measures calculated to prevent the infiltration of liberal ideas and to strengthen the efficiency of the Inquisition. On the other hand, in his relations with foreign governments, after some clumsy moves inspired by the intransigence of the *zelanti,* he soon came to appreciate the need for appeasement and moderation in view of the new outbreak of liberal propaganda, the revival of Gallicanism and the persistence of Josephism.

Pius VIII (1829–30).—The reactionary Leo XII was succeeded by Pius VIII, a disciple of Pius VII and of Consalvi, who reigned, however, for only 20 months. In strictly ecclesiastical matters Pius showed himself generally broad-minded and conciliatory, though not at the expense of principle; and in the administration of the papal states he both mitigated the authoritarian regime and showed wisdom in his social and economic policy (though he did not succeed in allaying the increasing discontent and agitation). In foreign policy, however, he gave a free hand to his secretary of state, the old cardinal Giuseppe Albani, who was wholly devoted to the Austria of the Holy Alliance. This caused him to be represented as having aligned himself altogether with the absolutist governments and as hostile to the Polish, Irish and Belgian risings of 1830 (the Belgian alliance of Catholics and liberals against the enlightened despotism of King William of the Netherlands was regarded as "monstrous" by the Vatican). Yet Pius made no difficulties about recognizing the July monarchy in France.

Gregory XVI (1831–46).—Historians used once to represent Gregory XVI (a former Camaldulian monk, Mauro Cappellari) as a typical example of a reactionary and narrow-minded pope; but this view is now disputed. Gregory indeed showed little sympathy for Italian nationalism or for his subjects' desire to see the administration of the papal states modernized; his monastic austerity moreover made him seek to isolate himself, while his rough manner made him seem even more intransigent than in fact he was. But even so his political and administrative record is less black than it has been painted by the early historians of the Risorgimento; and we must also recognize in this scholarly man an enlightened patron of the arts and of archaeology. Moreover, in religious matters his intelligent and carefully considered measures proved bene-

ficial to the church in more than one respect.

A former monk, Gregory naturally favoured the religious orders. He supported the inauguration of several new congregations, restored the Benedictines and the Dominicans in France and protected the exempt orders from encroachments by the bishops. This last-named line of action reflects the long-established papal policy of maintaining the Holy See's rights against all surviving traces of Gallicanism and of Febronianism; and Mauro Cappellari had already made himself the spokesman of ultramontanism in his book *Il Trionfo della* Santa Sede e *della* Chiesa (1799).

Having once been prefect of the congregation de Propaganda Fide, Gregory was a great missionary pope. In the Revolutionary and Napoleonic periods Catholic missions had suffered a serious setback, and everything now needed to be reorganized. The effort that had been begun in the last years of Pius VII was systematically encouraged and extended; and since 1826, when he became cardinal, Cappellari had been working for, centralization of the missionary enterprises. Gregory moreover did not flinch from bold innovations. For example, he envisaged a native clergy and even a native episcopate in the missionary countries (this however had no immediate result).

In Portugal, in Spain, in Switzerland, in Prussia and in Russia various politicoreligious disputes confronted the papacy under Gregory. The pope's underlying policy was to oppose any attempt at restricting the rights of the church, whether inspired by caesaropapism, as in Russia and in Prussia, or by liberalism, as in Switzerland. Yet on several occasions he showed himself ready to come to terms. For instance, after obtaining satisfaction on the matter of principle he agreed to the removal of the ultramontane archbishop of Cologne, K. A. von Droste zu Vischering, whom the Prussian government had arrested in 1837; and in 1845 he consented to a partial dissolution of the Jesuits in France. This same spirit was made especially evident in his attitude toward the young republics of South America (the bull Sollicitudo ecclesiarum of Aug. 7, 1831, declared that where there was a change of regime the Holy See would treat with the de facto government) and toward Belgium (where the revolution of 1830 had led to a liberal constitution). Thus it was that, despite his dislike of liberalism and of the revolutionary spirit, Gregory was prepared to negotiate with governments born of insurrection and refrained from condemning those Catholics who throughout Europe—in Prussia, in Poland, in Ireland (Daniel O'Connell) and in France (Charles de Montalembert) no-less than in Belgium—were appealing to liberal principles in order to secure their religious rights from their governments. Here Gregory appears not as a reactionary pope but as one who was ready for what the future held in store; yet it must be admitted that he felt no enthusiasm for these compromises, which he did his best to limit.

In matters of principle Gregory was indeed uncompromising. Rationalist naturalism he condemned in all its forms, together with fideism. The most famous of his pronouncements in this field is the encyclical Mirari vos (Aug. 15, 1832) against certain ideas that H. F. R. de Lamennais and the newspaper *L'Avenir* had been putting forward; viz., the separation of church and state, liberty of conscience and the freedom of the press. Gregory was opposed to liberalism not only because he regarded it as a manifestation of indifference to doctrine but also because his feeling for authority prompted him to defend kings even against rightful claims by their subjects and, ultimately, because from the moment of his accession he was haunted by the fear of seeing his own dominions eaten away by liberal ideas.

In fact at the very beginning of his pontificate there had been a revolt in the Romagna and in Umbria. Foreign intervention had been required to restore order, and as a consequence of this intervention Gregory had had to promise reforms (stipulated in the memorandum presented by the powers in May 1831). These reforms, though not very generally recognized, were quite numerous (particularly while Tommaso Bernetti was secretary of state) and for the most part reasonable and beneficial; but they still proved inadequate to the situation, mainly because they were limited to the administrative field and never extended to the political. Opposition therefore became rife, and repressive measures, designed to stifle it, only made it more bitter. Discontent was also further exasperated by the wholly negative attitude of Gregory and of his new secretary of state Luigi Lambruschini (a partisan of the old order who had taken Bernetti's place in 1836) toward Italian nationalism and patriotic feeling against the influence of Austria in the peninsula. Though his understanding with Metternich mas not nearly so close as his detractors thought, Gregory showed no sympathy whatever for the cause of Italian unity, even when thinkers such as Vincenzo Gioberti and the "Neo-Guelphs" proposed a federal union under the presidency of the pope himself.

IX. THE RISE OF DEMOCRACY AND RATIONALISM

Pius IX (1846–78).—Pius IX reigned longer than any former pope, and his pontificate was one of crisis and of new departure both from the political and from the religious point of view.

The Revolution of *1848* and the Roman Question.—Giovanni-Maria Mastai-Ferretti was elected pope, in opposition to the rival candidature of Lambruschini, by cardinals who were anxious about the liberal and national agitation then rife in the states of the church. Pius was thought at first to be far readier than in fact he was to come to terms with the movement for Italian unification and for constitutionalism; many indeed, hoped that he would put himself at its head. For some months this myth of a "liberal pope" won him immense popularity; then it was liquidated in the crucial period of 1848. It first became clear that, though he sincerely wanted to improve the lot of his subjects by administrative reform, Pius IX could not bring himself to reform the constitution. Any concession that his priestly monarchy might make to the laity. he feared, would be a limitation of the Holy See's spiritual independence. His allocution of April 29, 1848. then showed that, however much he sympathized with the Italian aspirations, he would never agree to play an active role in the war of independence against Austria, as this would seem to him incompatible with his duty as spiritual father of all the faithful. Economic difficulties combined with the pope's lack of political adroitness to precipitate a crisis. Rioting broke out, and on Nov. 24 Pius had to flee to Gaeta. In Feb. 1849 a republic was proclaimed in Rome, but this republic lasted only for a short time. The European powers upheld the pope, who was reinstated on his throne thanks to the French expeditionary force.

The ensuing work of restoration was reactionary and ill-conducted; and the presence of foreign troops increased popular resentment at it. It was thus not difficult for Cavour to exploit this situation in order to advance his plans for uniting Italy under the aegis of Piedmont; and after patiently undermining the authority of the papal government he seized the opportunity presented by the Franco-Austrian war of 1859 to annex the Romagna (March 1860) and then, on the defeat of the small pontifical army at Castelfidardo (Sept. 18), the Marches and Umbria. For the next ten years Napoleon III extended sufficient protection to enable the pope to retain Rome and the Roman Campagna. Then the Franco-German war broke out, and on Sept. 20, 1870, the Italians occupied Rome. Pius IX, who regarded himself less as a deposed sovereign than as the tenant of a property for which he had to answer to the church, refused to bow before the *fait accompli*. Rejecting the Italian offer of a "law of guarantees," he assumed the role of a prisoner in the Vatican.

The Direction of the *Church*.—At the very moment when the disappearance of the papal states removed it from the field of European diplomacy, the papacy was about to emerge as a world power with which every politician would have to reckon. This development, of which Pius IX's successors were to reap the benefit, was the result partly of missionary activity (which throughout this 32-year pontificate kept abreast of the colonial expansion of Europe overseas) and partly of the large-scale immigration of Catholics to Canada, then to Australia and, above all, to the United States, where promising new churches grew up. In Europe, meanwhile, the position of the church in the traditionally Catholic countries was being apparently consolidated by concordats that sometimes gave it very favourable terms (*e.g.*, the Austrian concordat of 1855); and the churches that had survived precariously since the Reformation in Protestant countries were reconstituted.

This was the case in England, where Pius restored the hierarchy in 1850; in the Netherlands likewise in 1853: and most markedly in Germany, where the *Kulturkampf* (see GERMANY: *History*) served to show how vigorous the Catholic Church had become in the space of a few years through its increasing reliance on the Holy See.

Expanding in numbers. the church was yet closing its ranks ever more firmly round the person of the Holy Father. One of the most striking features of this pontificate is the continuous advance toward centralization and uniformity within the church, a movement that was to determine the character of Catholicism for the following 100 years. The Vatican council (1870), by its solemn definition of the infallibility of the pope when he speaks ex cathedra and of his primacy of jurisdiction over the entire church, marked the end of all that was left of particularism in the local churches. From 1850 this policy was pursued in a number of ways, not without meeting with considerable opposition not only from the eastern patriarchates but also in France and in Germany (as can be seen from the size of the minority at the council and from the fact of the Old Catholic schism in Germany following the proclamation of the dogma). In any case. the decisive factor in the rapid and conclusive victory of ultramontanism (*q.v.*) was the personality of Pius himself and the immense influence, that he had won over laity and clergy alike. This expressed itself, particularly in France, in the unprecedented phenomenon of "devotion to the pope."

Though successful in the long run. the ecclesiastical policy of Pius IX and his successors had certain unfortunate consequences. While the church, at his death, was numerically stronger and more firmly bound together than ever before, it was dangerously isolated in the face of the general hostility of national governments and public opinion. The victories of Catholicism during his pontificate were largely due to the progress of ultramontanism and to the church's alliance with counterrevolutionary governments; but the very success of ultramontanism provoked a reaction of resentment in these governments when they saw the national clergies escaping from their grasp; and at the same time the partisans of democracy, who were becoming every year more influential. could not forgive the church for having lent all its support to conservatism since 1848. Pius, ill-advised by his chosen counselors, failed to adapt the church to the great changes in the political and social fields that were coming into being in the second half of the 19th century.

Doctrinal and Spiritual Achievements.—Piux IX failed also to provide that stimulus on the intellectual plane which was required to counteract the advance of rationalism and positivism. He allowed the church's attitude to science to be determined by narrow-minded persons who. rigidly adhering to supposed tradition, thought their duty fulfilled if they simply anathematized any new tendency that at a first glance seemed contrary to the faith.

Yet Pius made important contributions to doctrine. He defined two new dogmas, that of the Immaculate Conception of the Virgin (1854) and that of papal infallibility (1870); and his encyclicals, though hardly original in content, following as they do on those of Gregory XVI, nevertheless constitute a far more systematic and wider-reaching corpus than Gregory's. The encyclical Quanta *cura* (Dec. 8, 1864) and the controversial *Syllabus* that accompanied it deserve special mention in this corpus, to which the decrees of the Vatican council should have put the finishing touch. This council, however, which opened on Dec. 8, 1869, was interrupted by the outbreak of the Italian war in July 1870; and most of its sessions were consumed in long and passionate deliberations on the question of infallibility. In April, nevertheless, the important constitution Dei *Filius* had been approved, on the relation between reason and faith. Typical of the positive aspect of Pius IX's work, this represents a resolute attempt to eradicate the last traces of the naturalistic deism of the Enlightenment and to reassert the basic premisses of revealed truth as the core of Christian thought.

Together with this vast doctrinal enterprise, a considerable effort was made to enrich religious life; and this, indeed, was the major achievement of Pius IX's pontificate. While national traditions had to be sacrificed, the training of the clergy was made more thorough and there was a lasting increase in popular devotion. This achievement has often been belittled as superficial, but that it was not so is proved by the great revival of Catholic activity and by the expansion of the religious congregations. While local organizations and the Society of Jesus must be given the credit for some of these results, Pius himself played a large part in the achievement.

Leo XIII (1878–1903).—In former times the Romans had been prompt to divide candidates for the papal crown into three classes: scholars, politicians and *zelanti*. Vincenzo Gioacchino Pecci, however, who became pope as Leo XIII, seemed to fulfill all three roles. As an intellectual he was in touch with scientific progress; as a diplomat he understood politics; and as a shepherd of souls he cared for the inner life of the church and for the spread of missionary work.

Continuity and Innovation.—Both in his own time and in later historical works an exaggerated contrast used to be drawn between Leo XIII's pontificate and Pius IX's. In many important respects, however, there is an obvious continuity from the one to the other. Leo not only maintained the devotional practices that Pius had favoured, namely the cult of the Sacred Heart and devotions to the Blessed Virgin (the rosary in particular), but also showed himself to be no less vigorous an opponent of rationalism and secularism, against which he was quite ready to have recourse to the Syllabus—to the deep disappointment of those who had hoped for a liberal papacy. Likewise he disappointed those who had expected a reversal of the ultramontane tendencies that had prevailed under Pius. Leo in fact systematically encouraged ultramontanism by accelerating the process of centralizing the great religious orders; by promoting pilgrimages to Rome; by constantly exerting his authority over the national hierarchies; by personally intervening in the politicoreligious disputes of several countries in order to indicate to the laity or to the clergy what line they were to follow; and by increasing the power of the nuncios, whom he sought to establish as being no longer simply diplomats accredited to foreign governments but also the pope's commissioners to the local episcopates (*cf.* the note of Lodovico Jacobini. cardinal secretary of state, of April 13, 1885). Finally. on the Roman question. while ready to compromise on ways and means and to declare himself satisfied with very little territory, Leo refused to abandon temporal sovereignty as a principle, as he could not see how the Holy See and the church could remain independent without it.

Aware that no satisfactory situation could be reached by direct negotiation with Italy, he tried (without success) to make the question an international one, looking first to Germany, which was the dominant European power in the period following 1870, and subsequently to France.

In other respects, however, there is no doubt that Leo XIII's pontificate was characterized by a new spirit: in the first place, the pope was anxious to put a stop to the belief that the church was necessarily opposed to modern aspirations; secondly. he stimulated Catholic initiative with regard to social work; thirdly, he sought to open the way to a rapprochement with other Christian churches; and, finally, he showed himself ready to conciliate foreign governments, being willing to temporize rather than to break off relations and, unlike Pius IX, refraining from strongly worded protest even when he found himself forced to disagree.

Doctrinal Guidance.—Leo XIII's encyclical Aeterni *Patris* (1879) gave a decisive stimulus to the revival of Thomism, which, however, he hoped to see reconciled with scientific progress. Another encyclical. Providentissimus Deus (1893), defined in a fairly broadminded manner the principles on which Catholics should expound the doctrine of the divine inspiration of the Bible in the light of modern discoveries. He called upon Catholic historians to write objectively (in a brief of Aug. 18. 1883); and his opening of the Vatican archives to historians without regard to creed (1880) led to the establishment of a number of foreign historical institutes in Rome.

Not the least remarkable of Leo's encyclicals were those in which he gave a positive statement of the ideal of the Christian

state (*Immortale* Dei, 1885; Libertas, 1888). In these, he recognized that the concrete institutions of the *ancien régime* were no longer feasible and recommended that church and state should live together in peace within the framework of modern society, acknowledging the new regime of toleration as provisionally admissible. Similarly. the encyclical *Rerum novarum* (1891), though rather cautious in its approach and not very fruitful in its immediate results, showed that the papacy had taken cognizance of the working-class question and sought to take a hand in its solution by defining "social Catholicism" for the first time. Leo's interest in the social problem is partly to be explained by his desire to win the masses for the church so as to be able to reckon the support of this "real population" against the anticlerical policies often adopted by the bourgeoisie or "legal population." Of like inspiration were the papacy's efforts to organize the laity (notably through the Opera dei Congressi, the central body for Catholic social work in Italy).

Whereas Pius IX had wanted to Latinize the rites and to standardize the discipline of the Uniate patriarchates, Leo XIII on the contrary declared that eastern traditions were to be respected (cf. the encyclical *Orientalium dignitas*, 1894) and founded new seminaries in which the future clergy of the east could learn the spirit of Rome. His expectation that this would do much to promote the return of the schismatic churches to his fold was, however, disappointed, as also were the hopes that he had entertained of a *rapprochement* with the Church of England, for which Lord Halifax and the abbé Fernand Portal had been working. On the question of the validity of Anglican orders Leo had finally to give a negative reply (1896).

Foreign Relations.—In his dealings with foreign governments, Leo showed a strong preference for proceeding along diplomatic channels. His aim was to win the friendship of governments for the church by letting them appreciate the value of the church's moral support against revolutionary activity and by inducing Catholics to withdraw their obedience from lost causes (Carlism in Spain, monarchism in France); and he hoped that the church would receive substantial favours in return for services rendered. Thus, where Pius IX had been on the defensive. Leo adopted an active policy and won, indeed, some unmistakable successes: relations were resumed with Bismarck's Germany. the aftermath of the *Kulturkampf* going gradually into liquidation; disputes with Switzerland and with most of the South American republics were smoothed over; tension was eased in Russia; and much greater cordiality was established not only with Catholic Spain and Austria but also with the Protestant Anglo-Saxon powers.

Yet in certain essential respects Leo's pontificate was a failure. Attempts to conciliate Italy came to nothing. The hope of winning German support for a solution of the Roman question was frustrated when Germany, Italy and Austria signed the triple alliance. The new policy adopted when Mariano Rampolla became secretary of state in 1887, namely that of seeking the friendship of the democracies, the United States and, particularly, France, was no less disappointing. Moreover, Leo's whole French policy, based as it was on the new collaboration of Catholics with republicanism, was made bankrupt when many refused to follow the pope's directives and when the flood of anticlericalism grew so strong as to threaten the proper functioning of the concordat. These reverses. which served to keep the Roman question unsolved, prevented the Holy See from playing the part to which it aspired in the international field—though the pope's arbitration in the dispute between Spain and Germany over the Caroline Islands constituted a conspicuous success (1885). Nonetheless, Leo's policy enabled the church and the papacy to recover a considerable amount of their moral authority and, as a result. to gain a real political power. The growth of the Holy See's prestige in the course of this "glorious pontificate" can be measured by the number of new diplomatic missions established at the Vatican and by the volume of congratulation that reached the old pope on the occasion of his four jubilees.

Pius X (1903–14).—As Austria vetoed the election of Cardinal Rampolla. Giuseppe Melchiore Sarto became pope as Pius X on Aug. 4, 1903. His was a mind quite different from Leo XIII's. He had always hated "the political priest"; he had no liking for diplomatic maneuvers and little sympathy for liberal tendencies in the intellectual field; and he had an instinctive mistrust of popular government. Years of work as a parish priest had made him very conscious of the pastoral duties of the church and inclined him to consider every problem from the religious point of view; all who had come into contact with him thought of him as a saint. As Leo's policy of co-operation with secular governments seemed to him to have ended in failure, Pius decided from the start to concentrate his attention on the problems of the apostolate and to make the defense of Catholic religion the keynote of his pontificate.

A Conservative Pope.—Opinions differ widely on the means by which Pius went about his purpose and on the spirit that actuated him and his advisers (the chief of whom was the Spanish cardinal Rafael Merry del Val). Three aspects of his policy in particular have aroused bitter controversy: the repression of modernism; the reaction against the "Christian democrats"; and his attitude toward the separation of church and state in France.

Even before he became pope, Sarto had been alarmed at the dangers that might be inherent in the reforming movement known as modernism, a movement most marked in France and in Italy. The modernist tendency seemed to be to sacrifice certain essential traditional values in order to reach a premature accommodation with modern ideologies. Pius settled the question by putting a series of books on the Index, by issuing the decree *Lamentabili* and the encyclical *Pascendi* (both 1907) and finally by reorganizing the commission on the Bible and imposing rigorous control over all churchmen whose duty it was to teach philosophy and theology. Pius did not intend that these measures should put a stop to all intellectual life within the church; but his lack of personal acquaintance with critical methods made it impossible for him to distinguish precisely between the justifiable, the controversial and the objectionable elements in the new theories; and moreover, particularly after 1910, he was rather too open to pressure from the "Integrist" or extremely reactionary party in the curia. Most of the blame that the antimodernist reaction has incurred was called forth by disagreeable incidents in these last four years of Pius X's pontificate, when the activities of Mgr. Umberto Benigni's Sodalitium Pianum were often far from praiseworthy.

At first sight it seems even more paradoxical that a pope whose own antecedents had been among the people and who all his life championed the cause of the poor should have led the reaction against Christian democracy. What he found intolerable, however, was that some Catholics should make their social work a matter independent of the hierarchy and conduct it in an increasingly political direction. Accordingly he began his pontificate with a radical reorganization of the Opera dei Congressi in Italy and disavowed and then formally condemned both the Italian priest Romolo Murri's ".Popular Action" movement and, in 1910, Marc Sangnier's *Sillon* group in France. Some intervention on the part of the higher authority in the church was justified insofar as the Italian groups mere making certain concessions to modernism and the French were too outspoken on matters of doctrine; but the pope's choice of measures, together with the rather favourable attitude that he adopted toward Action *Française,* showed that the Vatican for the time being was drawing away from democratic ideas and inclining rather toward paternalism as a means of solving social questions.

All the factors contributing to the break between the papacy and the French government, which culminated in the law of 1905 separating church and state in France, were already on the scene at Pius X's accession; the break, in fact, was inevitable. Pius, indeed, saw the advantage of making the church of France wholly independent of the state, particularly where the choice of bishops was concerned. Must of the French bishops, however! would have been willing to try out open-mindedly the new legislation on *associations cultuelles* (associations for religious worship), which safeguarded all that could still be preserved of the church's material interests; and there was general surprise when Pius rejected the compromise oifered. In his view no departure could be admitted from the principle that the church's position must not be determined by unilateral action on the part of a government; and he

may also have been misinformed on the new spirit active in the French government's policy since the fall of Émile Combes.

The break with France, increased tension with Russia about religious affairs in Poland and some clashes with the United States combined to promote Austrian and German influence in the Vatican to such a degree that Pius has sometimes been called "the pope of the triple alliance." Yet his relations with the court of Vienna and, especially, with the German empire were not untroubled. For instance, there was the incident of the *Borromäus-Enzyklika* (1910), when great resentment was shown at the pope's slighting references to the Protestants in his encyclical on the occasion of the tercentenary of St. Charles Borromeo's canonization; there was the question of the antimodernist oath required from university professors;. and there was the controversy about mixed trade unions, in which the Vatican made clear its preference for unions organized on a strictly confessional basis.

The Pope as Reformer.—Whatever the final judgment on Pius X's defensive strategy may be, it would be unhistorical to represent his pontificate as one of defense and nothing more.

In the first place, there was an improvement in the papacy's relations with the Italian government. On the one hand, the facts of the Roman question came to be viewed in a more realistic light; on the other, the fear of socialism served to draw Catholics and liberal conservatives together. There was thus a gradual mitigation of the non *expedit,* which in the 1870s and 1880s had been developed into a prohibition against Catholics' taking part in Italian political life; the so-called "Gentiloni pact" of 1913 established seven conditions on which Catholics might vote for candidates at elections. Secondly, Pius, who seemed so old fashioned to his contemporaries, was in fact a great reformer. Clear-sighted and enterprising, he envisaged the reconstitution of Christian society as requiring not only the unequivocal disavowal of erroneous attitudes but also a positive effort toward adaptation and initiative in pursuing the essentially pastoral work of the church, so as to enhance its inner life and to make the best use of its strength.

The teaching of the catechism, preaching and the education of the clergy (this last being one of his major preoccupations) were all the objects of improvement or reform under Pius X; and some of his directives, though outmoded by later social developments, nevertheless mark him as one of the forerunners of "Catholic action," that is, the organization of the laity for special and direct collaboration in the apostolic work of the church (*cf.* the encyclical *Il* fermo proposito, 1905). Most important in the context of reform, however. were : (1) his eucharistic decrees. which eased the regulations governing daily communion, facilitated the communion of the sick and insistently enjoined that children should begin to communicate on attaining the age of reason; (2) his liturgical reforms, namely the revival of Gregorian plainsong and the recasting of the breviary and of the missal; (3) his decision, taken at the very beginning of his pontificate and despite numerous objections, to adapt and to systematize the canon law, which led to the publication of the new code in 1917 (to take effect in the following year); and (4) his reorganization of the curia, through the constitution *Sapienti* consilio (1908) which modernized the central administration of the church and its method of operation and enabled the Roman congregations to deal more effectively with the heavy task of centralization.

X. THE PAPACY IN THE INTERNATIONAL CRISIS, FROM 1914

Benedict XV (1914–22).—In view no doubt of the international situation the conclave of 1914 chose a clever diplomat, Giacomo della Chiesa, a former pupil of Leo XIII and of Rampolla, as Pius X's successor. The political isolation in which he found the Holy See, as a result of his predecessor's strategy of defensive withdrawal and intransigence, made it difficult for Benedict XV to play an effective role in the world crisis. Many people were disappointed by the strictly neutral attitude that he adopted in World War I and by his abstention from condemning any action of the belligerents. The western allies were bitterly indignant at his efforts to prevent the spread of a conflict that set Catholic against Catholic and at his attempt at mediation in 1917, which was a complete failure; but his conduct was to be attributed not so much to German influence in the Vatican as to his fear lest Orthodox Russia should receive any accession of power and, eventually. to his anxious desire to save central Europe from plunging into a chaos that could bring no good either to the church or to Europe in general (it must be remembered also that, while he considered the violation of Belgian neutrality to be legally indefensible, he shared the opinion of Pius X and, particularly, of Merry del Val that Austria's action against Serbia was legitimate).

In 1919, then, though its work for prisoners of war and its relief services for war victims had been universally appreciated, the Holy See had no such prestige among the nations as it had had under Leo XIII; Benedict was excluded from the peace negotiations, despite the efforts of papal diplomacy.

While it was mainly his activity in international affairs that attracted the attention of the external world to Benedict, his constructive work within the church itself was of considerable importance, even though his pontificate did not last long enough for him to bring to maturity several fruitful undertakings from which his successor was to benefit. He promptly put a stop to the maneuvers of the Integrists; he enhanced the competence of the Unione Popolare (an organization formed in 1906 to unite Italian Catholics of all classes in pursuance of the aims of the encyclical *Il fermo* proposito), thus marking a new stage in the development of "Catholic action"; and he sought concordats with the new states brought into being by the treaty of Versailles.

Of greater significance were his directives on missionary activity and his attitude to the eastern churches. His apostolic letter *Maximum illud* (1919) not only tried to dissociate missionary activity from imperialism and from colonialism by warning missionaries against showing "indiscreet zeal" for their own native country's interests, but also urged the pressing need for establishing an indigenous priesthood; and his wish to help the Uniate churches to develop in accordance with their individual traditions was expressed on several occasions (for instance through the foundation of the Pontifical Institute for Oriental Studies in 1917 and through the pope's support for the metropolitan of Galicia, Archbishop Andrzej Szeptycki, against the pressure brought to bear by the Latin Catholic Poles). By such means it was Benedict's intention to encourage the return of the schismatic churches of the east to the Catholic fold at a time when the collapse of imperial Russia and the political changes effected in the near east at the end of World War I gave rise to a renewal of speculation on the problem.

Pius XI (1922–391.--On Feb. 6, 1922, a successor to Benedict XV was elected in the person of Achille Ratti, a scholar who had been prefect of the Ambrosian library in Milan and then of the Vatican library, but one who had also had the opportunity, as nuncio in Poland, of displaying his energy, his organizing ability and his grasp of the complexities of 20th-century politics.

A learned humanist, Pius XI made it his business to ensure that the world should have a better knowledge of the scientific resources and the artistic treasures of the Vatican. He took an interest in the development of the positive sciences and organized the Pontifical Academy of Science (1936), to which he admitted non-Catholic scientists; and he both founded new research establishments or institutes of higher education (for instance the Pontifical Institute of Christian Archaeology; 1925) and expanded those already in existence (such as the Gregorian university and the College of the Propaganda). He was particularly concerned to raise the level of education in the clergy (see his constitution Deus scientiarum *Dominus,* 1931) and himself took charge of the Congregation for Seminaries and Universities in 1938. The intellectual prestige of Catholicism was considerably enhanced by his sympathetic attitude toward science.

The *Christian* Reconstruction of the World.—In pursuance of the program outlined in his first encyclical (L'bi *arcano,* Dec. 23, 1922), Pius XI worked unremittingly to construct a new "Christendom" in the hope that, after the outward forms of the old order had been relinquished, its spirit might be revived in contemporary society.

Pope between two world wars, Pius had as his mottu Pax *Christi* in *regno* Christi ("the peace of Christ in the Kingdom of Christ") and continually preached peace to the nations, reminding them of the basic conditions of peace in the Christian sense. He had no great faith in the League of Nations but gave what support he could to statesmen working to promote international co-operation, to halt the armaments race and to dispel the threat of war.

Pius was concerned to warn Catholics against excessive nationalism and was distressed at the fascination exercised over so many French Catholics by Action *Française*. His condemnation of the latter (1926) was clumsily launched and sternly and severely carried out, with the result that great resentment was felt in certain French circles; but it had the fortunate effect of clarifying the situation once and for all and of releasing the forces that were to be canalized in Christian social activity and "Catholic action." The strength of the reaction against Action *Française* must be considered in the light of that newspaper's anti-Christian doctrine.

Pius XI wished to make his pontificate one of reaction against the increasing materialism of modern life. This preoccupation was the source of his insistence on Christian education (the encyclical Divini *illius* magistri, 1929) and of his vigorous restatement of Catholic teaching on marriage and on the family (the encyclical Casti connubii, 1930); and it is in this light also that his interpretation of the new Feast of Christ the King, as expounded in the encyclical *Quas primas* (1925), is to be understood. Likewise the same intention is manifest in Pius XI's unceasing efforts to organize the laity, first in Italy and then throughout the whole church. so that every Catholic should do his best to bring Christian principles into action in the institutions of society and in private life. Calling for "specialized movements," he was impelled to give particular encouragement to the Jeunesse Ouvrière Catholique (a Christian youth organization for the working classes) in view of the progressive dechristianization of labour. These views also underlie his encyclical Quadragesimo *anno* (1931).

In addition, however, to a pressing concern with the religious life of both clergy and laity, Pius also followed the example set by Leo XIII and already repeated by Benedict XV of trying to establish the papacy on the international political scene and of increasing the number of his diplomatic contacts with foreign governments. In this respect he was able to profit from the trend of contemporary politics, which led governments away from the liberal ideal of separation and toward a desire for the collaboration of the papacy as an international moral force. While the Vatican had still to face some powerful adversaries in Mexico, in Czechoslovakia, in republican Spain and in the totalitarian states, it enjoyed excellent relations with the Anglo-Saxon world (in which Catholicism made steady progress) and found itself on better terms with the French republic (where anticlericalism was on the decline); and its negotiations with the new states formed after World War I met with a general measure of success.

Pius showed a preference for the concordat as the best formula for establishing his relations with foreign states, and more than 20 such agreements were concluded in the course of his pontificate, with the object of introducing the fundamental principles of the code of canon law into the legislation of the several states, or at least of gaining official recognition for the rights of the church.

Missionary Activity and Ecclesiastical Reunion.—Pius outdid his predecessors in support of overseas missions. He required every religious order to take an active part in this work, with the result that the number of missionaries doubled in the course of his pontificate; he promoted international missionary activity; and he encouraged the study of missionary subjects. Above all, he followed Benedict XV's example of denationalizing the missions, stressing the need for adapting methods to local traditions and the crucial importance of building up a native clergy. The encyclical *Rerum* ecclesiae and the consecration of the first Chinese bishops at the pope's own hands in 1926 were events of capital significance.

The same concern to distinguish the cause of the church from that of the western world can be seen in Pius XI's solicitude for the eastern churches. He encouraged historians and liturgiologists to study the Christian east, reacted strongly against attempts to Latinize the Uniate rites and inaugurated the work of codifying eastern canon law. Furthermore, in the first years of his pontificate, he tried, albeit unsuccessfully, to extend Catholic influence into Russia (in these efforts the titular bishop of Ilium, Michel d'Herbigny, was closely associated with him). He had the satisfaction of seeing the Christians of the Syro-Malankarese (in southern India) reunited with Rome in 1930. On the other hand, though at first the Vatican had shown itself well-disposed toward the Malines conversations (between the Belgian cardinal Desiré Mercier, Lord Halifax and other Catholic and Anglican churchmen), it soon assumed a sterner attitude toward Protestantism, and the encyclical Mortalium *animos* (1928) was completely negative in its response to the "ecumenical movement."

The *Lateran* Agreements.—Pius XI, as a historian, was aware of the element of contingency present in ecclesiastical institutions, and so he was even readier than his two immediate predecessors to seek a compromise solution of the Roman question. Negotiations with Mussolini, conducted on the papal side by the cardinal secretary of state Pietro Gasparri and the lawyer Francesco Pacelli, were begun in great secrecy in 1926 and resulted in the signature of a threefold agreement—political, financial and religious—on Feb. 11, 1929. (See ITALY: Religion)

Pius recognized the kingdom of Italy, with Rome as its capital. Italy in return recognized papal sovereignty over a minute territory of 44 hectares (the Vatican City), thus securing for the pope the full independence on which Leo XIII and his successors had always insisted; and the payment of an indemnity was a further point. In addition, several apostolic palaces, basilicas and ecclesiastical institutes were granted extraterritorial privileges and exemption from Italian taxes. Together with these political and financial agreements went a concordat between Italy and the Holy See. The pope recognized that the treaties and the concordat, though not connected with one another in law, were so connected in fact (simul *stabunt,* simul cadent, "they will stand together or fall together") and regarded the concessions made by Italy in the sphere of religion as compensation for the Holy See's abandonment of obsolete political claims.

The spectacular reconciliation of Italy and the Vatican did not eliminate all possibility of clashes. The first took place in 1931, on the subject of "Catholic action" and youth movements; and from 1938 the Italo-German alliance gave rise to more lasting differences. On the whole, however, relations remained quite good.

The Struggle Against Totalitarian Ideologies.—The fascist systems that emerged in Europe between World Wars I and II had certain characteristics which were not without appeal to the church. They were based, for instance, on ideas of authority, of order and of hierarchy; they advocated a corporative structure for society; they upheld the family; and they were opposed to Freemasonry and to communism. In 1930, moreover. it was communism that Rome regarded as the church's most dangerous enemy. It is thus not surprising that Pius XI should have been ready to establish good relations with fascist Italy and should have signed a concordat with Hitler in 1933, by which he hoped to alleviate the difficulties confronting German Catholics under the new regime.

But within a few years he saw how the leading fascist regimes were accentuating their anti-Christian tendencies (excessive nationalism, pagan state worship and racial prejudice); and he then came forward unreservedly against totalitarianism, whether of the left or of the right, to defend the rights of the individual human being on both fronts. This new phase of his pontificate had a climax in 1937, when he simultaneously published two encyclicals, *Divini* Redemptoris against atheistic communism and Mit *brennender* Sorge against naziism.

Thereafter Pius continually insisted on the great principles of morality that should underlie all political and social life; and since these principles were no longer at variance (as in Pius IX's time) with popular aspirations or with the immediate aims of other governments, but rather in line with much contemporary feeling, whether hopeful or fearful, the result was a new accession of moral authority to the Holy See and, also, a marked rapprochement between it and the western democracies.

Pius XII (1939–58).—Eugenio Pacelli, who was elected pope on March 2, 1939, had in 1930 succeeded the old Cardinal Gasparri

as secretary of state. From the outset he was faced with the prospect of World War II; and the first years of his pontificate were occupied mainly by the concerns to which that war gave rise.

The Papacy and World War II.—The change that had taken place since 1914 in the papacy's relations with the rest of the world meant that Pius XII was in a far better position than Benedict XV had been for effective action in the critical situations created by the spread of hostilities. He was careful, however, to speak and to act with discretion, so as never to give the appearance of committing the Supreme Shepherd of the Faithful to either of the belligerent camps; and he always refused to join any ideological crusade, whether against communism or against nazism.

His first concern was to lose no opportunity of reminding the world of the church's principles with regard to international order: the absolute condemnation of aggressive war; the primacy of the natural law over other laws; the existence of a natural community of nations governed by morality; and respect for the rights of minorities and for those of the individual. At the same time he exposed the causes of the war, calling persistently for an effort to eliminate scandalous inequalities between nation and nation in the economic sphere.

Pius tried hard, both by public speeches and discreetly through diplomatic channels, first to avert the conflict, then to limit its spread and eventually to bring it to an end. On several occasions he protested against the practice of "total war" by whatever side. He also organized missions of charity and relief and contributed to helping the victims of political trials or of racial persecution. This unambiguous attitude won for the papacy at the end of the war a higher place in the esteem of the world than it had occupied in the whole period since 1848.

The cessation of hostilities did not put an end to the pope's role of teacher of the nations. Throughout the years of the "cold war" he continued to expound the views of the church on the burning questions of the day, taking care always to remain above the two opposing ideological blocs and proclaiming the Holy See to be the champion of the individual against tyranny and of the worker against oppression.

Reforms and Warnings.—Peace failed to restore tranquillity either to the world or to the church. While his relations with most of the western countries were gratifyingly cordial, Pius could do nothing to prevent the liquidation of the Uniate churches of the Ukraine and of Transylvania or the persecution or intimidation of Catholics in other lands behind the "iron curtain." These were followed, also, by the collapse of the Chinese missions. Moreover, the awakening of the underdeveloped countries and the industrialization of Latin America raised some serious problems for the papacy to face.

At least the peace enabled Pius to devote more of his activity to his strictly pastoral duties. Even during the war, in 1943, he had published two encyclicals of doctrinal importance, *Mystici corporis* on the nature of the church, and *Divino afflante Spiritu* on biblical studies, which together embodied the results of 25 years' progress in Catholic theology and exegesis. From 1945 onward Pius delivered speeches, broadcasts and writings at a rate unprecedented in papal history, one after another determining how Christian morality was to be applied in practice in immediate situations. In his teaching on political and social problems his sympathetic understanding of contemporary aspirations was made evident enough. His Christmas message of 1944 and his address to jurists on the subject of tolerance in 1955 made many people look back with amazement at the distance traveled since the Syllabus.

To promote the liturgical revival Pius not only issued the encyclical *Mediator Dei* (1947) but also introduced several important reforms of a pastoral nature. He authorized the administration of the sacraments in the vernacular; relaxed the rules governing the fast before communion; and recast the office for the end of Holy Week. He took steps to make the religious orders more effective in the apostolate, and authorized the meeting, in Rome, of the first world congress on the apostolate of the laity (1951).

The pope's zeal for reform was apparent also in his readiness to introduce churchmen of various nationalities into the Sacred College and even into the Roman curia itself (where many had expected to see excessive numbers of Italians as a result of the Lateran treaty). Likewise Pius took a supranational view in his encyclical *Evangelii praecones* (1951) and other utterances on Catholic missions, in which he sought to hasten the establishment of local churches under their own bishops and gave proof again of his awareness of the increasing role to be assigned to the laity. In this the pope was extending the tradition of his predecessors. But he went further than they had ever gone when he took up a positive attitude toward developments in the "ecumenical movement," cautious though he was about it; particularly significant in this respect was the Holy Office's directive of Dec. 20, 1949.

The head of a church can never afford to do without caution; and from 1950 onward the need for caution was markedly present in the mind of Pius XII and perhaps even more so in the minds of his advisers. The faithful were constantly warned of the danger of hasty accommodations and compromises, whether in doctrine (the subject of the encyclical *Huntani generis* in 1950 and of several pronouncements on morals, as well as of increased activity by the Congregation of the Index and by the Holy Office), in pastoral affairs (as in the matter of the French worker-priests and in connection with some ill-considered irenical tendencies) or, finally, in political and social questions. Hopes of a postwar settlement with communism having been disappointed, the Vatican renewed its warnings against Marxist atheism and disavowed the "progressive" Catholics who, in one way or another, wanted to try to collaborate with the communist parties. This stiffening of attitude gave rise to some anxiety and made some people fear that the days of "integrism" were back again. Yet it did not seem to have endangered that spirit of adaptability which had been expressed so positively and so effectively in the years immediately preceding and which continued to find expression in several fields. Nor did the personal prestige of Pius XII appear to have suffered from it. Despite some bitter criticism, especially from the Russian quarter, his name was honoured not only within but also far beyond the frontiers of the Catholic world. He died on Oct. 9, 1958, and was succeeded by John XXIII (Angelo Roncalli).

TABLE XV.—*Popes of the 19th and 20th Centuries*

1800–23	Pius VII	1903–14	Pius X
1823–29	Leo XII	1914–22	Benedict XV
1829–30	Pius VIII	1922–39	Pius XI
1831–46	Gregory XVI	1939–58	Pius XII
1846–78	Pius IX	1958–	John XXIII
1878–1903	Leo XIII		

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(RR. A.)

PAPAGO, a tribe in Arizona and Sonora, closely related to the Pima, from whom they differed chiefly in a more scattered mode of life. Formerly their chief crops were maize, beans, and cotton, which they cultivated by irrigation, but which were replaced by wheat and cotton. More or less under the influence of Jesuit and Franciscan missionaries for over two centuries. they maintained much of their old life and religion. In 1921 those in southern Arizona numbered 6.100.

See Harold Bell Wright, *Tales of the Papago Indians* (1929).

PAPAL STATES: *see* STATES OF THE CHURCH.

PAPAVERINE, an opium alkaloid; it was first obtained by J. H. Merck in 1848. Papaverine is an important primary product for the synthesis of alkaloids. It was first synthesized by R. P. Pictet and A. Gams (1909) and had been converted into laudanosine in 1900, from which, in turn, glaucine was made by J. Gadamer (1911). Papaverine is used in medicine as an antispasmodic to relax smooth muscle spasms. Papaverine crystallizes in colourless prisms or needles, melts at 147° C. and is optically inactive. It is insoluble in water but dissolves readily in chloroform or hot alcohol. The hydrochloride crystallizes in plates and melts at 231° C. On gentle oxidation papaverine is converted into papaveraldine, which is the minor alkaloid xanthaline found in opium. The papaverine structure is equally important as a starting point for syntheses in the berberine series.

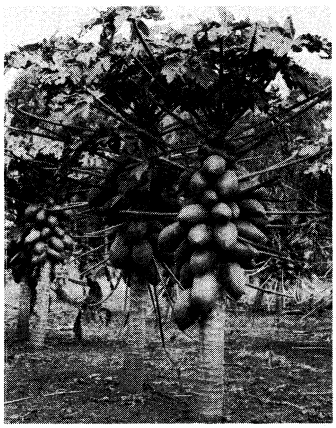
PAPAYA, the fruit of *Carica papaya* (family Caricaceae), a large herbaceous plant cultivated throughout the tropical world and into the warmest parts of the subtropics. Its origin is rather obscure; it may represent the fusion of two or more species of *Carica* native to Mexico and Central America. In any event it seems to have had its origin in that region.

The name papaw or pawpaw, often used in the West Indies, is likely to confuse this plant with *Asimina triloba* of North America. Papaya is believed to be a corruption of the Carib *ababai*. Several other common names are current in the western hemisphere: *mamão* in Brazil, *fruta bomba* in Cuba, *lechosa* in Puerto Rico and *melon zapote* in Mexico.

Papayas are usually grown from seed. Their development is rapid, fruit being produced before the end of the first year. Under favourable conditions the life of a plant may be five years or more.. The trunk, which may reach 20 ft. in height. bears no lateral branches but is crowned by deeply lobed leaves. sometimes 2 ft. across. borne on hollow petioles 2 ft. long. Normally the species is dioecious, male and female flowers being produced on separate plants; but hermaphrodite forms are known, and all sorts of irregularities in the distribution of the sexes are common. Changes in sex may take place. Staminate flowers are borne on pendent racemes three feet long; they are funnel-shaped. about an inch long, whitish, the corolla five-lobed, with ten stamens in the throat. The pistillate flowers are considerably larger, subsessile and often solitary in the leaf axils; they have five fleshy petals connate toward the base and a large cylindrical or globose superior ovary crowned by five fan-shaped sessile stigmas.

The fruit is commonly spherical to cylindrical in form, 3 to zo in. or even more in length, sometimes weighing as much as zo or 25 lb. In general character it strongly resembles a muskmelon. The flesh is deep yellow to salmon-coloured, about an inch thick, and there is a large cavity to the walls of which are attached the numerous round, wrinkled seeds the size of peas.

In flavour the fruit is slightly sweet. with an agreeable musky tang more pronounced in some varieties, and some climates, than in others. The papaya is a popular breakfast fruit in many tropical and subtropical countries.

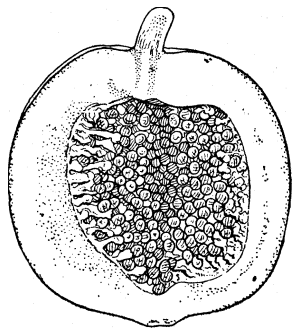


AUTHENTICATED NEWS

FIG. I.— GROVE OF PAPAYA TREES WITH FRUIT

The plant is killed by heavy frosts but has long been grown successfully in southern Florida and to a limited extent in protected locations throughout southern California, though the fruit does not usually attain full development of flavour in the latter region.

The unripe fruit. as well as other parts of the plant, contains a milky juice, in which is present an active principle known as papain. This enzyme greatly resembles pepsin in its digestive action. It is usually obtained by scarifying green fruits uhile they are still on the plant. After the juice exudes and coagulates, it is scraped off and dried, to be used in the preparation of various remedies for Indigestion and in the manufacture of meat tenderizers. Its value has long been recognized in the tropics, where it is a common practice to leave tough chickens or other meat wrapped in papaya leaves overnight before cooking, or even to rub them with the juice of the papaya to render them more tender. (W Po.)



BUREAU OF PLANT INDUSTRY U S DEPARTMENT OF AGRICULTURE

FIG 2— PAPAYA FRUIT (CARICA PAPAYA)

PAPEETE, capital of Tahiti: *see* TAHITI.

PAPER, the general name for the substance commonly used for writing upon or for wrapping. The word was derived from the French *papier,* through Latin from the Greek *papyros (see* PAPYRUS).

The art of making paper from fibrous matter appears to have been practised by the Chinese at a very distant period. Different writers have traced it back to the 2nd century B C. Paper first became available for the rest of the norld in the middle of the 8th century. In 751 the Arabs, who had occupied Samarkand early in the century, were attacked there by Chinese The invasion was repelled by the Arab governor, who in the pursuit, it is related, captured certain prisoners who were skilled in papermaking and who imparted their knowledge to their new masters. Hence began the Arabian manufacture, which rapidly spread to all parts of the Arab dominions.

The extent to which it was adopted for literary purposes is proved by the comparatively large number of 9th-century Arabic manuscripts on paper which have been preserved. The material of the Arab paper was apparently substantially linen.

It seems that the Arabs and the skilled Persian workmen nhom they employed at once resorted to flax, which grows abundantly in Khurasan, as their principal material, later also making use of rags, supplemented. as the demand gre . with any vegetable fibre that would serve; and that cotton, if used at all. was used very sparingly. Paper of oriental manufacture in the middle ages was usually distinguished by its stoutness. glossy surface and absence of watermarks. Paper was probably first brought into Greece from Asia. There is a record of its use by the empress Irene at about the end of the 11th century, but with one doubtful exception there are no extant Greek manuscripts on paper before the middle of the 13th century.

Paper in Europe.—The manufacture of paper in Europe was first established by the Moors in Spain in the middle of the 12th century, the headquarters of the industry being Xativa, Valencia and Toledo. But on the fall of the Moorish power the manufacture, passing into the hands of the less skilled Christians, declined in quality.

In Italy also the art of papermaking was no doubt established through the Arab occupation of Sicily. But the paper which was made both there and in Spain was in the first instance of oriental quality. In the laws of Alphonso X of 1263 it is referred to as cloth parchment, a term which well describes its stout substance. The first mention of rag paper occurs in the tract of Peter. abbot of Cluny (A D 1122–50), *adversus Iudaeos,* cap. *j.*

A few words may be said respecting manuscripts written in European countries on oriental paper or paper made in the oriental fashion. The oldest recorded document on paper was a deed of King Roger of Sicily, of the year 1102; and there are others of Sicilian kings, of the 12th century. A notarial register on paper, at Geneva, dates from 1154. The oldest known imperial deed on the same material is a charter of Frederick II to the nuns of Goess in Styria, of the year 1228. In 1231, however, the same emperor forbade further use of paper for public documents. which were in future to be inscribed on vellum *(see* PARCHMENT). In Venice the *Liber plegiorum,* the entries in which begin with the year 1223, is made of rough paper; and similarly the registers of the Council

of Ten, beginning in 1325, and the register of the emperor Henry VII (1308–13), preserved at Turin, are written on a like substance. In the British Museum there is an older example in a manuscript (Arundel 268) which contains some astronomical treatises written on an excellent paper in an Italian hand of the first half of the 13th century. In the Public Record office there is a letter on paper from Raymond, son of Raymond, duke of Narbonne and count of Toulouse, to Henry III of England, written within the years 1216–22. The letters addressed from Castile to Edward I, in 1279 and following years (Pauli in *Bericht, Berl. Akad.* 1854), are instances of Spanish-made paper.

In Italy the first place which appears to have become a great centre of the papermaking industry was Fabriano in the marquisate of Ancona, where mills were first set up in 1276; they rose to importance on the decline of the manufacture in Spain. The earliest known watermarks in paper from this factory are of 1293 and 1294. In 1340 a factory was established at Padua; another arose later at Treviso; and others followed in the territories of Florence, Bologna, Parma, Milan, Venice and other districts. From the factories of northern Italy the wants of southern Germany were supplied as late as the 15th century. But in Germany also factories were rapidly founded. The earliest are said to have been set up between Cologne and Mainz about 1320. England is said to have obtained paper at first from France and Burgundy. France owed the establishment of its first paper mills to Spain.

In the second half of the 14th century the use of paper for all literary purposes had become well established in all western Europe; and in the course of the 15th century it gradually superseded vellum. In manuscripts of the latter period it is not unusual to find a mixture of vellum and paper, a vellum sheet forming the outer, or the outer and inner, leaves of a quire, while the rest are of paper.

Paper in England.—With regard to the early use of paper in England, there is evidence that at the beginning of the 14th century it was a not uncommon material, particularly for registers and accounts. Under the year 1310, the records of Merton college, Oxford, show that paper was purchased "pro registro." There is, however, in the British Museum a paper manuscript (Add. 31, 223), written in England, of even earlier date than the one recorded in the Merton archives. This is a register of the hustings court of Lyme Regis, the entries in which begin in the year 1309. The paper, of a rough manufacture, is similar to the kind which was used in Spain.

The knowledge, however, which is available of the history of papermaking in England is extremely scanty. The first maker whose name is known is John Tate, who is said to have set up a mill in Hertford late in the 15th century; and Sir John Spilman, jeweller to Elizabeth I, erected a paper mill at Dartford, and in 1589 obtained a licence for ten years to make all sorts of white writing paper and to gather, for the purpose, all manner of linen rags, scrolls or scraps of parchment, old fishing nets, etc. (Dunkin, *Hist. of Dartford,* 305; Harl. ms. 2296, f. 124 b). But it is incredible that no paper was made in the country before the time of the Tudors. The comparatively cheap rates at which it was sold in the 15th century in inland towns suggest that there was at that time a native industry in this commodity.

As far as the prices have been observed at which different kinds of paper were sold in England, it has been found that in 1355–56 the price of a quire of small folio paper was 5 *d.*, both in Oxford and London. In the 15th century the average price seems to have ranged from 3 *d.* to 4 *d.* for the quire, and from 3 *s.* 4 *d.* to 4 *s.* for the ream. At the beginning of the 16th century the price fell to 2 *d.* or 3 *d.* the quire, and to 3 *s.* or 3 *s.* 6 *d.* the ream; but in the second half of the century, because of the debasement of the coinage, it rose, in common with all other commodities, to nearly 4 *d.* the quire, and to rather more than 5 *s.* the ream. The relatively higher price of the ream in this last period, as compared with that of the quire, seems to imply a more extensive use of the material, which enabled the trader to dispose of broken bulk more quickly than formerly, and so to sell by the quire at a comparatively cheap rate.

Brown paper appears in entries of 1570–71 and was sold in bundles at 2 *s.* to 2 *s.* 4 *d.* Blotting paper is apparently of even earlier date, being mentioned under the year 1465. It was a coarse gray unsized paper, fragments of which have been found among the leaves of 15th-century accounts, where it had been left after being used for blotting. Early in the 16th century blotting paper must have been in ordinary use, for it is referred to in W. Horman's *Vulgaria,* 1519 (p. 80 b): "Blottyng papyr serveth to drye weete wryttynge, lest there be made blottis or blurris"; and early in the next century "charta bibula" is mentioned in the *Pinacotheca* (i, 175) of Nicius Erythraeus. It is remarkable that, in spite of the comparatively early date of this invention, sand was used so long as an absorbent.

Paper in America.—The early printers of colonial America imported their paper from Europe, chiefly from the continent. The first paper mill was built in 1690 at Germantown, Pa., resulting from the combination of the needs of the Philadelphia printer, William Bradford, and the arrival of an ambitious German papermaker, William Rittenhouse. Two other mills were established in Pennsylvania in 1710 and 1729, one in Elizabethtown, N.J., in 1728, and the first in Massachusetts at Milton in the same year. Virginia's first paper mill was built at Williamsburg in 1744 by its first newspaper publisher, William Parks. The first in New York was built at Hempstead, Long Island, in 1768. With imports cut off during the Revolutionary War and increased needs for newspapers, broadsides, pamphlets, records, correspondence, etc., an acute paper famine developed. Under these conditions additional mills sprang into existence, and there were probably 80 or 90 when the war ended. Paper manufacturing was protected in the first tariff. In 1810 there were more than 200 mills in operation making about $2,000,000 worth of products.

For watermarks in paper *see* WATERMARKS. (X.)

MANUFACTURE

PAPERMAKING MATERIALS

Introduction.—The first manufactured paper was made in China about the dawn of the Christian era, from bamboo and rags; and rags continued to be the almost universal source of papermaking fibre until the middle of the 19th century (see *Early History* above). Other fibres, such as straw and other grasses and the inner bark of Japan's mitsumata (paper mulberry), came into use. Except for certain special papers (*e.g.*, asbestos paper) nearly all papers are made of cellulosic (vegetable) fibres. Some wool fibre is useful in papers to be tar-saturated for roofing felt, but other noncellulose and converted cellulose fibres, such as rayon and Celanese, are not acceptable to paper mills.

Nature's most prolific source of cellulose is the forest, though trees differ in the value of their fibre for making paper. The fibre of flax (linen), cotton, jute, sisal, manila hemp, etc., comes to the paper industry as a secondary product, after serving a purpose as cloth, clothing, sacking, rope, etc. Agricultural wastes—straw, corn stalks, bagasse (sugar-cane waste), bamboo and some other grasses—are used for making certain grades; some of these are utilized to great amounts. Finally, one of the most important sources of papermaking material is the recovery of fibre from old papers, bags and boxes.

Until comparatively recently, few people could read and write, and the demand for paper was consequently small. Worn-out clothing, which was largely linen, provided sufficient raw material. As literacy increased, and particularly after Johann Gutenberg's invention of printing with movable type about 1450, the demand for paper grew and the art of papermaking spread throughout Europe and to America. As a result of this and the invention of mechanical pulpers or beaters, (see *Manufacturing Processes* below) supplies of rags became inadequate, and other fibres, such as esparto grass and straw, came into extensive use. A great upsurge in paper consumption followed the invention of the papermaking machine in 1799, and during the next half century a serious raw-material famine developed. During that time, several processes for obtaining papermaking fibre from wood were invented. Pulpwood became the most important source of papermaking fibre and of cellulose for many chemical conversion products. The latter use requires a specially purified grade of

chemical wood pulp.

The world's forest areas (according to J. C. Weaver and F. E. Lukerman, *World Resource Statistics* [Minneapolis; 1953]) are divided as follows: North America, 21%; South America, 20%; Europe, 3%; U.S.S.R., 18%; Asia 13.5%; Africa, 23.5%; and Oceania. 1%. The best species for papermaking, and particularly the conifers, are predominantly in the north temperate zone. Some of the hardwoods were used from the first, and the development of the so-called semichemical process made many more species acceptable for pulping. This consequently increased the usable wood supply. The greatest enemy of the paper industry is fire in the forest, for which human carelessness is the principal cause. Fire, insects and disease destroy more wood than is usefully consumed.

A discussion of papermaking materials involves not only their source and characteristics, but also the methods by which the fibre is recovered and made available. The logical as well as the historical approach is to consider first the treatment of rags.

Rags.—The motion of the workman's arm and mallet as he macerated wet rags for the first primitive sheet of paper established the mechanical principle of a stamping machine in which stamps in a row were successively lifted and dropped by the action of pins set spirally on a shaft turned by a waterwheel or other power. This crude machinery was supplanted about 1750 in the Netherlands by the beater. The National Association of Waste Material Dealers in the United States established standard specifications for 27 grades of rags.

Rags arrive at the paper mill in bales weighing from 400 to 1,000 lb. *(see* Table I). The first three grades are used in some writing papers. which are then classified as 25%, 50%, 75% or 100% rag content, the other part being chemical wood pulp. Jute is used for strong wrapping and tag papers, hemp for sandpaper and electrical insulation paper, and roofing rags are used in felts (paper to be tarred for roofing and shingles).

TABLE *I.—Typical Yield From an Average Pack of 1,000 lb. of Mixed Rags*

Papermaking rags		Other types of rags	
Grade	Pounds	Grade	Pounds
No. 1 whites.	25	Soft woollens.	20
No. 2 whites.	50	Hard woollens	125
Whites and blues. . . .	225	Mixed linseys (½ wool, ½ cotton)	20
Jutebagging.	125	Wiping rags	60
Roofing stock	250	Quilts and white batting . .	85
		Rubbish	15
Total	675	Total	325

Source: J. N. Stephenson (ed.), *Pulp and Paper* Manufacture, vol. 2 (New Pork, 1951).

Rags require a preliminary treatment to prepare them for the high grades of paper for which they are now exclusively used. They are opened up and cleaned of loose dirt and dust in a box-like thrasher, in which a drum with pins on its surface whips them against a beam. ,Next they are sorted into kinds and colours. Pockets are emptied, buttons etc. removed, heavy seams ripped and large rags cut. Rags containing rubber or synthetic fibre cause trouble and are often difficult to detect. The rags are chopped into small pieces and then given a second dusting before they are fed to the rag boiler. Bits of iron are removed by a magnetic roll on the sorting conveyor.

Rags usually contain substances that interfere with further processing, such as starch. mineral loading, dirt and grease, some natural waxes and resinous materials, and colours difficult to bleach. To soften the rags, remove foreign matter and render the colour bleachable, they are treated with an alkaline cooking liquor in a kier or a rotary boiler for from 6 to 1 j hours at a pressure of 20 to 40 lb. per square inch. A detergent or wetting agent may be used to assist this process. The cooking liquor may be a solution of caustic soda, caustic lime or a mixture of soda ash (sodium carbonate) and lime. New rags require less drastic treatment than old, dirty rags. There are several variations of the cooking operation.

The rag boilers used in North American mills are usually cylinders or globes rotating about horizontal axes. Rags are charged through manholes in the boilers and spread out. Steam is introduced through one of the bearing trunnions. When the cooking operation is complete, the free liquor is drawn off and the boiler is rotated slowly with the manholes open to dump the rags. Hooks are used to remove the rags.

The kier is a stationary cooker with a perforated bottom. The cooking liquor is sprayed in at the top and percolates through the rags, passing through the perforated bottom to a reheater and is again introduced at the top of the kier. This equipment is common in the textile industry and is used to some extent in paper mills. particularly in England and continental Europe.

To rid the rags of chemicals and dissolved substances or attached materials, they are washed in a machine that removes such waste and, at the same time, ravels the fabric into threads. This washer is a tub with found ends and straight sides, with a centre partition the length of the sides. It is usually about 24 × 12 ft. and $3\frac{1}{2}$ to 4 ft. deep. A large roll having thin bars set in the periphery is located in one channel. These just clear a group of similar bars in the bottom of the channel under the roll. which is rotated on its shaft. In the other channel there is a rotating. screen-covered dipper which extracts dirty water from the rags at the same rate as fresh water is added. By lowering the roll so that the two sets of bars nearly touch, the rags are ravelled. When the washing is complete, the fresh water is shut off and the dipper run for a time to thicken the stock, now called half stuff. Then a bleaching solution (calcium hypochlorite) or chlorine gas is introduced and thoroughly mixed with it, after which the contents of the washer are dumped into a draining chamber with a perforated bottom. There the water drains away and the bleaching is completed, leaving the snow-white rag stock to be taken as needed for the next operation—beating (described below, under *Manufacturing Processes).*

Jute rags are given a similar treatment but do not bleach to a good wh te.

Straw is cooked with lime, lime and soda ash, or caustic soda in spherical rotary digesters. The contents are dumped on a draining floor and conveyed to the paper-mill beaters as required, where the necessary washing is done.

Esparto grass is an important papermaking material in England and continental Europe. It is usually cooked in digesters similar to kiers and is bleached when used in high-grade writing and printing papers.

Wastepapers constitute not only a major source of papermaking material. but at the same time contribute to the conservation of forests. The Waste Paper institute, a division of the U.S. National Association of Waste Material Dealers, Inc., in 1949 adopted standards for 24 grades of wastepaper. Close specifications were set for prohibitive materials and total outthrows.

Sources of waste paper include cuttings and shavings from conversion and printing plants, repacked books and magazines and mixed papers. Wastepapers are principally book and writing paper of bleached chemical pulp; newsprint paper; kraft bags and wrapping paper; corrugated board and boxboard cuttings.

The treatment of wastepaper depends on its character and the grade of product to be made. If it is to be used in coarse products like roofing paper or boxboard, only a sorting out of useless and harmful material is required. Modern pulping machinery will then prepare the material for the paper machine.

For conversion of printed papers to pulp again suitable for manufacturing printing paper, a process akin to that used for rags is required.

The first process for removing ink is ascribed to Matthias Koops, who obtained English patents in 1800. Henry E. Rogers, in 1849. was the first to use a de-inking system in the United States. (Lyman Horace Weeks, *History of Paper Manufacture in the United States 1690–1916* [New York, 1916].) Several methods and types of equipment are used. the fundamentals of which are similar. Mechanical, heating and chemical action are required.: the printed paper is broken up and fiberized by agitation in water containing suitable chemicals. Ink is a pigment in a vehicle such as boiled linseed oil. Such oil is attacked (saponified) by an alkali which loosens the pigment which then can be washed out of the fibre suspension. Some of the special heat-set inks and

synthetic adhesives present greater difficulty.

A type of washer commonly used consists of a series of screen-covered cylinders rotating in the dilute suspension of fibre. Water drains through the screen, carrying off some of the ink. The mat of fibre left on the screen is removed and diluted and the process repeated two or three times. Application of suction inside the cylinder increases its efficiency and capacity.

Wood Pulp.—Human ingenuity has always found sources of supply for specific human needs. The problem presented by scarcity of rags together with increasing demand for paper was solved, about the middle of the 19th century, by the invention of several processes for the manufacture of papermaking pulps from wood. In the century after the first chemical pulp was made, the production of wood pulps increased to the figures shown in Table II.

TABLE 11.—*Production of Wood Pulps, 1953*
(In short tons)

Area	Production	Area	Production
United States.	17,537,295	Other Europe (non-Communist)*	2,015,000
Canada	9,014,256	Union of South Africa†.	42,446
Latin America*	321,179	Japan	1,661,877
Sweden	3,539,649	Australia and New Zealand.	163,191
Finland	2,125,633		
Norway	1,185,845		
Germany (western)	1,103,940	Total	38,710,311

*Estimated. †1951.
Source: United States Pulp Producers Association, ***Wood Pulp Statistics, 1953*** (New York, 1953).

For 1937 the wood-pulp production in what became Communist countries was: U.S.S.R.. 924,000 tons; Baltic states, 215,000 tons; Poland, 191,000 tons; Czechoslovakia, 379,000 tons; Hungary and Rumania, 69,000 tons; Yugoslavia, 37,000 tons. The total production of Germany was 2,676,000 tons.

Classification.—Wood pulps may be classified first into two general groups—mechanical and chemical. Mechanical pulp, generally called groundwood, is not further divided except as fine, coarse or bleached; or by end use as book, news-grade, wallboard or screenings. Chemical pulps are classed by type as: unbleached sulphite (strong and news-gra'de); bleached sulphite (dissolving and paper-grade); bleached and unbleached sulphate (kraft); and soda. '(Dissolving and special alpha" applies to both bleached sulphite and sulphate pulps used primarily for such nonpaper products as rayon, cellophane, plastics, explosives, etc. "Semi-chemical" is a term applied to a process of cooking followed by mechanical treatment, whereby yields of more than 60% are obtained.

Wood Procurement and Preparation.—Nearly all the world's pulp mills are located in the temperate zones because the woods most used for pulping are the conifers (softwood treesj that grow in those regions. Threatened depletion of northern softwoods, along with improvement of pulping processes, has encouraged the establishment of pulp and paper mills in the southern United States, Australia, New Zealand and Africa. Spruce, balsam fir and hemlock are considered the best woods for sulphite and mechanical pulping; several varieties of pine provide the bulk of wood for sulphate (kraftj pulp; while hardwoods are largely used for groundwood, sulphate, soda and semichemical pulping. The principal European pulpwoods are Norway spruce, Scotch fir, poplar and aspen. Wood is transported from the forest by floating (driving) down rivers; towing across lakes or on salt water; or haulage by freight cars, trucks or sleighs. One cord (128 cu.ft.) of piled wood, or about 90 to 95 cu.ft. of solid wood, will produce an average of one ton of groundwood pulp or half a ton of unbleached chemical pulp. Some wood is cleaned of bark in the woods by shaving or peeling before the sap dries, or by portable barkers. Most wood is barked as four-foot bolts at the mill by tumbling and rubbing in huge drums, with showers flushing off the loosened bark through openings in the drum. The wet bark may be drained, pressed and burned, which disposes of a waste and may supply some steam. Some mechanical barkers take logs eight feet long, while longer logs, especially big ones on the west coast of the United States and Canada, are barked by high-pressure hydraulic jets.

In cold climates, mills that receive their wood by water in the summer must store sufficient supplies for operation during winter months. Part of the clean wood from the barkers is therefore piled by mechanical stackers. It is brought into the mill by cable conveyors as required and in some cases dumped into a pond where any ice is allowed to melt.

Groundwood (Mechanical) Pulp.—Spruce, balsam and hemlock are the woods considered best suited to pulping by this process, although some pine species and poplar are used to a considerable extent. The principle of groundwood manufacture is very simple, but the efficient production of uniformly good pulp requires careful attention. The fibres in wood lie parallel to the length of the tree. When a stick is pressed lengthwise against a roughened (dressed) grindstone revolving at a peripheral speed of about 3,500 ft. per minute for natural sandstone, or about 5,000 ft. per minute for artificial stones. the fibres are torn from the wood and rubbed to a certain degree of fineness. The character of the pulp depends on the quality of the wood, the pressure against the stone, the temperature of grinding and the pattern made on the stone by dressing it with a special tool. This pattern may be straight grooves either around or across the stone; a combination of the two, making pyramids; or spirals of varying slope and coarseness. The stones also may have different sizes and degrees of hardness and sharpness of grit.

Natural pulpstones are 27 to 36 in. wide by 54 in. or more in diameter. Artificial stones are 27 to 54 in. wide and 54 to 72 in. in diameter. Standard lengths of wood ground are 24, 32, 48 and 50 in. Smaller grinders are fed by hand and may have two, three or four pockets.

The continuous type has a tall chamber above the stone and the wood is drawn down against it by the movement of spikes on conveyor chains. Another (ring-type) grinder has a huge ring with teeth on the inner side, set off-centre so that the stone nearly touches it. Into the narrow angle so formed, the wood is pinched by the movement of ring (slowly) and stone (faster) in the same direction, and the stone grinds off the fibre.

Under the stone is the pit into which the pulp falls, being mashed from the stone by a shower. From there the thin pulp flows over a coarse screen that removes slivers and other unground bits of wood. The screened stock then passes through finer screens to obtain pulp suitable for papermaking. In order to save storage-tank space and pumping equipment, the pulp is thickened. This is done simply by submerging a rotating cylinder covered with wire screening in a vat, continuously fed by the thin pulp. Water flows through the screen and out of the ends of the cylinder, leaving a mat of groundwood on the surface. The pulp is squirted or scraped off. It is about 5% dry fibre and may flow to a storage tank, or be removed from the mire by contact with an endless felt and wound on a roll in a thick layer. When thick enough, the layer is cut loose and folded into a bundle, or lap, containing about 30% by weight of dry fibre. In this form groundwood is conveniently stored and shipped.

Chemical Pulps.—As mentioned above, there are two major chemical processes for preparing papermaking fibre from wood, the sulphite and sulphate (kraft) processes. Sulphite pulping is an acid process and the sulphate is alkaline. Other processes are the soda and the semichemical. All have a common operation—chipping. The chipper is a vertical steel disk with 4 to 12 radial slots in which knives are set. A chute or spout feeds the bolts of pulpwood endwise and at an angle of about 40° against the rapidly revolving knives. Thin slabs of wood are shaved off which break up into chips from $\frac{1}{2}$ to $1\frac{1}{4}$ in. long, depending on the type of cooking action to follow. Pieces that are too big are separated by screening and put through a rechipper.

Another feature shared by the various chemical processes is the vertical digester in which the wood is cooked. It has a conical bottom section, cylindrical centre section and domed top. Chips are fed in through a throat at the top which can be tightly closed with a cover plate. At the bottom is a fitting which provides inlets for the cooking liquor and steam, and an outlet for discharge of the cooked wood chips. Some digesters are kept at the

proper cooking temperature by continuous introduction of steam. In others. the cooking liquor is drawn off through strainers that hold back the chips, passed through a reheating chamber and fed back into the top of the digester. This system gives faster and more uniform cooking.

Purpose and Principles of Cooking Processes.—The approximate composition for European spruce wood is: cellulose. 50%; lignin, 30%; carbohydrates, 16%; protein, 0.7%; resins and fats, 3.3% Canadian woods have somewhat more cellulose and less resins and fats. Wood is a nonuniform material. The purpose of cooking is to separate the cellulose fibres from the noncellulosic material. The natural resistance of cellulose to attack by most chemicals is a fortunate characteristic. Lignin, which serves to bind the fibres together, is quite reactive and can be dissolved. While the hemicelluloses (carbohydrates) are nonfibrous, they may be retained in the pulp to some extent as they increase the yield of pulp and are useful in some grades of paper and board.

The soda process is the oldest, dating from the discovery of H. Burgess and C. Watt in England in 1851 that birch shavings could be pulped by boiling in alkali. Burgess came to the U.S. and set up a mill in 1854 where he cooked poplar with sodium hydroxide. The sulphite process is ascribed to B. C. Tilghman in the U.S. in 1867, C. D. Ekman in Sweden in 1874, Alexander Mitscherlich in Germany, and E. Ritter and C. Kellner in Austria. They cooked with sulphites and bisulphites and were plagued by the problem of acid corrosion of their equipment. A modified soda process was discovered in Norway in 1879 by C. F. Dahl, who made a strong brown pulp to which the name "kraft" was given. Toward the middle of the 20th century the so-called semichemical process, using chiefly a neutral sulphite cook, came into favour, marking a century of progress in wood-pulp manufacture.

Sulphite Process.—Cooking liquor for sulphite pulping begins with the burning of sulphur to form sulphur dioxide under conditions controlled to minimize formation of sulphur trioxide, which is troublesome. The dioxide is cooled rapidly and then bubbled through lime water or passed upward through a tower filled with limestone (calcium carbonate) over which water is showered. The result in either case is a solution of calcium bisulphite with an excess of sulphur dioxide as sulphurous acid. Sodium hydroxide, sodium carbonate: magnesium oxide and ammonia may also be used in specially designed systems. The important feature of acid making is the amount and proportion of combined (the sulphur dioxide as calcium bisulphite) and free sulphur dioxide as sulphurous acid. This raw acid is fortified with sulphur dioxide relieved from the digester during cooking. The liquor used for cooking contains about 1% of sulphur dioxide in combination and 3.5% to 4.5% free sulphur dioxide, a total of 4.5% to 5.5% sulphur dioxide. The corrosive action of this liquor requires that the steel digester is lined with acidproof brick and cement; or acid-resisting metals must be used.

When the digester has been filled with chips and liquor, admitted simultaneously, the cover is bolted on and steam is added to bring the pressure to 7½ to 90 lb. per square inch and maintain a cooking temperature of 136° to 150° C. (245° to 270° F.). Cooking time varies from seven to ten hours depending on whether the pulp is to be a strong, unbleached grade or high quality, bleached and purified for fine white papers, rayon and other conversion products of cellulose.

The chemical reactions occurring in the digester are quite complex and the subject of constant research. Fundamentally, however, the action of the bisulphite and free sulphur dioxide is to render soluble the encrusting matter, mainly by forming soluble lignin-sulphonates and by hydrolyzing gums, etc. When the digester is blown (emptied), the softened chips emerge at high velocity and break up against a firm target. Most of the waste liquor drains through the perforated bottom of the blow pit, and more is removed from the pulp by high-pressure hosing. The disposal of such wastes is a problem that is receiving serious studies by industry and governments.

The waste liquor, containing about 50% of the original wood, may be utilized in various ways. Some is evaporated and the residue burned to generate steam; some is recovered as a binder for roads or foundry cores, some is neutralized, and the sugars fermented to form potable and commercial alcohols. Using the alcohols as raw material, many other organic chemicals are produced. Waste liquor also became an important source of vanillin used for flavouring and as a base for other chemicals.

Soda and Sulphate *(Kraft)* Processes.—These processes differ essentially from the sulphite process in that the cooking liquor is alkaline and thus has less corrosive action on iron and steel, and digesters are not lined. The active substance in the alkaline cooking liquors is sodium hydroxide (NaOH) formed by causticizing a solution of soda ash or sodium carbonate (Na_2CO_3) with lime (CaO). In the soda process a small amount of sulphide is sometimes present, about 5% of the chemical charge. In the sulphate process the solution of sodium hydroxide usually contains 20% to 30% sulphide (reduced from Na_2SO_4 make-up). Recovery of the sodium is an important factor in the economy of alkaline processes.

The pines and hardwoods are readily cooked by alkaline liquors. The resins of pines. which cause trouble in the sulphite process, are converted to soluble soaps in the soda and sulphate processes and are washed out. When the digester is filled, the liquor may be put in with the chips or after the digester is partly filled. Direct steaming is used on some digesters. but the majority have liquor circulation systems with indirect heating. Operation of soda and sulphate digesters is much the same. The cooking time is much shorter than for sulphite. It takes one and one-half to two hours to reach the maximum temperature of 340° to 350° F., which would be held for about one hour for a hard stock for paperboard. For bleachable stock the maximum temperature would be maintained for one and one-half to three hours. The pulp is blown from the digester into a steel tank with conical bottom and agitator. This brown stock is brought to a uniform consistency and screened in a knotter as it passes to the washers, which are similar to those used on sulphite pulp. The rosin soap formed (particularly when cooking pinewood) produces foam on the black liquor washed out of the pulp; so a foam tank is used to remove foam before the liquor goes to the evaporators. There the liquor is thickened to a point where it contains about 50% solids, and these represent the lignin and other substances that made up about 50% of the original wood. This black, sticky mixture can be pumped while hot. It is fortified with chemical to replace losses and is sprayed into a special furnace where it burns and generates steam. The ash that forms contains most of the sodium in the original cooking liquor. In the soda process sodium carbonate remains; in the sulphate process, sodium sulphate is the makeup chemical and is reduced to sodium sulphide in the furnace. The presence of this sulphide in the cooking liquor modifies the effect of cooking and produces the stronger kraft pulp of the sulphate process.

In the recovery process (reuse of liquor) the smelt or molten black ash from the furnace is run into a dissolving tank where the smelt is dissolved in water to form green liquor. The green liquor is then causticized with lime to change the sodium carbonate to sodium hydroxide, producing white liquor containing the hydroxide and sulphide. After settling, the white liquor is available for a succeeding cooking operation. The reaction is $Na_2CO_3 + CaO + H_2O = 2\ NaOH + CaCO_3$ (sodium carbonate plus lime plus water equals sodium hydroxide plus calcium carbonate). The calcium carbonate that has settled out of the white liquor is fed to a lime kiln (about 8 ft. in diameter and 300 ft. long) where it is burned to drive off carbon dioxide, leaving lime for another turn in the causticizing operation.

Screening and Bleaching.—The washed pulp contains some large fibres and incompletely cooked bundles that must be removed by screening to produce a stock of uniform quality. Screens are of two general types. The flat screen is a box about 15 in. high, with a bottom of metal plates having slots from .006 to .014 in. wide. These grade the fibres passing through and retain material not acceptable for the grade of pulp required. A chamber below the screen plates has a flexible bottom that is given a pulsating movement to help draw fibres through the screen slots by suction.

In the rotary type screen, the plates form a cylinder that revolves very slowly and the thin pulp suspension is fed either to

the inside or outside of the cylinder. Either the screen is vibrated or the pulp is agitated to cause the fibres of correct size to pass through the slots.

Besides screens, several types of separators act by centrifugal force created by whirling the suspension of fibres.

A large proportion of wood pulp is converted in the same mill into paper or paperboard. In such a case the thin suspension passing the screens at a consistency of .3% to .% is thickened. as described above, to a consistency of 3% to 6% and held temporarily in storage chests fitted with agitators. Pulp to be stored for some time, or to be shipped, may be made into wet laps containing 30% to 45% dry fibre on met machines (as described above. under *Groundwood* Pulp). Bleached pulp is usually dried, cut into sheets and baled. A pulp drying machine consists of a vat for pulp in which rotates a large wire-covered cylinder, like a vacuum thickener. The layer of pulp is passed through one or two presses that squeeze out more water and then through a drying chamber, in mhich the sheet travels back and forth several times. The water content can be reduced to about 10% or 15%.

Bleached Cellulose.—This is required for the higher grades of printing, writing and specialty papers and for chemical conversion in the manufacture of artificial silk, explosives and other derivatives. Bleaching not only whitens pulp but refines it by removing substances that may be useless or harmful if used for the manufacture of some products. The objective is a pulp with maximum content of alpha-cellulose—the portion most resistant to ordinary atmospheric conditions but reactable to special chemical reagents. For the latter purpose it is called dissolving pulp. Other grades of bleached pulp. for nhich the treatment is less severe, contain varying precentages of beta- and gamma-cellulose, the more reactive but nonfibrous forms of cellulose. The bleaching also removes, as its primary purpose, residues of lignin, colouring matter and lower carbohydrates.

The process of bleaching wood pulp involves the chlorination of lignin to form a soluble compound, and the oxidation by chlorine compounds of other substances, rendering them colourless. When the composition of a substance is chemically changed, the chances are about 20 to 1 that the result will be nhite or colourless.

According to F. Kraft (Pulp *and* Paper *Manufacture,* vol. 1), sulphite pulps can usually be satisfactorily bleached in three stages (with intermediate washings): (1) chlorination. (2) alkali extraction and **(3)** hypochlorite (brightening) treatment. To bleach sulphate pulps, at least five stages are necessary. (1) chlorination, (2) alkali extraction, (3) high-density hypochlorite treatment, (4) alkali extraction, (5) final hypochlorite; but two additional stages are recommended. (6) second chlorination and (7) alkali extraction. A final addition of sulphurous acid is made to stabilize brightness and destroy residual active chlorine mhich can, especially at high temperature, cause formation of oxycellulose, a substance having no fibrous structure or strength.

Nonfibrous Materials.—Materials other than fibres and the process materials mentioned above are required in making paper. These include. colours—synthetic dyestuffs. natural vegetable colouring matters, and mineral pigments; sizing—rosin. glue and synthetic resins; chemicals—alum, ferrous sulphate, casein, lime, limestone. salt, sodium sulphate, sulphur, chlorine, sodium carbonate, e t ~and fillers and coating materials—clay, talc, gypsum, chalk, titanium, zinc pigments, etc.

MANUFACTURING PROCESSES

Introduction.—The manufacture of pulp from wood and other fibrous raw materials, along with the manufacture of paper from these pulps, has become one of the world's most important manufacturing industries. By the mid-1950s it ranked first in Canada and high in the United States. Finland, England, Germany. Sweden and other countries with high rates of paper consumption, and wherever extensive forests provided a basis for these articles of international commerce. In 1953 the United States led the world in consumption of paper with 32j lb. per capita.

Great changes in methods of manufacture have come with the invention of machinery and the discovery of improved processes, yet the fundamental principles persisted through 20 centuries of papermaking, and the primitive methods of the early days are still in use in some countries. In brief the manufacture of paper involves: (1) procurement of raw material; (2) preparation of fibres to give a uniformly distributed suspension in water; (3) formation of a sheet of interlacing, or felted, fibres on a surface of material through which superfluous water drains off; (4) removal by pressing and evaporation of further moisture to the point of equilibrium with the atmosphere; (5) giving such smoothness of surface as may be required.

Procurement of Raw Material.—This procedure necessarily varies with the type of mill and its location. Many mills are self-contained, particularly those making paper from rags, jute, manila rope. flax, straw, esparto grass and waste papers. Similarly self-contained are those producing their own wood pulp for newsprint, kraft wrapping and container board, and insulating boards. Most mills buy all or a portion of their fibre requirements, for economic or technical reasons. Thus, a writing-paper mill will process its rag stock and buy the grades of chemical pulp required for the qualities of paper produced; or a mill using wood pulp may not have sufficient pulp of its own and will have to purchase the balance required.

Preparation of **Stock.**—In no industry is it likely that preparation of the material is more important than in the manufacture of paper. It is necessary to start with raw materials as nature makes them. No tree is exactly like another, nor is any tree uniform throughout. yet the cellulose fibre from the pulp mill meets severe specifications for the several grades. Regardless of the care taken by the supplier of the raw material to the paper mill, the papermaker has a difficult task in preparing and blending the fibre and other materials so that they will form a sheet of paper with the qualities required. This is obvious when one compares such different products as tissue, writing and wrapping paper, boxboard, newsprint, wallboard. paper shingles, magazine paper, etc.

The basic operation is to work the proper fibres into such a condition that they will form a suitably felted sheet (mat of fibres) on the paper machine. In the case of newsprint, the groundwood and sulphite fibres have received considerable screening treatment in the adjacent pulp mill and are fairly uniform as to size of fibre and density of suspension. These pulps, therefore, need very little, if any, refining (described below) and require only thinning to a standard and constant concentration (consistency), mixing in correct proportions (approximately 85% groundwood and 15% unbleached sulphite pulp), adding automatically by meter certain amounts of blue and red dyestuffs to improve the approach to whiteness and perhaps other materials to give a special quality. The mixture (now called stuff) is held in a storage chest to be pumped as required to the paper machine. Most other papers require more extensive preliminary treatment. The preparation of rag-content papers requires the maximum processing and will illustrate the various operations and equipment.

Let us first consider the material In the first place the length of wood fibres from conifers (softwood) is 3.5 to 5.5 mm. (about $\frac{1}{8}$ to $\frac{1}{4}$ in.) and that of broadleaf (hardwood), about 1 mm. ($\frac{1}{25}$ in.). In each case the fibres are about 100 times as long as they are wide. Each fibre is a tiny tube, with thin tips. Many are broken in making groundwood pulp, and some are cut in making chips for chemical pulp. Other vegetable fibres are much longer; cotton fibres may be an inch or more long, with a diameter of about .02 in.

Beating.—Papermaking may be considered as beginning in the beater room. The mixture of fibre and other materials added to the beaters is known as the furnish. Each kind and grade of paper has its own particular furnish.

The beater is a machine fundamentally the same as the washer, but more carefully designed and built. The roll is much heavier and is capable of being set very accurately with respect to the bed plate, since the progressive adjustment of the roll position is the key to good beating. Each end of the roll shaft rests on a lever, the free ends of both being raised or lowered simultaneously by gearing; thus minute adjustment is possible and, because of the smallness of the fibres, necessary. A beater may hold from

300 to 3,000 lb. of stock, a common size being about 24 ft. long, 12 ft. wide, with ends of semicircular shape, and about $3\frac{1}{2}$ ft. deep. A centre partition provides a continuous channel. The essential part is the combination of roll. bed plate and backfall. The roll will have a radius approximately equal to the depth of the beater, and almost the full width of the channel in which it turns. Bars of steel about $\frac{1}{4}$ in. × 3 in. and as long as the roll width are set radially so as to project about half their width from the roll and are held by wedge strips of wood. Set in the floor of the beater, under the roll, is a box of similar bars, called the bed plate. Behind the roll the floor is given a hump (called the backfall) over which the stock is thrown by the rotation of the roll.

With the roll set to clear the bed plate comfortably, the beater is partly filled with water and the washed and bleached rags (called half stuff) are added gradually. The turning roll draws in the lumps of half stuff, which break up and are thrown over the backfall to circulate around the tub. Sufficient water is added to give a consistency of about 5% when all the fibre is in. Since few papers are now made of 100% rag fibre, the rag half stuff is beaten first and the wood pulp or waste paper stock added in due course. The majority of paper grades produced today contain 100% wood pulp.

As the beating proceeds, the revolving roll is gradually lowered until it is riding full weight on the fibres between it and the bed plate. This action splits and mashes the fibres, creating hairlike fibrils and causing them to absorb water and acquire a sliminess. These beaten fibres will then drain more slowly on the paper-machine wire and bond together more readily as more water is removed and the wet web is pressed. After drying, the paper made from such stuff will be exceptionally strong. Much of the beating action results from the rubbing of fibre on fibre. Long fibres will, of course, be cut to some extent; the lower the consistency and the more rapid the roll lowering the more the cutting, an operation which is completed in the refiner. During the beating, other materials are added: (1) The paper is made water resistant by sizing; *i.e.*, a rosin soap is well mixed with the fibre, and an alum solution is added to break up the soap and make the rosin stick to the fibre. (2) Dyestuffs are added to give the shade desired or improve the whiteness, and the alum helps to set the colour. (3) a filler, such as clay or chalk, may be added to give some special property to the paper. The result of all this preparation is called full stuff or just stuff and is emptied into the beater chest. Other types of beaters have been developed, but all have the same principle and function.

Refining.—The next operation is refining. the purpose of which is to brush out knots or clusters of fibre and to cut the fibres to a more uniform length. Some further conditioning may occur to give an increase in the area of fibre surface, which is a factor in making fibres adhere one to the other. It is important that the stuff entering the refiner is regulated to a correct and uniform consistency. This is accomplished automatically by an instrument which controls the amount of water added as the stuff is pumped from the beater chest. Refiners also operate on the principle of one set of bars or knives passing another set, but at a more accurately controlled distance and at higher speeds. The two distinct types are: (1) a conical plug with bars on the surface revolving in a shell with corresponding bars on the inner surface; (2) two disks, of which one or both rotate, and which are grooved with sharp-edged ridges. In the first type the plug is accurately centred in the shell and the machine is given a preliminary run with a slurry of sand to grind the bars to a perfect fit. In operation the plug is pushed in or drawn out by a special gearing (which may be automatically controlled) to regulate the degree of rubbing and cutting of the fibre. The stuff is fed in at the small end at a constant rate and emerges at the large end of the machine. It flows from there to the machine chest, of which there are two if the paper machine makes a variety of grades or colours, since it takes time to prepare for the switch-over mhen the first run is finished. Such changes may involve a thorough wash-up of chest and paper machine.

Paper Machines.—The paper machine is one of the most massive and at the same time most delicately adjusted pieces of mechanical equipment found in any industry. While machines for some high or special grades may be small enough to fit into a double bowling alley, a modem newsprint machine would occupy the area of a city street a block long. The speed of one machine might be 100 ft. per minute, while others run at more than 2,000 ft. per minute. The thickness of the paper varies from a delicate cobweblike film to heavy wrapping papers and building boards. To operate such a machine hour by hour and day by day with a minimum of breaks requires the highest engineering skill in design and manufacture. steadiness and perfect adjustment of the speed of several separate but interlocked parts, the careful preparation of the stuff and the intelligent operation of the machine by men of experience, using the best available instruments and control apparatus.

The stuff supplied to the paper machine will have been fully prepared for grades of paper containing other than wood pulps and for those grades of wood-pulp papers requiring beating or similar conditioning treatment, or the admixture of special materials. Such stuff can be pumped directly from the machine stuff chest to the paper-machine screens. When the stuffis a mixture of pulps in slush form (*e.g.*, newsprint is a mixture of groundwood and sulphite pulp), these pulps are each brought to a definite consistency and mechanically metered in fixed proportions into a mixing apparatus. which also automatically adds colour, alum and sometimes other materials. From the proportioning and mixing machine, the stuff is conditioned in a refiner en route to the machine chest, where repulped broke (trimmings and other spoiled paper from the machine) is added.

Stuff from the chest is pumped to a consistency regulator so that the volume and consequently the weight of stuff fed to the machine can be accurately controlled, so that the paper will have a constant weight and thickness. The regulated stuff gets a final screening and then flows to the head box. This acts like a reservoir behind a dam. The weight of stuff forces the stuff out through a narrow opening—the slice—onto a travelling endless wire screen; the speed of stuff is kept even with that of the wire by controlling the depth in the head box. The slice must be perfectly horizontal with a uniform opening in order to produce a level sheet of uniform thickness.

The wire part, or Fourdrinier, is essentially the same machine that was invented by Louis Robert in France in 1799. Robert sold his patent to Leger Didot, who took it in 1800 to England, where his brother-in-law John Gamble was granted a patent in 1801 for a machine improved with the help of Bryan Donkin. The first machine was started at Frogmore and another at Two Waters in 1804. Henry and Sealy Fourdrinier acquired all patent rights and further improved the machine which became known as the Fourdrinier.

An endless bronze wire screen passes around a breast roll at the feed end and a driving, couch, roll at the other. The wire returns over wire-carrying rolls, a stretch roll and a guide roll. The top run of the wire carrying the wet pulp suspension is supported by flat table rolls and flat suction boxes. A light wire-covered dandy roll rides on the wire between suction boxes. The driving roll may have a felt-covered top roll to press water out of the freshly formed paper or have one or two interior suction boxes (vacuum couch) with a rubber-covered presser roll to level the surface of the paper. As the stream of stuff.containing from 0.2% to 1.5% fibre, shoots out from the slice, the river of paper stock flows along with the wire and is confined for a short distance by rubber deckle strips just touching the wire on either side. While travelling this distance, much water drains through the wire while the fibres felt together to form the sheet of paper. Now the table rolls and suction boxes continue to draw out more water and the dandy roll smooths the surface. If a watermark is required, a pattern is formed of wire sewed on the dandy; it makes an impression in the soft mat that remains denser than the rest of the sheet. Next comes the couch press or vacuum couch roll which extracts enough water to bring the dry content of the paper to from 15% to 18%. The water that has been taken out by draining and suction is used for diluting the stuff by the consistency regulator, for showers and other uses, except when it is too strongly coloured.

The sheet as made on the wire has uneven edges and is somewhat wider than required at the reel when the natural shrinkage in drying has taken place. Furthermore, this shrinkage in width varies with the composition and condition of the stuff. So a narrow strip is cut off each side of the paper by two jets of water (squirts) directed at the wire. A third jet slides in a tube that extends across the machine; it is used for cutting the narrow lead strip (tail) that is first carried along to lead the paper through the machine. When this strip has progressed a sufficient distance. the squirt is slowly pushed across the wire and presently the full width of the sheet has been transferred to the next part of the machine. The same procedure is follo ed in passing the weak wet paper to each succeeding part. This passing of the tail is still done by hand on slow-running machines but becomes very difficult as the speed increases to about 500 ft. per minute. The operation is now effectively performed at speeds up to 2,000 ft. per minute or more by compressed air blasts between the wire and the presses, by a twin-rope carrier through the dryers and with air blasts again at the calender and reel. Some machines are provided with an endless felt which presses against the wire to pick off the paper and carry it through the first press. With thin tissues and some light wrapping papers, this pickup felt presses the wet sheet directly onto a drying cylinder. This is the Yankee machine that gives paper a one-side glaze.

Removal of Further Moisture.—As mentioned above, the paper leaves the wire with an average dry fibre content of about 18%; *i.e.,* for each pound of paper, the sheet at this point contains about $4\frac{1}{2}$ lb. of water. Mechanical pressing can reduce this ratio to about 1 lb. of paper to 2 lb. of water, and further drying must be done by evaporation, which may cost 12 times as much as pressing. There may be one, two or three presses between the wire and the dryers. A press consists of a bottom roll with a resilient rubber covering, driven by an electric motor. Above it is a top roll of granite or noncorrodible metal; its effective weight may be increased by weights and levers or by air or hydraulic pressure on its bearings. The paper is carried on the felt between the rolls. and water is squeezed out and runs through the felt and down off the bottom roll. Removal of this water is facilitated, and the efficiency of the press is increased, by making the bottom roll of a perforated shell with an interior suction box like that in the vacuum couch. The sheet goes to the dryers with 30% to 38% dry material and 62% to 70% water, depending on the grade of paper and condition of the felt and the machine. The paper is now strong enough to carry its own weight and for the tail to be slipped between the carrier ropes and whisked from the last press to the drvers.

Cylinder machines are used for making some thin papers and most paper boards, building papers, insulation boards and for drying chemical wood pulp. The sheet-forming part is described here because the drying and finishing parts are essentially the same for both paper and board. An important feature of the cylinder machine is that different kinds of stock may be used when there are two or more layers—top liner, filler and bottom liner. Some boards, of course, are made by pasting several sheets together. For a multicylinder machine there are several vats in which wire-covered cylinders rotate and perform as described above under *Papermaking Materials*. The stuff is prepared separately for the first, last and intermediate vats—chemical pulp, white or coloured. for liners and usually wastepaper for the filler. The top liner is formed on the first cylinder and taken off by the underfelt, which travels backward, picking up one or more layers of filler stock and a bottom liner if there is to be one from other vats.

These layers are pressed together by the couch roll on each cylinder and form a solid sheet, which is carried forward, overhead, to the presses. There the paper meets another felt and is carried between the two felts through several baby presses to set the sheet, then on the lower felt through a primary press and on a second lower felt through the main presses. Considerable additional pressure is applied to the presses, which are mechanically similar to those on a Fourdrinier paper machine. For thin papers, the presses are few, if any.

The first patent for a cylinder-type machine was granted in the United States to Charles Ringsey and one was granted to John Dickinson in England in 1809. The first paper machine in the United States and the first cylinder-type machine anywhere was installed by Thomas Gilpin at Wilmington, Del.. in 1817.

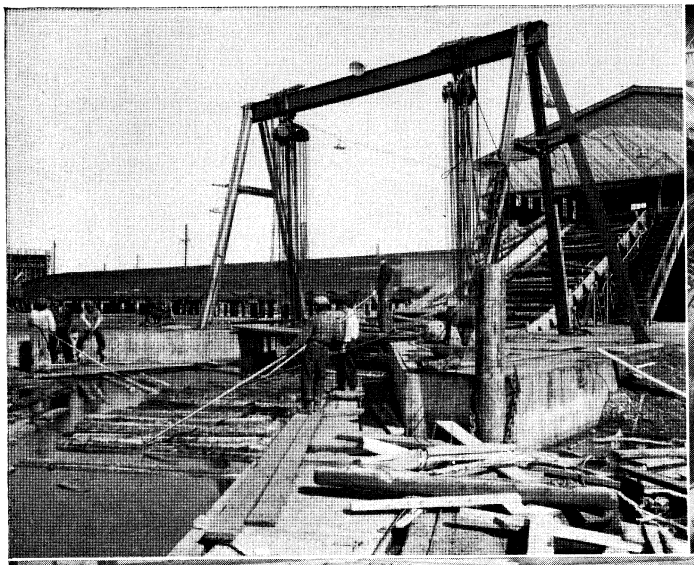
The dryer section of the paper machine is a set of hollow steam-heated cylinders by which the paper is dried from a moisture content of about 65% to 5%–8%. Front and back frames carry the bearings which are set so that the top dryers come down part way between the lower ones. Heavy cotton or cotton-and-asbestos felts run over both top and bottom rows and are held tight against the dryers by felt-carrying and stretch rolls. The purpose is to keep the paper flat and to prevent air from forming an insulating layer between paper and dryer shell. No felt is required for most paper boards. The rear journal (axle) of each roll has a double-barrelled fitting which provides an inlet for steam and outlet for the water formed when the steam condenses in giving up heat to dry the paper. The moisture evaporated from the paper—about two pounds of water for each pound of paper—is drawn off by fans through an economizer which heats fresh air for carrying off more moisture. The hotter the air, the more moisture it can absorb.

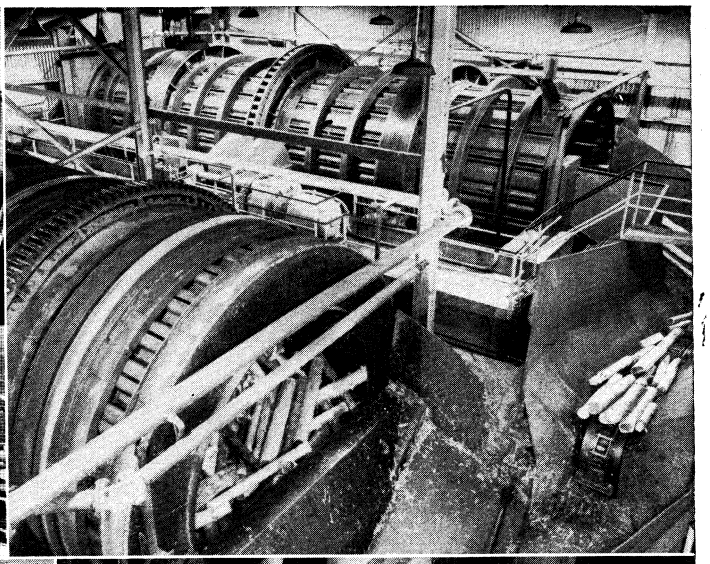
Calenders.—The smooth finish is produced by passing the paper through a stack of highly polished rolls. The bottom roll of a big machine will weigh more than 30 tons; the tremendous weight of the eight or nine others can be further increased by levers or pressure cylinders. Scrapers keep the rolls clean, assist in threading the paper and prevent paper from winding around a roll in case of a break in the paper web. Some board machines have two or even three calender stacks. An extra-high finish is sometimes attained by dampening the paper surface before it enters the calenders, and surface colouring can be done by adding a dyestuff to water which is applied from a reservoir attached to the stack.

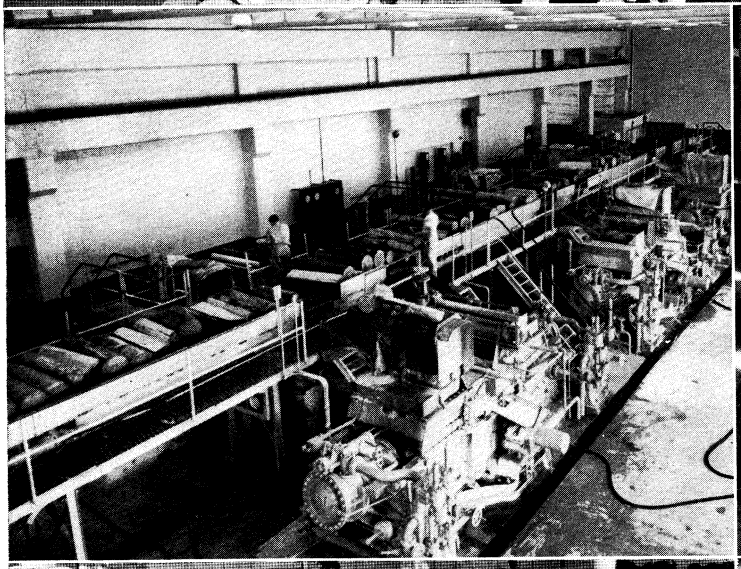
The paper is wound full width on a reel, using a steel core. Quick and skilful work is required to transfer the paper at high speed from a full reel to an empty core. The large jumbo rolls are then slit into widths required by the printer or other user and rewound into rolls of specified diameter, from nine-inch counter rolls of wrapping paper to five-foot rolls of straw board. When the paper is to be used in sheet form, the slitter may be combined with a cutter and piling attachment.

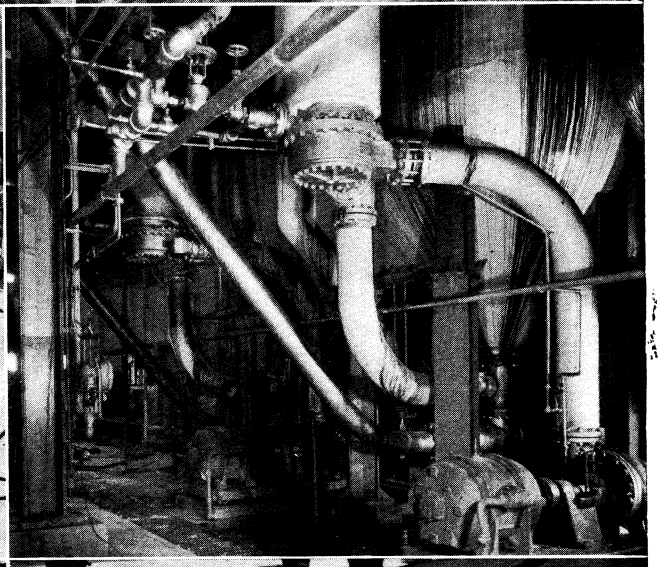
Some paper is unavoidably spoiled, but it is not wasted. The wet broke from the wire is mixed with white water draining through the wire and is used to dilute the stuff at the screens. The more solid broke at the presses and the dry broke from the dryers, calenders, winder and slitter must be repulped in a beater or pulper. It is stored in a chest and added in proper proportion to the machine sheet. In the case of machines making coloured papers, the broke is either dewatered and stored as wet laps or crumbs, or the dry broke from the machine room and finishing room is baled and stored dry.

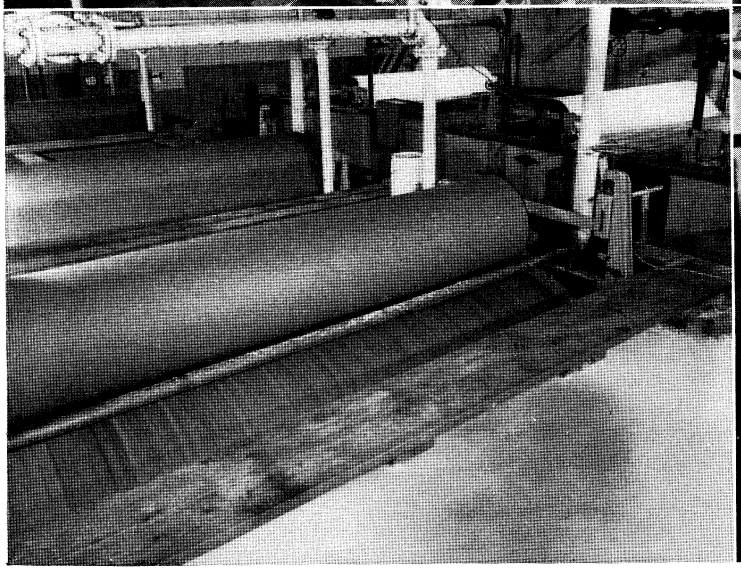
The papermaking machine requires large amounts of power and steam. On many machines a steam engine or turbine provides the power, and the exhaust steam from it is used in the dryers, where the temperature is regulated by adding necessary quantities of live steam. Other machines are driven by electric motors, either one big motor driving a main shaft to which the several parts of the machine are connected or a separate motor for each part. Like persons walking in file, who must neither hurry nor lag, so each part of the paper machine must be in step. The analogy differs, however, in that the pace changes; the paper stretches in the "draw" between the wire and the first press, so that the surface speed of the latter must he increased slightly. Like adjustment must be made, but less noticeably, from one press to the next and from the last press to the dryers. The delicacy of this adjustment can be understood when it is remembered that strips of wet paper are being moved and there may be 50 h.p. driving one press on the machine. Modern instruments can detect the situation and control the speed differences accordingly. Then, as the paper is dried, it shrinks. Therefore a long set of dryers is divided into sections whose speeds can be progressively decreased. The calender and reel drives are tied in with the rest of the machine, but the slitter and winder is driven independently because the inter-

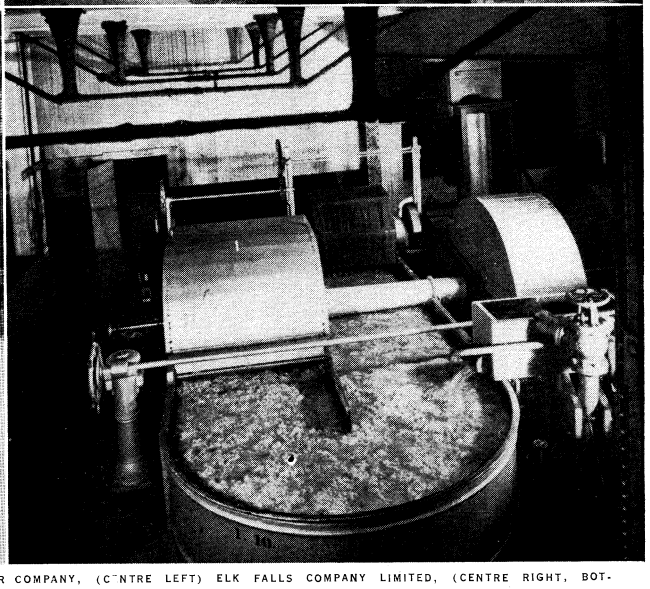












BY COURTESY OF (TOP LEFT) "PULP & PAPER MAGAZINE OF CANADA," (TOP RIGHT) CANADA PAPER COMPANY, (CENTRE LEFT) ELK FALLS COMPANY LIMITED, (CENTRE RIGHT, BOTTOM LEFT) MARATHON PAPER MILLS OF CANADA LIMITED, (BOTTOM RIGHT) HOWARD SMITH PAPER MILLS LIMITED; PHOTOS BY (TOP LEFT, CENTRE RIGHT, BOTTOM LEFT) ASSOCIATED SCREEN NEWS LTD., (CENTRE LEFT) INDUSTRIAL PHOTOGRAPHICS

PREPARING WOOD AND RAG FIBRE FOR THE PAPER MILL

Top left: Haul-up, or jack ladder conveys pulpwood logs to the cut-up mill and wood pile

Top right: Barking drums tumble the wood until bark is rubbed off. Uncleaned wood is pulled off the conveyor and rebarked

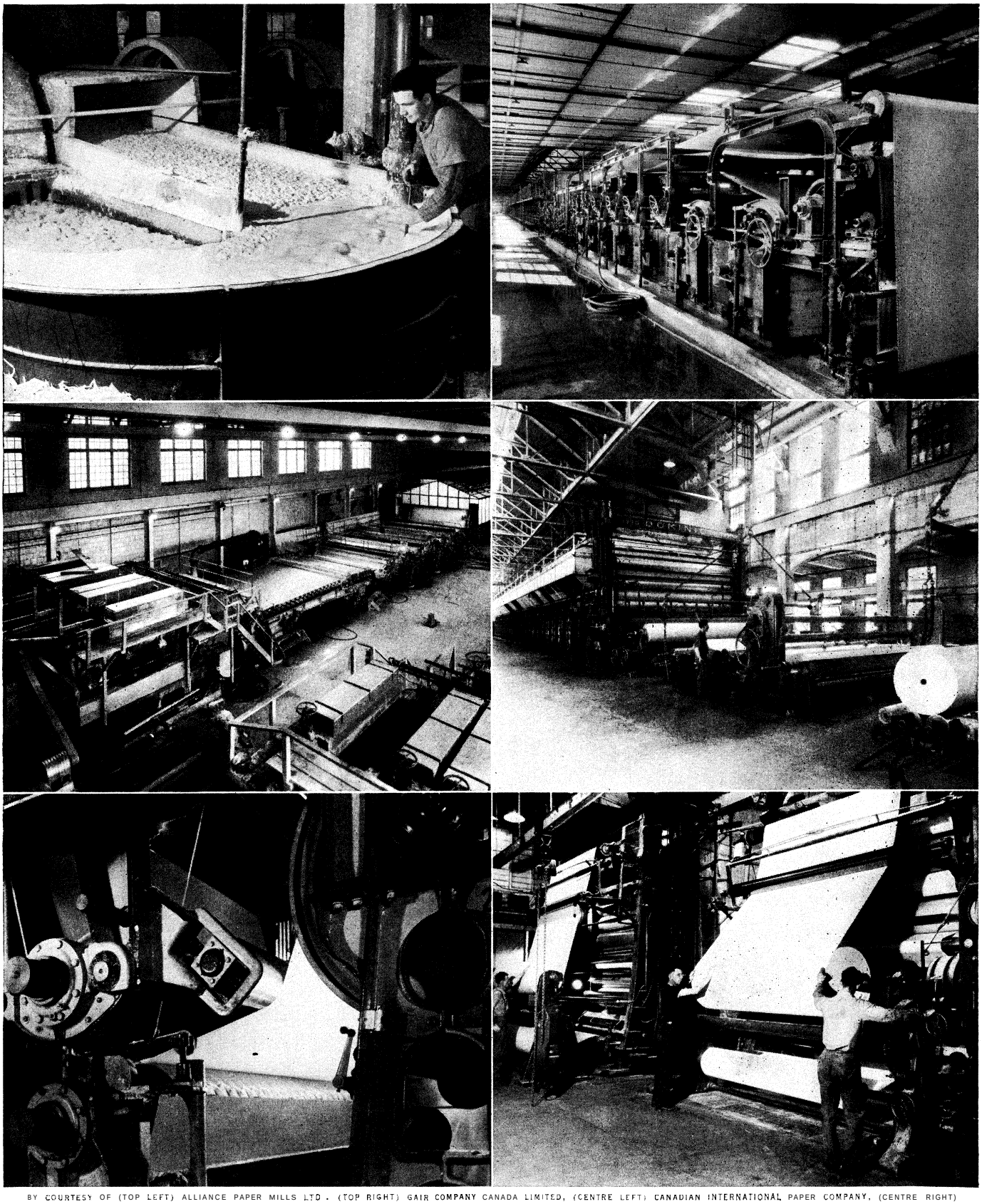
Centre left: Blocks are fed from flume to feed hopper of each grinder

Centre right: Digesters (rear) liquor circulating pump and reheater (foreground)

Bottom left: Deckers thicken chemical pulps before and after bleaching

Bottom right: Washing rag half stuff. The beater roll is in the left channel, the screen-covered dipper in the right

PAPER



BY COURTESY OF (TOP LEFT) ALLIANCE PAPER MILLS LTD., (TOP RIGHT) GAIR COMPANY CANADA LIMITED, (CENTRE LEFT) CANADIAN INTERNATIONAL PAPER COMPANY, (CENTRE RIGHT) POWELL RIVER COMPANY LIMITED, (BOTTOM LEFT) HOWARD SMITH PAPER MILLS LIMITED; PHOTOS (TOP LEFT) HERB NOTT & CO., (CENTRE LEFT) ASSOCIATED SCREEN NEWS LTD., (BOTTOM LEFT) ARNOTT & ROGERS

LATER STEPS IN PAPER MANUFACTURE

Top left: Dumping a beater of stuff for glassine paper. Note roll under hood at left

Top right: Vats, felts and presses of cylinder-type board machine

Centre left: Wet end of a newsprint machine: (left) screens and head box, (centre) wire and presses, (right) dryers

Centre right: Dry end *of* a newsprint machine: (left) dryers, (centre left) calenders and reel, (centre right) winder, (right) wrapper

Bottom left: Coating unit between paper machine dryers, making machine-coated magazine paper

Bottom right: Supercalendering fine printing paper

mittent load would momentarily disturb the other motors.

Special Paper Machines.—Special machines are required for many of the endless number of pulp and paper products, from the lightest tissue to heavy building boards. These machines are adaptations of the basic Fourdrinier and cylinder designs. A high-speed machine (2,500–3,000 ft. per minute) has a short Fourdrinier wire and a so-called Yankee dryer, 12–14 ft. in diameter. A transfer attachment picks the paper from the wire and presses it against the polished surface of the dryer until dry, when it peels off like a handkerchief dried on glass. The Yankee dryer is also used for other tissues, light wrappings, and for making creped papers. Creping is done by a "doctor" that scrapes the paper off before it is quite dry and wrinkles it in doing so. At the other end of the scale are building and insulating boards up to an inch or more in thickness. Both Fourdrinier- and cylinder-type machines are used. One of the latter has two-vacuum-equipped cylinders; the Fourdrinier type has high deckle boards and special suction units. The sheet is then gradually pressed between two felts or two wires to the desired thickness and cut into slabs. The cutter moves across diagonally to compensate for the forward movement of the board and to produce square ends. The boards are then fed successively by a "tipple" to a different deck of an eight-deck dryer and carried through it on chain-driven rollers. A typical board dryer is more than 500 ft. long, with five zones at increasing temperatures. The board must be heated gradually to the point where moisture left in the centre will migrate to the overdried surface layers and give a uniformly dry product. Hardboard, such as Masonite, is pressed and dried at the same time between the plates of a hydraulic press. Board sheets are then trimmed to standard sizes and wrapped.

Finishing Operations.—Newsprint, much book and magazine paper and many wrapping papers and boards need only to be wrapped, if ordered in rolls, when they come off the paper machine. Other papers require further finishing or special treatment, some of which is done by the converter. For example, a very smooth surface on printing papers is obtained by passing the web through a supercalender. This machine is similar to the paper-machine calender, but alternate rolls are made of circles of paper compressed to a dense, hard mass and ground to a true cylinder. The special surface on writing papers is produced by building a stack of alternate sheets of paper and sheets of linen, crash, rippled cardboard, etc., with sheets of zinc at intervals, and passing the "form" back and forth several times between rolls which exert a pressure on it of 60 to 80 tons. Another type of finish is the impression made by the embossing machine which has two rolls; one has the pattern embossed on it and the other may have a matching pattern engraved in its surface or be a roll of softer material which will take the indentation. To get sheets thicker than can be produced on the paper machine, pasting or laminating is employed. This also makes it possible to get a sheet composed of different qualities or colours. The laminator may operate with sheets or rolls. In the first case, paste is applied to both rolls of a pair. To paste two sheets, a dry sheet is placed in the collector, then two sheets are fed together, the bottom of one and the top of the other receiving paste, and so on, then a dry sheet is placed on the top of the pile, which is pressed. To get a three-layer sheet, a single sheet is fed alternately with the pairs; for a four-layer sheet, two singles are fed between pairs. The sheets are dried by hanging them with clips under a conveyor which carries them slowly through a heated drying chamber. Web pasters will laminate up to six sheets for wallboards, asphalted products, etc. In these laminators the outside sheets are fed dry, and the inner sheets pass through a bath of asphalt or adhesive, or over an applicator roll as in making moisture-proof kraft lining paper.

Coating Printing Stock.—Most important of special processes is the coating of paper for fine printing. The purpose is to fill the small depressions in the paper caused by irregularities in size of fibres or formation of the sheet and to give a surface of homogeneous material and structure which can be finished to almost perfect smoothness by the supercalenders. A mixture of clay or other white mineral matter, casein or other adhesive and dyes or other colouring matter is spread smoothly on one or both sides of the paper.

One-side coating is produced by an applicator roll and is then smoothed by brushes of finest badger hair. Two-side coating is obtained by passing the web through a bath or between a pair of applicator rolls and then between four to ten pairs of brushes. Drying of single-coated paper is done by carrying loops or festoons of paper on a conveyor, or over rollers through a drying chamber. Double-coated paper must be floated on hot air to set the coating before it contacts other support. Coating can also be carried out for certain grades and weights of paper by locating an applicator unit about two-thirds of the way down the length of the paper machine dryers, where the paper is sufficiently moist to permit penetration of the clay through the sheet. This is necessary in order to get equal smoothness on both surfaces.

Glue Sizing.—Somewhat akin to machine coating is the sizing of paper with glue, etc., which cannot be effectively done in the beater as described above for rosin sizing. Glue, or surface, sizing is obtained by passing the paper through a size tub, with press rolls to squeeze out the excess. Drying and finishing have been described. The paper is made stronger, is resistant to spreading of ink, and fibres are not picked up by the pen. Paper is waxed in a somewhat similar way by passing the web through a bath of molten wax, then over a chilling roll to harden the wax.

Shipping Containers.—The production of paper shipping containers had become an important part of the paper industry by mid-20th century, the great majority being corrugated boxes and wrappers. Both kraft paper and straw board are used for corrugating, the latter giving particularly strong flutings.

Sizes.—Sizes of paper are expressed in inches or centimetres, according to the country of manufacture or specifications of the order. Many of the sizes in common use were given names, such as atlas, crown, demy, elephant, emperor, folio, foolscap, post, pott, royal, etc., but names have been largely discontinued in favour of actual measurement. The folio sheet—17 × 22 in.—is generally accepted as standard for writing papers; 24 × 36 in. for wrapping and newsprint; 25 × 38 in. for book papers; and 20 × 26 in. for cover papers. A universal standard size, 25 × 40 in. (1,000 sq.in.) has been advocated. The traditional count is in quires of 24 sheets, and reams of 20 quires (480 sheets); but custom here also has changed, and most calculations are based on units of 500 or 1,000 sheets of the size and weight specified. For example, a paper order for stationery might be for 20-lb. 17 × 22 in. sheets, although the mill would ship it in sheets 22 × 34 in., and the printer would cut it into letterheads $8\frac{1}{2}$ × 11 in.

The complete Hunter Museum of Paper is maintained at the Institute of Paper Chemistry, Appleton, Wis.

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PAPERBOARD, one of the two chief products of the paper industry; the other being paper. Paper, a broader term than paperboard, includes all kinds of matted or felted sheets of fibres (usually vegetable, but sometimes mineral, animal or man-made) formed on a fine wire screen from a water suspension. The distinction between paperboard and paper is not sharp but, generally speaking, paperboard is heavier, thicker and more rigid than paper. In general, all types of fibrous materials 12 points (0.012 in.) or more in thickness are classed as paperboard. There are, however, some exceptions: Certain grades as thin as 0.006 in., such as corrugating medium, lightweight chipboard, bristol board, tagboard, etc., are classed as paperboard because their manufacture and use are entirely those of paperboard. Similarly, other papers such as blotting papers, felts and drawing papers are classed as paper even though they are 0.012 in. or greater in thickness.

The many types of paperboard represent a wide range of properties and uses. Examples are those various types used for shipping containers, folding cartons, setup boxes, fibre drums, milk containers. bookbindings, advertising displays, electrical insulation. file dividers, bottle caps, panel board, shoe board, gypsum board, sheathing board, post cards, car signs, coasters, matchboards, food boards and butter cartons.

The early history of paperboard is not entirely clear because of the confusion between paper and paperboard; this is quite natural inasmuch as paperboard grew out of the paper industry. Although the Chinese are credited with inventing papermaking at about the start of the Christian era, paperboard as it is known in modern times did not make its appearance until the development of crude printing presses and the appearance of books. The development of books brought about bookbinding and eventually bookboards (cover boards). The latter represented probably the first appearance of paperboard. These early bookboards have been of particular value to historians because they were made by pasting together pieces of scrap paper, principally from discarded books. By separating the bookboards, historians have been able to gather information from predecessor books that no longer exist. It is from these pasted sheets that the term pasteboard is derived.

The term cardboard is a vague and antiquated term applied to certain types of paperboard, notably boxboard, bristol board, bookboard. etc. Cardboard is too vague in meaning to be technical and in the paper industry has been replaced by the term board in combination with words indicating its character or use, *e.g.,* boxboard and container board. All paperboard is made on paper machines; however, boards for certain uses require thicknesses or fibrous combinations (or both) that are either not feasible or not economical to make on a conventional paper machine. In these cases the desired thickness or fibrous arrangement is achieved by pasting together layers of paperboard or paperboard and paper.

Pasteboard. — Much of what is popularly known as cardboard is pasteboard, made by combining several layers of paperboard or paper with adhesive. The pasting or laminating is usually done on a pasting machine (sheet pasting is also practised) that accommodates several rolls of paperboard or paper. The plies are brought together by squeeze or press rolls almost immediately after the adhesive is applied. Aqueous adhesives are used most frequently, although emulsions and nonaqueous adhesive (asphalt. microcrystalline wax, resins, etc.) are used to impart special properties. In the case of the aqueous adhesives. the "combined" board may or may not be heated to speed up the development of the bond. One of the perennial problems with pasted or built-up board is its tendency to warp. caused by unequal stress build-up primarily as the result of nonuniform absorption of moisture on the two sides of the board.

The raw material for paperboard can be the same as for paper, the choice depending on the economics and end-use requirements. In the U.S. most paperboard is made from virgin wood pulp and/or waste paper. A relatively small percentage of paperboard is made from cereal straws, reeds, etc. Countries without a readily available source of wood fibre make more extensive use of cereal straws and reeds.

Paperboard Machines. — Paperboard is manufactured on various types of paper machines, most of which employ either a cylinder or the Fourdrinier process.

The cylinder machine uses wire-covered cylinders or molds on which a web is formed. The cylinders are partially immersed and rotate in a vat containing a diluted stock suspension (dispersion of fibresj. The fibres are formed into a sheet on the cylinder as the water drains through and passes out the ends of the cylinders. The wet sheet is couched off (transferred from) the cylinder on a felt. A cylinder machine may consist of one or more cylinders, each supplied with the same or different kinds of fibres. In the case of a multicylinder paperboard machine, the wet web formed on each cylinder is successively couched one upon the other on an endless felt; thus. the sheet is formed by a series of individually formed sheets or plies of lesser substance. This makes possible wide variations in thickness or substance of the sheet as well as the kind of fibres used for each ply. The composite web or sheet is conveyed between endless felts to the press section, which squeezes out as much water as practical and at the same time helps bond the fibres together. The sheet then goes to the drier section where the remainder of the water is removed and the bonding of fibres completed.

The Fourdrinier paper machine differs from a cylinder machine in that the sheet is formed by flowing a dilute suspension of stock through a slice (narrow opening in the reservoir box) onto a moving endless belt of wire cloth supported in a horizontal plane by tubular rollers or a table. The water is removed downward through the wire and the fibres are retained on top of the wire belt. After sufficient water has been removed, the sheet is couched off onto a felt that carries it through the press and drier sections. The majority of the Fourdrinier machines used in the manufacture of paperboard are equipped with a secondary slice positioned part way down the wire. By this arrangement, most of the stock is applied at the primary slice and the rest at the secondary slice, providing greater product flexibility since stock applied at the secondary slice may be either a different type of fibre and/or more highly refined.

While a definite grain or fibre direction is apparent in all paperboards, the fibres in paperboard made by a conventional cylinder machine show a far greater directionality than a Fourdrinier-formed sheet. Various nonfibrous additives may be combined in the wet state or added to the surface of the board to impart special properties for specific use requirements.

In recent years two new designs of paperboard machines have been introduced, the dry-form cylinder and the Inverform machine. In the dry-form cylinder, the sheet is formed by flowing (approximately tangentially) a dilute suspension of stock onto the upturning surface of a revolving cylinder covered with a wire cloth or screen. The water is removed through the wire screen and the sheet is couched off as on a regular cylinder.

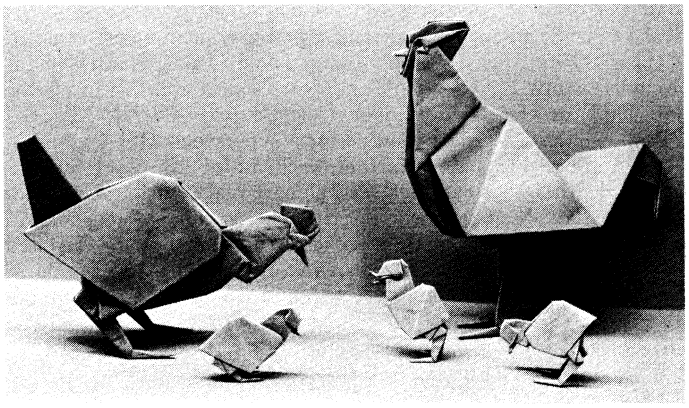
The Inverform machine consists essentially of a Fourdrinier wet end to which has been added one to five short-length endless top-wire sections. Each top-wire section is preceded by a flow box or slice; thus, the type and amount of stock added at each slice may be varied. The top wire is depressed into the fibre suspension, causing the water to flow upward as well as downward. The water flowing upward is removed by a special doctor (scraper) placed at an angle with the wire in such a way that the momentum of the moving liquid causes the water to run up the doctor and overflow into a trough.

See PAPER: *Manufacturing Processes.* (R. C. McK.)

PAPER FOLDING, as practiced for several centuries in the orient, is the art of folding objects out of paper without cutting, pasting or decorating. Its early history is not known, though it seems to have developed from the older, related art of folding cloth.

In Japan, where it is called *origami,* paper folding has reached its greatest development, with hundreds of traditional folds and an extensive literature dealing with the art. Japanese folds divide roughly into two categories: figures used in ceremonial etiquette (such as *no shi,* folded decorations attached to gifts), and, in the second category, birds, animals, fish, insects, flowers, human figures, furniture and other objects. Some of the animals have amusing action features; best known are the bird that flaps its wings when its tail is pulled and the frog that hops when its back is tapped. Akira Yoshizawa of Tokyo is considered the greatest of modern paper folders. He wrote several books on *origami* and created a large number of new, often fantastically complex, figures possessing great realism and delicate beauty.

After the 1930s there was an upsurge of interest in paper folding in Spain and South America. The great Spanish writer and philosopher. Miguel de Unamuno, made a hobby of paper folding, inventing many new animal construction and writing in his *Amor y pedagogía* (1902) a humorous essay on the art. In South America, Vicente Solórzano-Sagredo of Argentina was the leading expert on paper folding and author of the most comprehensive manuals in Spanish. George Rhoads of Evanston, Ill., and Giuseppe Baggi



BY COURTESY OF THE COOPER UNION MUSEUM

"BARNYARD GROUP," EXERCISE IN ORIGAMI BY AKIRA YOSHIZAWA, TOKYO

of New York were considered the most advanced of paper folders in the U.S.

Apart from the oriental tradition, the folding of coloured papers into ornamental designs was introduced by Friedrich Froebel into the kindergarten movement that he initiated in Germany in the 19th century. Later the Bauhaus, a famous German school of design, stressed the folding of paper as a method of training students for commercial design. Similarly independent of *origami* is the use of folded paper in mathematical recreations. Particularly intriguing are a variety of paper structures known as flexagons, discovered by Arthur H. Stone in 1939, that alter their faces in curious ways when properly flexed.

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(M. GA.)

PAPER **HANGING.** The unit of measurement for wallpapers in the United States is a roll containing 36 sq.ft. Narrow papers. 18 in. or 20½ in. wide, are put up in double rolls; 28-in. papers are put up in triple-roll bolts. English papers are 22 in. wide: while French commercial papers are about ½ m. or 19 in. wide. In estimating the amount of wallpaper needed, the length, width and height of the room as well as all openings, including doors. windows and fireplaces, should be measured. Usually it is well to let the dealer or experienced salesperson figure the exact amount of paper needed, because the type of design selected. especially large repeat patterns, may present special matching problems. For a rough estimate of plain or small patterned paper, the walls' total width (in feet) must be multiplied by the ceiling height (in feet) and divided by 30. The resulting figure is the number of single rolls required (U.S.); two rolls should be subtracted for three ordinary openings—windows, doors, fireplaces. It is wise to buy at least one extra roll. For double rolls the total may be divided by two, for triple rolls by three. Scenic papers are made in separate strips, 19 in. wide and from 6 to 10 ft. long. Since a different number of strips makes up each complete set, it is important to know dimensions of wall space when selecting the design.

Equipment. — Professional paper hangers use the following tools and equipment: trimming equipment; paste table. bucket and brush; smoothers, rollers and shears; basewheel or knife, ruler and yardstick; spirit level, chalk and chalk line; plumb bob, pencils and sponge; extension plank and stepladders; putty knife and wall knife or scraper; drop cloths and rags. The amateur paper hanger may substitute the following: shears. large and sharp or roller trimmer; table or large flat surface; pail with string tied across to hold brush; paste and a 3-in. (or wider) paint brush: paper hanger's smoothing brush or old clothes brush: seam roller or furniture caster; knife or razor blade; yardstick; chalk and thumb tack to be used with string and weight for plumb bob; stepladder; putty knife and patching plaster; wall size (a glue); sponge and bowl; newspapers for protecting floors. Kits of paperhanging tools are available in many stores where wallpaper is sold.

Preparation of Walls and Ceilings. — The surface on which wallpaper is to be applied must be dry, clean and smooth. It is advisable to remove all wall fixtures. Cracks should be filled with patching plaster, smoothed with a putty knife and, when dry, sandpapered to remove any roughness. Wall size should be applied to freshly plastered or painted walls and over spots and stains.

Although old paper may be left on the wall if it is not loose, professional paper hangers insist upon its removal because the paste may soften and cause loosening of the old paper. It may be removed by wetting and scraping, by steamer or by chemical removers. Glossy surfaces may be cut by (1) washing and sizing, (2) sandpaper, (3) ammonia or (4) commercial chemical preparation. When papering over wallboard, all joints and seams should be covered with tape or filled with patching plaster. Calcimined walls must be scraped or washed with warm water before sizing.

Before applying fine-quality paper it is usually advisable to put a lining paper on the wall; very expensive or antique papers should be applied only to walls that have been covered in advance with muslin, which will make it possible to remove the paper without tearing. Another protective measure for valuable papers is a surface treatment with a sizing (glue or gelatin) followed by clear shellac. This. however, should be tested on a small piece of the paper to see that the colours do not run when the liquid finish is applied.

Ceilings in papered rooms are usually painted. Whether painted or papered, they should be completed before the malls. The use of a border to conceal the joining of side wall and ceiling papers is optional. Where a wood molding is used, it should be removed before papering.

Application of Wallpaper.—If a fireplace wall is to be papered, the paper hanger should start with the centre strip over the fireplace. If there is no fireplace, the first strip usually is placed near the darkest doorway, where poor matching of the last strip will be least noticeable. Because door and window frames are seldom straight, it is necessary to establish a straight vertical guide line by means of a plumb line. This can be done by measuring along the wall from a door frame a distance 1 in. less than the width of the paper (17 in. for 18-in. paper). Near the ceiling, at this distance, a thumb tack is placed and from it is suspended a weighted string. Chalk is rubbed on the string, the string anchored at the bottom. Snapping the string leaves a true vertical chalk line on the wall.

All the strips of paper for one wall should be cut before any are applied. To get the length of the first strip, the distance from ceiling to baseboard should be found with a yardstick and 6 to 8 in. added. Before the next strip is cut, the marks saying "join here" must be matched, so that the pattern will be continuous. For large patterns, cutting from alternating rolls is sometimes economical. Strips should be cut for only one wall at a time and the strips kept in the order in which they were matched and cut.

Pasting is most conveniently done on a table from 6 to 8 ft. long and 2 ft. wide or on boards placed on a trestle. The pile of strips should be turned over so that all are wrong side up for pasting. Paste smears can be avoided if the edge of the wallpaper is lined up with the edge of the table. Paste should be applied on the bottom two-thirds of a strip, this end being then folded over itself, paste to paste, with 2 in. of pasted paper left exposed. Sides must be kept even. Paste then may be applied to the remaining one-third of the strip, 1 in. being left unpasted at the top. This end of the strip is also folded over itself, paste to paste, the 1 in. unpasted piece being lapped over the end of the first piece. Any selvages that have not been pretrimmed by the dealer must be trimmed off. Before hanging the first strip it is well to have all necessary tools within easy reach. Then, with

the I-in. unpasted end of the paper strip held in one hand, the last fold may be pulled apart and the top part applied to the wall, iined up carefully with the chalk line. If the strip is not straight, it may be pulled away and replaced. The smoothing brush is worked from top to bottom to remove any wrinkles. Then the bottom half is separated and the smoothing completed. With the back of a knife. a crease should be made along the door frame and at the ceiling and baseboard, the excess paper pulled away and cut off. Since butt joints look better than lapped edges, the edges of the strips should be made to meet but not overlap. A seam roller or caster may be used to smooth the joints.

Because corners in rooms are seldom true. special care needs to be taken at these locations. The last strip of paper at any corner should be cut ½ in. wider than the widest part—top or bottom. This ½ in. extends around the corner. The remaining width of this same strip is used on the adjoining wall after a vertical chalk line has been established to insure straight hanging. The edges will slightly overlap at the corner.

On washable paper, excess paste should be cleaned from each strip, with a sponge dipped in clear water, before the paste dries.

Since wall fixtures have been removed. paper may be hung over the openings and then cut, leaving the opening slightly smaller than the fixture. If a fixture cannot be removed, an X may be cut in the paper at the point where the fixture will he, the paper slipped over it and fitted around the edges. Space above and below windows can be cut and matched from leftover pieces.

See also WALLPAPER. (A. M. FI.; G. KA.)

PAPER MONEY: *see* ASSIGNATS; BANKING; BILL OF EXCHANGE; CHECK; CURRENCY; MONEY; PRICES, STATISTICS OF; QUANTITY THEORY OF MONEY.

PAPHLAGONIA, a district of Asia Minor, situated on the Euxine sea between Bithynia and Pontus, separated from Galatia by a prolongation to the east of tlie Bithynian Olympus. Although the Paphlagonians play scarcely any part in history. they were one of the most ancient nations of Asia Minor (*Iliad*, ii, 851). They were among the racer conquered by Croesus (Herod. i, 28), and they sent a contingent to the army of Xerxes in 480 B.C.

Paphlagonia passed under the Macedonian kings. and after the death of Alexander the Great it was assigned to Eumenes. It continued, however, to be governed by native princes until it was absorbed by the encroaching power of Pontus. The rulers of that dynasty became masters of the greater part of Paphlagonia as early as the reign of Mithridates III (302–266 B.C.), but it was not until that of Pharnaces I that Sinope fell into their hands (183 B.C.). From that time the whole province was incorporated with the kingdom of Pontus until the fall of the great Mithradates (*q.v.*) in 65 B.C. Pompey united the coast districts of Paphlagonia with the province of Bithynia. hut left the intrrior of the country under the native princes. until the dynasty became extinct and the whole country was incorporated in the Koman empire. All these rulers appear to have borne the name of Pylaemenes, as a token that they claimed descent from the chieftain of that name who figures in the *Iliad* as leader of the Paphlagonians.

Under the Roman empire Paphlagonia, with the greater part of Pontus, was united into one province with Bithynia.

Paphlagonia is a rugged mountainous country. but it contains fertile valleys and produces great abundance of fruit. The mountains are clothed with dense forests, conspicuous for the quantity of boxwood they furnish.

The coasts of Paphlagonia were from an early period occupied by Greek colonies. among which was the flourishing city of Sinope, founded from Miletus about 630 B.C. Large towns of the interior were Gangra, in ancient times the capital of the Paphlagonian kings, later called Germanicopolis, situated near the frontier of Galatia, and Pompeiopolis, in the valley of the Amnias (a tributary of the Halys), near which were extensive mines of the mineral called by Strabo *sandarake* ired sulfuret of arsenic), largely exported from Sinope.

See W. M. Ramsay, *Hist.* Grog. *of Asia Minor* (1890); *Cambridge* Ancient History, vol. iii (with useful bibliography).

PAPHOS, an ancient city and sanctuary on the west coast of Cyprus. The sanctuary and older town (Palaepaphos) lie at Kouklia. about 20 mi. W. of Limasol, about 1 mi. inland on the left bank of the Diorizo river (anc. Bocarus). New Paphos (Papho or Baffo), which had already superseded Old Paphos in Roman times. lies 10 mi. farther west, and 1 mi. S. of modern Ktima, at the other end of a fertile coast plain. I'aphos was believed to have been founded either by the Arcadian Agapenor, returning from the Trojan War (*c.* 1180 B.C.), or by his reputed contemporary Cinyras. whose clan retained royal privileges down to the Ptolemaic conquest of Cyprus in 295 B.C.. and held the Paphian priesthood until the Roman occupation in 58 B.C. The town certainly dates back to the close of the Bronze age (*c.* 1200 B.C.) and had a king Eteandros among the allies of Assur-bani-pal of Assyria in 663 B.C. In Hellenic times the kingdom of Paphos was second only to Salamis in extent and influence.

I'aphos owes its ancient fame to the cult of the "Paphian goddess." a nature worship like that of Phoenician Astarte. The Greeks identified both this and a similar cult at Ascalon with their own worship of Aphrodite (*q.v.*), and localized at Paphos the legend of her birth from the sea foam. accumulated there in masses on certain winds which also cause remarkable jets of spray. Her grave also was shonn in this city. She was worshipped, under the form of a conical stone. in an open-air sanctuary not unlike those of Mycenaean Greece, the general form of which is known froni late gcrns and Roman coins: its ground plan was discovered by excavations in 1888. It suffered repeatedly from earthquakes and was rebuilt more than once. In Roman times it consisted of an open court, with porticos and chambers on three sides, and a gateway through them on the east.

After the foundation of New I'aphos and the extinction of the Cinyrad and Ptolemaic dynasties. the importance of the old town declined rapidly. Though restored by Augustus and renamed Sebasté, after the great earthquake of 15 B.C., and visited in state by Titus before his Jewish War in A.D. 70, it was ruinous anti desolate by Jerome's time; but the prestige of its priest-kings partly lingers in the exceptional privileges of the patriarch of the Cypriote Church (*see* CYPRUS, CHURCH OF).

New Paphos became the administrative capital of the whole island in Ptolemaic and Roman days, as well as the head of one of the four Roman districts; it was also a flourishing commercial city famous for olive oil and for "diamonds" of medicinal power. In A.D. 960 it was attacked and destroyed by the Saracens. The site shows a Roman theatre, amphitheatre, temple and other ruins and rock tombs. part of the city wall, the moles of the Koman harbour and a ruined Greek cathedral. *See* also CYPRUS.

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PAPIAS, of Hierapolis in Phrygia, one of the "Apostolic Fathers" (*q.v.*). His *Exposition of the* Lord's *Oracles,* the prime early authority as to the Gospels of Matthew and Mark (*see* GOSPELS), is known only through fragments in later writers. chiefly Eusebius of Caesarea (H.E. iii. 39). The latter had a bias against Papias on account of the influence which his work had in perpetuating. through Irenaeus and others, belief in a millennial reign of Christ upon earth.

Eusebius calls him a man of small mental capacity. who took the figurative language of apostolic traditions for literal fact. This may have been so to some degree; but Papias (whose name itself denotes that he was of the native Phrygian stock, and who shared the enthusiastic religious temper characteristic of Phrygia, *see* MONTANISM) was nearer in spirit to the actual Christianity of the subapostolic age, especially in western Asia, than Eusebius realized. In Papias' circle the exceptional in connection with Christianity seemed quite normal. Hut if he n-as credulous of marvels, he was careful to insist on good evidence for what he accepted as Christ's own teaching. in the face of then current unauthorized views.

Papias was also a pioneer in the habit, later so general, of taking the work of the Six Days (*Hexaemeron*) and the account of Paradise as referring mystically to Christ and His church (so says Anastasius of Sinai).

About Papias' date, which is important in connection with his witness, there is some doubt. Setting aside the exploded tradition that he was martyred along with Polycarp (*c.* A.D. 155), there is the witness of Irenaeus that he was "a companion of Polycarp," who was born not later than A.D. 69. His other statement that Papias was "a hearer of John," may be waived because of the possibility of a false inference in this case. But the fact that Irenaeus thought of him as Polycarp's contemporary and "a man of the old time" (*archaios aner*), together with the affinity between the religious tendencies described in Papias' preface (as quoted by Eusebius) and those reflected in the Epistles of Polycarp and Ignatius, all point to his having flourished in the first quarter of the 2nd century. Indeed, Eusebius, who deals with him along with Clement and Ignatius (rather than Polycarp) under the reign of Trajan, and before referring at all to Hadrian's reign (A.D. 117–138), suggests that he wrote about A.D. 115. It has been usual, however, to assign to his work a date *c.* 130–140, or even later. So fact is known inconsistent with c. 60–135 as the period of Papias' life. Eusebius (iii, 36) calls him "bishop" of Hierapolis, but whether with good ground is uncertain.

Papias uses the term the Elders or Fathers of the Christian community, to describe the original witnesses to Christ's teaching! *i.e.*, His personal disciples in particular. It was their traditions as to the purport of that teaching which he was concerned to preserve. But to Irenaeus the term came to mean the primitive custodians of tradition derived from these, such as Papias and his contemporaries, whose traditions Papias committed to writing. So t a few such traditions Irenaeus has embodied in his work *Against Heresies*, so preserving in some cases the substance of Papias' *Exposition*. (*See* Lightfoot. *Apostolic Fathers, 1891*, for these, as for all texts bearing on Papias.)

See articles in the *Dict. of Christian Biog., Dict. of Christ nnd the Gospels*, and Herzog-Hauck's *Realencyklopädie*, xiv, in all of which further references will be found; also Lightfoot, Essays *on Supernatural Religion (1889)*.

PAPIER-MACHI? is repulped paper that has been mixed with glue or paste and is capable of being molded.

The art of making articles of papier-mâché, beautifully decorated in oriental motifs and handsomely lacquered, was known in the east centuries before its introduction in Europe. Molded paper products were first made in France in the early part of the 18th century, probably to utilize used paper and avoid complete waste of a costly material. Interest in papier-michi: spread to other countries and before the close of the century German and English manufacture rivaled French production in quantity and quality. Frederick the Great established a papier-mâché factory in Berlin in 1765.

Various paper materials came to be known as papier-michi:. By a process originating with Henry Clay of Birmingham, Eng.. in 1772, sheets of a specially prepared paper were covered with glue and then pasted together until a desired thickness of paper was reached. This material could be pressure-molded into a number of useful articles) notably trays and panels for furniture and coaches. It later provided the stock from which papier-mâché button blanks were stamped. Another type was ceramic papier-mâché, consisting of pulped paper mixed with glue, rosin, a drying oil and lead acetate: from it could be made such products as toys, picture frames, figurines and ornamental moldings. Still another type that served as a fine molding material was made by reducing dried paper pulp to powder and mixing it with paste and a small amount of potash.

Although the papier-mâché industry declined during and after the second half of the 19th century, the substance continued to have many uses. An application that remained important was the use of papier-mâché in matrices from which stereotype printing plates are cast. The paper mold, when curved in a casting device, produced curved plates that made printing from rotary presses practicable. Papier-michi: also continued to be used in the manufacture of toys, masks, model scenic materials and similar items.

(E. L. Y.)

PAPIN, DENIS (1647–*c.* 1712), French physicist, and inventor of a vessel which was the forerunner of the autoclave (*q.v.*), was born at Blois on Aug. *22, 1647*. Papin acted as assistant to Christiaan Huygens in his experiments with the air pump. Later he came to London and assisted Robert Boyle. He introduced a number of improvements in the air pump and invented the condensing pump. In *1679* he invented his "steam digester," a closed vessel with a tightly fitting lid in which water was heated. Because the steam was prevented from escaping, a high pressure was generated, causing the boiling point of the water to rise considerably. A safety valve guarded against excessive rise of pressure.

In *1684* Papin received from the Royal society an appointment as "temporary curator of experiments," with a small salary. In this capacity he carried on numerous and varied investigations in hydraulics (*Phil. Trans.*, 1685, etc.). In Nov. *1687* he was appointed to the chair of mathematics in the University of Marburg, and there he remained until *1696*, when he removed to Cassel. In 1705 G. W. Leibnitz sent him a sketch of Thomas Savery's engine for raising water, and this stimulated him to further work, which resulted two years afterward in the publication of the *Ars nova ad aquam ignis adminiculo efficacissime elevandam* (1707). In 1707 Papin returned to London where he died in obscurity, probably early in 1712.

Many of Papin's writings were collected by himself into a *Fasciculus dissertationzrm* (169*j*), of which he published also a translation into French, *Recueil de diverses pièces touchant quelques nouvelles machines* (1695). His correspondence with Leibnitz and Huygens, along with a biography by Ernst Gerland, was published as *Leibnizens und Huygens Briefwechsel mit Papin, nebst der Biographie Papins* (1881).

PAPINEAU, LOUIS JOSEPH (1786–1871), Canadian rebel and politician, son of Joseph Papineau, royal notary and member of the house of assembly of Lower Canada, was born at Montreal on Oct. 7, *1786*. He was educated at the seminary of Quebec, and was called to the bar of Lower Canada on May 19, 1810. On June *18, 1808*, he was elected a member of the house of assembly of the province of Lower Canada, for the county of Kent. In 181*j* he became speaker of the house, being already recognized as the leader of the French Canadian party. At this time there were many grievances in the country demanding redress, but each faction was more inclined to insist upon the exercise of its special rights than to fulfill its common responsibilities.

In Dec. 1820 Lord Dalhousie, at that time governor of Lower Canada, appointed Papineau a member of the executive council; but Papineau, finding himself without real influence on the council, resigned in Jan. *1823*. In that year he went to England to protest on behalf of the French Canadians against the projected union of Upper and Lower Canada, a mission in which he was successful. Nevertheless, his opposition to the government became more and more pronounced, till in 1827 Lord Dalhousie refused to confirm his appointment to the speakership, and resigned his governorship when the house persisted in its choice. The aim of the French Canadian opposition at this time was to obtain financial and also constitutional reforms. Matters came to a head when the legislative assembly of Lower Canada refused supplies and Papineau arranged for concerted action with William Lyon Mackenzie, the leader of the reform party in Upper Canada. In 1835 Lord Gosford, the new governor of Lower Canada, was instructed by the cabinet in London to inquire into the alleged grievances of the French Canadians. But the attitude of the opposition remained no less hostile than before, and in March *1837* the governor was authorized to reject the demand for constitutional reform and to apply public funds in his control to the purposes of government. In June a warning proclamation by the governor was answered by a series of violent speeches by Papineau, who in August was deprived of his commission in the militia.

Papineau had formerly professed a deep reverence for British institutions and had acquired a theoretical knowledge of the con-

stitution, but in his determination to apply the strict letter of the constitution he overlooked those elements and compensating forces and powers which through custom and usage had been incorporated in British institutions and had given them permanence. In his earlier career he had voiced the aspirations of a section of the people at a time when it appeared to them that their national existence was threatened. As party strife became more bitter, however, real issues were lost sight of and Papineau, falling in with the views of one O'Callaghan, who distrusted everything British, became an annexationist.

Realizing that his cause was not advanced by persuasive eloquence, he adopted a threatening attitude which caused many to waver in their allegiance. These he denounced as traitors, but a band of youthful enthusiasts encouraged their leader in his revolutionary course. The bishop of Montreal and of Quebec, and a large number of citizens, protested, but nothing less than bloodshed would satisfy the zealots.

On Oct. 23, 1837, a meeting attended by delegates from the six counties of Lower Canada was held at St. Charles, at which resistance to the government by force of arms was decided upon, and in which Papineau took part. In November preparations were made for a general stampede at hlontrcal, and on the 7th Papineau's house was sacked and a fight took place between the "constitutionals" and the "sons of liberty." Toward the middle of November Colonel Gore was instructed to arrest Papineau and his principal adherents on a charge of high treason. A few hundred armed men had assembled at Saint Denis to resist the troops, and on Nov. 22 hostilities occurred, lasting for several hours and resulting in a considerable number of casualties.

On the eve of the outbreak Papineau sought safety in flight, followed by other leaders of the movement. and on Dec. 1, 1837, a proclamation was issued. declaring Papineau a rebel and placing a price upon his head.

Papineau, mean hile, had found shelter in the United States where he remained in safety throughout the whole period of the fighting. The rebellion broke out again in the autumn of 1838, but it was soon repressed. Those who were taken in open rebellion were deported by Lord Durham in order to save them from the gallows and, although 90 were condemned to death, only 12 were actually executed.

Attempts were made to transfer the responsibility for the 1837 violence to O'Callaghan and other prominent leaders in the revolt, but Papineau's own words, "The patriots of this city would have avenged the massacre but they were so poor and so badly organized that they were not fit to meet the regular troops," indicate that he did not discountenance recourse to arms. It would seem also that Papineau may have been intriguing to bring about intervention by the United States, possibly with a view to annexation. Writing in 1848 about the events of 1837 he said: "The smallest success at Montreal or Toronto would have induced the American government, in spite of its president, to support the movement."

If Papineau's ambitions were indeed intervention and annexation, it would be inconsistent to regard his services to his fellow-countrymen as those of a true patriot since the independence of the French Canadians, which he professed to desire, could not have been achieved under the constitution of the United States.

In pursuing toward the end a policy of blind passion, Papineau overlooked real grievances and prevented action which might have remedied them. After the rebellion relief was accorded because the obstacle was removed. It appears evident that a broad-minded statesman or a skilfull diplomat would have accomplished more for French Canada than did the fiery eloquence and dubious methods of a leader who plunged his followers into the throes of armed rebellion and then, at the supreme moment, deserted them, fleeing first to the United States and then, in 1839, to France.

From 1839 till 1847 Papineau lived in Paris. In 1847 a general amnesty was granted; and. although in June 1838 Lord Durham had issued a proclamation threatening Papineau with death if he returned to Canada, he was now admitted to the benefit of the amnesty. On his return to Canada, when the two provinces were now united, he became a member of the lower house and continued to take part in public life, demanding "the independence of Canada, for the Canadians need never expect justice from England. and to submit to her would be an eternal disgrace." He unsuccessfully agitated for the redivision of Upper and Lower Canada, and in 1854 retired into private life. He died at Montebello, in the province of Quebec, on Sept. 24. 1871.

See L. O. David, *Les Deux Papineau;* Fennings Taylor. *Louis Joseph Papineau* (1865) ; Alfred De Celles. *Papineau-Cartier* (1906); *H.* J. Morgan, *Sketches of Celebrated Canadians* (1862); Rose's *Cyclopaedia of Canadian Biography Annual Register* (1836–37). Sir Spencer Walpole, *History of England* (5 vols., 1878–86), vol. k.

PAPINI, GIOVANNI (pseudonym GIANFALCO) (1881–1956), Italian writer and critic who helped to open Italian literature to foreign influences, was born in Florence. Jan. 9, 1881. He founded the reviews *Leonardo,* with G. Prezzolini (1903), and Lacerba, with A. Soffici (1913), and contributed to La *Voce.* Professedly an iconoclast. he demolished many established reputations in his books. *Crepuscolo* dei *filosofi* (1906) and *Stroncature* (1916). His autobiographical *Un uomo finito* (1912 ; Eng. trans., *A* Man—Finished, 1924), and his stories. *Il* Trngico *quotidiano* (1906) and *Parole* e *sangue* (1912), seem now uninteresting, and his poems. *Cento pagine* di *poesia* (1920) and *Pane e vino* (1926), mediocre, but his criticism has had lasting influence. An atheist, he was converted in 1919 and became a Roman Catholic, and his Storia di Cristo (1921, Eng. trans., *The* Story of *Christ,* 1923) achieved immense success. He died at Florence, July 7, 1956.

See G. Prezzolini, *Discorso su Giovanni Papini* (1915); *A.* Viviani, *Gian Falco* (1934). (F. DI.)

PAPINIAN (AEMILIUS PAPINIANUS) (*c.* A.D. 140–212), one of the last of the great Roman jurists, probably came from Emessa, Syr., and may have been a pupil of Q. Cervidius Scaevola. Having served under Marcus Aurelius, he became (203–205) *praefectus praetorio* under Septimius Severus. He was killed on the orders of Caracalla (*q.v.*) in the slaughter of supporters of Geta—according to legend, for his refusal to justify Caracalla's fratricide.

The greatest of the Severine jurists: Papinian's views show appreciation of the practical needs of life and lean to the equitable solution of problems. It is indeed the lofty moral tone of his views which explains Papinian's prestige in the Christian empire, for. in creative power. he does not really compare with the great earlier figures of Labeo and Julian.

His principal works were collections of cases—Quaestiones (37 books) and *Responsa* (19 books); but he also wrote *Definitiones* and monographs de *Adulteriis* and on aspects of municipal law. His style is precise and elegant. In the postclassical law schools, Papinian's authority was definitive: third-year students were styled *Papinianistae,* his *Responsa* being the basis of their studies. The Law of Citations (A.D. 426), regulating the forensic use of juristic literature, gave special prominence to Papinian's views.

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PAPIRIUS, LUCIUS (called CURSOR), Roman general. five times consul and twice dictator. In 325 B.C. he was appointed dictator to carry on the second Samnite War. After the disaster of the Caudine Forks (*q.v.;* 321 B.C.) Cursor to some extent wiped out the disgrace by compellirig Luceria (which had revolted) to surrender. In 309, when the Samnites again rose, Cursor was appointed dictator for the second time and gained a decisive victory at Longula. His son of the same name, also a distinguished general, completed the subjection of Samnium (272).

PAPPENHEIM, GOTTFRIED HEINRICH, GRAF ZU (1594–1632), field marshal of the Holy Roman empire, was born on May 29. 1594, at the little town of Pappenheim on the Altmühl, the seat of a free lordship of the empire. of an ancient family established there. He was educated at Altdorf and at Tübingen but abandoned the legal and diplomatic career on which he had embarked and took service first in Poland and then, at the outbreak of the Thirty Years' War. under the Catholic league.

Pappenheim displayed great courage at the battle of the White

hill near Prague (Nov. 8, 1620), where he was left for dead on the field. In the following year he fought against Mansfeld in western Germany. In 1623 he became colonel of a regiment of cuirassiers, afterward the famous "Pappenheimers." In the same year, as an ardent friend of Spain, the ally of his sovereign and the champion of his faith, he raised troops for the Italian war and served with the Spaniards in Lombardy and the Grisons. His long and heroic defense of the post of Riva on the Lake of Garda made his name. In 1626 Maximilian of Bavaria, the head of the league. recalled him to Germany to suppress an insurrection in Upper Austria. In a few weeks Pappenheim crushed the rebellion with ruthless severity (actions of Efferdingen, Gmunden, Vocklabruck and Wolfsegg, Nov. 15–30, 1626). After this he served with Tilly against Christian IV of Denmark, and besieged and took Wolfenbüttel (1627). His hope of obtaining the sovereignty and possessions of the evicted prince was, after a long intrigue. definitely disappointed. In 1628 he was made a count of the empire. The six-month siege of Magdeburg followed, and Pappenheim, like Tilly, had been accused of savage cruelty in the sack (May 1631). After the battle of Breitenfeld (*q.v.*), he covered the retreat of the imperialists from the field with care and skill and won glory by his operations on the lower Rhine and the Weser in rear of the victorious Swedish army. Being now a field marshal in the imperial service, he was recalled to join Wallenstein and assisted the generalissimo in Saxony against the Swedes; but was again dispatched toward Cologne and the lower Rhine. In his absence a great battle became imminent, and Pappenheim was hurriedly recalled. He appeared with his horsemen in the midst of the battle of Lutzen (Nov. 6–16, 1632). His furious attack was for the moment successful. But at about the same time as Gustavus was killed. Pappenheim also was mortally wounded. He died on Nov. 17 in the Pleissenburg at Leipzig.

PAPPUS OF ALEXANDRIA, Greek geometer, flourished about A.D. 320, as inferred from references to a solar eclipse in his commentary to Ptolemy's *Almagest.*

The great work of Pappus, written about A.D. 340, in eight books and entitled *Collection,* survives only in an incomplete form. the first book being lost, and the rest having suffered considerably. He also wrote commentaries on the *Analemma* of Diodorus, on Ptolemy's *Almagest,* on his *Planispherium* and *Harmonica,* and on Euclid's *Elements.* Citations from the commentary on the *Elements* are made by Proclus and others, while fragments of the portion relating to book x survive in the Arabic. Suidas also mentions geographical works.

The characteristics of Pappus's *Collection* are that it contains an account. systematically arranged, of the most important results obtained by his predecessors; and, secondly, notes explanatory of, or extending, previous discoveries. These discoveries form. in fact, a text upon which Pappus enlarges discursively. Very valuable are the systematic introductions to the various books, which set forth clearly in outline the contents and the general scope of the subjects to be treated. From these introductions we are able to judge of the style of Pappus's writing, which is excellent and even elegant the moment he is free from the shackles of mathematical terminology.

We can only conjecture that the lost book i, as well as book ii, was concerned with arithmetic, book iii being clearly introduced as beginning a new subject.

The whole of book ii (the former part of which is lost, the existing fragment beginning in the middle of the 14th proposition) related to a system of continued multiplication coupled with the expression of large numbers in terms of "tetrads" (powers of 10,000), due to Apollonius of Perga.

Book iii contains geometrical problems, plane and solid. It may be divided into five sections: (1) On the famous problem of finding two mean proportionals between two given lines. to which Hippocrates of Chios had reduced the problem of duplicating the cube. Pappus gives several solutions of this problem, including his own, and also a method of approximating continually to a solution, the significance of which he apparently failed to appreciate. (2) On the arithmetic, geometric and harmonic means between two straight lines, and the problem of representing all three in one and the same geometrical figure. This serves as an introduction to a general theory of means, of which Pappus distinguishes ten kinds with examples. (3) On a curious problem suggested by Euclid, i, 21. (4) On the inscribing of each of the five regular polyhedra in a sphere.

Of book iv the title and preface have been lost, so that its purpose has to be gathered from the book itself. At the beginning is the well-known generalization of Euclid. i, 47, then follow various theorems on the circle, leading up to the problem of the construction of a circle which shall circumscribe three given circles touching each other two and two. This and several other propositions on contact. *e.g.,* cases of circles touching one another and inscribed in the figure made of three semi-circles (and known as shoemaker's knife), form the first division of the book. Pappus turns then to a consideration of certain properties of Archimedes's spiral, the conchoid of Nicomedes, and the curve discovered by Hippias of Elis about 420 B.C., and known by the name quadratrix. Proposition 30 describes the construction of a curve of double curvature called by Pappus the helix on a sphere, a construction analogous to that of Archimedes's spiral in a plane. The area of the surface included between this curve and its base is found by the classical method of "exhaustion" equivalent to integration. The rest of the book treats of the trisection of any angle, and the solution of more general problems of the same kind by means of the quadratrix and spiral. In one solution of the former problem is the first recorded use of the property of a conic (a hyperbola) with reference to the focus and directrix.

In book v, after an interesting preface concerning regular polygons. and containing remarks upon the hexagonal form of the cells of honeycombs, Pappus addresses himself to the comparison of the areas of different plane figures which all have the same perimeter (following Zenodorus' treatise on this subject), and of the volumes of different solid figures which all have the same superficial area; and, lastly, a comparison of the five regular solids. Incidentally Pappus describes the 13 other polyhedra bounded by equilateral and equiangular but not similar polygons, discovered by Archimedes, and finds, by a method recalling that of Archimedes, the surface and volume of a sphere.

According to the preface, book vi is intended to resolve difficulties occurring in the so-called "Little Astronomy." It accordingly comments on the *Sphaerica* of Theodosius, the *Moving Sphere* of Autolycus, Theodosius's book *On Days and Nights,* the treatise of Aristarchus, *On the Sizes and Distances of the Sun and Moon,* and Euclid's *Optics* and *Phenomena.*

The preface of book vii explains the terms analysis and synthesis, and the distinction between theorem and problem. Pappus then enumerates works of Euclid, Apollonius, Aristaeus and Eratosthenes, 33 books in all, the scope of which he intends to describe, with the lemmas necessary for their elucidation. With the mention of the *Porisms* of Euclid we have an account of the relation of porism to theorem and problem. In the same preface are included (1) the famous problem known as "Pappus's Problem," which formed, so to say, the "text" of Descartes's *Géométrie;* (2) the theorems which were rediscovered by and named after Paul Guldin, but appear to have been discovered by Pappus himself. Book vii contains also (1), under the head of the *de determinata sectione* of Apollonius, lemmas which, closely examined, are seen to be cases of the involution of six points; (2) important lemmas on the *Porisms* of Euclid *(see* PORISMS); *(3)* a lemma upon the *Surface-Loci* of Euclid which gives a complete proof of the focus-directrix property of the three conic sections.

Lastly, book viii treats principally of mechanics, the properties of the centre of gravity, and some mechanical powers. Interspersed are some questions of pure geometry. Proposition 14 shows how to draw an ellipse through five given points.

Through an Arabic translation, made about A.D. 915 in Baghdad, a commentary of Pappus on the theory of irrational quantities, as presented in book x of Euclid's *Elements,* has come down to us. The main interest of the commentary consists in the great number of remarks about the historical development of the theory of irrationals from Theaetetus to Apollonius. From a purely mathematical viewpoint it must be said that Pappus nowhere goes beyond

an elaborate formal classification of irrational quantities.

As we know from book vi of the *Collection* Pappus was also interested in astronomy, which indeed was considered as part of "mathematics" in antiquity. It is certain that Pappus wrote a large commentary on at least the first six, perhaps on all 13 books of the *Almagest*. Preserved are only the commentaries to the lunar theory in books v and vi, the first of which was published in Basel (1538), both in a modern edition by A. Rome (1931). Again, the main importance of this work lies in its occasional historical references; the main text is an extremely pedantic exposition of Ptolemy's discussion, only rarely going beyond the obvious.

Of the *Collection* of Pappus the best edition is that of F. Hultsch, *Pappi Alexandrini collectionis quae supersunt* (1876–78). A French translation by P. Ver Eecke was published in 2 vol. (1933). Previously the entire *Collection* had been published only in the Latin translation (with commentary) by Commandinus (1588 *et seq.*). The commentary to Euclid x was published by G. Junge and W. Thomson, Arabic text with English translation and commentary (1930); the Greek text of the commentary to the *Almagest,* books v and vi, is given in vol. i of Rome, "Commentaires de Pappus et de Théon d'Alexandrie sur l'Almagest," *Studi e Testi,* vol. 54 (1931). The extensive introduction to the latter work also contains the determination of the date of Pappus.

See G. Loria, *Le scienze esatte nell' antica Grecia,* esp. pp. 656–703 (1914); T. L. Heath, *History of Greek Mathematics,* vol. ii, pp. 355–439. (T. L. H.; O. E. N.)

PAPUA, a name for the whole island of New Guinea, also used for British New Guinea, and known as Territory of Papua. *See* NEW GUINEA.

PAPUAN LANGUAGES are the languages spoken in New Guinea and in some islands mostly in its vicinity. They show a structure markedly different from that of the Malayo-Polynesian (*i.e.,* Indonesian, Micronesian, Melanesian and Polynesian) languages and of the Australian languages spoken by the indigenous population of Australia. The term "Papuan languages" is apt to mislead, because it gives the impression of the existence of a genetically related group of languages. In reality no facts are established which point to such a relationship. The languages designated by the term "Papuan" are all widely divergent in sound system, grammatical structure and vocabulary. Some of them have a highly developed verb system with elaborate distinctions for person and gender, others show in their noun system distinctions between singular, dual, trial and plural, structural traits which are absent in the Austronesian languages. In many Papuan languages the object precedes the verb. But all these and other traits, though present in some languages, may be absent from others and therefore cannot be used for a general characterization of the languages as a whole.

In certain regions of New Guinea the diversity of language is bewildering. Neighbouring tribes seem to speak quite unrelated languages. Nevertheless, hasty conclusions must be avoided. It must be taken into account that—as is known in other parts of the world—this impression of diversity often diminishes or even disappears when language research progresses.

This does not mean, however, that no genetic relations at all between the Papuan languages have been established. In some regions in New Guinea the Papuan languages are found to be very similar in structure (*e.g.,* in the so-called western and eastern highlands); on north Halmahera it seems preferable, according to H. Van der Veen, to distinguish between different dialects rather than between different languages. In the 1950s further attempts were made to connect the north Halmahera dialects with some of the Papuan languages of the Vogelkop peninsula to the southeast (H. K. J. Cowan, 1957).

Scientific knowledge of the Papuan languages is generally very slight. It has not even been possible to determine their number and their exact location, but it may be safely assumed that they number about 300. This lack of knowledge is caused in the first place by the inaccessibility of the interior of New Guinea. With several tribes the first contacts were not made until after World War II. Extensive parts of the interior still remained completely unknown by the 1960s. The number of linguists who have done fieldwork in New Guinea is exceedingly small. Most of the linguistic data are collected by missionaries, and for many languages translations of parts of the Bible or other religious literature form the only sources of information. Often these are not printed, but are only available in manuscript form. Only after World War II was linguistic research somewhat intensified.

GEOGRAPHICAL DISTRIBUTION

Papuan languages are spoken: (1) in the interior of Portuguese Timor and on a few islands in its vicinity (Kisar, Alor); (2) in the northern part of Halmahera (in south Halmahera, Austronesian languages are spoken); (3) in the whole interior of New Guinea from west to east, as far as Goodenough bay and Orangerie bay, and also in many places on the coast; (4) in New Britain and New Ireland (Melanesian languages are also spoken there); (5) on some of the Solomon Islands (Bougainville and the western Solomons.

1. Timor.—On Timor and adjacent islands the following Papuan languages may be distinguished. In the interior of Timor: Makasai, Bunak, Waimaha and Kairui; on Kisar: Oirata; on Alor: no generally accepted name.

2. North Halmahera.—According to Van der Veen (1915), ten clearly related dialects are spoken on north Halmahera: Galela, Tobelo, Tobelo-Boëng, Tobelo-Dodinga, Modole, Tabaru, Sahu, Loda, Ternate, Tidore.

3. New Guinea.—In the present state of knowledge it is impossible to give a complete and reliable list of the languages spoken in New Guinea. Many languages are still completely unknown. The existing surveys do not mention the same languages, and moreover the same language is often called by different names.

Netherlands New Guinea. Of the 48 languages mentioned by A. Capell (1954), only the following are more or less known by short grammars and word lists or both: Ayamaru, near Lake Ayamaru in the interior of the Vogelkop peninsula; Mansibaber, on the east side of the Vogelkop peninsula; Sentani, in the north near Lake Sentani, which is near Hollandia; Marind, on the southeast coast near Merauke; Riantana; Ndom; Kimaghama (these last three being spoken on Frederik Hendrik Island); Awju, southwest of Tanahmerah and on the upper Mapi river; Kamoro, on the Mimika river; Ekari, near Lake Paniai and Lake Tigi; Moni, east of Lake Paniai.

Australian New Guinea. In the mandated territory, of the 93 languages listed by Capell (1954), only the following have become more or less known: Arapesh on the north coast west of the Sepik river; Monumba and Ngaimbon on the north coast east of the Sepik river; Garus and Nobonob, also on the north coast north of Madang; Bongu on the north coast south of Madang; Kate, near Finschhafen; Ono, in the Kalasa district.

In Papua, of the 100 languages mentioned by Capell (1954), only the following have been studied: Kiwai, spoken on Daru Island, on the coast opposite this island and on the Fly river delta; Gogodala, on the Fly river opposite Madiri; Kerewa, in the southern part of the Kikori delta; Namau or Koriki, around Maipua, Purari river delta; Orokolo, on the south coast east of Maipua; Toaripi, on the south coast near the mouth of the Lakekamu river; Fuyuge or Mafulu, near Mafulu, Wharton range, central division; Binandere in the region of the Gira and the Mamba rivers.

4. New Britain and New Ireland.—Of the six to eight Papuan languages spoken on New Britain (according to Capell: Baining, Taulil, Gaktai, Sulka, Tumuip, Idue and perhaps Bau and Maseki) only Baining is fairly well known. On New Ireland the only Papuan language is Panaras.

5. Solomons.—Of the 13 Papuan languages, 9 are spoken on Bougainville. The remaining four are spoken on Vella Lavella Island southeast of Bougainville, on Renonga, an island south of New Georgia and on a few small islands northwest of Guadalcanal (Russell Islands and Savo). Of these languages Rugara and Nasioi on Bougainville and Bilua on Vella Lavella Island are fairly well known.

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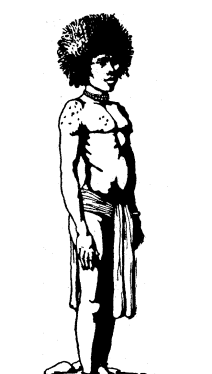
(E. M. U.)

PAPUANS (Malay *papúwah* or *puwah-puwah*, "frizzled," "woolly-haired," in reference to their characteristic hair-dressing), the name given to the people of New Guinea and the other islands of Melanesia. The pure Papuan is found in most parts of New Guinea and is an element in Melanesia. Papuan elements formerly existed in Australia, and the Tasmanian race may be akin to the Papuan. The typical Papuan is woolly haired, long headed, dark skinned, broad nosed. The nose is often prominent and convex.

Their culture is very diverse, and in parts has been affected by contact with other peoples. Modem research (Armstrong and Laudtman) has added much to our knowledge of the Papuans, and further investigations are being undertaken from Australia, which controls the area by mandate.

Social Order.—Custom regulates the duties in life, but where cases of doubt or difficulty arise, the old men—with more of social importance and individuality—discuss and decide the issue. Here and there are chiefs, or head men, and patrilineal succession is found in certain districts. The exogamic clans are local groups, totemic, and generally patrilineal, though kinship systems are "classifactory." Marriages are often regulated more by kinship, reckoned by genealogical methods, than by clanship. Exchange marriages are frequent. In Rossel Island—a mixed culture—a class system in decay was found by Armstrong. Once naked and unashamed, the people often suffer now from extreme prudishness. Polygamy was once prevalent. The initiation rites included lessons in morals. Prenuptial chastity was rare. Individual ownership of land was recognized. Children generally divided their father's property equally, but bequests (verbal) were respected.



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A PAPUAN NATIVE OF DUTCH NEW GUINEA

Magical practices were common, but the training of a magician was unpleasant and rigorous, the methods employed being of the ordinary type. (*See* MAGIC: *Primitive.*) Ceremonies—of a magico-religious nature—were performed in connection with fishing and cultivation, close connection between sexual activity and agricultural success finding expression in rites of a peculiar nature.

There is a belief in a class of powerful beings, most of which are mischievous but stupid, though some are good. Beliefs are vague. That of transmigration into animals has been recorded. Another is that the soul leaves the body at death and goes to an unknown island in the west. Some return and even marry mortals. Various forms of divination were employed. Spirits appeared in dreams; hero cults are recorded and of the Western Islands it is stated that they "had no deities or conception of a Supreme God." Ancestors are believed to control the food supply, and if customs are broken, withhold their favour.

Products.—Yams, taro and sweet potatoes constitute in some districts the main food of the people, while in others sago is the staple diet. Forest fruits and vegetables are also eaten. Maize and rice—which are not indigenous—are eagerly sought after. The Papuan varies his vegetable diet with the flesh of the wild pig, wallabi and other small animals. which are hunted with dogs. Birds are snared or limed. Fish abound at many parts of the coast, and are taken by lines, or speared at night by torch-light, or netted, or a river is dammed and the fish stupefied with the root of a milletia. Turtle and dugong are caught The kima, a great mussel weighing (without shell) **20** to **30** lb., and other shell-fish, are eaten, as are also dogs. flying foxes, lizards, beetles and all kinds of insects. Food is cooked in various ways. Cooking-pots, made at various parts of the coast, form one of the great exchanges for sago; but where such vessels do not reach, food is cooked by the women on the embers, done up in leaves, or in holes in the ground over heated stones. The sexes eat apart. In the interior salt is difficult to get, and sea-water, which is carried inland in hollow bamboos, is used in cooking in place of it. Salt, too, is obtained from the ashes of wood saturated by sea-water. In the Fly river region, kava, prepared from *Piper latifolium* or *P. methysticum,* is drunk without any of the ceremonial importance associated with it in Polynesia. As a rule the Papuans have no intoxicating drink and do not know the art of fermenting palm-sap or cane-juice. Tobacco is indigenous in some parts and is smoked everywhere, except on the northeast coast and on the islands.

Clothing and **Ornaments.**—The Papuan's chief home-made ornaments are necklaces, armlets and ear-rings of shells, teeth or fibre, and cassowary, cockatoo. or bird of paradise feathers—the last two, or a flower, are worn through the septum of the nose. With his head encircled by a coronet of dogs' teeth, and covered with a network cap or piece of bark-cloth, the septum of the nose transfixed by a pencil of bone or shell, and perhaps a shell or fibre armlet or two, the Papuan is in complete everyday attire. On festal occasions he decks his well-forked-out and dyed hair with feathers and flowers, and sticks others in his ear-lobe holes and under his armlets; while a warrior will have *ovula* shells and various bones of his victims dangling from ringlets of his hair, or fixed to his armbands or girdle. The Papuan comb is a long piece of bamboo split at one end into prongs, while the other projects beyond the forehead sometimes two feet or more, and into it are stuck the bright feathers of parrots and other birds. The fairer tribes at the east end tattoo. Men are not tattooed till they have killed some one. Raised cicatrices usually take the place of tattooing with the darker races.

The Papuans build excellent canoes and other boats, and in some districts there are professional boat-builders of great skill, though in others this is now a lost art. These boats are either plain dug-outs, with or without outriggers, or regularly built by planks tightly laced and well caulked to an excavated keel. The "lakatoi" is composed of several capacious dug-outs, each nearly 50 ft. long. which are strongly lashed together to a width of some 24 ft., decked and fitted with two masts, each carrying a huge mat sail picturesquely fashioned. On the deck high crates are built for the reception of pottery for conveyance annually to the Fly River district to exchange for sago.

Papuans use Pan-pipes, a Jew's harp of the Papuans' own fabrication, and the flute; on occasions of ceremony the drum only is used—this instrument being always open at one end and tapped by the fingers. To the accompaniment of the drum, dancing almost invariably goes, but rarely singing. All sorts of jingling sounds also are music to the ear, especially the clattering in time of strings of beans in their dry shells.

Nearly all Papuan houses are built on piles, and this not only on the coast but on the hillsides. In the north, the east and south-west of the island immense communal houses (*morong*) are met with. Some of these are between 500 and **700** ft. in length, with a rounded, boat-shaped roof thatched with palm-branches, and

looking inside, when undivided, like dark tunnels. In some districts the natives live together in one of these giant structures, which are divided into compartments. As a rule elsewhere each family has its independent dwelling. On the north coast the houses are not built on piles; the walls, of bamboo or palm branches, are very low, and the projecting roof nearly reaches the ground; a barrier at the entrance keeps out pigs and dogs. A sort of table or bench stands outside, used by the men only, for meals and for the subsequent siesta. In east New Guinea sometimes the houses are two-storied, the lower part being used for stores. The ordinary house is 60 to 70 ft. long, with a passage down the centre, and stands on a platform or veranda raised on piles, with the ridge pole projecting considerably at the gables so that the roof may cover it at each end. Inland villages are often situated on hills or on top of steep-faced rocks as difficult of access as possible, whence a clear view all round can be had, or the village is protected by high palisades and by fighting platforms on trees commanding its approaches. The "dobbos" are tree houses, built in high trees.

On the northeast coast many of the villages are tastefully kept, their whole area being clean swept, nicely sanded and planted with ornamental shrubs, and have in their centre little square palaver places laid with flat stones, each with an erect stone pillar as a back rest. Excellent suspension bridges span some of the larger rivers.

Weapons and Tools.—Papuan weapons are the bow and arrow (in the Fly river region. the north and northeast coasts); a knife of a sharp segment of bamboo; a shafted stone club—rayed, disk-shaped or ball-headed (in use all over the island); spears of various forms, pointed and barbed; the spear thrower (on the Finsch coast); and hardwood clubs and shields, widely differing in pattern and ornamentation with the district of their manufacture. The Papuan bow is rather short, the arrows barbed and tipped with cassowary or human bone. The Papuans were mostly ignorant of iron, but work skillfully with axes of stone or tridacna shell and bone chisels, cutting down trees 20 in. in diameter. Two men working on a tree trunk, one making a cut with the adze lengthwise and the other chopping off the piece across, will soon hollow out a large canoe. Every man has a stone axe, each village generally owning a large one. Their knives are of bamboo hardened by fire. In digging they use the pointed stick. In British New Guinea alone is the man catcher (a rattan loop at the end of a handle with a pith spike projecting into it) met with.

For war the men smear themselves in grotesque fashion with lime or ochres, and in some parts hold in their teeth against the chin a facelike mask, supposed to strike terror into the foe, against whom they advance warily (if not timidly), yelling and blowing their war trumpets. The war canoe (which is a long, narrow dug-out outrigger, capable of holding 28 men) is only a transport, for they never fight in it. The conch shell is the trumpet of alarm and call to arms.

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PAPYROLOGY. The care, reading and interpretation of the papyri from Egypt is the science of papyrology. Included in this study also are writings upon other materials, such as potsherds, parchments, wooden and waxed tablets and stone, whether in the classical languages or in Egyptian demotic. The paleographical and technical skills of scholars trained in this area have also been directed toward similar documents found elsewhere in the Greco-Roman world.

It was a revelation to classical scholars when, in the 19th century, Greek and occasionally Latin texts of every sort began to emerge in vast quantities from the dry sands along the Nile. Whether as individual papyrus sheets, as rolls or as booklike codices. they afforded a wealth of new information about the literature and the civilization of Greece and Rome and especially about the Egypt of Hellenistic and Roman times.

Discovery of Papyri.—Egypt.—The first papyrus roll to be brought to Europe was the so-called Charta Borgiana now in Naples. This account of compulsory labour upon an irrigation project in A.D. 192 was bought by a merchant in 1778; it is said that the villagers burned others when he would not buy them. In the 19th century, indifference gave way to a keen interest, as scholars realized the importance of the material. Papyri in varying states of disrepair were found by peasants in mounds at the desert's edge, sites of ancient settlements. The papyri were found in rubbish heaps, tombs and houses in those parts of Egypt where there is little or no rain and occasionally in charred condition in lower Egypt also; they were bought eagerly by dealers. Important groups of documents came from Memphis and Sakkara, a large fragment of Homer from Aswan, and a substantial manuscript of the little-known Attic orator Hypereides from Thebes. The ancient Arsinoe (Medinet el-Fayum. southwest of Cairo) yielded an enormous mass of papyri, partly in Arabic, which were bought by the Austrian archduke Rainer and taken to Vienna.

After the Egyptologist Sir Flinders Petrie began to find Greek papyri in his excavations at Gurob (1889–90), the systematic search for them was undertaken by the Egypt Exploration fund, and the English papyrologists B. P. Grenfell and A. S. Hunt excavated many sites. At Tebtunis (southern Fayum) a cemetery of sacred crocodiles yielded wrappings made from used papyrus documents of the Hellenistic period; 13 seasons of digging at Oxyrhynchus in middle Egypt (1896–1909) brought to light thousands of texts including large numbers of previously unknown literary works. This example was followed by scholars of other nationalities, French, German, Italian and American. Excavations have been undertaken by the University of Michigan in the northern Fayum and by Achile Vogliano at Tebtunis and the near-by Medinet Madi. After 1920, a Société Egyptienne was established for the purchase of papyri, and the government has taken active steps to prevent loss or damage of papyri found accidentally or in clandestine excavations.

Near East.—Finds in the near east also have been significant. A jar found by a peasant at Avroman (Kurdistan) about 1909 contained parchments of the Parthian period, three of which were preserved. All are contracts, two in Greek, one in Middle Persian (Pahlavi). At Dura-Europos on the middle Euphrates, systematic excavations between 1921 and 1936 of the French academy and Yale university revealed 155 documents, a few literary, the rest either legal papers or records of a Roman military unit. At Hafir al-Auja (Nessana) in southern Palestine, in a desert region, the ruins of two churches excavated in 1937 by the H. D. Colt expedition recovered nearly 200 literary and nonliterary papyri of the Byzantine period. After World War II, sensational discoveries of parchments and papyri were made first by Bedouins and then by archaeologists in caves west of the Dead sea, in the Wadi Qumran and the Wadi Murabbaat. See DEAD SEA SCROLLS.

Mediterranean.—A certain number of papyri have survived from antiquity in libraries. Some of these are literary; others, like the "Ravenna papyri," are high documents of church or state. Herculaneum (Campania) has yielded charred rolls of literary papyri. A find of 45 wooden tablets, sealed in a jar, containing business documents was made by peasants in 1928 at an unknown location on the frontier between Tunisia and Algeria.

Study—Collections.—The largest collection of papyri is that of the archduke Rainer in Vienna, amounting to well over 100,000 pieces, half of them in Arabic. Probably second in size is that of the Egyptian museum in Cairo, with those of the Berlin museum, the British museum and the Universities of Oxford and Michigan following in that order. Notable collections exist also in Florence and Milan in Italy, Heidelberg in Germany, Strasbourg and Paris in France, Manchester in England and at Yale, Columbia and Princeton'universities in the United States. In addition, there are many smaller groups of texts in private and public collections throughout the western world.

Handling.—Papyri present special problems of cleaning and decipherment. They are normally found dirty, crumpled, stuck together, ragged and full of holes. Charred papyri present particular difficulties. Hugo Ibscher of Berlin became an expert in opening,

arranging and cleaning them, and his methods are followed by scholars and museum personnel. The papyri must be humidified, separated, sorted and mashed with great care, and then stored between sheets of blotting paper, glass or cellophane. Reading is done with magnifying glass and a mirror to concentrate light upon the text. and is often aided by infrared photography. See further publications of Friedrich Preisigke in bibliography below.

Publication — There is a generally uniform method of publication of papyri which greatly facilitates research. The pattern. as first established by Grenfell and Hunt, consists of: (1) description of a papyrus, its date and hand and general interest and importance; (2) text and translation; (3) commentary. Publications of papyri are designated by the name of the collection (place of finding. the editor or other distinguishing feature) and accepted abbreviations are standard. Well in excess of 30,000 documents of all sorts have been published, less than 20% of those known to exist.

Literary Texts. — More than 2,500 manuscripts of Greek and Roman literary works, principally papyri, are on record. These vary from tiny scraps to large rolls or codices and range in date from the 4th century B.C. to the 8th century A.D. Somewhat more than half belong to texts known previously through medieval manuscripts; their importance consists in the light they throw upon the history of these texts and upon the literacy of Greco-Roman Egypt Homer's Iliad is much the most frequent, with the Odyssey second. Demosthenes, Euripides, Hesiod, Isocrates. Plato, Thucydides, Aeschylus and Xenophon follow in that order, with many known Greek authors represented by at least one papyrus. In general, Egypt read the authors uhose survival through the middle ages mas due, in the main, to their ancient popularity. The papyrus texts of these works, however, have proved discouraging to modern criticism, since they show that medieval manuscripts do not represent a single ancient tradition.

About 45% of the literary papyri remain unidentified and are classed only as epic, comedy, history or the like. Others belong to authors or to norks which did not survive the middle ages. and their discovery has been sensational. Perhaps the most important single find was that of the Constitution *of Athens* by Aristotle, acquired in 1890 by the British museum through the agency of John Alexander, an American missionary teacher in Asyut, a discovery of first importance to Athenian constitutional history. Of less, but still great importance, was the discovery about the same time, of extensive remains of four orations of Hypereides. In history, the most important find was that of the *Hellenica* (at Oxyrhynchus) by an unknown historian of the 4th century B.C., describing events of the beginning of that century; the most tantalizing is the fragment of a history of his own reign by King Ptolemy III Euergetes. In philosophy, there are a treatise of Epicurus On Exile and a number of tracts by the Epicurean writer Philodemus (from Herculaneum). Drama is represented by many extensive fragments of previously unknown plays by the great masters, including a satyr play, Ichneutai, by Sophocles; there are several incomplete plays of Menander and one practically complete, *Dyscolus;* numerous finds of poetic texts, Archilochus, Alcman, Sappho, Alcaeus, Hipponax, Bacchylides, Pindar, Corinna, Timotheus. Herodas and Callimachus, are only the most notable of those poets who have become known, or better known, through papyri.

Latin papyri are in general much rarer than Greek, so Latin literature has benefited less in this way. Among a number of manuscripts of known authors special interest attaches to a text of Virgil from Nessana with a word-by-word translation into Greek; this is of the 6th century A.D.

Popular *Literature,* Science and Magic. — There is also a large number of semiliterary texts, ranging from the collection of his onn poems by the 6th-century amateur Dioscorus to crudely written religious talismans and magical spells. Also noteworthy are aorks of literary criticisms, grammars and commentaries on classical writers, and the Acts *of* the Pagan *Martyrs,* accounts of trials of notables of Alexandria before various Roman emperors, as well as a complete school book (3rd century B.C). In science, medicine is best represented, but manuscripts dealing with chemistry, mathematics, astronomy, botany, zoology and even cooking, are not uncommon.

Biblical *Manuscripts.*—Papyrology has contributed remarkably to knowledge of the Bible. Finds both in Egypt and at the Wadi Qumran provide evidence for the Hebrew Old Testament and of its translation into Greek, back to the 2nd century B.C., before the establishment of the Masoretic text; and they support in some degree the theory that the standard Greek translation, the Septuagint, was only one of several such translations in existence at that time. A fragment of the Gospel of John belongs to about A.D. 125 and shows that that work was composed at least as early as the end of the 1st century A.D. Seven Biblical papyri belong certainly to the next century, and nearly 20 more to the 3rd. There are 66 such manuscripts known from Egypt, and the Dead sea documents have added many more.

Judaism and Christianity. — The caves of the Wadi Qumran have supplied numerous sacred writings of an Essene community of Jews of about A.D. 70, and the caves of the Wadi Murabbaat have yielded texts of a more orthodox sort from the time of the Bar-Cochba rebellion 65 years later. These manuscripts are preserved and studied in Jerusalem in the Palestine museum and the Hebrew university. Egyptian papyri have brought to light many Greek texts of the early Church together with Coptic manuscripts of Gnosticism and Manichaeism. Notable are two fragments of the Sayings *of* Jesus from Oxyrhynchus in a papyrus of the 2nd or 3rd century, which may go back to a tradition prior to the four canonical Gospels. Several apocryphal gospels have appeared, including one of unknown name dating about A.D. 150 which is an abbreviated synopsis of the four. A Greek fragment of Tatian's Diatessaron was found at Dura. In the patristic field, two major works of Origen, part of the Against Celsus and a new text, Conversations *with* Heracleides, were found in 1941 in the Tura caves near Cairo. Information about the great persecution under the emperor Decius, about A.D. 250, is given by the nearly 50 certificates of pagan sacrifice found in the Fayum and at Oxyrhynchus; apparently inhabitants of Egypt, in one case even a priestess of the crocodile god Petesuchos, were required to sacrifice so as to prove that they were not Christians.

Nonliterary Texts. — These texts include a great variety of documents. From Egypt there are papyri and ostraca (shards); from Nessana, papyri; from Avroman and Dura, parchments and papyri; from Pompeii and Tunisia, waxed and wooden tablets. The contents are short texts, tax receipts, accounts, letters and contracts. Parchments and papyri, whether as single sheets or as rolls, were adapted to every sort of writing, public or private. Laws. decrees, official correspondence, records and returns, contracts, accounts, memoranda and private letters including such specialized types as questions to an oracle or invitations to dinner are all represented. They provide the historian with an inexhaustible source of material, the most valuable of which comes in the form of great archives reflecting the activity of an individual: Zenon of Caunus at Philadelphia in the Fayum in the 3rd century B.C.; the Macedonian Ptolemaeus, a recluse in the Serapeum at Memphis in the 2nd century, B.C.; and Aurelius Isidorus at Karanis in the Fayum in the time of Diocletian and Constantine. Similar, smaller archives exist, often scattered widely and many papyri are isolated.

History. — These texts tend to reflect history rather than to record it, but they supplement and amplify knowledge in many ways. Little would be known of the internal history of Egypt under the Macedonians and Romans, of Dura under the Parthians and Romans, and of Nessana under the Byzantines and Arabs without them, and it is certain that the history of the Bar-Cochba rebellion must be rewritten in the light of the texts from the Wadi Murabbaat. The most specific contribution of the texts is in the field of chronology. A Dura parchment, for example, shows that the Parthians did not occupy that city until after 116 B.C., and the Karanis papyri show that the usurper Domitius Domitianus was recognized as emperor in Egypt between Aug, and Nov., A.D. 296. Two papyri of the Zeno archive from the winter and spring of 253–252 B.C. report the journey of the princess Berenice to Syria to marry King Antiochus II, ending the Second Syrian War. More

importantly, the texts throw light on the careers and personalities of such prominent persons as Tiberius Julius Alexander, Philo's nephew, governor of Egypt and a supporter of the future emperor Vespasian. Two edicts of Germanicus and a letter of Claudius to Alexandria are important additions to historical knowledge. Late papyri give nelcome information on the policies of Egypt's rulers after the Arab conquest.

Political *Institutions.*—The papyri have given a vivid and detailed picture of the administration of Egypt under the Macedonians, Romans and early Arab caliphs; the emphasis at all periods remains the same: finance. Already under the pharaohs, Egypt was famed as the land of a highly organized central bureaucracy managing a society divided into strict castes; and Ptolemaic kings, Roman emperors and Moslem conquerors continued the system with few changes. The economy was based on registry and control of labour and a detailed land survey. Each year the sowing was performed after the inundation according to a vast plan originated in the villages, consolidated in the provinces and approved in the capital, Alexandria. The operation was closely supervised by special officials, who, as their instructions went, were to see that the plan was meticulously followed, but at the same time abuses were to be checked and everyone kept in good humour. A decree of Ptolemy II protected the native population of Palestine from private exploitation and required the registration of cattle. The great revenue laws papyrus of the same king lays down in minute detail the operation of industry under a government monopoly and another law protected the Nile transport system from piracy and malfeasance. Dikes and canals were maintained by compulsory labour. Periodic royal indulgences promised better conditions for the taxpayers. Nevertheless, taxes were piled upon taxes. especially under the Romans, who added a census, a poll tax and a central land registry. Service in the army and police was a hereditary obligation, and only the few cities enjoyed some administrative autonomy. In the later empire, new cities were created and required to assume responsibility for imperial taxation, a crushing burden on the propertied classes.

Law.—Administrative law in Ptolemaic Egypt is well known from the type of documents mentioned in the preceding section, but the civil and criminal codes in the Hellenistic world can be recovered only from the practice appearing in the documents Royal courts existed in Egypt and at Dura. deciding private suits and complaints according to instructions issued by the king. In Egypt, at least, access to these courts was through a petition addressed to the king, but handled at the level of the provincial governor. The law of contracts, on the other hand, was based on customary usage depending in part on the status of the contracting parties. Greeks and Egyptians remained separate, at least in theory, and the practices of the former were affected by the city to which they belonged, in Egypt or perhaps elsewhere. Status, that is, was personal. Procedures were adopted, nevertheless, to make possible desired commercial relationships, and something like general legal practice was worked out so that contracts would be valid everywhere. These contracts testify to a wide variety of transactions: sale and mortgage, rent and lease, loan and deposit. service and apprenticeship, as well as the personal relationships, marriage, divorce, testamentary disposition and adoption. Considerable interaction occurred between Greek and oriental practices. With the Roman conquest, this Hellenistic *jus* gentium encountered an already highly developed Roman *jus civile,* and under the Roman administration there were legal documents of the first importance, a gnomon or manual of the administrator of the privy purse, extracts from the civil law of Alexandria, decisions of the emperor Septimius Severus and a fragmentary text of the decree of Caracalla extending citizenship to all the inhahitants of the empire (A.D. 212). Fragments of Gaius and Ulpian show that the Roman jurists were studied in Egypt. Jurisdiction was under the provincial governor who presumably issued a provincial edict for the guidance of all concerned. Local issues were settled by delegation to civil and. military officials.

Culture.—In Egypt and, in a small way, at Dura, the documents throw light on Hellenistic demographic and cultural phenomena, the spread of culture into the near east, following the conquests of Alexander the Great. They reveal who were the Greeks migrating into the new areas, uhere they settled and their way of life, their relations with the natives; and in reverse, how life in the orient was affected by the newcomers. There is no doubt that, following Alexander's lead, many Iranians, Babylonians, Aramaeans and Egyptians continued to play a large part in government. business and society. while learning Greek and Greek ways. A letter of the Zeno archive preserves the complaint of a Semite who charges discrimination "because I cannot pass as a Greek." On the other hand, many Greeks married native women and generations of mixed blood followed the pioneers. This process can be traced through personal names. The immigrants worshiped native deities, sometimes calling them by Greek names. but were not readily admitted into the local priesthood. All worshiped the official gods as well as the kings of the ruling dynasties. a practice continued in the deification of the Roman emperors. The blend of Greek rationalism and oriental mysticism produced the great world religions of the empire: Mithraism, the worship of Isis and Osiris and Christianity. A similar blend appears in economic life also. although the social pattern, including such things as the family, entertainment, clubs, education, dress and food, remains largely Greek. Trade and commerce, banking and finance, may be followed in detail. Prices are preserved frequently enough to make possible some economic statistics.

Language.—The documents provide an immense fund of material for tracing the development of popular Greek over 1.000 years. The same is true to a lesser extent of Latin and the Oriental languages. In general, wide literacy, based upon a system of public and private schools, is attested by the numerous finds of literary papyri, especially at Oxyrhynchus, and this served as a brake upon the tendency of the spoken language to change too rapidly, especially in a multilingual society. The process which transformed ancient Greek into modern Greek was well under way in this period. Some personal letters of the later Roman period, for example. are hardly intelligible in terms of classical Greek. This Hellenistic Greek has been profitably used in the interpretation of the New Testament.

In the field of paleography, the papyri illustrate the development and history of both cursive writing and book hand, as well as a system of punctuation. Accents appeared in manuscripts of Greek authors. occasionally as early as the 2nd century A.D. The codex or book appeared as a successor to the roll at about the same time, and was used at first only for Christian texts. Parchment was used for books which were originally made up of papyrus quires, in late antiquity and became the normal material for such purposes in the middle ages.

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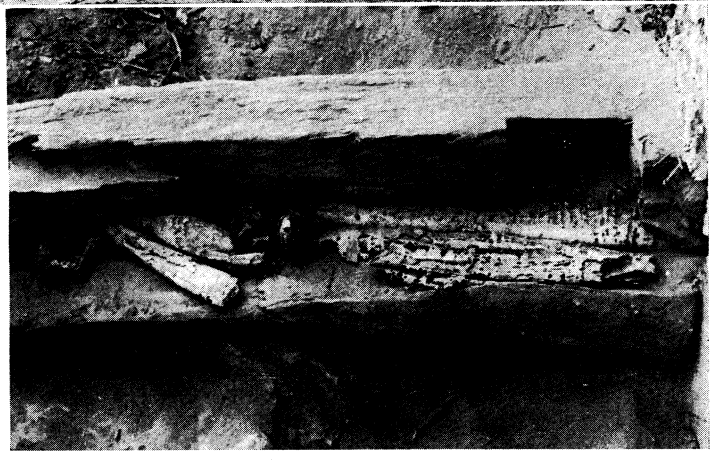
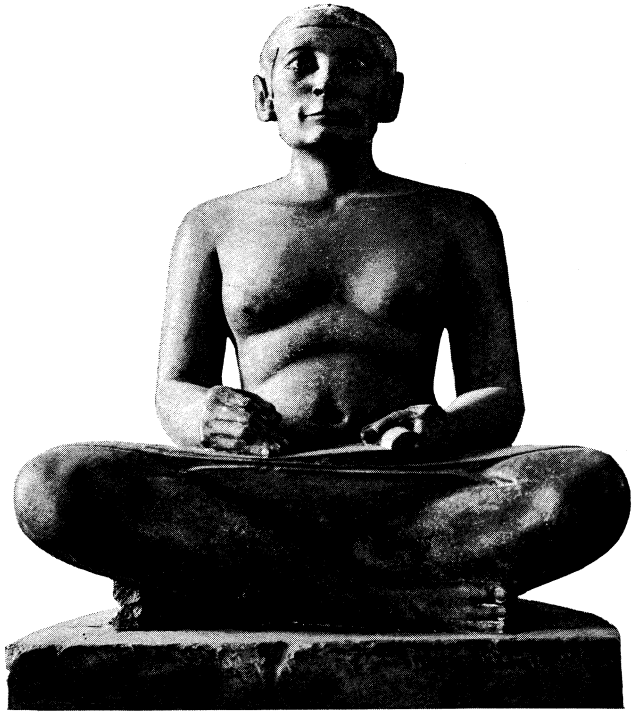
House and granary of the 2nd century A.D. uncovered at Karanis, a site southwest of Cairo excavated by the University of Michigan. *See* photograph at right



Some of the papyrus documents discovered at Karanis shown where they were found, concealed within the wooden threshold beam of a house



Statue of an Egyptian scribe of the Fifth Dynasty. He is shown holding a partly opened scroll of papyrus. Made of painted limestone with inlays (in the eyes) of quartz, crystal and ebony. In the Louvre, Paris

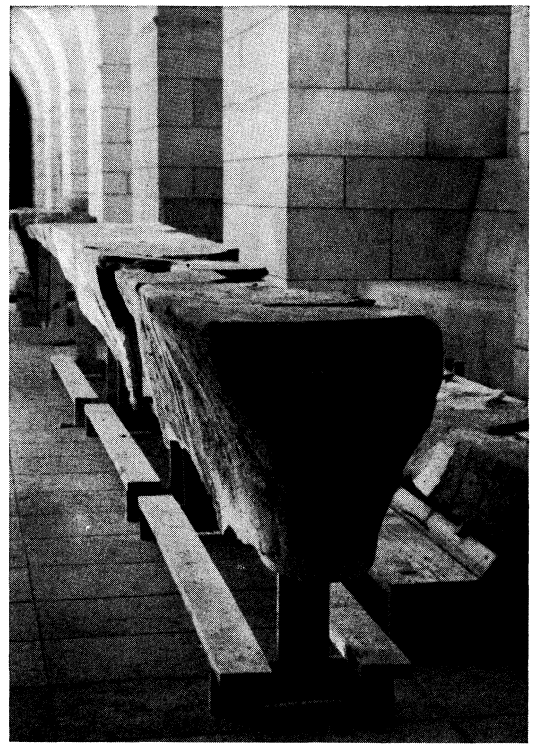
Egyptian fellahin searching for papyri among the debris of a rubbish mound. Findr from this type of digging are usually sold to antique dealers

EXCAVATIONS IN EGYPT AND A SCRIBE

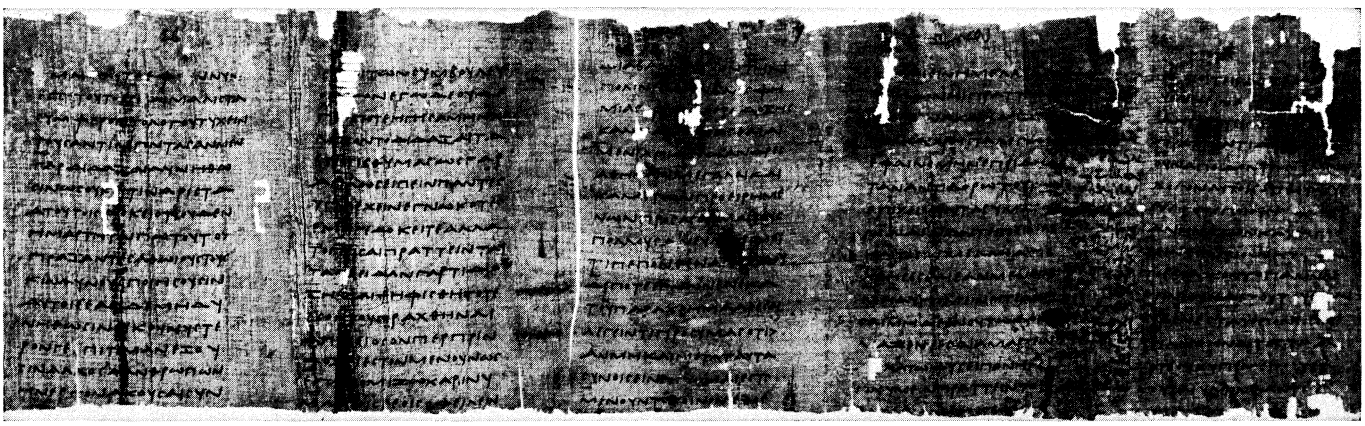
BY COURTESY OF (TOP, CENTRE RIGHT) KELSEY MUSEUM OF THE UNIVERSITY OF MICHIGAN: PHOTOGRAPH, (BOTTOM LEFT) ALINARI

PAPYROLOGY

Left, early Greek writing in Egypt: a royal edict, Zenon papyri, 3rd century B.C. *Right,* one of the so-called Ravenna papyri, rare examples of texts preserved outside of Egypt



Reconstructed sections of what may have been a **scriptorium,** the room in which papyri were copied, at Wadi Qumran, the area associated with the Dead sea scrolls (*q.v.*). Reassembled scriptorium is at the Palestine Archaeological museum

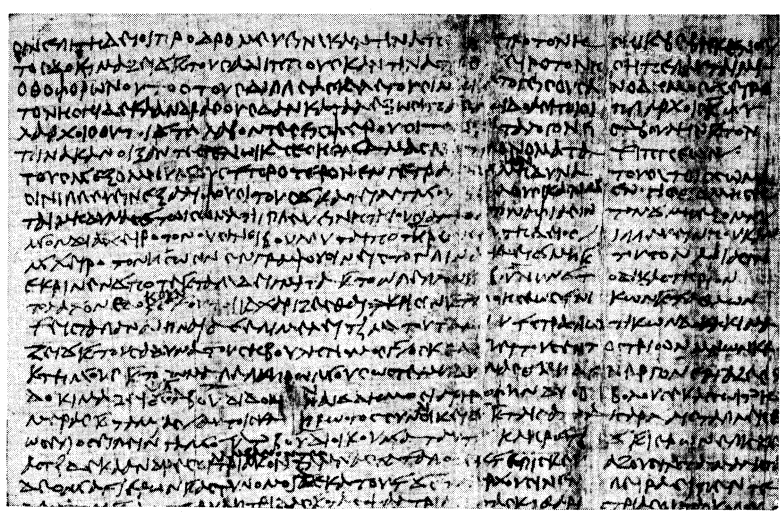


Part of a fragment of a 2nd century A.D. literary text, ***Prooemia,*** compiled partly by Demosthenes. From Oxyrhynchus

A SCRIPTORIUM AND EXAMPLES OF EARLY TEXTS

Gospel of John, of which this **fragment is the** earliest known **piece of New Te**stament writing in existence; 2nd century A.D.

Section of the Constitution of Athens (*q.v.*), a historical treatise by Aristotle which **was** discovered in the late 19th century; considered one of the most important papyri extant



BY COURTESY OF (TOP LEFT) KELSEY MUSEUM IF THE UNIVERSITY OF MICHIGAN, (TOP CENTRE) BIBLIOTECA APOSTOLICA VATICANA, (TOP RIGHT) PALESTINE ARCHAEOLOGICAL MUSEUM, (CENTRE, BOTTOM RIGHT) BRITISH MUSEUM, (BOTTOM LEFT) THE JOHN RYLANDS LIBRARY

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PAPYRUS, the paper reed. *Cyperus papyrus,* in ancient times cultivated in the delta of the Nile in Egypt, where it was used for various purposes, and especially as a writing material. *Cyperus* is a member of the sedge family. the Cyperaceae, to which the bulrushes also belong. For botany of the plant, *see* CYPERACEAE. *Cyperus papyrus* is now extinct in lower Egypt but is found in the upper Nile regions and in Ethiopia, as well as in Syria and occasionally southern Europe.

The first accurate description of the plant is given by Theophrastus, who states that it grew in shallows of two cubits (about three feet) or less, its main root being of the thickness of a man's wrist and ten cubits in length. From this root, which lay horizontally, smaller roots pushed do n into the mud, and the stem of the plant sprang up to the height of four cubits, being triangular and tapering in form.

Theophrastus also enumerates the various uses to which the papyrus plant was applied. Of the head nothing could be made but garlands for the shrines of the gods, but the wood of the root was employed in the manufacture of different utensils as well as for fuel. Of the stem of the plant were made boats, sails, mats, cloth, cords and, above all, writing materials. Its pith was a common article of food, being eaten both cooked and in its natural state. Herodotus, too, notices its consumption as food, and incidentally mentions that it provided the material of which the priests' sandals were made. He likewise refers to its use as tow for calking the seams of ships. That the plant was itself used also as the principal material in the construction of light skiffs is shown by sculptures of the 4th dynasty, which shows men building a boat with stems cut from a nearby papyrus plantation. Isa., xviii, 2 refers to "vessels of papyrus upon the waters."

A B

FROM (PLANT) CONSTANTIN. "MERVEILLES DE LA NATURE; (BAILLIÈRE, SON), (A, B) BAILLON, "HISTOIRE DES PLANTES" (H. BONNAIRE)

PAPYRUS (CYPERUS PAPYRUS), SHOWING MATURE PLANT WITH SHOOTS 3–12 FT. HIGH

(A) Single flower showing three stamens and trifid stigma. (B) Single floral spike. (A and B enlarged)

The widespread use throughout the ancient world of the writing material manufactured from the papyrus plant is attested by early writers and by documents and sculptures. Papyrus rolls are represented in ancient Egyptian wall paintings, and many examples of the rolls themselves are extant. Papyri have often been found in tombs in Egypt, in the hands or swathed with the bodies of mummies. The ritual of the dead is most frequently the subject. Besides the ritual and religious rolls, there are also hieratic, civil and literary documents, as well as papyri relating to sales of property, etc. Coptic papyri mainly contain biblical or religious texts or monastic deeds. Papyrus was also known to the Assyrians, who called it the reed of Egypt. That the Greeks also used papyrus early in their history is proved by the reference of Herodotus to its introduction among the Ionian Greeks, who called it "skins." the material to which they had already been accustomed. In Athens it was doubtless in use for literary as well as for other purposes as early as the jth century B.C.

Papyrus also made its way into Italy, but at how early a period there is nothing to show. It may be presumed, however, that from the very first it was employed as the vehicle for Roman literature. Under the empire its use must have been extensive, for not only was it required for the production of books. but it also was universally employed for domestic purposes, correspondence and legal documents. So indispensable did it become that Pliny reports that in the reign of Tiberius, because of the scarcity and dearness of the material caused by a failure of the papyrus crop, there was a danger of the ordinary business of life being deranged.

Manufacturing Methods. — The account given by Pliny *(Natural History,* xiii, 11–13*)* of the manufacture of the writing material from the papyrus plant should be taken strictly to refer to the process followed in his own time; but, with some differences in details. the same general method of treatment had doubtlessly been practised from time immemorial. His text. however, is so confused. both from obscurity of style and from corruptions in the manuscripts, that there is much difference of opinion as to the meaning of many words and phrases employed in his narrative, and to their application in particular points of detail.

In one important particular, however, affecting the primary construction of the material, there can be no doubt. The stem was cut into longitudinal strips. those from the centre of the plant being the broadest and most valuable. The strips were laid side by side to the required width, thus forming a layer across which another layer of shorter strips was laid at right angles. The two layers thus "woven" formed a sheet, which was then soaked in water of the Nile. The mention of a particular water has caused trouble to the commentators. Some have supposed that certain chemical properties of Nile water acted as a glue or cement to cause the two layers to adhere; others. with more reason, that glutinous matter contained in the material itself was dissolved by

the action of uater, whether from the Nile or any other source; and still others read in Pliny's words an implication that a paste was actually used.

The sheet was finally hammered and dried in the sun. Any roughness was leveled by polishing with ivory or a smooth shell. But the material was also subject to other defects, such as moisture lurking between the layers. which might be detected by strokes of the mallet; spots or stains; and spongy strips, in which the ink would run and spoil the sheet. When such faults occurred. the papyrus had to be remade.

To form a roll the several sheets were joined together with paste (glue being too hard), not more than 20 sheets to a roll. (There are, however, still extant rolls consisting of more than the prescribed number of sheets; perhaps the number was not constant in all times.) The roll (*scapus*) seems to have been a standard length of papyrus, as sold by the stationers. The best sheet formed the first or outside sheet of the roll, and the others were joined on in order of quality, so that the worst sheets were in the centre of the roll. This arrangement was adopted. not for the purpose of fraudulently selling bad material under cover of the better exterior, but in order that the outside of the roll should be composed of that which would best stand wear and tear. Besides, in case of the entire roll not being filled with the text, the unused and inferior sheets at the end could be better spared, and so might be cut off.

Writing Material.—Eight different kinds of papyrus writing material and their dimensions are also described by Pliny. The best quality, formed from the middle. and broadest. strips of the plant, was originally named *charta hieratica*, hut afterward, in flattery of the emperor Augustus, it was called, after him. *charta Augusta*. The grades descended in quality and size to the *charta emporetica*, the common packing paper. A ninth grade was added in the reign of Claudius.

The first sheet of a roll was named *protokollon*, the last *eschatokollion*. Under the Romans. the former bore the name of the *comes largitionum*, who had control of the manufacture, with the date and name of place. It mas the practice to cut away the portion thus marked. but in case of legal documents this mutilation was forbidden by the laws of Justinian. On the Arab conquest of Egypt in the 7th century. the manufacture was continued, and the protocols were marked at first. as it appears, with inscriptions in both Greek and Arahic. later in Arahic only.

Later Cultivation and Use.—Papyrus was cultivated and manufactured for writing material by the Xrahs in Egypt down to the time when the growing manufacture of paper in the 8th and 9th centuries rendered it no longer a necessity. (*See* PAPER.) It seems to have given place entirely to paper in the 10th century. It is not probable that it was ever manuiactured from the native plant anywhere but in Egypt. At Rome there was certainly some kind of industry in papyrus, but it seems probable that this was confined to the remaking of material imported into Italy. This second manufacture is thought to have been detrimental to the papyrus, as it would then have been in a dried condition requiring artificial aids, such as a more liberal use of gum or paste, in the process.

As to cultivation of the plant in Europe. according to Straho the Romans obtained the papyrus plant from Lake Trasimene and other lakes of Etruria, but this statement is unsupported hy any other ancient authority. At a later period. however. a papyrus was cultivated in Sicily, which has been identified with the Syrian variety (*Cyperus syriacus*), far exceeding in height the Egyptian plant, and having a more drooping head. It grew in the east and south of the island. where it was introduced during the Arah occupation. It was seen in the 10th century by the Arab traveler Ibn Haukal in the neighbourhood of Palermo, where it throve luxuriantly in the pools of the Papireto, a stream to which it lent its name. From it paper was made for the sultan's use. Rut in the 13th century it began to fail, and in 1591 the drying up of the Papireto caused the extinction of the plant in that district. It is still to be seen at Syracuse, but it was probably transplanted there at a later time and raised only as a curiosity, as there is no notice of it to he found previous to 1674.

Even after the introduction of vellum (*see* PARCHMENT) as the ordinary vehicle for literature, papyrus still continued to some extent in use outside Egypt, and was not entirely superseded until a late date. It ceased, however. to be used for books sooner than for documents. In the 5th century St. Augustine apologizes for sending a letter written on vellum instead of the more usual substance. papyrus. Of medieval literary Greek papyri very few relics have survived. but documents of the 8th and 9th centuries have been discovered in Egypt. Medieval Latin manuscripts on papyrus in book form are still extant. The employment of the material in Italy for legal purposes is illustrated by the large number of documents in Latin. preserved at Ravenna. that date from the jth to the 10th century. In the papal chancery it was used at an early date, and in the 10th century papyrus was used. to the exclusion of other materials, in papal deeds. Of the Merovingian period there are still extant several 7th-century papyrus deeds; under Charlemagne and his successors it was not used, and by the 12th century the manufacture of papyrus had entirely ceased. See also PAPYROLOGY. (E. M. T.; X.)

PAQUET, ALFONS (1881–1944), German writer and traveler whose works include lyric poetry, plays and novels, was born in Wiesbaden, on Jan. 26, 1881. He studied in London and in Heidelberg, Munich and Jena. From the early 1900s he traveled widely, visiting Siberia and Manchuria, North America, the near east and various places in Europe. He wrote on Palestine (1915) and Communist Russia (1919). The background of Lieder *und* Gesang (1902) is London and of the novel *Kamerad Fleming* (1911) Paris. The novel Die *Prophezeiungen* was published in 1922. His plays include *Limo* (1913). *William Penn* (1927) and Stein (1933). He died in Frankfurt am blain Feb. 8, 1944.

PAR: see INTERNATIONAL PAYMENTS; STOCK.

PARA, a northern state of Brazil, bounded on the north by British Guiana. Surinam and the territory of Amapá, on the east by the Atlantic and the states of Maranhão and Goiás, on the south by Mato Grosso and on the west by Amazonas. Area, 474,-896 sq.mi.; pop. (1960) 1,550,935. The chief city and capital is Belém, pop. (1960) 359,988; other important towns include Santarém, Óbidos and Bragança.

The state of Pará lies along the equator and is crossed by the main channel of the Amazon river. The climate is equatorial: contrary to popular impression, the temperatures are never so high as in central United States—a temperature of 100° has never been recorded. The average is about 78°, with a range between coldest and warmest months of about 4°. Rainfall and humidity are high. The year is divided into a very rainy season from January to June and a season of less rain for the rest of the year. Wherever there is exposure to the easterly winds the humidity is compensated for and the climate is quite comfortable. Except for a few patches of savanna, most of the state is covered with a tropical rain forest or selva.

An enormous amount of water pours into the ocean through the state of Para. The Amazon itself winds about on its flood plain, leaving a maze of abandoned channels in the form of oxbow lakes and an intricate crescentic pattern of levees and swamps, much like the lower Mississippi. At Óbidos the flood plain is scarcely a mile in width, but it opens out again downstream. The margins of the flood plain are marked by valley bluffs—steep slopes which rise abruptly about 150 to 200 ft. above the river. The flood plain —which is somewhat less than 10% of the total area of Pará— is inundated each year during high-water stages but the country above the valley bluffs is never flooded. The chief towns are located on the bluffs at places where the main channel of the river swings against the margin of the flood plain. The Amazon receives the water of several great tributaries. From west to cast on the southern side are the Tapajóz, the Xingú and the Tocantins. No large tributaries reach the Amazon on the northern side within Par&. At the mouth of the Amazon is Marajó Island (*q.v.*). It is 183 mi. long by 124 mi. wide, with an area of 15,444 sq.mi. The northwestern part of the island is a part of the flood plain; but in the east and south the island is made up of higher ground. The Tocantins provides most of the water in the Pará river. on the southern side of Marajó Island, while the main stream of the

Amazon passes to the north. The Pará river and the Amazon are connected by a network of side channels. Lying across the mouth of the main stream, north of Marajó Island, are two smaller islands which, like eastern Marajo. stand above the floods. They extend in a southeast to northwest direction: Caviana is 48 mi. long and Mexiana is 34 mi. long.

The soils of much of Pará are not fertile. The alluvial material on the flood plain could yield abundant crops, especially rice, but the settlers along the Amazon have never made much use of it. Beyond the valley bluffs where the land is never flooded and where mud and silt are never deposited, the soil has for a long time been exposed to the action of percolating rain water. Water sinking into the soil carries the finer soil particles down far beyond the reach of shallow-rooted crops; it also dissolves and carries away the more easily soluble of the minerals. The result is a sandy soil made up largely of iron and aluminum compounds in which crops do poorly. Trees, with deeper roots, can grow luxuriantly in the moist climate; but agriculture without modern fertilizing techniques has never been successful. The native Indians used a small clearing only for a year or so before shifting to a new clearing; much of their food supply came from the river itself—from fish, turtles and turtle eggs.

The Amazon region was never very attractive to the Portuguese settlers. Belém was founded in 1615, chiefly to keep other European nations from settling there. Jesuit missions were the first settlements upstream, as at Santarém in 1661. In the 1870s a colony of people from the southern United States, together with slaves they brought with them, settled near Santarém and tried to plant cotton and sugar cane. The colony was never successful. Between 1850 and 1910 there was a period of feverish activity as workers went out into the forests to tap the rubber trees. Rubber in large quantities was shipped out through Belém and the city grew rapidly in size and importance. Production dropped rapidly after 1910. Even the Ford plantations on the Tapajóz, although technically successful, failed to produce enough rubber for the needs of the Ford industries.

The chief exports of Pará are gathered from the forest. They include Brazil nuts, medicinal plants, insecticides and some rubber. Between Belém and Bragança there is a small farming area, producing cotton, cacao, manioc, sugar cane, rice, tobacco and maize. New Japanese colonists along the Amazon are growing jute in increasing quantities. The savannas of Marajó Island are used for the pasture of cattle. (P. E. J.)

PARÁ CITY: see BELÉM.

PARABLE, a form of illustration (Greek para-bole, a juxtaposition for comparison) in all folk literature, especially Semitic. The Old Testament and the Talmud abound in parables. but the Christian west well-nigh restricts the term to those of Jesus. A parable pure in form offers a single point of comparison between an abstract declaration or demand and a vivid story or situation. Thus (the value of) the Kingdom of God is like (the value of) the one precious pearl for which a merchant sacrificed all he had (Matt. xiii, 45–46).

A true parable is self-explanatory. But the author of the Gospel of Mark, reflecting one facet of early Christian opinion, regarded (some, not all?) parables as mysteries requiring detailed explanation (Mark iv, 10–12; the *mashal* of the Old Testament was sometimes a riddle). Consequently he allegorized the Parable of the Sower, which originally taught: be no more perturbed at the varying receptivity of men than the sower is at that of soil. Considering it an allegory, he made it yield a whole series of parallels to details in the story. This tendency recurs in Matt. xiii, 36–43 as compared with xiii, 24–30, though here "the enemy" is perhaps an allegorical element in the story itself. (KE. G.)

PARABOLA, in geometry, is a conic section (*q.v.*). This curve may be obtained as the intersection of a circular cone, right or oblique, with a plane which is parallel to one element of that cone (see fig. 1).

This curve, however, may be defined directly as a plane curve, without the help of space considerations, as follows: a parabola is the path of a point which moves in the plane so as to remain equidistant from a fixed point F (the focus) and a fixed line d (directrix) (see fig. 2).

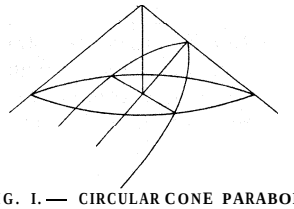

FIG. 1.— CIRCULAR CONE PARABOLA

Let D denote the foot of the perpendicular from the focus F upon the directrix d. The midpoint O of the segment FD = p lies on the parabola, for O satisfies the above definition; the point is called the vertex of the parabola. The perpendicular to DF at the vertex O is the tangent at O to the parabola.

If on the indefinite line DF a point E is taken on the same side of O as the focus F, the perpendicular to DF at E contains two points of the parabola which may be located as the points of intersection M, M' of that line with the circle having F for centre and ED for radius.

The two points M, M' are symmetrical with respect to line DF, and therefore this line is said to be the axis of symmetry, or, briefly, the axis of the parabola.

The perpendicular to the axis DOF of parabola at the focus F meets the parabola in two points P, P' such that FP = FP' = FD. The segment PP' is said to be the *latus* rectum of the parabola.

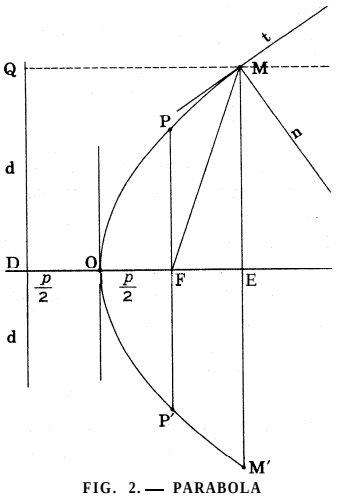

FIG. 2.— PARABOLA

As the point E moves farther and farther away on the axis in the direction DOF, the segment MM' increases in length indefinitely. Hence the parabola is an open curve of infinite extent. No point of the parabola lies on that side of the tangent to the parabola at O which contains the directrix.

If vertex O is taken as the origin of a rectangular system of coordinates. and DF as the x-axis, the tangent to the curve at vertex O will be the y-axis; the eauation of the curve will be $y^2 = 2px$, where $2p$ = DF is said to be the parameter of the curve.

Indeed, co-ordinates of points F, D are respectively $(p/2, O)$, $(-p/2, O)$, and if co-ordinates of point M are (x, y), we have: $QM = DE = p/2 + x$, $FM^2 = ME^2 + FE^2 = y^2 + (x - p/2)^2$. Now QM = FM, by definition, hence $(p/2 + x)^2 = y^2 + (x - p/2)^2$, which, after simplification, gives the stated result.

The properties of the parabola obtained by construction may readily be verified using this equation.

Books dealing with conic sections contain many properties of the parabola. Some examples are:

1. The two tangents drawn to a parabola from a point on its directrix are perpendicular to each other; the line joining their points of contact passes through the focus.
2. The normal n at a point M of the parabola bisects the angle formed by the focal radius FM of M and the parallel through M to the axis of the curve (see fig. 2).

The latter proposition has an interesting and important optical interpretation, as follows: if a ray of light FM emanates from a source placed at the focus F of a parabola, its reflection in the curve at the point M travels in the direction parallel to the axis of the parabola.

This property is one of the many practical applications of the parabola (see PARABOLOID). The cables of suspension bridges take on a parabolic shape. A cannon ball or a ball thrown by hand has for its trajectory an arc of a parabola. The graph of a quadratic polynomial, $y = ax^2 + bx + c$, is a parabola.

The path of a point moving in the plane so that the ratio of its distance to a fixed point F (focus) and a fixed line d (directrix) has a fixed value e is either an ellipse (*q.v.*) or a hyperbola (*q.v.*) according as the value of e is smaller than unity or exceeds unity. In the case of the parabola the two distances involved are equal to each other, hence their ratio e is exactly equal to unity. Thus

if focus F and directrix d are kept fixed and e is given a number of different values, we obtain a series of ellipses as long as those values of e are smaller than unity and a series of hyperbolas for the values of e greater than unity. The parabola thus becomes the curve of transition, or the connecting link between the two sets, with $e = 1$.

The focus-directrix definition for all three varieties of conics was known to the ancients It is to be found in the mathematical *Collection* of Pappus (c. A.D. *300)* and is quite likely due to Euclid (c. 300 B.C.).

In the light of this definition the parabola may be said to be an elongated ellipse whose second focus, second vertex and centre all coincide with the point at infinity of the axis of the parabola. Many properties of the parabola may then be derived from those of the ellipse.

Thus the reflective property of the parabola mentioned before is a modification of a property of the ellipse, namely, a ray of light emanating from a source placed at a focus of an ellipse is reflected by the curve in such a manner that the reflected ray passes through the second focus. On the other hand the parabola may be said to touch the line at infinity at the infinite point of its axis. The parabola is thus a special case of the hyperbola whose two points of intersection with the line at infinity are distinct. (N. A. CT.)

PARABOLOID, in geometry, is a quadric surface (*q.v.*) having no centre of symmetry.

Consider two perpendicular planes in which are located two parabolas A, B having a common vertex and a common axis d.

1. The two parabolas A, B open in the same direction (see fig. *1).*

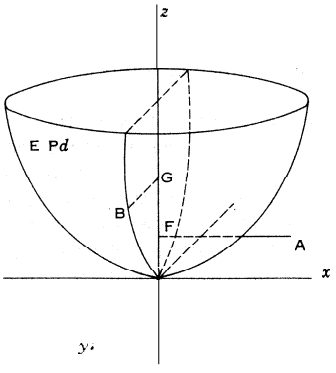

FIG. I. — ELLIPTIC PARABOLOID

If a variable ellipse E whose plane is perpendicular to the axis *d* moves so that the ends of its major and minor axes lie on A and B, respectively, the surface generated by E is an elliptic paraboloid (E.P.). The planes of A and B are planes of symmetry of E.P.; the common vertex and common axis d are the vertex and the axis of E.P.

If A and B are congruent, ellipse E becomes a circle and the E.P. becomes a paraboloid of revolution (P.R.) which may be generated by revolving either of the parabolas A, B about its axis. The focus of the revolving parabola is the focus of the P.R. The P.R. serves to make parabolic mirrors, used in headlights. Because of the reflective property of the parabola (*q.v.*), such a mirror reflects the rays of light emanating from a source placed at its focus into rays parallel to the axis of the mirror.

The canonical equation of the E.P. is $x^2/a + y^2/b = z$. For P R. we have $a = b$.

2. The two parabolas A, B open in opposite directions. If one of the parabolas, say A, remains fixed and B moves rigidly while its plane remains parallel to itself and the vertex of B remains on A, the surface generated by (B) is an hyperbolic paraboloid (H.P.) (see fig. *2).*

An H.P. may also be generated by a variable straight line which is parallel to a fixed plane and intersects two fixed skew lines, neither of them parallel to the fixed plane. Through any point of an H.P. two straight lines may be drawn which, throughout their lengths, lie on the surface. The H.P. is thus a doubly ruled quadric surface.

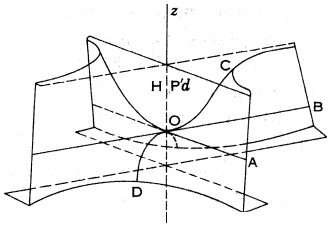

FIG 2.—HYPERBOLIC PARABOLOID

The equation of an H.P. is $x^2/a - y^2/b = z$, with $ab > 0$. If $a = b$ the H.P. is said to be equilateral. The equation of the latter surface may also be put in the form: $2xy = a^2z$. (*N. A.* CT.)

PARACELSUS (THEOPHRASTUS BOMBASTUS VON HOHENHEIM) (c. 1490–1541), physician and alchemist, was born near Einsiedeln in the canton Schwyz in Switzerland. The epithet Paracelsus was probably his own invention, and was meant to denote his superiority to Celsus. Paracelsus studied at the University of Basel and then with J. Trithemius, abbot of Sponheim, but he soon departed to the mines in Tirol where he became absorbed in the mechanical difficulties of mining, in the nature of minerals and in the diseases of miners.

On his return to Basel in *1526.* Paracelsus lectured on medicine at the university. The lectures, in German rather than Latin, were preceded by a solemn burning of the works of Galen and Avicenna; they discredited past and contemporary medicine and set forth the lecturer's own theories and methods of treating disease. His opponents pointed out that he possessed no degree and that there were serious defects in his system. The controversy came to a crisis through a dispute about fees and in *1529* Paracelsus resumed his wanderings. In *1541* Archbishop Ernst invited him to settle at Salzburg under his protection, and there he died on Sept. *24.* The cause of his death is uncertain; his enemies asserted that he died in consequence of a drunken debauch, but others maintain that he was thrown down a steep incline by emissaries of jealous physicians and apothecaries. He was buried in the churchyard of St. Sebastian, and in *1752* a monument was erected to his memory.

In his works, Paracelsus shows a genuine desire to promote the progress of medicine. but it is questionable whether he introduced a single new truth. Fundamentally, his system is based on a visionary Neoplatonic philosophy in which the life of man is regarded as inseparable from that of the universe. For him, the scriptural *limus* terrae from which the body of man is created is in reality an extract of all beings previously created. It is primarily a compound of "salt," "sulfur" and "mercury," the separation of these mystic elements in man being the cause of sickness. The separation is due to the failure of the Archaeus, an occult vital force which is situated in the stomach. to perform its function of separating the useful from the poisonous. For the treatment of disease, Paracelsus introduced mineral baths, made opium, mercury, lead, sulfur, iron, arsenic, copper sulfate a part of the pharmacopoeia and popularized tinctures and alcoholic extracts. Since man contains all elements and requires them for the curing of his diseases, the physician must know the physical sciences and alchemy; he must also know astronomy, for not only do the stars influence disease, but man, like all terrestrial beings, is penetrated by the astral spirit; third, the physician must know theology, since, in addition to body and spirit, man has a third factor, the soul. which was created by God. and to which the spirit serves as a kind of body. With Paracelsus' lofty views of the true scope of medicine it is impossible to reconcile his ignorance, his superstition and his erroneous observations.

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PARACHOR, a characteristic of any substance; the value of this property is given by the value of the function $M\gamma^{\frac{1}{4}}/(D - d)$ where M is the molecular weight of the substance, y is the surface tension of the liquid in contact with its saturated vapour, and D and d are the densities of the liquid and saturated vapour, respectively. The values of γ, D and d are all to be measured at the same temperature. The term parachor was introduced by S. Sugden (J. Chem. *Soc., 1924).*

If the parachor of two liquids is independent of temperature, the ratio of the parachors is the ratio of the molar volumes, MID, of those liquids when both are determined for the same surface tension. not at the same temperature. Though the dimensions of the parachor are not those of the volume, the parachor is regarded as a molal volume corrected for the forces of attraction between molecules; hence the name (Gr. *para,* "by the side of"; *chora,* "space"). The parachor was found to be an additive function of atomic and structural constants called by Sugden "atomic

and structural parachors." He and his collaborators have made many interesting applications of the function to determinations of chemical constitution. The method is not always reliable, however.

See S. Sugden, *The Parachor and Valency,* p. 30 *et seq.* (1930); *G.* W. Thomson in A. Weissberger, *Physical Methods of Organic Chemistry,* 2nd ed., vol. i, pp. 413–425 (1949). *(G.* W. Wd.; T. F. Y.)

PARACHUTE, an umbrellalike device that offers resistance to the air and thus retards the rate of descent of a falling body or the speed of an airplane or missile. Parachutes are used chiefly to enable persons to descend safely to the ground from a plane in flight. They can also be used to drop supplies, equipment, bombs or other munitions. Parachutes are sometimes used to reduce the speed of a plane or missile as it comes in for a landing or approaches its target; in this case the chute is securely fastened to the plane or missile and acts as a brake.

Early Uses of Parachutes. — Louis Sébastien Lenormand of France is generally credited with being the first to demonstrate the parachute principle in 1783, when he made a jump from a high tower. The idea had been anticipated by Leonardo da Vinci (1514), Fausto Veranzio (1595) and the Montgolfier brothers (1779). Jean Pierre François Blanchard, a pioneer French balloonist in 1785 placed a dog in a basket to which a parachute was attached and dropped it from a balloon high in the air. Blanchard claimed that he himself descended from a balloon in a parachute in 1793.

Another French aeronaut André Jacques Garnerin (1769–1823) is credited with being the first to use a parachute regularly and successfully. His first public exhibition of parachuting was made in Paris, France: Oct. 22, 1797, when he successfully jumped from a height of more than 2,000 ft. He gave a similar exhibition in England on Sept. 21, 1802, when he jumped from a height of about 8.000 ft. His parachute was umbrella-shaped, made of white canvas and approximately 23 ft. in diameter. Jordaki Kuparento, a Polish aeronaut. made a successful emergency descent by parachute in 1808 when his balloon caught fire at a considerable height.

Transition to Modern Use. — The first successful use of a parachute in a descent from a moving airplane was made in 1912 by Capt. Albert Berry at St. Louis, Mo. During 1913–14 there was much discussion concerning the practicability of using parachutes for escapes from airplanes, but by the time World War I started (1914), the question had not been satisfactorily decided. The primary reason for the indecision was the size of the parachutes then in common use; it was thought to be practically impossible for a pilot to clear the plane without fouling of the parachute or the suspension lines. At the beginning of World War I, therefore, parachutes were used only by observers in captive balloons. some of whom made seven or eight parachute descents daily. Parachutes mere improved in Germany to the extent that German aviators used them extensively as life-saving devices in the last months of that war. The American first pursuit group from Sept. 26 to Nov. 11, 1918. brought down 11 enemy aircraft from which the pilots escaped by means of parachutes.

The allies were debating the advisability of using parachutes when the armistice was signed and in 1919 the seat pack type of parachute was adopted as regular airplane equipment by the U.S. army. Although pilots were reluctant to use parachutes, they were eventually convinced of their value, and the first U.S. army order making it compulsory to wear them was issued by the adjutant general in 1922. Soon the British Royal Air Force adopted the U.S. type of parachute with its cushionlike pack.

During the years following World War I, efforts in the technical development of parachutes were also made in Italy, Germany and the U.S.S.R., but the transition from chutes used in balloons to those suitable for fast heavier-than-air craft was slow. There were many problems involved in developing a parachute suitable for use from fast-moving planes, but they were gradually solved.

At the beginning of World War II the armies of all major countries were well equipped with parachutes for various purposes. The principal uses of parachutes were to enable men to escape from disabled aircraft; to drop men and material for combat actions or to drop supplies into inaccessible positions; to place agents in enemy territory; to stabilize and retard aerial bombs, mines and torpedoes; and to slow aircraft during approach and landing. During World War II the possibilities of the use of parachutes for aerial warfare as well as for civilian use were strongly indicated and successfully applied. The following is a brief review of the most remarkable incidents of parachute use during the war years.

Wartime Use of Parachutes. — Gen. William Mitchell (*q.v.*) of the U.S. air corps is credited with having been the first military leader to declare publicly after World War I that air infantry and parachute troops would play an important part in the next war. Some experimental work was done under his direction with parachute troops (paratroops) and air-borne infantry, in the early 1920s, but this work was temporarily abandoned in the U.S. The U.S.S.R. and Germany, however, did not neglect the training of paratroops. The U.S.S.R., in practice war games, landed whole divisions of troops by parachute. Germany experimented in this field too, but, because of the restrictions of the treaty of Versailles, no publicity was given to the trials.

During the winter of 1939–40, at the height of its campaign against Finland, the U.S.S.R. used many paratroops as air infantry, transporting these troops behind the Finnish lines and dropping them, together with machine guns, ammunition and other material, by parachute. In April 1940 the Germans. at war with Great Britain and France, entered Norway by air, sea and land. Paratroops were used in this campaign with great success, the first time that they had been so used by Germany. The Germans landed men, machine guns, light artillery, food and ammunition successfully by parachute. In May 1940, German troops invaded the Netherlands. Belgium and Luxembourg, again using parachutes to good advantage. Glider troops, the so-called air infantry, participated in the air-borne invasions of the Netherlands and they, together with the paratroops, contributed to the speedy success of the Germans. Before the end of World War II parachutes were used by both sides for mass landings of men and matériel.

Diversified use of parachutes requires a large number of specially designed and developed types of parachutes. This tendency to use specialized types continued and was intensified after the war. A separate branch of aeronautical sciences developed to deal with all problems involved in the reduction of speed of moving objects through air by means of parachutelike devices.

Man-Carrying Parachute. — As noted above, this type of parachute consists of a canopy, suspension lines, chute pack, pilot parachute and harness. The harness is a system of webbings laid upon the body of the wearer in such a way that the forces of the parachute can be transmitted to the man without causing discomfort or injury at the instant of the parachute inflation.

Attached to the harness is the parachute pack, which includes the parachute canopy, suspension lines and pilot parachute. The pack can be so arranged that the man sits on it, or it can be fastened to his back, or it can be fastened by means of snap hooks to the chest portion of the harness.

The pack can be opened by means of a ripcord. which must be pulled by the man or by an automatic timing device, or by means of a static line fastened to the aircraft. The manual operation of pulling the ripcord is used for pilot escape; the static line system is used by paratroopers. After the pack is opened the pilot parachute is ejected into the air stream where it quickly inflates and pulls the main parachute out of the pack. Modern man-carrying chutes are made of nylon with a specific weight of 1.1 oz. per square yard and a tensile strength of 40 lb. per inch of width. The suspension lines are also made of nylon.

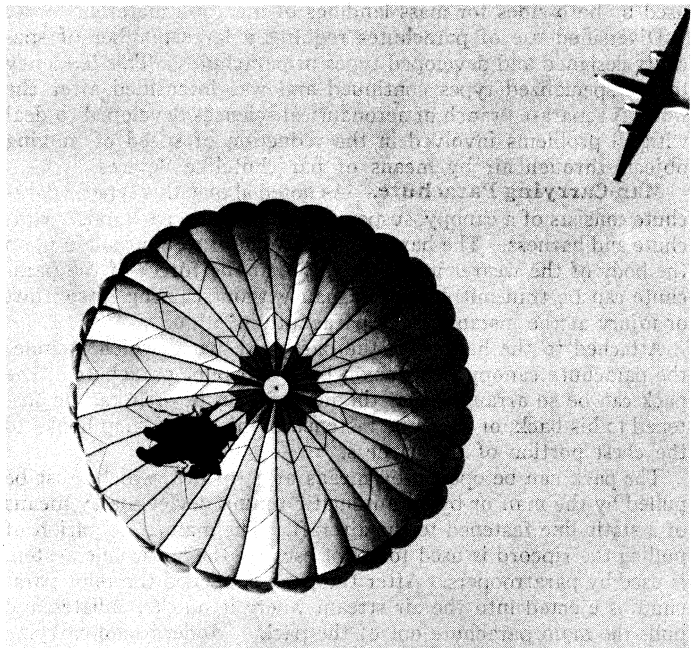
The pilot-escape parachute has a diameter of 28 ft. and provides sufficient drag to slow the rate of descent of a 200-lb. man to approximately 20 ft. per second (f.p.s.). Parachutes for air-borne troops are usually somewhat larger; the U.S. army parachute for air-borne troops is 35 ft. in diameter and provides for the very heavily laden paratrooper about the same rate of descent. Chest type parachutes are usually about 24 ft. in diameter with an approximate rate of descent of 25 f.p.s. for a 200-lb. load. The rate of descent of 20 f.p.s. is considered a safe sinking speed for untrained parachutists while 25 f.p.s. is acceptable for untrained

men only under emergency conditions. For dropping cargo, parachutes up to 100 ft. in diameter are used. and for very heavy equipment several parachutes are combined.

How Parachutes Are Made. — The canopy of a flat parachute as described above is made of 24 or 28 triangular-shaped panels, each made of several small pieces of a fabric stitched together so that a tear would never become larger than the piece in which it originates. The individual pieces are senn together to triangular gores in such a manner that the direction of the yarn of warp and filling intersect the centre line of the gore under an angle of 45°. This measure increases the strength of the parachute. The gores are then sewn together to form a circular canopy with a small vent in the middle The shroud lines are run through the seams that bind the panels together. Each shroud line runs from the D-ring by which it is attached to the harness, over the top of the canopy and down to another D-ring, which is also attached to the harness. In general, a 24-ft. canopy has 24 panels and 24 shroud lines; the latter are brought down in four groups of six each. A 28-ft. canopy has 28 panels and 28 shroud lines, and the lines are brought down in four groups of seven each. The length of the lines below the periphery is usually equal to the diameter of the flat parachute canopy.

The containers or pack covers are made of strong nylon. They are of different sizes and shapes. and are most ingeniously made to assure that the pilot chute is released first; that the canopy is smoothly pulled out by the pilot chute; and that the shroud lines do not become entangled.

The harness is a cleverly designed contrivance that attaches the parachute firmly and safely to the wearer. It may be released from the parachutist's body instantly in the event of a landing in high wind or in water. This quick-release feature is important because the parachutist may be severely injured or drowned if he is unable to free himself quickly from the parachute and is dragged



BY COURTESY OF U S AIR FORCE

FIG. 1 — PERSONNELPARACHUTE

Descending chutist and underside of conventional 28-ft. circular flat chute used by U.S. air force, showing triangular-shaped panels and shroud lines leading to harness

over the ground or through the water.

How Parachute Descents Are Made. — In the drag-off method, formerly widely used, the jumper crawled out of the cockpit onto the wing or fuselage, far enough so that his parachute would not be fouled by the tail assembly. and pulled the ripcord. allowing the drag of the filling canopy to draw him away from the plane. This procedure cannot be used in modern aircrait. In the free-fall method, which generally succeeded the drag-off method, the parachutist steps. falls, jumps or is ejected from the aircraft and the ripcord is pulled when he is clearly separated from the plane. When jumping from a high-speed aircraft, a definite time delay may be necessary in order to avoid exposure of the parachute to an airstream with too high a velocity.

When mass jumps are made, as in the dropping of parachute troops, the parachute is usually pulled out of the pack automatically by a static line attached to the airplane. This line is sufficiently long to make sure that the parachutist is clear of the aircraft before his parachute opens. Between static lines and the parachute is one weak link which finally breaks and thereby disconnects the parachutist from the airplane.

Opening Shock and Maneuverability. — The stretching of the suspension lines and of the canopy to the full length and the filling of the canopy occur more or less simultaneously. However: the main portion of the inflation follows the stretching of the lines. During the filling a strong force, called the opening shock. is exerted upon the suspended man or the load. Opening shocks between 4,000 and 5.000 lb. have to be expected at speeds of 400 m.p.h. and at low altitudes. At speeds higher than 400 m.p.h. the opening shock may be so great that a man may be fatally injured or his parachute destroyed. It has also been found that up to 40,000-ft. altitude the opening shock of parachutes increases with altitude, and may be assumed that this also is true up to higher altitudes. The violence of the opening shock depends also on the type of parachute. The desire to reduce the violence of the opening shock has been a strong incentive for the design of improved types of parachutes.

A certain degree of maneuverability can be achieved with every parachute; *e.g.*, in order to glide to the left an experienced parachutist will pull down on the suspension lines on the left-hand side. The possibility of directing to a selected point is so small that in general. the armed services of the larger countries do not attempt to train their men in the art of chute maneuvers. Sport jumpers, however, acquire great skill in this matter and yearly meets are held in which many nationally selected crews compete in target jumping.

Parachute Evolution. — Up to the beginning of World War II, practically all parachutes in use were of the solid, flat type, consisting of a more or less flat circular canopy made of solid cloth. This type of parachute had certain undesirable features such as high opening shock and an inherent tendency to oscillate or glide. In order to achieve a high degree of air resistance without excessive opening shock and uncomfortable or dangerous oscillations, extensive studies were conducted in wind tunnels and other aerodynamic research facilities. The results of these efforts were radically new types of parachutes, the ribbon parachute (1938) and the guide surface parachute (1943), both of German origin. Between these two extremes a number of in-between designs can be found.

Solid. flat parachutes with medium porosity are all unstable; they either oscillate. glide or perform a combined motion. Ringslot parachutes, which consist of concentrically arranged rings of cloth and open spaces are more stable than any flat parachute made out of solid cloth. The ribbon parachutes belong to the same family, and their geometric porosity is of the same order as that of ringslot parachutes; however, the individual units of material and open space are smaller, and the stability of ribbon parachutes is in general better than that of the ringslot parachutes. Formed gore parachutes attempt to control parachute behaviour by shaping the canopy. They are characterized by the drawn-in skirt and are generally more stable than the comparable flat parachutes with the same porosity.

In the design of the guide surface chutes, the concept of parachute shaping has been carried considerably farther. They are made of low-porosity cloth and have a conical surface at the lower portion of the canopy. Guide surface chutes are most stable in their class. They are specialized for stabilization of bombs, mines and torpedoes (stabilization type); for the recovery of guided missiles and escape capsules (universal type); and for rescue of men from high-speed aircraft (personnel type).

Ejection Seats and Escape Capsules. — In high-speed aircraft

it is very difficult, sometimes impossible, for the pilot to leave the disabled aircraft. The airplane may tumble or spin and the accelerations during such uncontrolled flight may make it impossible for the pilot to bail out. The high velocity air stream may press the pilot with so much force against a part of the aircraft that he is unable to free himself. Furthermore, if the pilot should be able to leave the aircraft the air stream would probably blow him against the tail structure with great force. To meet this problem, high-speed military and research aircraft are equipped with cartridge-actuated ejection seats.

Under normal flight conditions an ejection seat is used like any regular pilot's seat. In an emergency the seat is ejected from the aircraft structure by means of a cylinder and piston arrangement actuated by the explosion of a small charge of propellant. The pilot is literally blown out of the airplane. During the period of ejection the pilot has an upward velocity of approximately 60 ft. per second, which is usually sufficient to clear safely the tail structure of the aircraft. The ejection seats also have a number of safety arrangements that prevent arms and legs from being violently moved by the air stream. In seats without these precautions dislocation of joints or bone fractures have occurred. (See fig. 2.)

During the ejection the pilot is held in the seat by a lap belt, and his parachute is connected to his harness. The parachute remains inactive until the pilot is separated from the ejection seat by the opening of the lap belt. When the seat and the pilot have drifted far enough apart, the parachute is automatically opened and the pilot descends in normal fashion. The instant of the opening of the lap belt and the opening of the parachute is carefully timed in order to avoid excessive opening shocks and also to allow the bail-out altitude to be as low as possible.

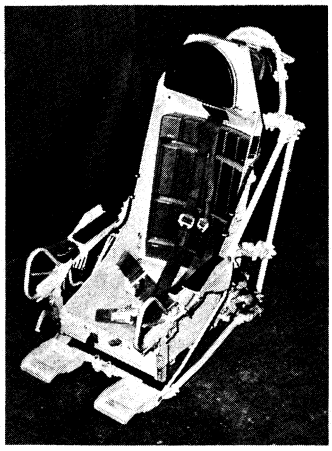


FIG. 2.— PILOT EJECTION SEAT FOR JET FIGHTER PLANE

The use of ejection seats is limited to high subsonic, transonic and low supersonic speeds since the high velocity air stream imposes unacceptable deceleration of the pilot in the ejection seat. In addition, the air blast may tear away protective helmets, oxygen masks and garments and thereby jeopardize the pilot's life. For the protection of a single pilot or a crew of two, pilot escape capsules have been proposed. These capsules are a part of the aircraft structure, usually the cabin or cockpit, and in case of emergency they are separated from the air frame.

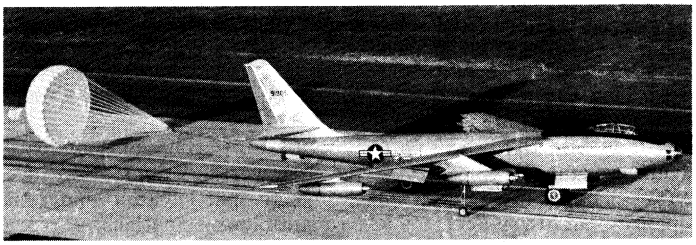
Properly designed pilot capsules appear to be suitable for escapes from supersonic and hypersonic aircraft as well as for space vehicles. During the descent, two or three parachutes are used to stabilize and to decelerate the capsule.

Landing-Brake Parachutes.— Parachutes of this type serve to reduce the speed of an aircraft during its landing approach and to shorten its landing run. This method was a standard procedure in the landing of German troops transported in glider airplanes during World War II and after the war it was widely used for military aircraft. Ringslot or ribbon parachutes are used for this purpose.

Because of a favourable flow pattern surrounding the parachute, landing-brake parachutes are deflected upwardly and do not touch the ground until the aircraft speed is almost zero at which time the parachute partially collapses and glides over the ground. (See fig. 3.)

In some cases a small parachute is used during the landing approach and a larger one to reduce the landing run. In general, the parachute used during the approach must be small enough to allow the aircraft to remain air-borne and able to climb again. This requirement is necessary because the pilot may wish to discontinue the landing maneuver and fly another approach.

Pilotless Aircraft and Missile Recovery Parachutes.— A number of small, pilotless airplanes used for target practice can be recovered after their fuel is expended or after they are hit by a projectile. As some of these targets fly at high subsonic speed, it has been necessary to develop intricate parachute systems for initial deceleration and final landing. These parachute systems have not been developed for the recovery of manned aircraft in spite of numerous patent applications and other proposals.



BY COURTESY OF BOEING AIRPLANE COMPANY

FIG. 3.— A 32-FT. LANDING-BRAKE RIBBON CHUTE SLOWING DOWN A 600-M.P.H. BOEING STRATOJET ON RUNWAY

In the development of missiles it is sometimes highly desirable to recover entire missiles, because the recovery of a missile which did not function satisfactorily is very essential since it allows the investigation of the cause of malfunction. The first example of a missile recovery came in 1943 when the German V-2 missile, during its flight test program, was recovered by a ribbon parachute. The recovery of missiles is now a well-established practice. The recovery of capsules which are ejected from satellites or space vehicles and which may contain instruments or living beings is a further extension of the technique of missile recovery methods.

Care of Parachutes.— The life of a man depends upon the quality, freshness and packing of each parachute manufactured or repacked. Parachutes not regularly used should be unpacked, inspected, dried out and repacked once in every 30 to 60 days. Air-conditioned and practically dustproof sheds have been designed for this purpose.

Each man-carrying parachute carries information as to the date on which it was last inspected, dried and packed, together with the name of the inspector. Parachutes made out of nylon or other synthetic material are taken out of personal use after they reach a certain age, because the physical properties of these materials deteriorate with time regardless of use. In the United States the age limit for nylon is seven years. (H. G. He.)

Sport Parachuting.— The two criteria of sport parachuting are style during free fall—the period after exit from the aircraft and before the opening of the parachute—and accuracy in landing. By spreading and arching his body a parachutist can hold a stable position during descent in free fall, or he can make turns, loops, and barrel rolls, and increase or decrease his rate of descent. By combining these techniques a parachutist may catch up to another parachutist during free fall and actually pass a baton for a free fall relay event.

Sport parachutes that give the parachutist control of his direction and a horizontal speed of close to 10 m.p.h. have permitted improved standards of accuracy in landing. Distance is measured from the exact centre of the crosslike target to the point of impact of the parachutist.

In 1960 the world records (the average of two successive jumps in 24 hr.) were 1.02 m. in the 1000-m. (3,300 ft.) jump and 0.62 m. in the 1500-m. jump.

Sport parachutes have large holes that permit the air to escape and drive the parachute in the direction opposite the hole, much like a low-power jet engine. The parachutes may be rotated by a light pull on a control knob that regulates the direction of the escaping air. The curved surface of the parachute moving through the air gives lift like an airplane wing. This lift effect greatly reduces the landing shock.

A device called the sleeve that controls the deployment of the

parachute canopy is perhaps the main technological development behind the growth of sport parachuting. The sleeve is a three-way safety factor. It draws the parachutist upright during deployment and thereby virtually eliminates the opening shock. It controls the canopy during deployment and makes it impossible for a man to wrap up in the parachute while it opens. The sleeve also lessens the possibility that the canopy will remain closed by removing the pilot chute pressure from the apex of the canopy during the opening.

An outgrowth of informal competition for accuracy, sport parachuting came into its own at the first world championship meet in Yugoslavia in 1951 with five countries participating under the sponsorship of the Federation Aeronautique Internationale. World championship meets are held every two years. The United States was represented for the first time in 1954 when Fred Mason took 21st place in the second world championship meet at St. Yan, in France.

The first U.S. sport parachuting team competed in 1956 in the third world championship meet in Moscow, U.S.S.R. The first two sport parachuting centres in the United States were created in 1959 at Orange, Mass.. and Hemet, Calif.

Improved equipment and techniques created an amazing safety record for the sport. The Telsan technique of parachuting instruction permits persons who have never before seen a parachute to make a static line jump, during which the parachute opens automatically, after only four hours of instruction. In France. 100,000 student jumps were made without a fatality. Strict international regulations condemn unsafe practices. Sport parachutists are required to open their parachutes at a safe altitude of 2,200 ft.

The sport of parachute jumping is governed in each country by the parachute branch of the national aero club. In the United States the official body is the Parachute Club of America, a branch of the National Aeronautic association. (J. A. I.)

PARADISE. A Persian word, meaning a royal park or enclosed pleasure garden, found in three late passages of the Hebrew Old Testament. Neh. ii. 8, Cant. iv, 13, Eccles. ii, 5, in much the same sense. The Greek Old Testament uses it much more freely, especially as a name for the garden of Eden in Genesis, and in other passages where the Hebrew has "garden of God" or simply "garden." The name has thus passed into use as the title of the happy garden in which our first parents lived. Other forms of the myth may be traced in the Old Testament. Behind the dirge of Ezekiel on the king of Tyre (Ezek. xxviii) lies a myth which pictures the primeval man as dwelling in the garden of God, situate not in a desert plain but on the mountain of God. He wears glorious apparel, studded with gems. He is originally blameless, but sins, and is banished from the mountain, which, like the garden in Genesis, is the dwelling place of God. These myths are not of Hebrew origin, but belong to the common stock of Semitic tradition.

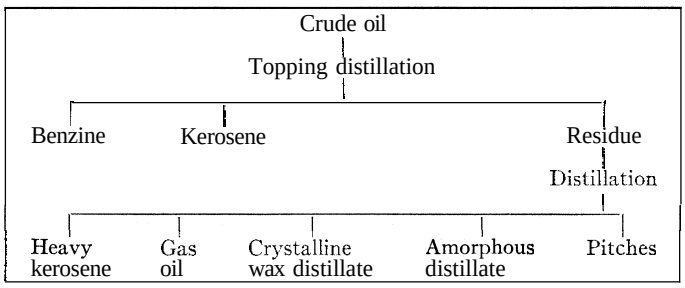
Among the Sumerians there were myths about the paradise in which man had lived before the flood, and his loss of this primitive bliss. While certain features of the Babylonian myths are found in the Hebrew stories no close parallel to the latter has yet been discovered in cuneiform. and it is unlikely that they were borrowed directly from Babylon. Many peoples had myths telling of a golden age when men dwelt happily with the gods in some fair isle or happy garden: sometimes this paradise was thought still to exist. If only the way to it might be rediscovered' So Gilgamesh, the hero of the Babylonian epic, travelled a perilous journey to the island where Utnapishtim, the Babylonian Noah, dwelt with the gods; there he indeed obtained the plant which conferred immortal life, but a serpent stole it from him as he returned. But though man might not in this life find the road to paradise might not the dead return there? The Semites generally, and the Hebrews in particular, thought of the dead as maintaining a shadowy existence in a gloomy cavern of the underworld. When, however, the hope of a Messianic kingdom upon earth dawned there was developed also the idea that the righteous dead might be raised to share its bliss. It is noteworthy that the Messianic kingdom renews on earth some of the felicities of the garden of Eden: the land becomes miraculously fertile, even the desert blossoming as the rose, and the beasts live in idyllic amity. The conception is developed by the Jewish apocalyptic writers, especially the author of *Enoch,* who wrote in the early second century B.C.

Later this paradise of hope becomes more supernatural, and is situated not on earth but in heaven. The book of *Enoch* divides the underworld into four parts, tenanted severally by the wicked, the moderately wicked, the moderately good. and the supremely good; the good even there enjoy some measure of felicity ere they are raised to share the happiness of the Messianic kingdom. Paul gives the name paradise to the third of the seven heavens recognized by the Rabbinic schools. In Rev. ii, 7 paradise mould seem to be the final state of bliss attained by the saints. The visions of the New Jerusalem coming down out of heaven to the earth (Rev. xxi, xxii) recall in several features the paradise from which the earliest man was driven: in it are miraculous trees, giving food and healing; through it flows the river of water of life; and there, free from sorrow, pain and death, dwell the saints in the presence of God.

See EDEN, and particularly the articles *Blest, Abode of* ***the*** in the *Encyclopaedia of Religion and Ethics.* (W. L. W.)

PARAFFIN, the term given to a mineral wax and also used as a generic name for a particular series of hydrocarbons. Refined commercial paraffin is a white, translucent, waxy solid devoid of taste and smell and characterized by chemical indifference. The industry owes its origin to James Young, who in 1850 applied for his patent "to obtain . . . paraffin from bituminous shales" by slow distillation. Paraffin is obtained from the many crude petroleums that are designated paraffin-base oils because of their wax content. The wax-bearing crudes of America contain on the average less than 5%, those of Galicia about 6%, the oils of Burma 10% and Scottish shale oil about 13% of merchantable wax.

Manufacture.— The manufacture of paraffin by modern methods falls under two heads. First, the distillation of the crude oil and second, the extraction of wax from the distillate. **A** process that has become almost conventional starts with crude oil and brings about by continuous distillation the removal of petrol and kerosene, leaving what may be called a "topped" oil.



In the majority of cases this topped oil contains heavy oil, such as gas oil, that is used for enriching water-gas in the gasworks, lubricating oils, wax and pitch, as is clearly shown in the above diagram. This residue oil is again distilled continuously and run down to heavy kerosene, gas oil, wax distillates and pitch. In more recent practice the distillation is carried out in a pipe-still through which the oil passes at high velocity under pressure and is discharged as vapour into a fractionating column. From the top of the column may be easily obtained an overhead distillate, *e.g.,* petrol, and at various "decks" or trays at different distances from the top may be withdra n fractions of higher and higher boiling point. But, in the majority of cases the wax distillates are of two kinds, known as crystalline or pressable and amorphous or non-pressahle. As will be seen later, this difference is probably a function of the crystal size.

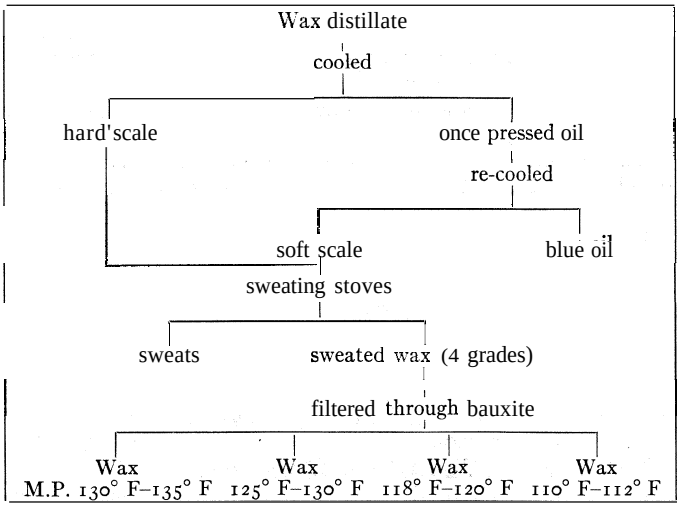
Crystalline (or Pressable) Wax Distillate.— This material in effect is a mixture of crude lubricating oils and crystalline paraffin hydrocarbons that possess no lubricating power whatever. It is necessary to remove the wax firstly because of this lack of ability for lubrication and secondly because the high melt-

ing point of wax would render the lubricating oils solid or semi-solid at ordinary temperatures, and thirdly because of the market value of the wax. This wax distillate, then, is passed on to the paraffin sheds, as the extraction plant is usually termed. and is allowed to repose in tanks to promote thorough settling and the maximum reduction in temperature. It is then transferred to a plant in which it can be cooled artificially to any particular temperature required. The refrigerating plants that achieve this cooling usually depend for their effect on the expansion of liquid ammonia or liquid carbonic acid gas. In modern practice heat exchangers are used so that the cold filtrate from the filter-presses can be employed further to chill the incoming wax distillate to the refrigerators. It is frequently convenient to cool the wax distillate in two stages, but this procedure depends largely on the content of wax and its nature. There have been devised many types of cooling apparatus of which that patented by James Bryson of Scottish Oils Ltd.. is typical. This type consists of an inner cylinder in which the wax distillate passes and which is provided with a scraper. The cylinder is surrounded by a concentric casing through which cold brine is circulated after having been chilled by contact with pipes in which the refrigerant is being evaporated. The plant designed by A. C. Thompson uses direct cooling in preference to brine cooling and the oil is pumped over the vessel that contains the expanding ammonia or other cooling agent.

A more recent type is the Allen-Moore, in which the oil to be cooled passes into thin cells provided with scrapers and cooled by contact with the refrigerant. Broadly speaking it is advisable to cool the wax distillate slowly. In this way large crystals are produced from which the adherent oil easily drains.

The frozen mass containing the crystallized paraffin is now pumped through filter-presses under high pressure, *e.g.,* 500 lb. per sq.in. The filter-presses are kept in sheds which are well insulated from outside conditions and chilled to the necessary temperature by radiators in which cooled brine is circulated. When the filter-press is fully charged with wax, it is opened and the contents are discharged into a trough situated below the press and conveyed by a screw conveyor into the refining section. If a second cooling is necessary, the expressed oil.,commonly called the "blue oil," is re-cooled to a lower temperature in a similar plant and filter-pressed again.

Example of Treatment of Wax **Distillate**



A modern filter-press consists of a series of thin circular steel plates fitted with steel gauze on each side and provided with a circular opening in the centre to permit oil to be fed into each chamber. Heavy canvas is cut to fit the plates and is either sewn or firmly clamped round the hole in the centre. Spacing rings are placed between each pair of plates, thereby forming chambers in which the wax cakes form. The series of plates and rings are assembled on the press frame and the whole closed under a pressure of about 700 ib. per sq.in. by means of a hydraulic ram. This type is built to hold up to 400 or 100 plates 48 in. in diam. and to work up to 500 lb. pressure. The spacing rings used to form the chambers vary in thickness from $\frac{3}{8}$ in. to 1 in.. enabling the thickness of the wax scale cakes to be altered according to the quality of the oil being pressed. For instance, should the oil contain an easily pressable crystalline wax scale a thick cake would be desired in order to work the press at its maximum capacity by reducing the number of plates in use. but should the oil contain a soft wax it might be advantageous to reduce the thickness of the cake.

Pressing. — The oil is pumped by means of low-pressure pumps through the chillers into a tank kept at the exact temperature required and thence by means of a high-pressure pump into the main line feeding the presses, any oil over the amount taken by the presses being returned to the tank through a relief valve set at the maximum pressure required. This allows perfect control to be exercised over the temperature and pressure of the oil.

The paraffin distillate from the stills. usually having a settling point of from 70° F to 80° F. and a recoverable wax content ranging between 5% and 10%, is chilled to the temperature which will give a pressed oil having the desired set point and then fed into the presses. The oil is let into the presses very gently and when the pressure starts to rise the rate of increase is kept slow and constant.

When the pressure has reached its maximum the press is allowed to remain under pressure until it is required to be emptied ready for a new charge and this permits the wax scale to become as free from oil as possible.

The Refining of the Crude **Paraffin.**—The original wax distillate is now separated into blue oil and crude scale; the latter still contains a little adherent oil and this must be removed and the crude wax chemically treated to remove colouring matter and odorous impurities.

The process that follows achieves the removal of low melting waxes and adherent oil and is called the "sweating process," first developed by Price's Candle Company. There are innumerable modifications of the sweating process, which may be regarded as a fractional melting operation. and perhaps the simplest to understand is that devised by N. Henderson. In this there is a frame on which are set nine shallow trays one above the other. In each tray wire gauze is stretched 2 in. from the bottom. The frames can be set in rooms or stoves provided with heating and cooling arrangements. The trays are first set level and water is run in to the depth of the gauze. Then the melted wax is run on to the water surface and is allowed to solidify. After solidification the trays are tilted and the water run off. The temperature inside the stove is gradually raised and fractional melting goes on until the material on the gauze is of the correct melting point.

The "sweats" are run off and may be again put through the process. After drawing off the sweats the temperature is still further raised and the sweated wax is melted and run to the next stage of the process.

The oil and soft wax that sweats out during the process are divided into fractions, graded according to their setting points.

The first runnings from the trays up to a set point of about 90° F, termed "light foots oil." is in the ordinary process used as works fuel; it has no other commercial value and the wax it contains is of too low a melting point to justify repressing or further redistillation.

The next fraction sweating out. from a set point of 90° to 110° F, termed "heavy foots oil." is generally pumped back for incorporation with the wax distillate cut from the crude oil.

Wax that sweats out above this point till the end of the operations is reached is re-sweated to give a wax of a lower grade, or if only one grade of finished wax is being made it is mixed with the scale from the filter-presses to make up the next sweating chamber charge.

The setting points and fractions obtained are, of course, purely arbitrary and are governed by the number of the grades of finished wax being made, as well as by the method and temperatures used in processing the wax. It still contains colouring matter and there-

fore must be decolorized.

The Finishing Treatment. — In many refineries the wax is melted and run into agitators, where it is treated with successive amounts of strong sulphuric acid. The agitators are lead-lined and steam-jacketed and the mixture of acid and wax is violently stirred up by air agitation. The agitation is carried on for 30 min., and then an hour is allowed for settling. At the end of this time the acid sludge is drawn off and the melted wax is run into another agitator, in which it is washed with hot water and then with caustic soda and finally with a hot water spray. After removing all traces of water by long settling, the wax is dried finally by blowing air through it. Alternatively the use of caustic soda may be dispensed with by following up the acid treatment with agitation in the presence of finely divided absorbent clay. Even at this stage the wax is not entirely colourless and odourless and it is necessary to filter it through ignited fuller's earth.

Another method of treatment that has been found very effective and that dispenses with the acid treatment altogether is achieved by filtering the wax-scale through recently ignited bauxite. This mineral is essentially a mixture of alumina and ferric oxide and has a very porous structure. To prepare it for use, the crude rock is ground and sieved to form coarse particles that pass through a 10-mesh sieve and are retained on a go-mesh sieve. The bauxite is then passed through a furnace at about 600° C, where it is ignited and becomes substantially free from water. The bauxite is now put into filters that are jacketed and the melted wax is allowed to flow through, samples being tested to see that the colour of the effluent wax is up to standard. The wax is run to trays, allowed to solidify, and packed in bags; each cake of wax is about 12 in. × 18 in. × 1½ in. in dimensions and weighs about 10½ lb.

Refined wax is always passed through a filter-press equipped with double sheets of filter paper before final caking. The wax should be entirely odourless and a cake of wax freshly broken should possess no smell at the plane of fracture. It should be colourless, stable to heat and light, and of the correct melting point. It should be free from opaque blemishes ("mottling") and should not be crumbly or flaky. It is sold commercially in terms of melting point, *e.g.,* hard wax in the grade that melts between 130° F and 135° F.

It has been found in the case of certain sulphurous oils that a preliminary treatment with alkaline hypochlorite before filtration materially assists in the production of a non-odorous wax.

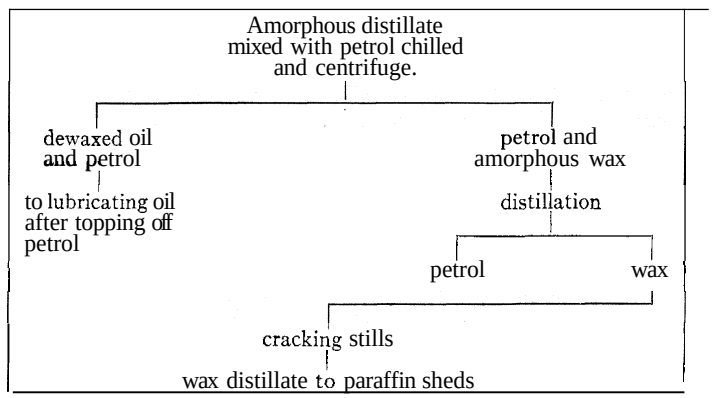
Amorphous Wax — Non-pressable. — After the pressable wax has been distilled off from the crude oil residue there appears a fraction containing wax, the crystal size of which is very much smaller than that of the preceding fraction; this is the so-called amorphous distillate.

Until recent times fractions and residues of petroleum containing this material that could not be handled in filter-presses were allowed to stand, well diluted with petrol, in tanks at a low temperature and for a long period of time. The slow imperceptible action of gravity gradually precipitated the slightly heavier wax out of the slightly lighter solution. There was left at the bottom of the tank a soft salve-like mass and above it a petrol solution of dewaxed oil. In many cases the precipitate was so amorphous that it could be worked up for petroleum jelly and this was particularly the case when a residue was being treated.

A revolutionary idea has changed this procedure. It is to the credit of Sharples, who had successfully separated cream from milk by means of high speed centrifuges, to apply this method to the separation of amorphous wax from its accompanying oil.

Sharples' Process. — The amorphous distillate is diluted with approximately an equal bulk of petrol or a fraction of petrol from which the more volatile part has been distilled off The mixture is now very slowly cooled till it reaches a temperature of about 10° F throughout a period of 20–30 hours. It is then conveyed into the bowl of a centrifuge rotating at 30,000 revolutions per minute when the slightly heavier wax is flung outward against the periphery nhilst the slightly lighter solution occupies the middle of the boul. by natural law. The centrifuge runs continuously and there are consequently ejected from spouts at the top. (a) amorphous wax that is melted by suitable heating means and (b) a petrol solution of de-waxed oil. These run away to separate tanks. The wax obtained after removing some of the solvent that is conveyed with it is in the micro-crystalline state and it is converted into macro-crystalline wax by a redistillation under cracking conditions, that is to say, by distilling at a relatively high temperature, thus permitting a re-adjustment of the molecules. The distillate from the amorphous wax contains oil and crystalline wax and may be put through the sheds along with the pressable wax distillate.

Sharples' System



Uses of Paraffin. — Although paraffin wax may be regarded as a by-product of petroleum distillation, the world's supply is very considerable, amounting to approximately 200.000 tons a year. It finds its chief use in replacing and as a substitute for certain expensive natural waxes such as beeswax. It enters largely into the composition of floor polishes; it is used for filling leather and as an insulator in the electrical trades. A very large amount is also used for water-proofing paper and cardboard. and thus is an essential component of water-proof receptacles for packing; during World War I, for example, jam pots were made of stout paper rendered air-tight and water-proof by means of paraffin. In a similar way it may be applied for water-proofing fibres before weaving, and very large amounts of water-proofed textiles are now manufactured.

The softer paraffins are used in the manufacture of ointments and salves, and a large amount is applied in rendering match sticks water-proof and flammable.

The above uses, however, are only minor when compared with the vast quantities used in the manufacture of tapers, candles and night lights. In making candles it is not usual to employ pure paraffin, because it has a tendency to stick to the moulds and, moreover, may soften too easily in service, so the paraffin is mixed with stearic acid and palmitic acid that are obtained by the decomposition of many natural fats. The effect of the stearic acid is to give a less plastic composition, one that is stiffer and not so likely to bend in warm weather.

The earlier candles were usually made of tallow, were very soft and the wick required constant snuffing, but in the modern wax candle the wick is so woven that it tends to bend over during burning and so be consumed in the hot edge of the flame as fast as the burning proceeds. (A. E. D.)

PARAFFIN HYDROCARBONS. Paraffin (alkane) is the generic name given to the saturated hydrocarbons having the general formula C_nH_{2n+2}. The paraffins are major constituents of natural gas and petroleum. Paraffins containing fewer than j carbon atoms per molecule are gaseous at room temperature, those having a carbon content of C_5–C_{15} are usually liquids, and the straight-chain paraffins having more than 1 j carbon atoms per molecule are solids. Branched-chain paraffins with five to eight carbon atoms per molecule have a much higher octane number than straight-chain paraffins and, therefore, they are the more desirable constituents of gasoline (petrol).

The hydrocarbons are not miscible with water; they are

soluble in absolute alcohol, ether and acetone. All paraffins are colourless.

Synthesis. — Paraffins can be prepared as follows: (1) Hydrogenation of olefins in the presence of catalysts such as nickel or platinum. (2) Transformation of alkyl halides into alkyl magnesium halides (Grignard reagents), which are then decomposed with water or dilute mineral acids. (3) Reduction of ketones by means of amalgamated zinc and hydrochloric acid (Clemmensen reduction) or with hydrazine and sodium ethoxide (Wolff-Kishner reductionj. (4) Reduction of an alkyl halide by means of such reagents as lithium aluminum hydride ($LiAlH_4$), sodium and alcohol, hydrogen and platinum. etc. (j) Dehydroxymethylation of primary alcohols by reaction under pressure with hydrogen in the presence of a nickel catalyst at 150°–225° C. (302°–437° F.); methane and water are formed as by-products. (6) Reaction of alkyl halides with metallic sodium (Wurtz synthesis); the yields of the desired paraffins are sometimes, however, very low. (7) Reduction of carbon monoxide with hydrogen at 200°–250° C. and at atmospheric pressure in the presence of a catalyst consisting of cobalt. thoria and kieselguhr (Fischer-Tropsch synthesis). This process. which yields a mixture of straight-chain paraffins, was used in Germany during World War I1 for the production of gasoline and lubricating oils.

Reactions. — The paraffins are resistant to the action of aqueous solutions of acids; alkalies and oxidizing agents at room temperature. This inertness gave rise to the name "paraffin" (Lat. *parum*, little; *affinis*, akin).

Thermal and Catalytic Cracking.—At a sufficiently high temperature paraffins decompose to lower paraffins, olefins and hydrogen. Propane at 600" C. decomposes as follows:

$$CH_3CH_2CH_3 \rightarrow \underset{\text{(ethylene)}}{CH_2=CH_2} + \underset{\text{(methane)}}{CH_4}$$

$$CH_3CH_2CH_3 \rightarrow \underset{\text{(propylene)}}{CH_3CH=CH_2} + H_2$$

Ethylene and methane are the principal products. Paraffins of higher molecular weight. on cracking, form hydrogen and a complex mixture of olefins and lower-boiling paraffins.

In the presence of a silica-alumina catalyst at 500°–550° C., paraffins decompose to form a complex mixture composed mainly of branched-chain paraffins and olefins. This method is used commercially for making high-octane gasoline.

Isomerization.—In the presence of catalysts such as aluminum chloride-hydrogen chloride, n-butane is reversibly isomerized to isobutane. The isomerization occurs at about 80°–12j° C. and at a pressure of 3 to 10 atm.

$$CH_3CH_2CH_2CH_3 \rightleftarrows CH_3\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_3$$

The isomerization of C_5 and C_6 hydrocarbons is carried out under 10–30 atmospheres of pressure in the presence of hydrogen and a platinum-alumina catalyst containing some halides.

Oxidation and Chlorination. — Paraffins in the presence of oxygen or strong oxidizing agents at high temperatures undergo complete oxidation to carbon dioxide and water.

$$C_nH_{2n+2} + \frac{3n+1}{2}O_2 \rightarrow nCO_2 + (n+1)H_2O$$

Under certain controlled conditions of contact time and in the presence of air, a partial oxidation of paraffins is feasible. A complex mixture of oxygenated compounds consisting of alcohols, ketones, aldehydes and acids results from such a reaction.

The chlorination of paraffins occurs at 250° C.. or at lower temperatures if induced by light or organic peroxides. The chlorination reaction yields a mixture of chlorinated hydrocarbons.

$$CH_3CH_2CH_2CH_2CH_3 + Cl_2 \rightarrow \begin{cases} CH_3CH_2CH_2CH_2CH_2Cl \\ CH_3CH_2CH_2CHClCH_3 \\ CH_3CH_2CHClCH_2CH_3 \end{cases}$$

Nitric Acid. — Paraffins react with nitric acid in the vapour phase to form nitroparaffins.

$$RH + HONO_2 \xrightarrow{420^\circ\text{ C.}} RNO_2 + H_2O$$

The reaction is accompanied by the scission of carbon-carbon bonds. In the nitration of propane, for example, not only 1- and 2-nitropropane ($CH_3CH_2CH_2NO_2$ and $CH_3CHNO_2CH_3$) are formed, but also nitroethane ($CH_3CH_2NO_2$) and nitromethane (CH_3NO_2).

Sulfur Dioxide and **Chlorine.**—Paraffins form sulfonyl chlorides by reacting with sulfur dioxide and chlorine in the presence of light or organic peroxides.

$$RH + SO_2 + Cl_2 \xrightarrow{\text{light}} RSO_2Cl + HCl$$

The products thus obtained from paraffins with 12 to 16 carbon atoms per molecule can he transformed into sulfonates that are valuable as detergents and netting agents.

Addition of **Carbenes.**—Carbene or substituted carbenes which are formed by photochemical or thermal clecomposition of the corresponding diazocoinpounrls add to paraffins:

$$RH + CH_2N_2 \xrightarrow{\text{light}} RCH_3 + N_2$$

$$RH + N_2CHCOOR^1 \xrightarrow[\text{or heat}]{\text{light}} RCH_2COOR^1 + N_2$$

Alkylation of **Paraffins.**—*Thermal.*—Paraffins such as propane, butane and isobutane react with olefins at elevated temperatures and pressures to form addition products.

$$\underset{\text{(isobutane)}}{CH_3\text{–}\underset{\displaystyle CH_3}{\underset{|}{C}}H\text{–}CH_3} + \underset{\text{(ethylene)}}{CH_2=CH_2} \xrightarrow[290\text{ atm.}]{500^\circ\text{ C.}} CH_3\text{–}\underset{\displaystyle CH_3}{\underset{|}{C}}\text{–}CH_2\text{–}CH_3$$

(2,2-dimethylbutane)

Catalytic. — Isobutane reacts catalytically with olefins of lower molecular weight. The catalysts most commonly used are aluminum chloride-hydrogen chloride, hydrogen fluoride and concentrated sulfuric acid. The catalytic alkylation proceeds at 0° to 35° C. and at pressures of 2 to 10 atm.

$$\underset{\text{(isobutane)}}{CH_3\text{–}\underset{\displaystyle CH_3}{\underset{|}{C}}H\text{–}CH_3} + \underset{\text{(ethylene)}}{CH_2=CH_2} \xrightarrow[35^\circ\text{ C.}]{AlCl_3\ HCl} CH_3\text{–}\underset{\displaystyle CH_3}{\underset{|}{C}}H\text{–}\underset{\displaystyle CH_3}{\underset{|}{C}}H\text{–}CH_3$$

(2,3-dimethylbutane)

$$\underset{\displaystyle CH_3}{\underset{|}{CH}}\text{–}CH_2\text{–}CH_3 + \underset{\text{2-butene}}{CH_3\text{–}CH=CH\text{–}CH_3} \xrightarrow[0\text{–}35^\circ\text{ C.}]{H_2SO_4\text{ or HF}} C_8H_{18}$$

The outstanding application of this reaction is the production of high-octane gasoline; it was in wide use during World War II.

Dehydrogenation.—Paraffins with two to five carbon atoms per molecule undergo dehydrogenation to olefins when brought into contact with a suitable catalyst at atmospheric pressure.

$$\underset{\text{n—butane}}{CH_3CH_2CH_2CH_3} \xrightarrow[525^\circ\text{ C.}]{Cr_2O_3\ Al_2O_3} \underset{\text{2—butene}}{CH_3CH=CHCH_3} + H_2$$

Heptanes and hydrocarbons of higher molecular weight undergo dehydrogenation to aromatic hydrocarbons.

$$\underset{\text{n—heptane}}{CH_3CH_2CH_2CH_2CH_2CH_2CH_3} \xrightarrow[500^\circ\text{ C.}]{Cr_2O_3\ Al_2O_3} \underset{\text{toluene}}{\text{C}_6\text{H}_5\text{CH}_3} + 4H_2$$

This aromatization of paraffins has a wide commercial use.

(H. Ps.)

PARAFFIN OIL: see KEROSENE.

PARAGONITE, an uncommon rock-forming mineral belonging to the mica group. It is commonly found as very fine-grained pearly scales in dense masses; single crystals are exceptionally rare. It is colourless and cannot be distinguished optically from muscovite (q v). Paragonite usually occurs in schists with kyanite, chloritoid and staurolite.

It is found at Fenestrella, Italy; Alpe Sponda, Switz.; and Chester, Pa. A sodium mica, the chemical composition is close to $NaAl_2(AlSi_3)O_{10}(OH)_2$ with some K substituting for Na; Li, Fe^{+3} and Mg for the first Al; and Si for the second Al. Three polymorphs are recognized. Paragonite and fluoroparagonite have been synthesized. For further discussion see MICA. (H. S. Y.)

PARAGUANÁ PENINSULA, extending northward from Falcón state in northwestern Venezuela, lies between the Caribbean and the Gulf of Venezuela. Politically, it is a part of Falcón (*q.v.*); Coro. capital of the state. lies at the base of the isthmus. The peninsula is arid and of little use for agriculture. Lagoons line the coast. Population is sparse. Besides oil operations, the main activities are grazing of goats and fishing for mackerel, shrimp, shark, tuna and diving for pearls. Important petroleum pipelines have been built from the oil fields on the east side of Lake Maracaibo (*q.v.*) to terminals on the west side of the peninsula, where several companies have large oil refineries.

At Amuay terminal, the harbour has been dredged to 41 ft. to handle tankers up to 47.000 tons and four 1,100-ft. piers have been constructed for handling large tankers. A new international port has been built at Guaranao bay on the western side of the peninsula and large ships can be accommodated. Guaranao is one of the best sheltered and deepest bays on the peninsula. This port has grown in importance with completion of the hard-surface highways from Coro to Barquisimeto and from Coro to Maracaibo. Pueblo Nuevo is the principal settlement. (L. WE.)

PARAGUARÍ, a department of southern Paraguay. Area 3.187 sq.mi. Pop. (1950) 159,161. It is drained by the Tebicuary, tributary of the Paraguay river, and by Lake Ypoi (Laguna Verá), Paraguay's largest lake. The northern area of the department contains part of the forested Asunción prong of the Brazilian plateau. The southern districts are rich agricultural lowlands producing tropical subsistence and cash crops. Population is well distributed. There are many processing and marketing centres and the department is served by the main Asunción-Villarrica railway which passes through the capital, Paraguari, and by the Asunción-Encarnación highway. Caapuclj is the principal centre of the south of the department and near it are important iron ore resources. (G. J. B.)

PARAGUARÍ, capital of the department of the same name in southern Paraguay, lies 45 mi. S.E. of Asunción. It is the trading centre of the fertile and active agricultural region which slopes southward and westward from the Paraguayan extension of the Brazilian plateau to the Paraguay river. Pop. (1950) 4,658. It is connected with Asunción by road and rail, with Villarrica by the Central Paraguayan railway and with Encarnación by the new trunk road. known as route 1.

Cotton, tobacco, sugar. oranges, rice, maize and hides are among the products which it handles or produces. Ceramic works, tanneries and food-processing plants are located in the area. Essence of petitgrain, a base for perfume from bitter orange leaves, is an important product.

Originally a Jesuit mission, the city was formally organized in 1775 by Agustin Fernando de Pinedo. In 1811, when Paraguay decided not to join with the Argentine colonies in their revolt against Spain. Paraguari was the scene of an important battle in which the Argentines under Manuel Belgrano were repulsed and Paraguay's independence was secured. It is the headquarters of Paraguay's artillery regiment and school. Santo Tombs grottoes, on a hill near the city, are noted for their hieroglyphic inscriptions, presumably the work of early indigenous peoples. The 75-ft. long cavern is a centre of Good Friday pilgrimage. (G. J. B.)

PARAGUAY, a republic in the south central part of South America. Area 157,047 sq.mi. Pop. (1950 census) 1,408.400. Paraguay is bounded on the east by Brazil and Argentina, on the west by Bolivia, on the north by Brazil and Bolivia and on the south by Argentina. No part of the country lies within 600 mi. of the ocean and this landlocked situation distinguishes and conditions Paraguay's economic and political life.

Physical Features.— Paraguay proper, the country between the Paraguay and the Paranb. is traversed in the north and northeast by a broad irregular belt of highlands. a continuation and outwork of the great interior plateau of Brazil, marked especially by the Cordillera Amambay on the Brazilian frontier and by the Cordillera Mbaracayú. The elevation rarely exceeds 2,200 ft.

On the western side these highlands terminate with a more or less sharply defined edge, with the country sloping gradually up to their bases in gently undulating and ill-defined valleys; on the eastern side they send out broad spurs enclosing deep-cut valleys and the whole country retains more of an upland character.

The streams that flow westward to the Paraguay are consequently to some extent navigable, while those that run eastward to the Paraná are interrupted by rapids and falls, often of a formidable description. From the Asunción plateau southward, near the confluence of the Paraguay and Paraná, there is a vast stretch of marshy country, draining partly into the Ypoa lagoon, and smaller tracts of the same character are found in other parts of the lowlands, especially in the valley of the Paraguay. Many parts of the country sloping to the Paraná are nearly covered with dense forest and have been left in possession of the scattered native tribes. The country sloping to the Paraguay and comprising the greater part of the settled districts is grassy and open, though the hills are usually covered with forest and clumps of trees are common in the lowlands. The soil is mostly dry, porous and sandy, although extensive areas of the country are covered with red clayish soil.

Geology.— The Paraná plateau of southern Brazil extends into eastern Paraguay, where it occupies about half the area of the country east of the Paraguay river. It is a tableland formed of nearly horizontal beds of Triassic sandstone capped by late Triassic basalt and dissected by the gorges of the Paraná and its tributaries.

West of the plateau is a lower foothill zone composed of almost horizontal Devonian and Permian beds, a southward continuation of the Paleozoic beds exposed at the foot of the Mato Grosso plateau. The surface of the broad lowland, known west of the Paraguay river as the Chaco, is formed. so far as is known, of Tertiary and Quaternary beds through which protrudes, in the northern part, a low range of ancient gneiss known as the Sierra de Quince Puntas.

Climate, Vegetation and Animal Life.—Most of the country is subtropical and the climate is mild and salubrious. Temperatures during the antipodean summer frequently range above 100" F., but during the winter from June to mid-September they average 70° F. and frost is not unknown in the south and highlands In the most populated areas near and east of Asunción the rainfall averages 52 in., while in the Chaco west of the Paraguay river it is only 32 in. and in the region bordering Brazil it rises to 80 in. Most of the rainfall comes in the warmer months and it often occurs in the form of cloudbursts which diminish its benefits. The north wind from the Brazilian jungles, the viento *del norte,* occasionally has disagreeable effects.

Paraguay's abundant hardwood forests lie principally in its most easterly regions near the upper Paranb river and include indigenous varieties such as urunday, cedron. curupay and lapacho. The lack of softwoods for common purposes is a handicap, but enough lightwoods exist to float the heavy woods in huge rafts down the Paraná to the extensive Argentine market.

In the Chaco to the north along the Paraguay river are found scattered stands of quebracho, a hard red tree (quebra hacho, or break-ax) which yields a tanning extract exported in large quantities to England and the U.S. Medicinal herbs, shrubs and trees (the latter including the paratodo, with some of the properties of quinine) are in profusion and are exploited by European firms, as are also dyeaoods to some extent.

The famous yerba maté, or Paraguay tea, a holly (*Ilex paraguayensis*), occurs in the northeast in a wild state and in the southeast under cultivation by German-Paraguayans. Many large trees of species such as the samahu, the lapacho and the ceiba give spectacular floral displays which confer a unique beauty on the Paraguayan landscape often noted in South American literature.

The fauna includes the jaguar or ounce, quite abundant in the tropical Chaco and known as the tzgre, the dangerous large wild boar, the water hog or *carpincho,* many varieties of deer and the armadillo and anteater. There are many tropical birds such as the American ostrich (*ñanduguassu*), ibis and heron, toucan, black duck (*m'biguá*), doves, partridges and parakeets and parrots (papagaya). Insect life is extensive and large red anthills are often seen.

HISTORY

The first European to reach Paraguay was probably the semi-legendary Alejo Garcia, a Spaniard wrecked on the south Brazilian coast. Just after 1j20 he headed an expedition into the interior, reaching the outer confines of the Inca empire, but on the return journey he was killed someahere in Paraguay. Reports sent ahead. however, influenced Sebastian Cabot, who in 1526 and in 1529 explored the Parana and the Paraguay rivers in what is today Paraguayan territory. A decade later, on Aug. 1j, 1537, Asunción was founded by Domingo Martinez de Irala, who was to be the dominant figure in Paraguay for the next 20 years.

The Indians whom the Spaniards found in Paraguay belonged to many tribes but possessed a common language, the Guarani. They were chiefly agriculturists and continued to live side by side with their conquerors, and the culture of the country remained distinctly Indian. From Asunción as a centre, Spanish adventurers pushed northeastnard into La Guayrá, on the upper Paraná, and westward into the Gran Chaco; and, before long, vast numbers of natives were reduced to serfdom. Under Paraguay was included the entire region along the Paraná and Uruguay rivers, as well as. for administrative purposes, the present Argentine province of Buenos Aires. Not until 1620 were Paraguay proper and Rio de la Plata (or Buenos Aires) separated as distinct governments. Both were dependent on the viceroyalty of Peru until 1776, when Buenos Aires was made into a viceroyalty, with Paraguay under its jurisdiction.

The first Christian missions were established by the Franciscans between 1542 and 1560, but neither they nor the first Jesuit missionaries were able to make their enterprise a permanent success. A second band of Jesuits. who began their work in 1608. succeeded in establishing a kind of *imperium in imperio* in the east and south of Paraguay proper, and for a century and a half the history of Paraguay was largely the history of the Jesuit missions. In 1750, however, Ferdinand VI of Spain ceded to Portugal a part of this region in exchange for territory elsewhere. The Jesuits resisted the transfer, and the combined forces of Spain and Portugal defeated them only after several engagements. For more than a century thereafter the region was bitterly disputed between Spain and Portugal and their respective successors. Meanwhile, the missions never recovered their prosperity, and the Jesuits were finally expelled in 1767. In 1811, following the outbreak of the Hispanic American wars of independence, Paraguay resisted efforts from Buenos Xires to expel Spanish authority. It soon set up its own government, however, and by 1814 it was under the dictatorship of J. G. R. Francia (*q.v.*). After Francia's death in 1840, the chief poner passed to Carlos Antonio López (*q.v.*), who was succeeded by his son Francisco Solano López in 1862. Francia and the elder López had developed a strong Paraguayan army. The latter had fruitlessly sought adjustment of Paraguay's boundary disputes with Argentina and Brazil. The younger López attempted a vigorous foreign policy, and in 1864, on the occasion of Brazilian armed intervention in an Uruguayan civil war, went to war with Brazil. In order to strike at southern Brazil. he attempted to cross Argentine territory early in 1865. The result was the alliance of Argentina, Brazil and Uruguay for the purpose of overthrowing López and obtaining a settlement of Argentina's and Brazil's disputed boundaries with Paraguay on their own terms. Invasion of Paraguay followed. A tenacious five-year struggle. involving huge loss of life and of treasure. was terminated only by the complete defeat of the decimated Paraguayan forces and the death of the fleeing López at the Aquidaban river (March 1. 1870). During this warfare every able-bodied Paraguayan was in active service: whole battalions of women and regiments of boys of 12 to 1j years' of age were formed. The bravery of the Paraguayans became a tradition, and from a population of 1,337,439 at the outbreak of aar, the country was reduced, according to some estimates, to less than 250,000 of whom only 28.746 were men.

After insistent claims by Argentina to the entire Chaco, Brazil in 1872 signed a separate treaty with Paraguay taking only the latter's territory north of the Apa river. Not until 1876 did Argentina conclude a peace treaty with Paraguay, contenting itself with what is now the Argentine province of Misiones and the southern Chaco, and leaving the region between the Pilcomayo and Verde rivers to be decided by the president of the U S. Thus Paraguay profited by the rivalry between its two powerful neighbours. Pres. Rutherford B. Hayes in 1878 awarded to Paraguay the area between the two rivers above mentioned, and as a result of his decision a favourable relationship was established between Asuncion and Washington. D.C. Argentina accepted the award with good grace, posing as a friend to Paraguay, in contrast with Brazil's reputed desire to absorb that country.

Even before the final withdrawal of the Brazilian occupation troops in 1876, the Paraguayans had adopted in 1870 a new and liberal constitution which was to last for 70 years. In 1880 under the presidency of Gen. Bernardino Caballero a real revival of national spirit and activity began; the two political parties were formed which thereafter alternately ruled the country — the Colorado or Red party, representing popular and progressive tendencies, and the Liberal or Blue party, representing the conservative landowners and clericals. Because of factional plots and revolutions, no president served out his elected term until Eduardo Schaerer, who took office in 1912 after the conclusion of one of Paraguay's most protracted and sanguinary civil wars. Under Manuel Franco, elected in 1916. the country steered a neutral course during World War I. In 1920 came the presidency of Manuel Gondra. Paraguay's most internationally distinguished statesman and the sponsor of the well-known Gondra arbitration conventions adopted by the Pan-American conference of 1923; but Gondra resigned and was followed by the tno Ayalas, Eusebio Ayala until 1923 and then Eligio Ayala until 1928. The latter introduced financial and administrative reforms and was followed by José P. Guggiari, another Liberal.

The Chaco boundaries with Bolivia, while never formally fixed, had in fact remained more or less static until 1929, when Bolivia began developing petroleum resources through the Standard Oil company in the eastern Chaco. In that year the Pacific coast settlement between Chile and Peru, under U.S. auspices, excluded Bolivia from the Pacific seacoast. Bolivia also secured large loans in New York city and employed a German general, Hans von Kundt. to build up and command its armies and to establish military posts in territory which Paraguay regarded as its own. Frontier incidents multiplied, and on June 1j, 1932, Bolivia captured Fort López (Pitiantuta), deep in the central Chaco, and seemed likely to attain the Paraguay river as an outlet to the ocean, its putative objective. The Paraguayans took up arms nith great vigour, recaptured Pitiantuta in mid-July, expanded their army rapidly to 20 times its normal size of 3,000, and organized a supply line via Puerto Casado. With the able Eusebia Ayala again in the presidency, and with Col. José Félix Estigarribia in command of its forces. Paraguay was able in the autumn of 1933 to take the offensive. and by June 193j, in a succession of battles. had driven the Bolivians back to the original informal boundary, captured their headquarters and taken between 30.000 and 40.000 prisoners. In this victorious position Paraguay accepted an armistice arranged on June 12, 1935, by a committee of neutrals composed of representatives of Argentina, Brazil, Uruguay, Chile, Peru and the United States. and active hostilities ceased.

Early in 1936 the committee secured the mutual return of prisoners by the tuo combatants. and finally in July 1938 it settled the general peace terms, subject to an arbitral decision on the exact location of the frontier. This award was forthcoming in October and gave Paraguay at least three-fourths the disputed area. It thus emerged from the Chaco War, one of the longest and most sanguinary which Latin America had seen, with an expansion in territory and military prestige.

Col. Rafael Franco converted groups of young officers in the Chaco to the idea of a quasi-fascist regime, with their aid took over the presidency in Feb. 1936 and attempted a series of measures such as Italy had witnessed a decade earlier. Beset by many revolts, he became increasingly autocratic. and in Aug. 1937 an army-navy coup forced him out of office in favour of Félix Paiva, head of the university. Paiva, with the aid of the army under Col. Ramón Paredes and of former Pres. Eusebio Ayala, restored a more normal administration; he called elections in April 1939

which resulted in the presidency of General Estigarribia, hero of the Chaco War. Taking office in August, Estigarribia secured a $3,500,000 loan from the Export-Import Bank of Washington and commenced building a highway to Brazil (with which no direct communication existed) to enable his country to balance relations with its two great neighbours. In the summer of 1940, after quelling several conspiracies, he put through the adoption by plebiscite of a new constitution giving the president unprecedented powers and authority; but in September he was killed in an aeroplane accident, leaving a precarious political situation.

The minister of war, however, Gen. Higinio Morínigo, enjoyed the firm confidence of the army, which shared his view that the country needed an enforced truce from political partisan factional conflicts; he assumed the presidency and drew his cabinet from a group of conscientious and well-educated devotees of the principles of Catholic social action. He was thus able to govern firmly and repress repeated attempted coups by the Liberals, the National Front and later an unstable combination of the two. In 1943 he was elected president in an army-supervised plebiscite, having in the meantime given Paraguay's support to the Allied cause against Germany and Italy. While not restoring free democracy, he gave an efficient administration, aided financially and otherwise by Brazil and the U.S., despite Argentine anti-Allied pressures.

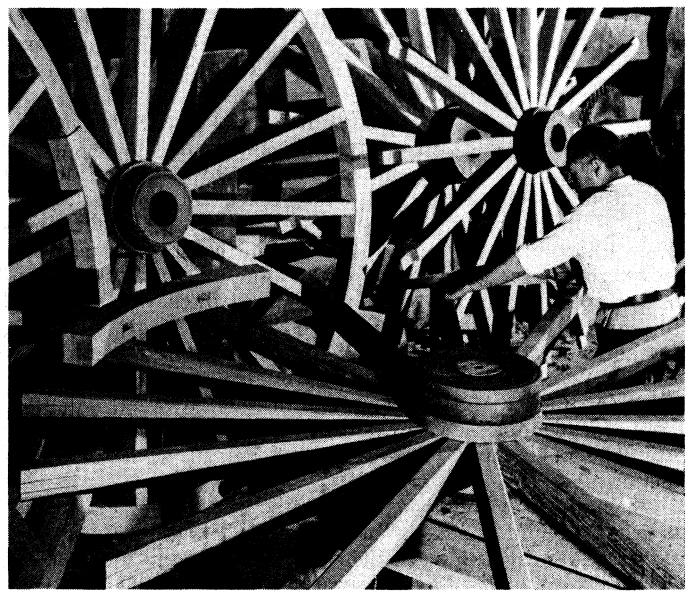
By 1947 a coalition of Liberals and Februarists was able to stage a strong revolution by force of arms, and at one time it controlled a good part of the country before it was defeated. General Morinigo then governed with the help of the Colorado party; and early in 1948 a nonpolitician Colorado, the distinguished writer Juan Natalicio Gonzalez. was elected president. In 1949 he was replaced by the veteran political leader of the Colorado~Federico Chaves, who, after a military interim under Gen. Raimundo Rolon, was confirmed by a newly chosen house of deputies and in 1953 was elected for a four-year term.

Pres. Chaves instituted state-aid measures, and his directed-economy regime became similar to that of Argentina. A pact of economic union was concluded with that country, and Gen, Juan Perón visited Asuncibn and granted commercial assistance. Conservative Colorados and the army became uneasy; and in May 1954 the head of the armed forces, Gen. Alfredo Stroessner, assumed power and after elections in July became president without relinquishing his military position. Depression due to poor agricultural conditions forced a continuation of state controls and an intensification of economic co-ordination with Argentina. Paraguay profited, however, by the desire of other countries to weaken those trends, and it made favourable financial, commercial and communications arrangements with Brazil, the United States and Uruguay. Upon his fall, Perbn was accorded asylum on Oct. 2, 195j, by Gen. Stroessner in Paraguay, but later flew to Nicaragua.

SOCIAL AND ECONOMIC CONDITIONS

Population. — The Guarani Indians, whom the Spaniards regarded as the best of the South American Indians because they were semisedentary and were courageous and independent in spirit, amalgamated freely with the white colonists from the outset, and contributed significantly to the homogeneous Paraguayan racial type, which is predominantly Caucasian except in the remoter sections. The minor Indian tribes, such as the Lenguas, the Guayaqui and the Maccas, never intermarried with the whites and have largely disappeared save for about 10,000 Maccas in the Chaco. Immigration from Spain, while sporadic, was very substantial, and after World War I there was a good number of Italian and German immigrants with skills or savings or both. In southeastern Paraguay are several settlements of German-Brazilians.

Paraguay has been called the most "colonized" country in the world, as its sparsely settled regions of clement climate and fertile soil have attracted groups from various countries desirous of founding communities for religious or other purposes. The government facilitated these movements by granting free land and exemption for one or two decades from taxation and military service. Notable are the New Australian colony near Villarrica, the Hutterite colony 50 mi. N. of Asuncion and the Japanese colony of Ibytimy not far from Paraguari. Leaders of groups from the U.S. included George Lewis (Tex) Rickard and William (Alfalfa Bill) Murray. In general, although there were still more than 100 officially recognized colonies in the 1950s, and about 20 without specific governmental exemptions, these nuclei tended to be absorbed and lose their identities, partly because their products must move too far to find markets economically and partly because of the assimilative capacity of the basic Spanish-Guarani Paraguayans. An outstanding exception is the Mennonite movement, which has two colonies in the central Chaco and one east of the Paraguay river, with a total population of about 15,000 and with a completely separate life. Of Russian-German origin, and reaching Paraguay partly from Canada and partly from Europe, these tenacious German-speaking and pacifistic people seemed to be able to survive long in their new habitat.



THREE LIONS

CARPENTER MAKING HIGH WOODEN WHEELS TO BE USED ON CARTS, WHICH ARE THE CHIEF MEANS OF CONVEYANCE IN PARAGUAY

Broadly speaking there is as large a proportion of pure white families in Paraguay as in any of the Indian countries of Latin America, and the proportion of white blood is so high that the so-called mestizo type common in the other Indian countries is rare. The Guarani language, greatly modified by Spanish and modern influences, is a sort of lingua franca among most Paraguayans but has disappeared from the newspapers and public use, except in parts of the hinterland.

The principal cities are: Asuncion, the capital and metropolis (pop., 1950 census, 201,340); Villarrica, centre of the farm belt (14,680); Concepción, northern centre (14,640); and Encarnación, in the southeast (13,321).

On the Paraguay river 80 mi. S. of Asunción is Pilar (5,061), a rapidly growing textile centre founded by an Italian anti-Fascist in the late 1920s; and on the west bank in the north are the active quebracho ports of Sastre, Pinasco and Casado.

Government. — The constitution adopted July 10, 1940, after being drafted by Pres. José Félix Estigarribia and a committee chosen by him provided sweeping presidential powers. The president is elected by popular suffrage of all males 18 years of age or more for a five-year term; he may be re-elected for a second term. The congress, of 40 members, is likewise elected for five years by popular vote and must act on all laws proposed by the president in the session in which they are submitted, failing which they are deemed to have been adopted. The president's veto is absolute, and he may dissolve the house at any time. When the house is not in session the president may issue decree-laws, subject to legislative approval later; and he may at any time declare a state of national emergency which augments his authority. There is no senate, but an advisory body known as the council of state is

composed of the cabinet members plus the archbishop, the rector of the university, the president of the central bank and other leaders. all chosen directly or indirectly by the president. The president has broad appointive powers, including the cabinet ministers, who are not responsible to the legislature; all civil administrators; all military and naval officers; all diplomats; and all higher ecclesiastical authorities. He also designates all judicial officers, and these serve terms coinciding with the presidential term so that the judges of both the supreme court and the minor courts of first instance always have been named by the president in power. The most important member of the cabinet is the minister of interior, who controls the national police and governmental commissioners throughout the country, thus safeguarding public order and repressing subversive plots and movements. The minister of foreign affairs ranks next, and on occasions when foreign officials are present is permitted pro tempore precedence. The ministers of national defense, finance, agriculture, the national economy, education and public health follow. The government being a centralized one, the names and areas of the various departments and districts have no permanent significance, and virtually no elective local officials exist.

Religion and Education. — Roman Catholicism is the established religion, but the constitution guarantees full liberty to all creeds. Asunción is the seat of the archdiocese of Paraguay, under whose jurisdiction come the diocese of Concepción and Chaco and that of Villarrica. About one-half the priests belong to the Salesian, Franciscan and other regular orders, and many of these are Europeans or Paraguayans trained in Europe. The other half are secular clergy, in charge of ordinary parish work, and they as a rule furnish the bishops and archbishops because they are more predominantly Paraguayan.

Education was strongly promoted beginning in the 1930s, and the literacy index rose above that of several Latin-American countries. There were in 1953 more than 1,800 primary schools with more than 6,000 teachers; 87 secondary schools; and 12 normal schools, of which the Asuncion Normal school was quite large and modern. Educational missions from Brazil and the U.S. were secured. The budget allocations for public instruction in 1952–53 formed about 13% of the budget.

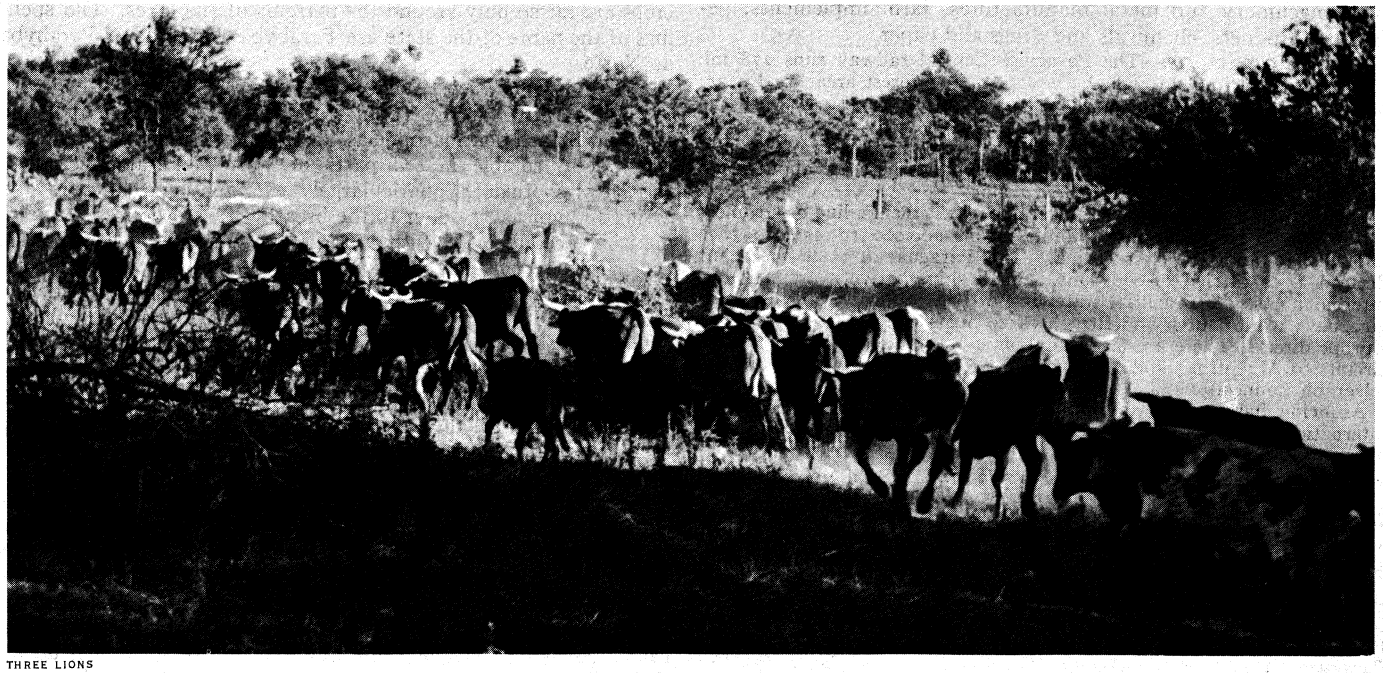
There are four regional agricultural schools, in addition to the Estigarribia National School of Agronomy at San Lorenzo near the capital. The Jesuit (French) junior college of San José at Asuncion has an excellent reputation, as does the International college, a junior college operated by Protestant support from the U.S. A national college in the same city has several hundred students. The National University of Paraguay in Asunción, formed in 1889 from separate law and other schools previously existing. had in 1953 more than 2,100 students and 110 professors.

Defense. — Paraguay jealously guards its reputation for military prowess, gained in the López and Chaco mars, and feels that its strategic location between Argentina. Brazil and Bolivia calls for strong defenses. The armed forces aggregate about 10,000 men, of whom approximately 1,500 are in the navy and 1,000 in the air force. Normally there are foreign military, naval and air advisory missions from Brazil, the U.S. and Argentina, which replaced those from Germany first and France later prior to the Chaco War. Modern weapons and methods are sought to the greatest extent possible; the navy in 1952 had two fairly modern Italian gunboats and other minor river craft. Military expenditures for fiscal 1952–53 were set at $10,750,000—34.8% of the budget.

Finance. — The currency unit is the guarani, devalued in 1954 from 6 per $1 U.S. to 21 per $1; but the latter rate was used only for essential imports and vital exports and capital movements, while less vital transactions were at 64 guaranies per $1 or at free market rates ranging up to 79 per $1 in 1954. The fiscal year runs from July 1 to June 30 each year; and for 1954–55 the budget nas $45,000,000 (converting guaranies at the official rate of 21 per $1). The internal public debt in 1953 nas 268,000,000 guaranies, compared with 79,000,000 five years earlier. The external debt was $9,620,000 in 1953, compared with $12,401,700 in 1949. New methods of revenue collection influenced an Export-Import bank loan in 1954 of $7,000,000 for an Asunción nater system. The International Bank for Reconstruction and Development in 19jz granted a $5,000,000 loan for agricultural development. In general Paraguay's external obligations were well sustained; but exchange reserves, $12,000,000 early in 1954, were $4,000,000 in mid-1955.

Circulating media in 1953 comprised 478,000,000 guaranies in currency and 539,000,000 in demand deposits. The currency in 1954 was 660,000,000 guaranies. Public credits by the Central Bank in 1953 were 608,000,000 guaranies. and by its filial, the Bank of Paraguay, 382,000,000. The loans of this latter bank cover most of the ordinary banking of the country. Asunción has branch banks of Argentine, British and Brazilian nationality, with total loans outstanding early in 1954 of 75,000,000 guaranies.

Agriculture and Industry. — Agriculture has been the basis of Paraguay's economic life, and the principal trading products have been cattle and cotton. The cattle industry declined steadily



THREE LIONS

CATTLE ON AN "ESTANCIA," OR RANCH, IN THE CHACO REGION NORTH OF CONCEPCIÓN ON THE PARAGUAY RIVER

after World War II because of price ceilings and droughts, and the herds by 1953 were estimated at about 4,200,000 head, about seven-eighths of the figure 10 years before. Cotton on the other hand increased steadily, the 1953 yield being 38,000 short tons. Other trading products are tobacco, vegetable oils and sugar. The food crops, which do not enter into trade, include mandioca, maize, sweet potatoes, rice and peanuts. The citrus fruit production, formerly large, had declined by 1953 to 27,000,000 fruit, mainly oranges.

Yerba maté, which in 1940 was more than 18,000 tons, had fallen in 1952 to 12,000 tons because of Argentine tariffs, general decline in consumption and fixed low prices. A unique Paraguayan farm product is oil of petitgrain, a perfume base, which is produced in spare time by boiling bitter-orange leaves in yard kettles.

The leading industry of Paraguay is quebracho tanning extract, with production of 35,000 tons in average years. The production of canned beef is also ordinarily large. The textile industry in 1952 produced almost 14,000,000 yd. of cotton cloth and 6.000.000 yd. of woollens. Woollen ponchos and blankets are a strong line, and there is a silk and rayon mill at Pilar. The crushing of oil-seeds and palm kernels is also important. Other products are flour, beer, footwear, furniture, soap, glass and ceramics. tobacco manufactures, pharmaceuticals and processed foods. A Paraguayan specialty is a peculiar rum distilled from fermented sugar-cane juice, known as *caña,* which is popular with cattle herders in the southern South American cattle countries.

Minerals.——With the exception of remote manganese deposits in the northeast near the cataracts-of Guayrá, Paraguay has no substantial metallic minerals, according to surveys made under U.S. auspices during World War II. Mica, kaolin and clay exist in good quantities and have been exploited modestly. Petroleum explorations by the Union Oil company of California from 1944 to 1949 apparently demonstrated that rumours of oil in the Chaco were unfounded. However, the country possesses vast quantities of excellent limestone on the Paraguay river north of Concepción at Valle Mi, and the manufacture of cement, aided by Belgian enterprise, is not inconsiderable.

Commerce.— Paraguay's exports in 1954 were valued at $33,970,000 and imports at $32,884,000. Both are controlled nith a view to preventing a balance of trade which would deteriorate the currency and financial standing of the nation. The chief exports are usually lumber, cotton, quebracho and canned beef; with lesser shipments of hides, vegetable oils, tobacco, essential oils, yerba and rum. The principal imports are nontropical foodstuffs, textiles, machinery and metal manufactures, farm implements. petroleum products, chemicals and drugs and paper.

Communications.— The Paraguay Central railway runs 278 mi. S.E. from Asuncibn, through the best farm and forest areas, to Encarnación on the upper Paraná, where it connects by car ferries with the Argentine railways at Posadas.

There are about 550 mi. of modern gravel-crowned highways, mainly converging on Asunción, plus 80 mi. of asphalt; there are about 4,000 mi. of primitive roads for ox-drawn traffic.

River traffic is large, and the Argentine government's line of steamers (formerly the Dodero line) handles from 400,000 to 450,000 tons annually to and from Argentina. The Paraguayan state merchant fleet in 1952 carried 69,000 tons. Small ships actively ply between internal ports. A Brazilian state line carries traffic with Brazil and Uruguay; while Dutch and British cargo boats connect Asuncion with Europe direct. There are 6,500 government-operated telephones, with circuits to Argentina; and 3,500 mi. of telegraph, with external radio-telegraph connections.

Asuncibn has become an important centre and junction point for international air lines, and the government operates several internal lines.

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PARAGUAY RIVER (Port. RIO PARAGUAI), chief tributary of the Paraná, rises in the Brazilian state of Mato Grosso on the south slope of the Serra dos Parecis and flows southwest and then south for a total of 1,584 mi. It is an important artery of the Plate river system serving the interior of South America. See PLATA, RIO DE LA.

PARAÍBA, a state of northeast Brazil, bounded on the north by Rio Grande do Norte, on the east by the Atlantic, on the south by Pernambuco and on the west by Ceará. Area 21,836 sq.mi. Pop. (1950) 1,713,259. The chief city and capital is João Pessoa (*q.v.*) with its port Cabedelo. Other important towns are Campina Grande, Cajazeiras and Patos.

Climate and original vegetation divide Paraiba into two contrasted areas. Along the coast and inland as far as Campina Grande is an area that receives rain each year and was once covered by dense forest. West of Campina Grande is the land of uncertain rainfall, semiarid at best. which was once covered by a deciduous, thorny. scrub woodland called caatinga. In the zone of the caatinga there are only small "islands" of abundant rains and forests on the tops of the higher mountains. There is no coastal plain, but behind a zone of coastal mesas (taboleiros) there is a hilly upland known as the Borborema which occupies most of the eastern part of the state. Farther inland Paraiba shares with Cearb the broad plains nith erosion remnants.

Originally settled in 1584 as the captaincy of Itamaracb, Paraiba shared in the sugar-cane wealth of that period. It still produces some sugar, but cotton, sisal, oiticica oil, goat skins and minerals are more important. The clearing of the backlands (*sertão*) has produced severe floods and droughts, so that settlement in the caatinga is dependent on irrigation. The federal government built a number of reservoirs, but because of the hilly land, irrigated crops are raised only around the margins of the lakes. Old spellings of the name of the state are Parahyba, Parahiba or Parahyba do Norte. (P. E. J.)

PARAKEET: see PARROT.

PARALDEHYDE (para-acetaldehyde, paraldehydum in U.S. and British pharmacopoeias), a colourless liquid of characteristic odour, soluble in ten parts of water. Paraldehyde is a relatively nontoxic hypnotic largely excreted by the lungs and giving an unpleasant odour to the breath. It is produced by polymerizing acetaldehyde with a trace of sulfuric acid; with the concentrated acid this reaction is accompanied by considerable generation of heat. The resulting liquid is neutralized with calcium carbonate and purified by fractional distillation. Paraldehyde has the same molecular formula both in the gaseous phase and in solution. It boils at 124° C. (melting point 12.5" C.).

See also ALDEHYDES AND KETONES.

PARALLAX is the difference in direction of an object caused by a change in the position of the observer. This method is used in astronomy as the direct way of measuring the distance of a celestial body. At the level of theory, the measurement of the distance to an inaccessible point is an elementary exercise in geometry. From a known baseline with known base angles, the apex angle can be arrived at through geometrical proof. This apex angle is the parallax. When the parallax is known, the two sides of the triangle formed by two set points of observation and the object can be calculated. Though this seems straightforward, it is nevertheless difficult when applied to the delicate problem of determin-

ing celestial distances because the baseline must be sufficiently long enough to provide the geometrical construction of triangles that will allow precise measurement.

The parallaxes of the sun and the moon are defined as the difference in direction as seen from the observer and from the earth's centre. In fig. *1* let O be the observer on the surface of the earth. E the centre of the earth and M the position of the moon; then the angle OME is the parallax This varies with the altitude of the moon. If the moon is directly overhead, the parallax is zero, and it is greatest when the body is at the horizon, when z equals 90°. At an angular distance z from Z we find from the triangle OME that $\sin p = a/r \sin z$. When $z = 90°$, $\sin p = a/r$ and this value is called the horizontal parallax or briefly, the parallax. For all bodies except the moon, p is so small that it does not differ appreciably from sin p and it is usually expressed in angular measure.

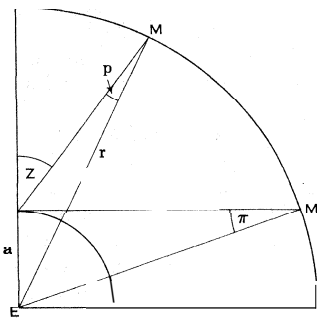


FIG. 1.— CHANGE OF PARALLACTIC ANGLE WITH ALTITUDE

A further refinement is required because of the spheroidal figure of the earth and the numerical values generally given are those of the equatorial horizontal parallax.

Lunar Parallax.— The moon, being by far the nearest of the celestial bodies, was the first to have its parallax determined. Hipparchus (*150* B.C.) determined the moon's parallax to be *58'* or at a distance of approximately *59* times the earth's equatorial radius as compared with the modern value of *60.2* times.

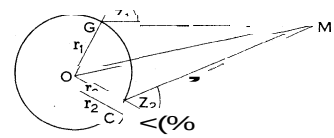


FIG. 2.— MEASUREMENT OF PARALLAX BY OBSERVATIONS FROM A NORTHERN AND A SOUTHERN OBSERVATORY

Parallax of the moon is directly determined from observations of declination made at two places such as Greenwich, Eng., and the Cape of Good Hope, which are nearly on the same meridian. The theory of the observations will be readily grasped from fig. *2*.

Angles Z_1 and Z_2 are observed and other data are obtained from the latitude of the observatories and the known size and shape of the earth. In practice, stars are observed in positions near the moon to eliminate uncertainties of refraction and instrumental errors. In this way T. Henderson obtained a value of 57′2″.3 for the moon's equatorial horizontal parallax in *1837*. From a series of observations of a small lunar crater (1905–10) the value 57′2″.5 was found.

A second method rests on a comparison of the force of gravity at the earth's surface with its value at the moon. If M and m are considered the masses of the earth and moon. r the mean distance, P the sidereal period of revolution of the moon about the earth and k the constant of gravitation, $M + m = 4\pi^2 kr^3/P^2$ where $\pi = 3.14$. Also, g, the value of gravity at the earth's surface, determined accurately from pendulum observations $= kM/a^2$. Hence

$$\left(\frac{a}{r}\right)^3 = 4\pi^2 \frac{M}{M+m} \cdot \frac{a}{gP^2}$$

As the quantities on the right-hand side are known with great accuracy, a/r is accurately determined as 57′2″.7.

Solar Parallax. **Trigonometrical** Methods.— In accordance with the law of gravitation the relative distances of the planets are known. and tables of their positions and movements take the distance of the sun from the earth as the unit of length. The measurement of the distance or parallax of any one of the planets will determine the value of this unit. The smaller the distance of the planet, the larger the parallactic displacements to be measured, with a corresponding increase in accuracy of the determined parallax. The most favourable conditions are therefore provided by the observation, near the time of opposition. of planets approaching close to the earth. The determination can be based either on simultaneous or nearly simultaneous observations from two different places on the earth's surface; or on observations made after sunset and before sunrise at the same place, when the displacement of the place of observation produced by the rotation of the earth provides the baseline for the measurements.

The first reasonably accurate determination of the sun's parallax was made in *1672* from observations of Mars at Cayenne, French Guiana, and Paris, France, where a value of 9″.5 was obtained. Venus can approach nearer to the earth than Mars can, but it is then between the sun and the earth. Edmund Halley in *1679* therefore suggested the utilization of the transits of Venus across the sun's disc. The transits of *1761* and *1769* were extensively observed by astronomers dispatched to various parts of the world, but the results were disappointing because of the impossibility of determining with sufficient precision the times of the planet's ingress and egress. The transits of *1874* and *1882* were widely observed for the same purpose, but it proved impossible to secure uniformity of judgment on the part of the observers, and the results fell far short of expectations.

In *1877* Sir David Gill made an expedition to Ascension Island and observed the opposition of Mars, using a heliometer to measure the distance of the planet from neighbouring stars, making observations after sunset and before sunrise. A value of 8″.78 was deduced. The successful result of this series of observations led Gill to make an elaborate series of heliometer observations of the small planets, Victoria, Iris and Sappho, in *1888–89;* the starlike images of these small planets are favourable for accurate measurement. The resulting value of the solar parallax was 8″.80.

In *1898* the small planet Eros was discovered; it has an orbit so elliptical that at its nearest approach Eros comes within about 15,000,000 mi. of the earth. The opposition of *1901* (when the least distance was less than *30,000,000* mi.) was extensively observed at many observatories and gave a value for the solar parallax of 8″.804. A more favourable opposition occurred in *1931* when the least distance was only *16,000,000* mi. From observations made photographically at observatories in both hemispheres, Sir Harold Spencer Jones derived a solar parallax of 8″.790 ± 0″.001. This parallax corresponds to a distance of *93,005,000* mi.

Methods Depending on Velocity of Light.— The value of the velocity of light has been determined with very high precision and may be utilized in several different ways. 4 direct method is the converse of the procedure of Ole Roemer in the discovery of the velocity of light; *i.e.,* to use the light equation, or time taken by the light to reach us at the varying distances of Jupiter. Great accuracy is hardly obtainable in this way. A second method is by means of the constant of aberration which gives the ratio of the velocity of the earth in its orbit to the velocity of light. As aberration produces an annual term of amplitude *20″* in the positions of all stars its amount has been determined in numerous ways. Observations made at Greenwich in the years *1911* to *1936* gave the value 20″.489 ± ″.003 leading to the value 8″.797 ± 0″.013 for solar parallax. This method is not free from the suspicion of systematic error.

The velocities of stars toward or from the earth are determined from spectroscopic observations. By choosing times when the orbital motion of the earth is carrying it toward or from a star. the velocity of the earth in its orbit may be obtained. In this way the solar parallax was found from observations at the Cape of Good Hope to be 8″.802 ± ″.004.

Gravitational Methods.— In the theory of the moon there is a term of period one month known as the parallactic inequality. The coefficient of the term contains the ratio of the parallaxes of the sun and moon as a factor. The large size of this coefficient makes it of value. From the discussion of occultations of stars from 1672 to *1908*. Spencer Jones found the value 125″.023 ± ″.033 for this term giving for the solar parallax 8″.796 ± ″.004.

The ratio of the mass of the earth + moon to that of the sun may be determined from the disturbing action of the earth + moon on the elliptic motion of the planets. The ratio of the moon's mass to that of the earth is *1181.53,* and thus the ratio of the

earth's mass to that of the sun is found. In a manner similar to that described above for the moon's parallax the solar parallax is then derived. From an exhaustive discussion of the perturbations of the planet Eros from its discovery in 1898 up to and including the favourable opposition of 1931, Eugene Rabe made a very accurate determination of the solar parallax as $8''.7984 \pm ''.0004$.

Stellar Parallax. — The stars are too distant for any difference of position to be perceptible from two places on the earth's surface; but as the earth is 93,000,000 mi. from the sun, stars are seen from widely different viewpoints in the course of the year. The effect on their positions is called annual parallax, defined as the difference in position of a star as seen from the earth and sun. Its amount and direction varies with the time of year, and its maximum is a/r where a is the radius of the earth's orbit and r the distance of the star. The quantity is very small and never reaches 11206,265 in radian or 1'' in sexagesimal measure. Unsuccessful attempts to measure the parallax of a star were made continuously after the acceptance of the Copernican system, including one by James Bradley which led to the discovery of aberration (see ABERRATION OF LIGHT) and by Sir William Herschel which led to the discovery of binary stars. The first successful results were obtained in 1838 when the parallax of α Centauri was announced by Henderson, a Lyrae by Friedrich Struve and 61 Cygni by F. W. Bessel. For his observations Bessel used the heliometer. He found the parallactic shifts of 61 Cygni relative to two neighbouring stars which from their magnitude and small proper motions were judged to be so distant that no parallactic effect could be perceived. With instruments of this kind having small object glasses of not more than 4 or 6 in. and focal lengths of a few feet, research on stellar parallax was carried on to the end of the 19th century and the parallaxes determined of approximately 75 of the brightest stars and those showing the largest proper motion.

The introduction of photography at the beginning of the 20th century simplified the problem, and a number of observatories engaged in the work and determined the parallaxes of many stars with great accuracy. Two observational conditions have to be fulfilled: (1) the telescope must be in the same position for observations at different times of the year; (2) by some means (*e.g.*, a rotating shutter with a suitable slit) the photographic image of the star observed must be made equal to that of the stars with whose position it is compared. In practice, a few photographs are taken when the star is on the meridian shortly after sunset at one period of the year and shortly before sunrise at another period. As the stars' positions change as a result of their proper motion. a minimum of three epochs is required, but the possibility of systematic errors makes it desirable to extend the observations over a larger number of epochs. With 25 photographs spread over five epochs, the parallax of a star is obtained with a probable error of less than $\pm 0''.010$, although the diameter of the photographic disc of the star is seldom less than $2''.0$. The concerted action of observatories in the northern and southern hemispheres resulted in the determination of the parallaxes of about 6,000 stars, about equally divided between stars north and south of the equator. These include most of the stars brighter than $6^{m}.0$ and many fainter stars whose comparative nearness is suggested by their proper motions.

The unit in which stellar distances are expressed by astronomers is the distance of a star whose parallax is $1''$. This is called a parsec and is equal to 206,265 times the earth's distance from the sun or approximately 19,000,000,000,000 mi. One parsec is equal to 3.26 light years.

The star with the largest known stellar parallax $0''.76$. is a Centauri. Fifty-six stars are known within a distance of 10 parsecs from the sun. These stars include the bright stars α Centauri, Sirius. Procyon and Altair, but the majority are faint telescopic objects. While 30 stars are single, 20 belong to double-star systems and 6 are grouped into 2 triple systems, of which a Centauri is one.

For the more distant stars, trigonometrical methods are inapplicable, but the parallax can be derived from the apparent magnitude of the star, if there are any means of knowing the absolute magnitude of the star; *i.e.*, the magnitude the star would have at the standard distance of ten parsecs. For Cepheid variables this can be inferred with considerable accuracy from their periods, and for many stars a reasonable guess can be made from the spectral type and proper motion. The formula connecting absolute magnitude and apparent magnitude with parallax is $M = m + 5 + 5\log\pi$ and expresses the condition that the light received from a star varies inversely as the square of the distance.

Spectroscopic Parallaxes. — The spectra of nearly all stars can be grouped into a small number of classes, which form a continuous sequence varying with the effective (surface) temperatures of the stars. The Henry Draper classification, using the letters O–B–A–F–G–K–M, is generally adopted, usually in combination with a decimal subdivision for refined work.

Empirical studies show that the spectra of the stars also include important clues to their true luminosities. A. Maury noticed that stars of the same spectral class often had marked differences in line sharpness; E. Hertzsprung found that the sharp-lined stars were intrinsically brighter than the broader lined objects. In 1914. W. S. Adams and A. Kohlschiitter established the spectroscopic differences between giant and dwarf stars of the same spectral type and laid the foundation for the determination of spectroscopic parallaxes. These differences, depending upon the intrinsic brightness of the star, allow an estimate of its absolute magnitude, and the parallax can then be deduced by means of the formula given above. This method has been applied extensively to most of the brighter stars in the northern hemisphere, using stars of known parallax as standards.

In *An Aflas of Stellar Spectra* (1943) *W. W.* Morgan, P. C. Keenan and E. Kellman at the Yerkes observatory set up a two-dimensional classification system of stellar spectra which was universally adopted and greatly improved the accuracy of spectroscopic parallaxes. The Yerkes system of classification assigns a precise system of Draper classes and five-luminosity classes, using the Roman numerals I to V, dividing the stars into supergiants, bright giants, subgiants and dwarf stars, dependent upon intrinsic brightness, as determined from the spectral lines most sensitive to this property. These luminosity classes are then calibrated in terms of absolute magnitude. While for the dwarf stars the calibration of absolute magnitude can be obtained directly by the trigonometric method, the calibration of the other classes must be established indirectly on the basis of distances obtained from statistical methods.

Dynamical Parallaxes. — If the relative orbit of a visual binary system is known, the following relation connects the combined mass, M, of the two stars expressed in the sun's mass as unit, the orbital period, P, expressed in years, the semimajor axis of the relative orbit, a, expressed in seconds of arc and the parallax $:

$$p = a/\sqrt[3]{MP^2}.$$

Both a and P are known but not M; it will be noted that an error in the value of M gives rise to a much smaller error in p. Thus, for instance, increasing M by a factor of 8 only halves the value of $. The value of p obtained by assuming the combined mass to be equal to the mass of the sun is called the hypothetical parallax.

In many visual pairs the complete orbit has not been observed. If s denotes the apparent distance in seconds of arc, w the relative motion in seconds of arc per year, a hypothetical parallax can be derived from the formula

$$p = 0.418\sqrt[3]{sw^2}$$

By use of the relationship between mass and luminosity of a star, it is possible, knowing the spectral type of the star, to derive a correcting factor which will give a more accurate value of the parallax. Parallaxes so determined are called dynamical parallaxes. Details are given in *The Masses of the Stars* by *H.* N. Russell and Charlotte E. Moore (1940), which lists the dynamical parallaxes of 166 binaries with determined orbits and of 2,363 pairs showing relative motion.

Average Parallaxes. — The solar system is moving through space with a velocity of 19.5 km./sec., carrying it four times the earth's distance from the sun in one year. This produces a general drift in the angular movement of the stars away from the apex or point in the sky to which the movement is directed. Were the stars at rest, this would give a ready means of determining their individual distances. As the stars are all moving, the method gives the average distance of a group of stars examined, on the assumption that their peculiar motions

are eliminated. In this way the mean parallaxes of stars of successive apparent magnitudes of different galactic latitudes and of different spectral types are obtained. Thus the mean parallax of 5th magnitude stars (*i.e.*, of stars just visible to the naked eye) is ".018; and of the 10th magnitude stars (*i.e.*, of stars giving $\frac{1}{100}$ of their light) is ".0027.

As spectroscopic observations have given the mean peculiar velocities of stars of different types, the average proper motions perpendicular to the direction of the solar motion may also be used as a criterion of parallax. There is great diversity in the parallaxes of individual stars included in these mean values. (F. D.; H. S. Js.; K. A. Sd.)

PARALYSIS or PALSY, a medical term usually implying the loss or impairment of voluntary muscular power. This article deals with paralysis from organic disease; for functional paralysis, *see* HYSTERIA.

The different forms of paralysis arising from organic disease can be understood best in terms of the location of impairment of function within the parts of the body responsible for voluntary movement. There follows therefore, first, a general account of the anatomy of the motor system, and then a survey of some of the more common diseases that affect parts of this system.

The Motor System.—This system includes certain parts of the nervous system and the bodily musculature. Although the anatomy of the muscles is relatively uniform, and their function is more or less apparent simply from observation of the body in action, the motor portions of the nervous system are concealed and anatomically complex. The pathway over which nerve impulses governing volitional movement must pass consists of two main components, an upper and a lower. The upper has its origin in the giant pyramidal nerve cells of the precentral convolution of each hemisphere of the brain. These nerve cells, or neurons, give rise to long processes (nerve fibres) which descend to end in relation to the neurons of the lower component, located in the brain stem and spinal cord. The long descending fibres of the upper motor neurons are collected together in compact bundles known as the pyramidal tracts. The spinal portion of the lower component of the motor pathway consists of neurons located in the anterior columns or horns of gray matter which extend throughout the length of the spinal cord. The nerve fibres which originate from these anterior horn cells emerge from the spinal cord in the ventral roots and are distributed to the muscles of the trunk, neck and limbs by the spinal nerves. The neurons of the brain stem, or bulbar portion of the lower component, are arranged in anatomically and functionally distinct collections, or nuclei, and give rise to nerve fibres which are distributed by the motor cranial nerves to the ocular muscles and the muscles of the jaws, face, palate, pharynx, vocal cords and tongue. Nerve impulses governing voluntary movement originate in upper motor neurons, are transmitted from these to lower motor neurons and thence to muscles. Although this concept of a motor system consisting of three elements—upper and lower motor neuron and muscle—is somewhat artificial, it is most useful in the differential diagnosis of the wide variety of diseases that produce paralysis.

The most important anatomical factors that determine the extent and distribution of paralysis from diseases of the nervous system are the relationships of the neural pathways to each other and to the two sides of the body. Both components of the neural pathway are bilaterally symmetrical. With few exceptions, lower motor neurons innervate muscles on their own side of the body. The relationship between upper and lower motor neurons, however, is more complex. Most of the fibres of each pyramidal tract that enter the spinal cord undergo a massive crossing at the lower end of the brain stem known as the pyramidal decussation, and terminate, therefore, in relation to anterior horn cells of the opposite side. For this reason, the motor outflow to the limbs on one side of the body originates from the opposite side of the brain. On the other hand, the motor nuclei on each side of the lower brain stem, or bulb, that innervate the muscles responsible for chewing, speaking and swallowing receive upper motor nerve fibres derived from both pyramidal tracts. Some of the motor neurons in the brain stem, however, such as those that innervate the lower facial muscles, do not have bilateral pyramidal connections, but, like the anterior horn cells of the spinal cord, receive upper motor nerve fibres chiefly or solely from the opposite pyramidal tract. (The neural mechanisms that control eye movements form a special case because of their great complexity).

The pyramidal tracts extend from the cerebral cortex to the lower end of the spinal cord, and their extraordinary length alone is an important factor in the frequency with which they are affected by disease. The distribution of paralysis resulting from disease of the pyramidal tracts is accounted for by the side and level affected and by the peculiarities of their connections with the system of lower motor neurons. A lesion implicating the pyramidal tract in one hemisphere of the brain, for example, results in hemiplegia, or paralysis of the muscles of the lower face, arm and leg on the opposite side. There is little or no disturbance in speaking, cheuing or swallowing, since the muscles responsible for these functions are innervated from bulbar nuclei having bilateral pyramidal connections. It is as if a factor of safety in the form of a double mechanism were provided for the vital function of swallowing. For the same reason, although the corner of the mouth on the affected side of the body droops from paralysis of the lower facial muscles, there is little or no weakness in those of the upper part of the face, which wrinkle the forehead and close the eye. On the other hand. disease of both pyramidal tracts above the level of the bulb produces not only bilateral hemiplegia but also difficulty in speaking, chewing and swallowing from weakness or paralysis of the muscles of the jaws, palate, pharynx, vocal cords and tongue. This is known as pseudobulbar palsy. The term "bulbar palsy" refers to paralysis of these muscles from disease of the corresponding lower motor neurons, either within the bulb itself, as in bulbar poliomyelitis, or affecting their peripheral processes, as in some forms of polyneuritis.

Throughout most of their descent within each cerebral hemisphere, the pyramidal tracts of the right and left sides are widely separated from each other. In the brain stem and spinal cord, however, they are confined within a small space, and both are likely to be damaged even by asymmetrically placed lesions. If the level affected is in the brain stem, or high in the spinal cord, all four limbs will be weak, while a lesion below the cervical segments of the cord will produce paralysis of both legs (paraplegia).

Aside from the extent and distribution of paralysis, there are other associated signs and symptoms that depend on which of the three elements of the motor system is diseased. When paralysis is a result of damage to upper motor neurons, for example, there is an associated increase in the tone of the muscles involved, which is manifested by stiffness, or spasticity, and by an increase in the activity of the tendon reflexes. This is a determinant of disability as well as a clue to diagnosis, for weakness and spasticity do not necessarily parallel one another in degree, and often the major source of disability in a mildly weakened limb is severe spasticity. In hemiplegia, the spasticity is usually greatest in antigravity muscles and contributes to the typical hemiplegic posture and gait, with the upper limb held close to the body at the shoulder and flexed at the elbow, wrist and fingers, and the leg maintained in rigid extension at the knee.

When paralysis arises from disease of lower motor neurons or muscles, the tone of the affected muscles is decreased, and the tendon reflexes are diminished or abolished. Paralysis of this kind is known as flaccid paralysis in contrast with the spastic paralysis of upper motor neuron disease. Two further attributes of lower motor neuron paralysis are wasting or atrophy of the weakened muscles and fasciculations. Atrophy is also a more or less regular accompaniment of primary muscular diseases. Although a certain degree of wasting of muscle mass from disuse may occur in long-standing, severe paralysis from pyramidal tract disease, this never reaches the proportions possible in lower motor neuron and muscle disorders. Fasciculations are spontaneous twitchings or contractions of small groups of muscle bundles visible as a rippling play of activity in muscles beneath the skin. They are almost exclusively a sign of lower motor neuron disease and are most prone to occur in slowly developing lesions that affect the cell bodies of motor neurons within the brain stem or spinal cord rather than their peripheral processes. They are sometimes seen, however, in health, especially after muscular exertion and in elderly persons, for reasons that are unknown.

There is one other characteristic of the lower motor neuron that has important clinical implications — the capacity of its peripheral process to regenerate provided the cell body is intact. This is true of all nerve fibres, both motor and sensory, that lie outside the central nervous system. Paralysis from peripheral nerve affections. such as injury or neuritis, therefore, is not necessarily permanent. This capacity to regenerate is not a property of central nerve fibres, and destructive processes within the central nervous system produce irreversible results.

Diseases that Produce Paralysis. — Most of the commonly encountered diseases that produce paralysis can be divided into two main groups depending on whether they entail structural alterations in nervous or muscular tissue, or lead to metabolic disturbances in neuromuscular function.

Of the diseases that produce destructive changes in the motor system, some act in a systematic way and affect one of its three elements more or less extensively and exclusively. More often, however, one element or neighbouring portions of two of the three elements are involved over a limited extent by a single focal lesion.

The most common cause of hemiplegia is damage to the pyramidal tract in one hemisphere of the brain from obstruction (blood clot or thrombosis) or rupture (cerebral haemorrhage) of a major cerebral artery. (See STROKE; THROMBOSIS AND EMBOLISM.) Brain tumour is another but less common cause of hemiplegia. In contrast with the apoplectic onset of hemiplegia of vascular origin. hemiplegia from a brain tumour develops and increases in severity gradually over a period of weeks or months. Regardless of its nature, when the lesion is in the left hemisphere in a right-handed person, the resulting right hemiplegia is often associated with one oi the various iorms of aphasia (see SPEECH DISORDERS).

Bilateral hemiplegia with pseudobulbar palsy results from diffuse, bilateral brain disease such as occurs at times in severe cerebral arteriosclerosis or cerebral vascular syphilis. The terms "cerebral palsy" and "spastic diplegia" refer to bilateral hemiplegia resulting irom prenatal developmental brain deiects or from injury to the brain at birth. The bilateral hemiplegia of cerebral palsy may or may not be associated with mental retardation, involuntary movements (choreoathetosis) and convulsive seizures in any combination.

In contrast with the brain, the spinal cord is rarely the site of vascular obstruction or haemorrhage. The more common causes of damage to the pyramidal tracts in the cord include deformities of the spinal column irom bone and joint disease and from injury to the spine with fracture and dislocation, spinal cord tumours and a number of poorly understood inflammatory and degenerative diseases of the spinal cord such as myelitis (*q.v.*), multiple sclerosis and the cord changes often associated with pernicious anaemia. Perhaps one of the most common causes of slowly progressive spastic paraplegia in persons oi middle age or older is degenerative arthritis of the spine with protrusion of an intervertebral disk cartilage into the lower cervical portion oi the spinal canal.

Of the diseases that attack lower motor neurons and result in flaccid paralysis with muscular wasting, the most common are poliomyelitis (infantile paralysis, *q.v.*) and polyneuritis, the iormer affecting the cell bodies of bulbar and spinal motor neurons, the latter their peripheral processes *(see* NEURITIS). Bell's palsy is a peripheral neuritis of unknown cause affecting a single nerve trunk — the facial nerve — and resulting in paralysis of all the muscles oi one side of the face. It is usually rapid in onset; on the affected side the facial lines are smoothed out, the forehead cannot be wrinkled or the eye closed, and the corner of the mouth droops. It is thereiore easily distinguished irom the lower facial weakness of a cerebral lesion (with which it is nevertheless sometimes confused and interpreted as a "stroke"). Bell's palsy is a benign condition, and in the majority of cases recovery occurs, though it may take many months.

Amyotrophic lateral sclerosis is a rare, chronic, progressive disease of the nervous system oi unknown cause in which there is a remarkably systematic and extensive degeneration of both components oi the motor pathway, resulting in a combination of bulbar and pseudobulbar palsy, widespread weakness with atrophy and fasciculations, and increased tendon reflexes.

Diseases that result in paralysis through primary changes in muscle tissue are iewer and far less common than those of the nervous system. Of the Sew conditions belonging in this category, progressive muscular dystrophy is the only one that is apparently confined to the muscles. This is a iamilial, hereditary disease characterized by slowly progressive, symmetrical muscular weakness and wasting. Typically, the muscles of the pelvic and shoulder girdles and those of the proximal portions of the limbs are the earliest and most severely affected. There are several different iorms oi the disease. One variety has its onset before puberty, is more common in boys and usually progresses to severe disability within a few years. It is known as pseudohypertrophic muscular dystrophy. because in the early stages there is oiten a false appearance of excessive muscular development, particularly in the calves, irom the deposition of fat and fibrous connective tissue among the degenerating muscle fibres. The other types oi dystrophy differ less from each other than from the pseudohypertrophic type. In general, they begin after puberty in adolescence or young adult life, and the sexes are more equally affected. Their progress is very slow, especially when the onset occurs after the age of 20, and life expectancy, therefore, is not necessarily shortened, nor is severe disability inevitable. Pseudohypertrophy is rare.

Muscular weakness without structural alteration in nerve or muscle tissue may be a symptom of disturbances in metabolism arising irom a wide variety of causes, some relatively well understood, others unknown. Among such conditions are included a number of diseases of the endocrine glands, certain intoxications and several metabolic defects of unknown origin. Weakness, at times reaching severe proportions, is a more or less regularly observed feature oi hyperthyroidism and of both adrenal cortical hyperiunction (Cushing's syndrome) and hypofunction (Addison's disease, *q.v.*). Among the intoxications that produce muscular paralysis of this kind are botulism (*see* FOOD POISONING, BACTERIOLOGICAL), poisoning irom certain snake venoms and tick paralysis. The latter is a rapidly developing generalized paralysis resulting irom a toxin elaborated by a species of wood tick which may be fatal in from two to five days unless the tick is discovered and removed irom the skin.

The most common example of a metabolic disorder in neuromuscular function oi unknown cause is the disease known as myasthenia gravis. In this condition there is muscular weakness, without atrophy, which may be mild or severe and either generalized or restricted to a few muscle groups. Some of the muscles innervated by cranial nerves are affected in almost every case. The weakness of myasthenia gravis results from a remarkably localized defect in the chemical processes involved in the transmission of impulses from motor nerve endings to muscle fibres. Although the cause of this defect and its precise nature are quite unknown, there are several drugs that are known to iacilitate the transmission of impulses from nerve to muscle. One of these, neostigmine, proved to be most useful in the treatment of myasthenia gravis. The majority oi patients benefit greatly from the constant use of this drug, but it is not a cure, since it does not correct the basic, unknown deiect. (*See* also PARALYSIS AGITANS.)

See Donald McEachern and Reuben Rabinowitch, "Advances in the Neuromuscular Disorders," *Advances in Internal Medicine,* vol. iv (1950); W. R. Brain, *Diseases of the Nervous System* (1951). (S. SN.)

PARALYSIS AGITANS (PARKINSON'S DISEASE). This is a relatively common malady which produces such a striking picture that almost any observant person can recognize it at a glance. The stooped posture, the slowness of movement, the carriage of the arms in front of the body, the short-stepped festinating gait, the fixity of facial expression and the tremor of the hands are the characteristic signs.

The onset of the disease is usually late adult life but it may begin as early as the third decade. The course is slowly progressive over 10 to 20 or more years. The first symptom may he the scuffing of one foot in walking, a sense of heaviness of a limb, or a gentle tremor of one hand; and the other symptoms follow in slow procession. The hand riting becomes small and this and other manual skills are gradually lost. Speech is poorly articulated and swallowing and chewing are laborious. Locomotion is increasingly difficult and ultimately the patient finds it an effort even to arise from bed or a chair or to walk; and there is a tendency to lose balance and to fall. In the advanced stages the patient is greatly handicapped in all voluntary movement though not as a rule paralyzed. An unexpected call for action, such as an emergency. may momentarily excite the patient to perform some movement with surprising facility. The senses and the intellect are preserved.

The cause of the disease is unknown. There is a tendency, rather slight to be sure, for more than one member of a family to be affected. The nerve cells in certain of the basal ganglia of the brain (the *substantia nigra, locus caeruleus* and sometimes the *glohus pallidus,* and their afferent and efferent nerve connections) degenerate. The affected nerve cells often contain a cytoplasmic inclusion body (Lewy body). In a closely related disease with almost identical symptoms, *i.e.,* postencephalitic Parkinson's disease, a filterable virus is believed to attack the same parts of the brain. There is no specific therapy but several drugs, particularly those of the belladonna family, partially alleviate the tremor and muscular rigidity. Several surgical operations on the brain had been proposed by the latter 1950s, but were still in the experimental stage. (R. D. A.)

PARAMAGNETISM is the kind of magnetism associated with a weak attractive force between magnetized bodies. If a body is repelled by the poles of a magnet (*e.g.*, a strong electromagnet) it is diamagnetic (see DIAMAGNETISM). If the body (like iron) is attracted strongly, the phenomenon is called ferromagnetism (*q.v.*), a kind of magnetism of great practical importance. If the substance is attracted weakly it is paramagnetic.

The first comprehensive investigation of paramagnetism was begun in 1845 by Michael Faraday. It is known now that most of the elements and many compounds are paramagnetic. Most of the compounds containing iron, palladium, platinum and the rare-earth elements have strong paramagnetism; this is attributed to incomplete electron shells in the atoms, which behave as small permanent magnets that have a slight tendency to become parallel to an applied magnetic field. The heat motions of the atoms oppose the alignment of the atomic moments by the magnetic field, consequently the paramagnetism becomes weaker at higher temperatures.

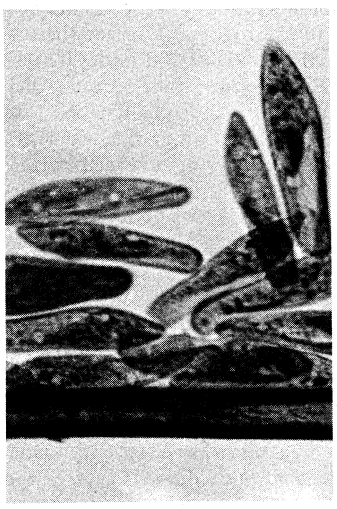
Substances of another class, including the alkali metals sodium, potassium, etc., have weak paramagnetism; this is independent of temperature and is caused by the "free" conducting electrons of the metal.

The magnetic susceptibility per atom of most weakly paramagnetic substances is 10 to 100 $\times$ 10^{-6} (*i.e.*, 10 to 100 millionths); that of strongly paramagnetic substances 100 to 10,000 $\times$ 10^{-6} (*i.e.*, 100 to 10,000 millionths); while a representative diamagnetic susceptibility is -10×10^{-6} (*i.e.*, minus 10 millionths). Ferromagnetic materials in which the atomic moments have a strong tendency to become parallel have enormously larger susceptibilities, ranging from about 1 to 10^6 (*i.e.*, from 1 to 1,000,000). (See MAGNETISM.) (R. M. B.)

PARAMARIBO, the capital of Dutch Guiana or Surinam (see GUIANA), in 5° 44′ 30″ N., 55° 12′ 54″ W., 20 mi. from the sea on the right bank of the Surinam, at Paramaribo a tidal river nearly 1 mi. broad and 18 ft. deep. Pop. (1950) 74,337. Built on a plateau about 16 ft. above low-water level, Paramaribo is well drained. clean and in general healthful. The straight canals. the broad, tree-planted streets, the spacious squares and the solid public buildings recall the Netherlands.

The Indian village of Paramaribo became the site of a French settlement probably in 1640, and in 1650 it was made the capital of the colony by Lord Willoughby of Parham. The town was partly burned in 1321 and again in 1832.

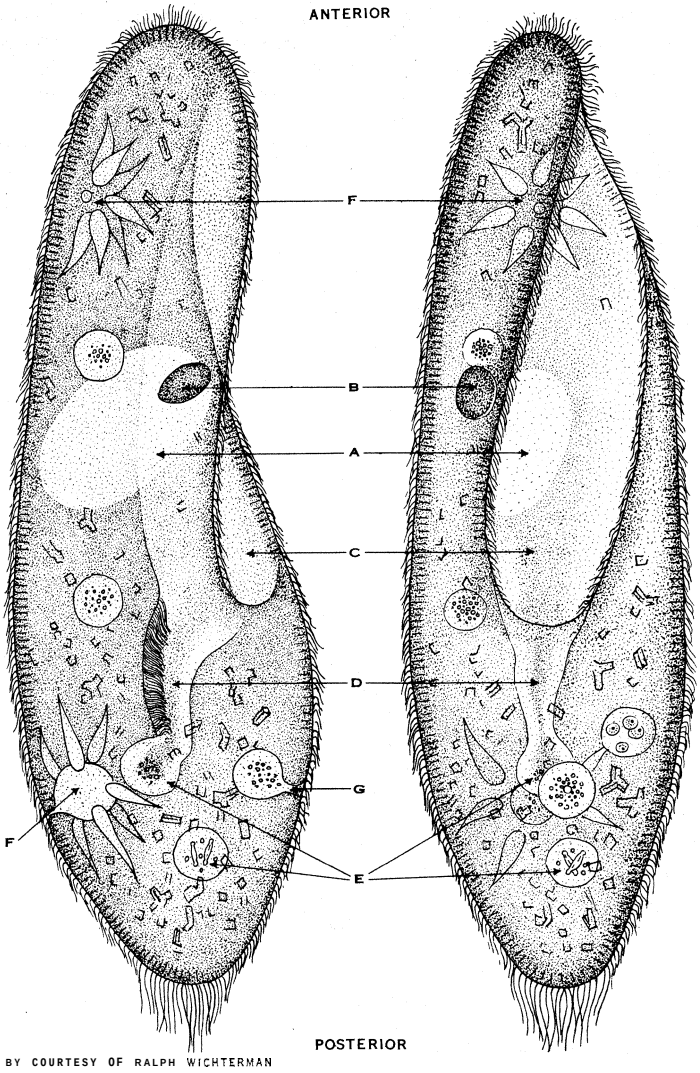
PARAMECIUM. In bodies of fresh water throughout the world — especially in quiet ponds having some decaying organic matter — may be found paramecia, certain free-living microscopic one-celled animals (Protozoa; *q.v.*) roughly slipper-shaped and completely covered with short, fine hairlike filaments or cilia (*q.v.*).



BY COURTESY OF RALPH WICHTERMAN

FIG. 1.—LIVING PARAMECIUM CAUDATUM PHOTOGRAPHED ALONGSIDE A HUMAN HAIR (Magnified $\times$ 130)

They belong to the genus *Paramecium*, which genus, along with other similarly ciliated protozoans, is included in the holotrichous group (order Holotricha) of the class Ciliata. *Paramecium* includes at least eight well-defined species. all of which can easily be cultivated in the laboratory in a nutritive broth or infusion made by boiling hay or dried pondered lettuce in distilled water. The different species vary in size but most are slightly larger than the period at the end of this sentence. Certain species such as *Paramecium caudatum* are gracefully streamlined and elongate and are frequently referred to as the slipper-shaped animalcules (see fig. 1). Others, such as *Paramecium bursaria* (the green paramecium) resemble a foot imprint.



BY COURTESY OF RALPH WICHTERMAN

FIG. 2.— DETAILED STRUCTURE OF PARAMECIUM CAUDATUM

(Left) lateral view and (right) ventral view (greatly magnified). (A) macronucleus, (B) micronucleus, (C) oral groove, (D) gullet, (E) food vacuoles, (F) contractile vacuoles, (G) anus (magnified X 600)

Structure and Function. — Depending on the species. paramecia are rounded or obliquely truncated (squared off) at the anterior end and somewhat pointed, cone-shaped or rounded at the posterior end. On the ventral or oral surface a depression or groove (oral groove) runs obliquely back from the blunt anterior to about one half the body length. The posterior end of the oral groove leads into a small ventral opening. the cell mouth. Leading from the mouth internally is a short S-shaped cylindrical cavity called the gullet. which is widest near the mouth and tapers posteriorly. A flexible membrane. the pellicle, covers the entire body, including the oral groove; it bears lengthnise rows of cilia. A thin layer of clear, firm protoplasm (ectoplasm) lies directly beneath the pellicle and encloses the inner, more fluid portion of the protoplasm (endoplasm). The endoplasm contains granules, food vacuoles and crystals of different sizes. (See fig. 2.)

Cilia are of fairly uniform length except at the posterior end where they are longer and less active than elsenhere Each cilium arises from a small spherical body (basal granule or kinetosome) embedded in the ectoplasm. These basal granules are protoplasmic self-reproducing units which are connected to each other by extremely fine fibrils. Cilia beat in a wavelike rhythmic manner serving to propel the animal through the water and to capture food. The animal is able to reverse its ciliary activity and swim backnard as well as forward. Those cilia lining the oral groove sneep a current of water containing food organisms (usually bacteria) into the mouth. down the gullet and into a forming food vacuole.

After the food vacuole is full of water and food material, the vacuole breaks away from the gullet, passes into the endoplasm and is then circulated within the body by the streaming of protoplasm (cyclosis). The food in the vacuoles is acted upon by enzymes secreted by the animal and is converted into more protoplasm. Undigested material is retained in the food vacuoles and is passed out of the body at the anus, located in a region near the posterior end of the gullet. The anus is seen only when the animal is in the process of passing out undigested material.

In the ectoplasm is a layer of thickly set, spindle-shaped bodies (trichocysts) which are placed at right angles to the body surface. Extrusion of the trichocysts may be evoked by different kinds of stimuli—chemical, electrical and mechanical. Upon stimulation, the trichocysts are extruded very quickly, usually within several milliseconds. Some may be partly extruded and attached to the body while others may be fully thrown out, free and needlelike, six to ten times the length of resting unextruded ones. The function of trichocysts is unknown. Originally believed to be a defense reaction, their extrusion now appears to represent a reaction to injury.

All species of paramecium contain two, occasionally three, contractile vacuoles located close to the surface away from the mouth (aboral surface) and nearer the ends of the body. These vacuoles collapse alternately and each empties its liquid contents to the outside of the body through a small pore. In canal-fed vacuoles a number of small canals radiate from the vacuole and empty into it as seen in P, *caudatum*. Their function is primarily to regulate the water content within the animal. Since the expelled water may also contain some nitrogenous or waste products of metabolism, contractile vacuoles would be considered excretory structures also.

Cells of other animals characteristically possess one nucleus: but in paramecium two kinds of nuclei are present: a large ellipsoidal macronucleus and one or more small micronuclei which are generally close to or impressed against the macronucleus. The paramecium cannot live without its macronucleus but can survive without the micronuclei. The macronucleus is the centre of all metabolic activities and, like the micronucleus, possesses genes which are the bearers of hereditary characteristics. In the various sexual processes, the micronucleus plays an active part in heredity; it is this nucleus which gives rise to new macronuclei.

Reproduction.—Binary Fission.—The commonest type of reproduction in paramecia is binary fission: one fully grown animal divides into two daughters with the result that there may be two, three or more generations a day. The micronuclei undergo mitosis but unlike mitosis in other animal cells, the nuclear membrane does not break down during the process. As with other cells during mitosis, each daughter in a paramecium receives an equal set of chromosomes. In binary fission, the macronucleus elongates, constricts, then divides directly into two, one passing to each daughter cell. As a result of fission, each daughter has self-duplicated itself from the nuclear and cytoplasmic material of the parent to grow into an adult.

Sexual.—Paramecia also undergo the following types of sexual reproduction: conjugation: autogamy (discovered by W. F. Diller in 1934) and cytogamy (discovered by R. Wichterman in 1939). Conjugation (cross-fertilization) is characterized by the temporary union of two animals and involves micronuclear divisions, exchange and fusion of micronuclear elements (see below). Autogamy (self-fertilization) involves similar micronuclear divisions but occurs in single animals without the co-operation of another individual. Cytogamy (another type of self-fertilization) resembles conjugation in that two animals join together but do not undergo nuclear exchange—nuclear events are similar to those which occur in autogamy and conjugation.

Mating Types.—The two paramecia joined in conjugation are to the onlooker identical in structure—no difference which might suggest sexes are noticeable. However, the discovery by T. M. Sonneborn in 1937 of paramecia which are morphologically the same but physiologically different made it clear that there are definite mating types. With this discovery it became possible to crossbreed the members of pure lines of paramecia, those derived from one isolated individual by simple fission alone (clones) and in the absence of all sexual processes.

In a clonal culture, all the progeny as a result of this uniparental reproduction are of a given mating type. Upon mixing together animals from two different clones, the animals either mate or do not mate. If they are of opposite mating type, paramecia may clump or agglutinate into large masses. From these masses emerge pairs of joined individuals that enter into and complete conjugation. And by using special methods it is possible to show that each member of a pair in conjugation is from an opposite mating type. By extensive experimental mixing (two paramecia at a time) of all possible combinations of clones of paramecia that were isolated from nature, it was possible to determine many different mating types which have been placed in larger specific groups called varieties. Animals of opposite mating type within a variety will mate and conjugate when mixed, but paramecia of one variety ordinarily will not mate with those of other varieties. Opposite mating types have been discovered in most species of paramecium and in other ciliate Protozoa.

Details of the systems of mating types and varieties for the different species are quite complex.

Besides being useful for general study and teaching purposes, paramecium has proved to be an important research organism widely employed in cytogenetics, nutrition, serology, radiation biology and many other fields of biology.

See R. Wichterman, *Biology of Paramecium* (1953); G. H. Beale, *Genetics of Paramecium aurelia* (1954). (R. WI)

PARAMOUNT, a city of Los Angeles county, Calif., U.S., just east of Los Angeles and abutting Long Beach on the south. The site was once a part of the Nieto Spanish land grant. As the first settlement, under the Cooperative Colony Trust company (1866–67). it was called Clearwater and began as a dairy centre. In 1891–92 the southern portion of the Clearwater community created a separate town called Hynes, which subsequently became the collecting and distributing centre of a large hay business. In 1949, the two communities were consolidated as Paramount, which nas certified as a city in 1957. Industries (aluminum awnings, furniture, plastics, machine shops, resins) moved into the area and replaced much of the original dairying. The city has been governed from its inception by a council of five citizens who select a mayor and vice-mayor and appoint a city manager, other administrators and commissioners. For comparative population figures see table in CALIFORNIA: Population. (H. P. Jo.)

PARANÁ, a state in the south of Brazil, bounded north by São Paulo, northwest by Mato Grosso, west by Paraguay and Argentina, east by the Atlantic and south by Santa Catarina. Pop. (1950) 2,115,547, (1958 est.) 3,314,000; area 77,551 sq.mi. Parana is in the temperate zone, except for a small segment in the extreme north, and the state in general has a healthful climate. A well-drained rolling plateau sloping gradually west to the Rio Paraná constitutes the greater part of the region. Most of the settled portions of the state are located between 2,000 and 3,000 ft. above sea level. The narrow belt of tropical rain forest which presents a screen of dense growth along the Brazilian coast to about 30° S. is found between the escarpment and the sea coast. Throughout the state there is uniform and ample precipitation. Natural vegetation consists mainly of semideciduous forest, intermittent prairie grassland and the frost-resistant pine forests at higher elevations.

The stands of Paraná pine (Araucaria brasiliana) represent the largest and best softwood forests in South America. The plains in the western part of the state contain important tracts of *Ilex paraguayensis,* the tree whose leaves are used for maté (or hervamate). Lumber and maté are the principal exports of Paraná. Other items of commercial importance grown there at various altitudes include coffee, cereals, cotton; potatoes and livestock. The state has tno railroads which provide a serviceable system. One, the trunk line from Sbo Paulo to Rio Grande do Sul, crosses the eastern portion of the state; it has branches east to Curitiba and Paranaguá and north to Ourinhos. The other, in the north. extends from Mandaguari to Ourinhos and São Paulo. Important rivers are the Paranapanema, the Ivaí, Pequiri, Chopin and the Iguassu. The territory of Iguassú, provided for in the federal con-

stitution of 1937 and created by decree law in 1943, was abolished in 1946 and its area incorporated into the state of Paraná.

Northwestern Paraná, developed chiefly by Paraná Plantations Ltd., a British company organized in 1925, is one of Brazil's latest zones of pioneer settlement and the far west extension of the coffee frontier. Exceptionally fertile soils, favourable climatic and terrain features and satisfactory transportation facilities make this a valuable area. Londrina (pop. [1950] 33,095), a modern city, is the commercial, political and cultural centre of this zone.

The racial composition of Paraná tends to be heterogeneous since in addition to the Latin races represented, there are Germans and Slavic peoples, the latter being notably Poles, Russians, Ukrainians and Ruthenians. The Japanese population is considerable and continues to grow.

Curitiba, the capital (pop. [1950] 138,178 [city]), lying at 2,979 ft. elevation, has an average annual temperature of about 62° F. Commercially it is important as a centre for the maté trade and to a lesser extent for coffee and Paraná pine. Other cities include Ponta Grossa, Paranaguá and Cornélio Procópio.

Paraná was settled in the 17th century by *bandeirantes* (prospectors) following the discovery of gold near Curitiba in 1645. The region was a district of São Paulo from 1668 until 1853 when it was created a province of the empire. Paraná became a state of the federal union in 1889. (J. L. TR.)

PARANÁ, Argentine city and capital of the province of Entre Ríos, is located on the east bank of the Paraná river, 240 mi. N.W. of Buenos Aires (365 mi. by navigable channel). Pop. (1947) 84,153; (1960) 111,258. The climate is mild (mean annual temperature 66° F.) with adequate rainfall for crops and grazing. The gently rolling hills are admirably suited as vast grazing tracts for cattle, sheep and horses and the raising of corn and flax. The city was founded in the late 16th century with the name of Bajada by Spanish settlers from Santa FC. During the 19th century it served as provincial capital except for the period 1854–82 when Concepción on the Uruguay river was declared the capital. From 1852 to 1862, while Buenos Aires was separated from the Argentine confederation, Paraná became the residence of the national authorities. Because of flood danger the city is situated on high ground 2 mi. from the river bank but it is closely connected with the port of Bajada Grande by railroad and highway. Although this port is classified as a seaport, only ocean-going vessels of less than 12-ft. draft can ascend the channel. Several ferry services connect Paraná with the city of Santa Fé on the opposite bank. The eastern part of the province and the cities along the Uruguay river are linked to the capital by a provincial railroad net. Air communication is facilitated by a municipal airport. (Js. R. S.)

PARAÑAQUE, a small municipality of Rizal province, Luzon, Republic of the Philippines, on Manila bay south of Manila; although it is politically separate from Manila it is part of the metropolitan urban area. Pop. (1948) 28,884; (1960) 62,030. In 1948 nearly 300 small farms still produced rice and vegetable crops, but a decade later most of these had become urban area or were included in the expanded Manila international airport established at Nichols field, former U.S. air base.

Parañaque has long been famous for its fine hand embroideries, a continuing household industry. (J. E. SR.)

PARANÁ RIVER, forms with its tributaries, the larger of the two river systems that empty into the Rio de la Plata estuary. An important commercial artery, it rises on the plateau of southeast central Brazil and generally flows south for 1,826 mi. to join the Uruguay river. *See* PLATA, RÍO DE LA.

PARANOID REACTIONS. Under this term are included paranoia and paranoid states. The word paranoia was used by the ancient Greeks, apparently in much the same sense as the modern popular term insanity. Since then it has had a variety of meanings. Toward the end of the 19th century it came to mean a delusional psychosis, in which the delusions develop slowly into a complex, intricate and logically elaborated system, without hallucination and without general personality disorganization. Sometimes the fixed delusional system, which may be grandiose, persecutory or erotic, is more or less encapsulated, thus leaving the rest of the personality relatively intact. Though a great many patients with paranoia have to be hospitalized, some do not, and among these an occasional one succeeds in building up a following of persons who believe him to be a genius or inspired. Today the term paranoia is reserved for all rare, extreme cases of chronic, fixed and highly systematized delusions. All the rest are called paranoid states; *i.e.,* states resembling paranoia but less severe.

Paranoid states are relatively common psychotic disorders, characterized by persistent delusions and by behaviour and emotional resoonses that are consistent with the delusional ideas. Hallucinations are absent; and there is no general personality disorganization, such as that commonly seen in schizophrenia. Paranoid states may develop gradually or appear suddenly; they may remain chronic or clear up. Complete recovery is not rare, although, of course. if a person has always been distrustful before his illness he is likely to remain distrustful after ard. The delusions in paranoid states are usually delusions of persecution, and to these this article will devote most of its attention.

Persecutory Paranoid State.—Individual susceptibility to paranoid developments varies greatly. The person most vulnerable to a persecutory paranoid state is the tense, insecure, suspicious person who has little basic trust in other persons, who has always found it difficult to confide in others, tends to be secretive, usually has few close friends and is addicted to solitary rumination. These characteristics are sometimes hidden behind a façade of superficial sociability and talkativeness. Above all, there is a rigidity about such a person's thinking which becomes most obvious when he is under emotional stress. This may give an impression of certainty and self-assurance. but actually it is based upon profound insecurity, upon a need to be dogmatic because of an inability to tolerate suspended judgment.

The insecure, distrustful, solitary person finds his world unsafe, something that needs watching. Characteristically, he does not understand motivation well, either in others or in himself. Because of this he easily misinterprets what others do and say, and fails to recognize hostile overtones in his own behaviour, even when they are obvious to others. An ambitious person with paranoid trends, for example, may push ahead without due regard for others' feelings, uhich he does not understand, and then become deeply hurt or enraged when others oppose him or snub him. A passive person, similarly, may unconsciously invite domination or encroachment by others, and then react with angry resentment or fright when it comes. A common result of all this is that a person with these personality trends unintentionally creates an atmosphere of tension around himself. even when he is relatively well.

Self-Reference.—A chief contributing factor to this atmosphere of tension is the tendency to self-reference; *i.e.,* to misinterpret remarks, gestures and acts of others as intentional slights or as signs of derision and contempt, directed at the hypersensitive person. It is normal, of course, to assume occasionally that criticism, contempt or derision is directed at oneself when actually it is not. But the average person is able to shrug it off, after a brief period of resentment, or to challenge it, and thus find out his error of interpretation. The person aho can neither shake off his hurt feelings nor correct his mistakes of self-reference is in more than average danger of developing delusions.

Self-reference becomes paranoid delusion when a person persists in believing that he is the target of hostile actions or insinuations, aimed at him by some enemy or band of enemies, when this is actually not the case. The identifying marks of delusional conviction are (1) readiness to accept the flimsiest evidence in support of the belief, and (2) inability to entertain seriously any evidence that contradicts it. It is this biased selection of available evidence that gives to paranoid development its appearance of irresistible progression.

Paranoid self-reference is never a purely random matter; it always has some kind of pattern. The patient is always selectively hypersensitive to certain kinds of implied threat, to certain kinds of situations and personalities. This selectivity actually corresponds to the patient's own pattern of fears, wishes, guilt, weaknesses and frustrations. The persecution he anticipates may be sexual in character, it may be a direct assault or it may be some threat to his freedom, reputation or security. The immediate

effect of increased delusions of self-reference is to increase the patient's vigilance, to make him look for possible clues as to what seems to be going on around him, and to make him prepare to defend himself or to counterattack.

Precipitating Factors.—Paranoid states often develop so gradually that, on looking back, it is not possible to be sure just when mere suspicion changed into delusional conviction. Even when the onset seems abrupt, in retrospect it often can be seen that the onset actually was preceded by a rising tide of anxiety and distrust, that finally got out of control and broke out as delusional belief. The commonest precipitating factors are temptation and frustration. Temptation to commit or to fantasy some forbidden hostile or erotic action may arouse primitive impulses and intolerable guilt. Frustration also can arouse intolerable guilt because of the hostility it stimulates. The frustration may come from actual failure and humiliation, from feelings of intense rivalry and jealousy or'from the loss of a major source of gratification. There may be real or imagined rebufi, neglect or hostile treatment by others. Frustration also comes when youth begins to disappear or health fails, or when the person is incapacitated, isolated or subjected to socio-economic downgrading, as in losing his job, status or income.

The paranoid patient gets rid of his intolerable sense of guilt through unconscious mechanisms of denial and projection. He denies his primitive hostile or erotic impulses and projects them —that is, he ascribes them to other persons. Projection is rarely done at random. Usually the patient unwittingly selects as the alleged carriers of his own impulses and his own guilt, persons who have corresponding minimal unconscious trends. These trends he magnifies and sees them as dominant, conscious characteristics of the person he accuses. Someone who actually dislikes the patient, for example, someone who may not even realize it, is selected as a major hater and tormentor—even as a potential murderer; or someone of the same sex, who is fond of the patient or who has minimal unconscious homosexual trends, becomes for the patient a frightening homosexual threat.

Clinical Course.—The clinical course of a paranoid development may be as follows. The stimulation of erotic and hostile impulses, directly or indirectly through frustration or temptation, results in a high level of anxiety. This anxiety the patient ascribes to external danger of attack; but actually it signals internal danger from poorly repressed impulses. It seems to him that things around him have somehow changed. and he tries to understand what is happening. He becomes increasingly uneasy and vigilant. scrutinizing his environment with growing suspicion and distrust. In trying to understand his situation, he does what he has always done: he observes silently, looks for hidden meanings and watches for clues in the little things others say and do, their gestures and facial expressions, their tone of voice, their smiles and frowns.

Unfortunately, a person who is already convinced that something strange is going on around him, or that he is in personal danger, always can find confirmation of his suspicions and fears if he looks hard enough. The anxious paranoid person may begin by noticing little things. His personal effects may seem to him to have been disturbed, as though someone had been rummaging through them, perhaps looking for evidence of some kind. The feeling he has is vague but uncomfortable. When he cannot find something that he himself may have misplaced, he concludes that someone must have deliberately taken it or moved it to annoy him or make him look stupid. If he finds a book upside down he may interpret it as a sign that someone is testing his intelligence (to see if he can notice things) or is casting a derisive slur on him by indicating that he cannot even read.

As the patient notices such details it seems to him clearer and clearer that he is the victim of some plot, that he has been singled out for some reason to be persecuted. Self-reference becomes still more intense. Strangers in the street seem to be talking about him or laughing at him and they signal to each other about him by gestures. He feels watched and followed and he sees signs that his movements are being reported. A magazine seems purposely left open at a certain page so that a story, picture or advertisement will communicate something to him, or will further anger or arouse him. Some patients are convinced that their telephone wires are being tapped or that microphones are hidden in the walls. If the process progresses, the patient begins to hear specific references to him on radio and television, in the cinema and at sermons. This apparent publicity frightens and angers him further.

When apparent persecution reaches this degree of intensity and complexity it is natural to assume an organized source. The search for some unifying explanation leads many paranoid patients to conclude that the "plot" is being engineered by certain specific persons, some of them actual persons who can be pointed out, some of them imaginary. Such an imagined community of alleged conspirators is called a paranoid pseudo-community. Its make-up often follows the familiar patterns of mystery stories. The patient may speak of criminals. gangsters, dope rings and spy rings, of political, racial and religious haters. He may complain of plots at work to deprive him of job, reputation or life, or of enemy neighbours who are trying to ruin him and drive him from his home.

Abnormal as it is, this organized delusion of a hostile pseudo-community has certain immediate advantages for the patient. It substitutes a definite, known delusional danger for a vague unknonn one, and most human beings find known dangers easier to endure It is also easier to prepare oneself to meet a specific knonn danger than to meet a diffuse threat. And, finally, the hostile pseudo-community seems real enough to the paranoid patient for him to be able to make it the target of his hostility. Now he can discharge some of his unmanageable aggression directly by combating the supposed band of persecutors. His destructive impulses. instead of disorganizing him as they easily might, are turned outward against his imaginary enemies. This does not solve his problems by any means, but for the time it does preserve him from personality disorganization.

Persecutory paranoid illnesses have more than one possible outcome. 4 great many patients. even those with well-marked delusions, regain their premorbid level completely; they become clinically well. Others remain chronically delusional. Some of these seem merely morose, suspicious and resentful, concealing their delusions behind complaints of never getting a square deal or behind assertions that the world is full of hatred and immorality. Some chronically paranoid persons suffer occasional outbursts of hostility that make others fear them or avoid them. Some spend a great deal of energy and money in pressing an endless succession of lawsuits (litigious paranoia), which are really attempts to combat an unconscious sense of guilt by forcing courts to demonstrate the litigant's innocence, at the same time punishing the persons he accuses in place of himself.

Occasionally a paranoid person explodes into action, either fleeing from his alleged persecutors or attacking them. In either case the explosive action is inappropriate to the real social context, since the plot and the persecutors are imaginary. As a rule, society takes steps, vigorous or even violent, to interfere with the flight or the attack. The patient then feels that his worst fears are being confirmed, that he is at last being actually attacked.

Therapy.—In persecutory paranoid reactions the primary therapeutic aims are a reduction in anxiety and the re-establishment of genuine communication. Excessive anxiety lies behind excessive paranoid projection; and the delusions themselves are only products and indirect expressions of these more basic processes. If anxiety and projection subside. the patient becomes able to communicate profitably. His greatest need then is for someone in whom he can confide safely. Friends, relatives and others have by this time already tried reassurance, argument, reasoning and demonstration without success.

To be able to meet a paranoid patient's needs, the therapist must be a neutral person. one aho is not driven by his own anxiety to offer too much reassurance, to belittle the patient's fears or to argue with him. If the patient can form a relationship with a neutral therapist who does not take sides, but listens with appropriate considerateness and respect, the generalized paranoid suspicion may give way to a specific trust. If this occurs, it may then become possible to work through some of the ramifica-

tions and origins of the paranoid illness, and the patient may modify or replace his pseudo-community with something approaching the real community.

Other Paranoid States.— In addition to the common persecutory type of paranoid reaction, four others deserve mention: (1) delusional jealousy; (2) erotic delusions; (3) paranoid grandiosity; and (4) folie *à deux*.

Delusional Jealousy.—Even normal jealousy is made up of an irrational mixture of anger toward both the beloved and the rival, of sorrow and of a painful loss of self-esteem. Delusional jealousy goes farther. exhibiting some of the definitely paranoid characteristics present in persecutory delusions. There is, for example, hypersensitivity to even the most minute evidence confirming the patient's suspicions. and unreasonable resistance to all contradictory evidence. The patient watches intently for signs that he is right. as if he wants to be. In some cases it is obvious to an observer that he has an unconscious attachment for his rival, and that he identifies with his beloved. Primitive defensive operations of denial and projection are basic to all delusional jealousy.

Erotic *Delusions*.—These are fixed beliefs that one is loved sexually by another person who is indicating his affection through innumerable little signs. The alleged lover is usually of the opposite sex, and is often someone prominent in politics or in the field of public speech or entertainment. Prominent persons often receive letters hnd telephone calls expressing erotic delusions. and occasionally' are accosted at public meetings by a paranoid person who makes an avowal and expects an acknowledgment. Such action on the part of the patient may lead the person who is the focus of the delusion to complain to the police. The erotic delusions are sometimes manifestations of self-love which is denied and projected on to another person. Sometimes the erotic delusion is a defensive maneuver which replaces the denied unconscious real homosexual trends with a more acceptable delusional heterosexual attachment. It is to the last-mentioned defensive maneuver that Freud's classical formulation refers: denial, "I don't love him," and delusional substitution, "I love her because she loves me." Some persons with erotic delusions suffer also from personality disorganization, and belong rather to the schizophrenic group than to the more organized paranoid reactions (see SCHIZOPHRENIA).

Paranoid Grandiosity.— This is much less common than delusions oi persecution, and when it occurs the paranoid illness is usually more severe. Unlike the grandiose delusions in mania and in schizophrenia, paranoid grandiosity tends to be well-organized, relatively stable and persistent. The complexity of delusional conviction varies from rather simple beliefs in one's alleged talent, attractiveness or inspiration to highly complex, systematized beliefs that one is a great prophet, author, poet, inventor or scientist. The latter extreme belongs to classical paranoia. Very rarely does a patient with paranoid grandiosity actually contribute something useful to the social environment. More often he joins some fanatical movement in current vogue, in this way succeeding sometimes in sublimating his excessive zeal and saving himself from further illness.

Folie *à Deux*.—This name is given to an interesting development in which a dominant psychotic person induces a delusion, usually persecutory, in a dependent, submissive person. If the two are separated, the dependent member of the pair usually recovers rather quickly. As a rule. the two members have been living for a long time in close contact. The commonest combinations are two sisters, husband and wife, mother and child, in that order. The preponderance of women and children seems related to a relationship of dominance and submission between the one who induces the delusion and the one who adopts it. Cases of *folie à* deux in which personality disorganization occurs are considered to be schizophrenic. In these, the outlook for recovery of the dependent member after separation is also good.

See also PSYCHIATRY; PSYCHOTHERAPY; PSYCHOSES; PSYCHOLOGY, ABNORMAL.

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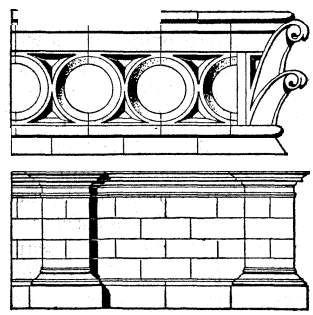
PARANTHELIA, an image, in the parhelic circle situated from 90° to 140° of parhelic arc from the sun. See also HALO.

PARAPET, a dwarf wall or heavy railing around the edge of a roof, balcony, terrace, stairway, etc., either to prevent those behind it from falling over or to shelter them from attack from the outside. Thus battlements (*q.v.*) are merely one form of defensive parapet arranged to allow those within to discharge missiles without exposing themselves. In many cases roof and terrace parapets are only continuations of the wall below, but in some instances they are projected forward beyond the face of the wall and carried upon brackets or a molded cornice.



TOP: FRENCH GOTHIC, 13TH CENTURY: BOTTOM: RENAISSANCE

Parapets, during the classic ages. were often formed of large slabs of marble pierced with holes, forming a pattern of squares and diagonals; an example still exists in the ruins of the palace of Tiberius on the Palatine hill at Rome. Parapets with fish-scale patterns were also used and are indicated in extant wall paintings in Pompeii. English late Gothic parapets frequently adopted the battlement form.

During the Renaissance. the use of the balustrade largely superseded the parapet, but in north Europe, the transitional early Renaissance styles offer many examples of fantastically scrolled and pierced parapets.

PARAPSYCHOLOGY. The addition of the Greek prefix para to the word psychology produced a term defined as meaning a derivative of psychology. with special reference to those allegedly supernormal capacities of the human organism such as telepathy, clairvoyance, precognition and other not generally agreed upon functions. The modern exponents of these ancient beliefs centred around the parapsychology laboratory at Duke university and the activities of the several societies for psychical research. After 1933. J. B. Rhine at Duke university conducted experiments on extrasensory perception (ESP), defined as perception beyond the range of the known sensory processes.

While the work at Duke is best known and precipitated the most controversy, some of the most convincing experimentation has originated in other laboratories. Contrary to a widespread impression that only Rhine gets these results, numerous published investigations originating outside Duke have been favourable to the parapsychological claims.

The work of the parapsychology laboratory at Duke received continuous and serious criticism after the results of experiments there were published. The experiments themselves in written form gave the impression of considerable psychological sophistication. Briefly, experiments were carried out as outlined below.

Clairvoyance Tests.— Clairvoyance is defined as supernormal knowledge of events, scenes or other information which, at the time it is received, is not necessarily in the mind of some other person. Thus it is claimed that success on clairvoyance tests demonstrates the capacity of persons to have supernormal knowledge concerning the order of symbols existing in a deck of shuffled cards.

A special deck of cards is used, made up of five cards each of five different symbols: cross, circle. star, wavy lines and a square. Because of the structure of the special deck, the probability for success (correct guesses) in each set of 25 guesses is $\frac{1}{5}$ or 5 out of 25 guesses as an average number, if a large number of such sets of 25 guesses are collected. It is reasoned that, if the subjects consistently obtain averages of six or seven hits per deck, these results are not to be explained in terms of the operation of mere chance. Statistical techniques are available for determining when excesses over the expected number of successes, or deficiencies in the number of successes, significantly differ from the number of such successes which may reasonably be attributed to the operation of chance. Rhine and others obtained results which are significantly different from (both higher and lower than) those which would be predicted by the chance hypothesis.

Open *Matching* Test.—One card of each symbol is selected from a deck of ESP cards. These key cards are placed face up in a row in the middle of the table; the rest of the pack is laid aside. Another deck of ESP cards is thoroughly shuffled and cut, the cards are held face down in the subject's hand as though he were about to deal the cards. The subject is then requested to decide which symbol on the table in front of him will match the symbol which is present on the top card of the shuffled deck. After this decision is made by the subject, he deals the top card and places it just below the guessed symbol of the key card. He continues through the deck in this fashion, matching up his guesses as to the nature of the symbol of each face-down card with the key symbols appearing on the table.

Blind ,Watching Test.—This test is like the open matching test except that here the key cards are face down and their position is unknown. The five key cards are shuffled out of sight of the subject and placed face down by the experimenter.

The rest of the test is carried out in the same manner as the open matching test. It should be noted that in this test the subject should not see the symbols on the key cards placed in front of him.

Single Card Calling Test.—This is conducted by guessing the symbol on the top card of a shuffled ESP deck, removing that card still face down, guessing the symbol on the next card and so on through the deck.

Pack Calling Test.—In this the subject makes a set of 25 consecutive calls directed at a shuffled but unbroken deck of ESP cards. Usually the deck of cards is placed in front of the subject, but sometimes it is not present in the same room. Successes with this technique were reported consistently from the parapsychology laboratory and in an experiment conducted by D. R. Schmeidler and G. Murphy at Harvard university

Telepathy.— The parapsychology laboratory also studied telepathy by means of several techniques.

Pure Telepathy *Method.*—This is a test for extrasensory perception of thought alone. No cards are used to guide the choices of the agent. He simply chooses a random order of the ESP symbols and holds these in mind (without writing them down) until the receiver or percipient has made his choices. Success in this test allegedly depends entirely upon reading the sender's thoughts.

General Extrasensory Perception Test.—In this test the sender shuffles and cuts a deck of ESP cards and looks at the face of each card while the receiver attempts to read the mind of the sender and guess the symbol on which the sender is concentrating. When one card is finished, the test proceeds to the next card and so on through the deck.

Distance Telepathy Test.—In the methods discussed above, the subject and experimenter were usually in the same room. Some results were collected in which the subject and experimenter were separated by several rooms or by a considerable distance. A few experiments were successful in eliminating the hypothesis of chance causation of results when subject and experiments were separated by many miles.

Precognition.— Several techniques also were devised for the study of precognition, defined as the hypothesis that future events may be apprehended extrasensorily and extrarationally. In one technique the percipient tries to call through the *future* order of a whole deck, after which the deck is shuffled mechanically and its resultant order matched with the call sequence. In another procedure the individual target card is presented to the agent (or sender) two or three seconds after the percipient announces his guess.

Psychokinesis.—Whereas in telepathy and clairvoyance the subject's psychological state is influenced by the external world. occurrence of the reverse process, that of influencing physical events by paranormal means, has also been alleged. In these "mind-over-matter" experiments, the subject attempts by thinking or willing to determine (without physical contact) the outcome of a mechanically performed dice throw. If the outcome he is set to produce, is itself randomly selected, such an influence (called psychokinesis) can be detected by statistical analysis of a series of such attempts. The experimental evidence for the psychokinetic effect is considerably weaker than that for ESP. and many psychologists who accept the reality of ESP remain unconvinced of psychokinesis.

Sources of Error.— As indicated above, this experimental work was subjected to continual critical comment. Criticism may be summarized under the headings of (1) minimal and subliminal sensory cues, (2) mental habits and preferences, (3) recording errors and errors of experimental method, (4) statistical methods, (5) outright fraud by the experimenter himself (*i.e.*, faking the data). The antagonism aroused among scientists by positive parapsychological findings is evidenced by this fifth kind of attack, which is rare in scientific criticism generally unless specific evidence of fraud is available.

Sensory Cues.—The human organism is incapable, in many instances, of reporting correctly on the stimuli operating on the organism at the time. Behaviour is determined and modified by small noises, weak visual stimuli, subliminal odours, etc., of which the subject is entirely unaware. This phenomenon has led to considerable false evidence for parapsychological phenomena and, in some of the early work of the parapsychology laboratory, appears to have been responsible for certain of the extrachance scores in telepathy and clairvoyance experiments. For example, some of the ESP cards used in these experiments were so printed that the symbol on the face of the card could be read from the back, if the light reflecting from the back of the card entered the subject's eye at an angle of approximately 60°. Conditions of experimentation in which subject and experimenter are in the same room should also be avoided. because of the possibility of minimal auditory communication.

Mental Hubit.— It is a well-known fact that choices made by human beings in situations such as those described in the pure telepathy method above do not correspond to the choices of material made by a randomizing procedure. A simple experiment to demonstrate this phenomenon of mental habit or preference may be carried out by asking a group of persons to make five successive guesses of the results of tossing an imaginary coin. The subjects record a pattern of heads and tails. If these patterns are subjected to statistical analysis, it may be demonstrated that certain patterns—such as heads, heads, tails, heads, tails or tails, tails, heads, tails, heads—occur at frequencies well beyond the expected or predicted frequency if actual coins were used. If the target and call series are both products of human thought, extrachance results may arise solely on this basis, no paranormal communication being involved. Therefore the target series in either clairvoyance or telepathy tests must be determined either by machine (shuffling, dice-throwing, electronic randomizing device) or, as became common practice after the 1940s, by the use of a table of random numbers.

Recording Error.— The precise way in which the results of guessing have been reported has also been suggested as a possible source of error which would allow the occurrence of extrachance scores by perfectly normal and well-understood means. In many of the parapsychological techniques, the experimenter also serves as the recorder. Expectancy of successes, excitement and divided attention at the time of recording will produce erroneous results which are very difficult to trace in terms of causation, once they

have been written down. Experiments utilizing electrical or photographic recording have shown that experimenters personally favourable to the paranormal claims tend to record more hits than actually occur, while those of adverse bias show a tendency to misobserve or misrecord in favour of misses. Electrical, mechanical or photographic means of recording both call and target series are preferable. It is undesirable for the experimenter to act as agent himself, unless another observer records his calls.

When human recording is used, the obvious solution is to have agent and percipient, with their respective observers, in different rooms. In any case, separate records of target and call series should be routine in every experiment. The human organism is not an objective recording device, as the history of error in experimental psychology and in psychical research amply testifies.

Statistical Methods.—The first critical comment directed at the experiments on extrasensory perception had to do with statistical methods, particularly in the designation of the theoretical probability of success. Reasonable agreement was reached that the statistical methods used in research on extrasensory perception are sufficient to provide information by means of which the hypothesis of chance expectancy may be denied.

Fraud.—Even prior to the passionate controversy of the late 1930s, several experimental series yielding clear positive findings had been published which seemed adequately protected against all sources of error except deliberate fraud by the experimenter. Several others appeared later. Beginning in 1943. the British investigator S. G. Soal and his colleagues rearoused scientific interest by publishing the results of a long and carefully controlled experimental series run on two unusually and consistently high-scoring subjects (Basil Shackleton and Gloria Stewart). No significant experimental or statistical criticism of this research appeared. In addition to giving powerful support for the reality of ESP, this research was also distinguished by its careful examination of special aspects of the telepathic process. Among the matters investigated were the effect of several agents sending together or in opposition, influence of lead screens (none), mathematical features of the internal relations within the subject's guessing sequence, influence of manipulating the guessing rate, persistence of positive findings when agent and percipient were separated by the English channel. The orderliness and consistency of the findings on these two subjects, as well as their remarkably good scoring levels over very long series, impressed those psychologists who are acquainted with the research even more than the extremely high levels of statistical significance attained.

Trends.--Other developing trends in parapsychology are: research upon ESP in animals; further collection and detailed qualitative examination of spontaneous cases (*i.e.*, paranormal cognition not appearing in the laboratory but in the course of daily life), aiming at a theoretical formulation of the process; experimentation with target stimuli to permit a partial hit or degree of success rather than a categorical hit or miss (*e.g.*, cards showing clock hands from whose true position the subject's guess may err in varying degrees). Many are seeking correlates (*e.g.*, personality traits, belief in ESP) or conditions (*e.g.*, timing, drugs. hypnosis, rewards) which will assure success. Theorizing suffers from the restricted range of extra-chance deviations available for manipulation and analysis. Skeptics stress the "erratic" character of the phenomena. Many psychologists withhold credence pending specification of methods of procedure and subject-selection which will consistently yield results.

Parapsychology in Contemporary Science.—The situation of parapsychology in contemporary science is anomalous. The great majority of U.S. psychologists do not accept it as a fact. and only a very small minority of them are acquainted with the post-1935 research, most of which appears in journals to which very few subscribe or books which are not read. This negative attitude is less characteristic of British and continental psychologists. The net evidence for the reality of ESP is approximately as weighty as that for numerous other concepts widely held by psychologists. The chief obstacle to a more widespread scientific acceptance of the findings! as some of the fairest and most competent skeptics have pointed out, is the almost complete lack of any plausible theoretical account as to the underlying causal processes. This difficulty is more than merely the absence of a good theory, since the majority of observed empirical relationships in other branches of psychology also have not been given rigorous theoretical derivation but are nevertheless assimilated simply as brute facts. What disturbs the psychologist about ESP is the great difficulty he has in imagining even the general kind of scientific explanation that could be forthcoming for such a phenomenon as, say, precognitive telepathy. Philosophical critics have pointed out the conceptual difficulties involved in the notion that a future event, not yet "in existence," causally influences the present.

Ordinary telepathy and clairvoyance pose similar conceptual problems. The alleged facts of parapsychology do not actually challenge any established laws of general psychology; what they seem to challenge is the modern psychologist's basic views concerning the reduction of the cognitive functions of organisms to the physiology of their material components as these are influenced by substances or energies (of the kinds presently known to physics) impinging upon the body surface. In a sense, the threat presented to psychologists by these data is not so much scientific as metaphysical; *i.e.*, the facts appear to generate major difficulties for physiological reductionism as a complete view of the human organism.

In 1938, L. Warner and C. C. Clark conducted a survey on ESP, by mailing questionnaires to a sample of members of the American Psychological association. The same questionnaire survey was repeated three times in the 1950s to show what change had occurred in the climate of opinion over the intervening years. The percentage of full-member psychologists considering ESP as either an established fact or as a likely possibility had risen slightly, from 8.8% in 1938 to 16.6% in 1952. Corresponding figures for two samples of younger psychologists (recently granted the Ph.D.) were 29.7% (1950) and 31.8% (1955), suggesting that those who will constitute the coming generation are more favourably inclined to accept the reality of parapsychological phenomena than were their predecessors.

See also PSYCHICAL RESEARCH; SPIRITUALISM.

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(P. E. M.)

PARASCHOS, ACHILLES (1838–1895), Greek poet, born at Nauplia in the Peloponnese on March 6, 1838, was the central figure of the Greek romantic school of poetry in its second and last period (c. 1850–80). His models were Alfred de Musset, Victor Hugo and Lord Byron, but he fell far short of their achievement. His manner is unrestrained and his language grandiloquent. owing much to the Phanariote poets, whose tradition he continued (see GREEK LITERATURE). He touched on all the usual romantic subjects, but love and patriotism were his favourites. In his numerous lyrics he made use of both *katharevousa*, the "refined" Greek, inherited from the Byzantine scholars. and the demotic, the spoken language, but his vocabulary remained as limited as his ideas. Perhaps no other modern Greek poet was more admired by his contemporaries. His poems were published in Greek in 2 vol. (1881. 1904). He died at Athens on Jan. 26, 1895.

See C. A. Trypanis, *Medieval and Modern Greek Poetry* (1951).

(CE. A. T.)

PARASELENE (MOCK MOON), a bright spot on a lunar halo resembling the moon, appearing at the intersection of the inner halo and the parhelic circle. See HALO.

PARASITIC DISEASES. Parasites which produce damage to their hosts are referred to as pathogens, and the condition resulting from this damage constitutes disease. In a broad sense disease states produced by any microorganism—virus, bacterium, rickettsia. spirochete, fungus or animal parasite—might logically be considered under the topic "parasitic diseases," but conven-

tionally the subject is restricted to morbid states resulting from infection with animal parasites. (See also BACTERIAL AND INFECTIOUS DISEASES; BACTERIOLOGY; IMMUNITY; PARASITISM AND PARASITOLOGY; RICKETTSIAE; VACCINE THERAPY; VIRUSES; etc.)

Diseases caused by animal parasites may, for convenience, be grouped etiologically as those caused by Protozoa, the simple animals usually considered as consisting of a single cell which performs all the functions of the animal body, and those caused by Metazoa, or many-celled animals in which the cells and tissues are characteristically specialized in function. It must be remembered, however, that a majority of the Protozoa and Metazoa are not parasitic and that those which have become adapted to parasitism are not *ipso* facto pathogenic. Moreover, there is a wide range, from the essentially harmless species, such as the parasitic Endamoeba *coli,* to highly pathogenic forms such as the malaria parasite Plasmodium *falciparum* and the blood fluke Schistosoma japonicum.

Types of Parasitic Damage. — The damage that results from the presence of animal parasites in their host may be classified as traumatic, lytic, obstructive, loss of nutriment, intoxicative, allergenic and proliferative.

Traumatic.—This consists in the tearing of cells and tissues out of their normal state and relationship to one another, as when a tapeworm or a hookworm in its attachment damages the intestinal mucosa, or when eggs, larvae and adult worms migrate through tissues, producing microscopic or macroscopic mechanical injury.

Lytic.—This is the digestion of cells and tissues by ferments secreted by the parasite and is illustrated by the action of the pathogenic amoeba *Endamoeba* histolytica or by the larvae of the blood fluke as they enter the skin and make a pathway into the cutaneous blood vessels.

Obstructive. — A mass of the giant intestinal roundworm *Ascaris* lumbricoides, or a 25-ft. length of tangled tapeworm (Taenia saginata), may produce massive obstruction in the intestinal tract, or a single large worm may obstruct the common bile duct (Ascaris), a ureter (Dioctophyma renale) or a bronchus (the leech *Limnatis* nilotica).

Loss of Nutriment. — Most parasites live in locations within the host where they have ready access to predigested food, or they sap nutritive substance from the tissues. Many microscopic parasites, even in large numbers, cause no appreciable nutritional drain on the host, but others, such as the larger tapeworms, constitute a real burden, particularly if the nutritional threshold of the host is already critical. Moreover, hookworms may suck blood from the intestinal blood capillaries in excess of the ability of the blood-forming organs to replenish, so that a continual blood loss produced by hundreds of hookworms causes severe anemia.

Intoxicative.—The metabolic products of the parasite, both secretions and excretions, cause irritation of the host's tissues, locally and throughout the system, with resultant toxic manifestations.

Allergenic. — This is essentially a host sensitization reaction to proteins and other foreign substances elaborated by the parasite. It is evidenced by the chills and fever of malaria following cyclic release of the plasmodia into the blood plasma, and by the systemic reaction in many of the helminthic (parasitic worm) infections.

Proliferative. — In some parasitic diseases, as amoebic colitis, there is practically no tissue reaction to the invader. On the other hand. in visceral leishmaniasis, caused by the flagellate Leishmania *donovani,* macrophage production is stimulated to a degree where it embarrasses normal production of neutrophils and red blood corpuscles. In helminthic (worm) infections such as Manson's filariasis, schistosomiasis and clonorchiasis, host tissue proliferation is so extensive as to cause growths which seriously reduce normal function of tissues and organs. In addition to these types of damage, lesions produced by animal parasites may allow bacteria and other pathogens to enter the tissues and set up supervening diseases.

Strains. — The disease process varies not only with respect to the species of pathogenic microorganism but also to a considerable degree depending on the pathogenicity of a particular strain of the parasite for the particular host. Thus, Endamoeba histolytica, always an actual or potential tissue invader, may produce no detectable symptoms in one person who may temporarily be considered as an asymptomatic carrier, while another person exposed to the same strain may develop acute dysentery or amoebic liver abscess. This difference has resulted from variations in the dose of inoculum of the same strain (*e.g.,* number of organisms), from enhancement in the pathogenicity of the amoeba by serial passage, from differences in tolerance between the two hosts or from intrinsic difference~in pathogenicity. Another striking example is that of vivax malaria encountered by U.S. and Australian troops in parts of New Guinea during 1943–45. This strain proved to be much more pathogenic than those previously encountered elsewhere in malarious areas, as demonstrated by the severity of the clinical manifestations, the tendency to repeated relapse and resistance to chemotherapy which had proved effective in the treatment of other strains of vivax malaria.

Immunity. — In general, there is neither racial nor age immunity to parasitic infections, yet there are notable exceptions. Negroes are essentially resistant to certain strains of vivax malaria which produce serious symptoms in Caucasians. but they are as susceptible as whites to quartan malaria. Again, there is some suggestion that small children are more likely to acquire Giardia lamblia infection than are their elders, and the same is true of infection with the dwarf tapeworm (*Hymenolepis* nana).

However, little by little, evidence has accumulated to indicate that in several animal parasitoses prolonged exposure develops a certain degree of tolerance or even a substantial immunity to the identical strain of the organism, although there is no appreciable tolerance to other strains of the same species of parasite. This phenomenon is even more striking in some of the viral and bacterial diseases.

Hosts.--In some parasitic diseases man is the only known satisfactory host of the pathogen. This holds true for the four species of plasmodia which produce human malaria, for the flagellate protozoon which causes Rhodesian trypanosomiasis, for the hookworm Ancylostoma *duodenale* and for the blood fluke *Schistosoma* haematobium. In other instances domestic and wild animals are as susceptible as is man. Examples are found in Endamoeba histolytica, which as readily parasitizes monkeys, kittens and rats as it does man; Leishmania donovani, for which the Chinese and golden hamsters are highly susceptible; *Trypanosoma cruzi* of tropical America, of which the mammalian reservoir hosts are legion, and Schistosoma japonicum, with dogs, cats, hogs. cattle, sheep, goats. horses and many species of rodents naturally infected in endemic areas. In a few known instances, as *Ascaris* lumbricoides of man and the pig and Hymenolepis nana of man, the rat and the mouse, the parasites found in the different hosts are morphologically indistinguishable, yet the respective hosts are highly refractory to cross infection. This suggests that within recent biological time immunological host differences have been developed. Still other parasites, which are occasionally found in man, commonly occur in domestic or wild animals. The situation here results from differences in habits and customs governing degrees of exposure to infection, and is not one of susceptibility.

PROTOZOA AND PROTOZOAN DISEASES

There are six recognized classes of the Protozoa; viz., Rhizopoda (synonym Sarcodina), Ciliata, Mastigophora (at times referred to as Flagellata), Cnidosporidia, Sporozoa and Suctoria. The Cnidosporidia and Sporozoa contain only parasitic species. while the other four class groups have many more free-living than parasitic forms. The Cnidosporidia and Suctoria have no species which parasitize man or higher animals (except where specifically indicated, examples below are taken from the field of human medicine).

Rhizopoda.—The Rhizopoda move by means of extensions of their ectoplasm. The forms of most human interest are the amoebae, naked protoplasts which divide by binary fission and in

several species have an encysted stage. Among the parasitic species a complete life cycle consists in (1) the trophozoite. the growing and multiplicative period; (2) the precyst (a rounded-up trophozoite nhich has evacuated all its undigested foods); (3) the cyst, which has a thin tough wall and serves as the source of infection for the next host; (4) the metacyst or recently excysted multinucleate trophozoite; and (5) the metacystic trophozoite, which initiates the new infection Six species of amoebae produce infection in man; viz., *Endamoeba histolytica,* the only amoeba known to produce disease in man; E. *gingivalis;* E. *coli; Endolimax nana; Iodamoeba bütschlii;* and *Dientamoeba fragilis. E. gingivalis* and *Dientamoeba fragilis* apparently have only a trophozoite stage. E. *gingivalis* lives along the gingival margins of the gums, especially in unhygienic mouths, but there is no substantial evidence that it is responsible for pyorrhea alveolaris or other diseased conditions of the mouth. It is probably transmitted by droplet spray or by kissing.

The other five species inhabit the large bowel and the distalmost portion of the small bowel. Except for *E. histolytica* they are lumen parasites and with the possible additional exception of *D. fragilis* produce no detectable pathology.

Endamoeba histolytica is a tissue parasite, entering the intestinal mucosa at separate pinpoint sites and typically penetrating by lysis down into the submucosa, where the lesions tend to develop radially, at times extending into the muscular coats and rarely producing perforation. Frequently there is subsurface tunneling, so that the mucosal blood supply is cut off and an indolent ulcer develops or denudation occurs. Erosion of small blood vessels produces hemorrhage, so that dysentery is frequently, although by no means always, an accompaniment of the infection. The lesions develop first and most commonly in the caecal and in the sigmoidorectal areas. although at times the entire large bowel may be ulcerated. The appearance of the individual lesion as seen through a proctoscope, the cellular elements in the stool, the normal blood picture and the lack of prostrating symptoms all serve to differentiate intestinal amoebiasis from acute bacillary dysentery (*e.g.,* shigellosis). At times the amoebae get into mesenteric venules and are carried to the liver, where they may colonize and cause amoebic hepatitis or liver abscess; or they may reach the lungs, brain and other organs and tissues and produce lesions.

Amoebiasis is practically world-wide in its distribution. Surveys in Canada, southern Argentina and Sweden indicate its presence and clinical importance in cool temperate regions. Nevertheless, it is usually more prevalent and the symptoms are more pronounced in warm climates. Possibly as much as 10% of the earth's population harbours E. *histolytica,* although a much smaller percentage suffers from clinical amoebiasis. The infection is transmitted by means of polluted water, food and food handlers, filth flies and by person-to-person contact. Control of amoebiasis and possible ultimate eradication depend on attacking these sources of exposure.

Diagnosis of amoebiasis depends specifically on recovery and recognition of E *histolytica* in the patient's stools or tissues. Treatment is relatively satisfactory when iodoxyquinoline compounds, carbarsone or some of the antibiotics are employed for the intestinal infection, and chloroquine or emetine hydrochloride for the extraintestinal focuses of the disease.

Ciliata.—The Ciliata have an ectodermal covering of many short, hairlike structures, the cilia. Only one species. *Balantidium coli,* parasitizes man, with resultant diarrhea or dysentery, at times even more severe than that produced by E. *histolytica.* It is typically an infection of warm climates, where hogs and monkeys are reservoirs.

Mastigophora.—The Mastigophora or flagellate Protozoa possess one or more long, threadlike extensions of their ectoplasm termed flagella. The common intestinal flagellates of man are *Giardia lamblia, Chilomastix mesnili* and *Trichomonas hominis,* all of which are lumen parasites. None of these is primarily pathogenic, although at times *Giardia* produces an irritation of the duodenum with attendant mucous diarrhea. It may be controlled by administration of atabrine (*e.g.,* mepacrine or quinacrine hydrochloride). *Trichomonas vaginalis* is frequently associated with vaginitis and at times causes an aggravating type of vaginal discharge.

Six species of extraintestinal flagellate Protozoa produce human disease; namely, *Leishmania donovani,* causing visceral leishmaniasis or kala azar; L. *tropica,* causing cutaneous leishmaniasis; *L. braziliensis,* causing mucocutaneous leishmaniasis; *Trypanosoma gambiense* and *T. rhodesiense,* causing African "sleeping sickness"; and *T. cruzi,* causing American trypanosomiasis or Chagas' disease. The three species of *Leishmania* are transmitted by blood-sucking gnats belonging to the genus *Phlebotomus;* the African trypanosomes by species of *Glossina* (tsetse flies); and T. *cruzi* by species of hemophagous bugs (*Triatoma, Panstrongylus,* etc.). Visceral leishmaniasis has extensive endemic focuses in China, eastern India, the Mediterranean countries, the Sudan and South America. Cutaneous leishmaniasis occurs in numerous focuses from northwest India to western Africa. Mucocutaneous leishmaniasis extends from southern Mexico to southern Brazil. African trypanosomiasis practically covers the tropical heart of that continent. Chagas' disease is prevalent in almost every country from southern Mexico to northern Argentina and central Chile.

Visceral leishmaniasis produces a profound increase in the macrophages, with compensatory reduction in neutrophils and anemia. There are enlarged liver and spleen, engorged bone marrow, edema, an undulant type of fever, and high susceptibility to supervening bronchopneumonia, dysentery and, in children, gangrenous inflammation of the mucosa of the mouth. This disease is particularly prevalent among children in China and Mediterranean countries. Except for the strain of the organism causing the disease in the Sudan, pentavalent antimony compounds are satisfactory chemotherapeutics. Cutaneous leishmaniasis causes a granulomatous "button" or crater at the site of inoculation. Mucocutaneous leishmaniasis begins similarly but extends characteristically to the junction of the skin and mucous membranes, usually around the mouth and nostrils, where it causes mutilating lesions. Control of the three types of leishmaniasis was demonstrated by periodic spraying of dwellings with 5% DDT in kerosene to kill the vector. (*See* also LEISHMANIASIS.)

The trypanosomiases of Africa first develop as a blood-stream infection, then involve the lymph nodes. especially those of the posterior cervical triangle of the neck, and, in the Gambian infection, the central nervous system ("sleeping sickness" stage). The parasites never enter tissue cells, but by their metabolites produce profound systemic intoxication and cellular inflammation. The Rhodesian type is fulminating, and the patient invariably succumbs before the parasites enter the central nervous system. Moderately efficient drugs (*e.g.,* tryparsamide and suramin) are available for the treatment of the earlier stages of the disease. American trypanosomiasis, commonly referred to as Chagas' disease, has an initial lesion at or near the site where the organisms are discharged in the bug's feces and are rubbed into the skin or mucous membrane. This is frequently at the outer canthus of the eye or angle of the mouth. The parasites first multiply in macrophages within the superficial lymph nodes, then are disseminated in the flagellate stage through the blood stream to the spleen, liver, bone marrow, myocardium, thyroid gland, adrenal gland and brain. In each of these organs the parasites become intracellular and multiply, producing proliferative and necrotic damage. The symptoms are protean, depending on the organs and tissues primarily affected. Chemotherapy is not satisfactory in Chagas' disease, but with application of DDT and particularly benzene hexachloride (Gammexane) to destroy the vectors, there is definite hope of control. (*See* also SLEEPING SICKNESS; TRYPANOSOMIASIS.)

Sporozoa.—The Sporozoa have an asexual development (schizogony) alternating with a sexual generation (gametogony and sporogony). The only sporozoan parasite of the human digestive tract is *Isospora hominis.* It is endemic in the southwest Pacific region and requires no intermediate host. The parasite invades the epithelial layer of the lower portion of the small intestine and possibly the caecum, causing considerable tissue damage and pro-

ducing an exhausting diarrhea. (See also COCCIDIOSIS.)

The most important tropical disease is malaria, which is produced by four sporozoan parasites, *Plasmodium* vivax, causing vivax malaria (so-called benign tertian malaria); *P.* malariae, causing quartan malaria; *P. falciparum,* causing falciparum malaria (tropical. estivo-autumnal, malignant tertian malaria); and P. ovale, causing ovale malaria. Vivax malaria is widely distributed throughout the tropical and temperate zones; quartan malaria is a relatively minor disease except in isolated focuses and in tropical Africa; falciparum malaria is a disease of the tropics and subtropics; and ovale malaria is confined mostly to central East Africa. All human strains of Plasmodium are transmitted by species of *Anopheles* mosquitoes. The asexual cycle in man includes incubation in exo-erythrocytic cells. probably including the reticuloendothelial system, parenchyma cells of the liver and the endothelial lining cells of the smaller blood vessels; and soon blood-stream infection, with asexual multiplication of the parasites within red blood cells and destruction of these cells more or less every 48 or 72 hours, depending on the species of Plasmodium. This causes systemic sensitization, with characteristic chills and fever when the reaction becomes sufficiently intense. Thereafter the typical paroxysm is repeated quite regularly as often as new broods of parasites are thrown out temporarily into the blood plasma, at least until the body's defense mechanism is able to cope with the parasites by phagocytosis. (For a more detailed account see MALARIA.)

METAZOA AND METAZOAN DISEASES

The Metazoa comprise a large number of phyla and include both invertebrate and vertebrate groups. Those which contain important disease-producing parasites are the Helminthes, or parasitic worms, and the Arthropoda, consisting of the insects and their allies. Except insofar as arthropods are involved as vectors in the transmission of Protozoa and helminths, this medically and economically important phylum is not considered here. (See ENTOMOLOGY.) Helminths are not a single assemblage of closely related species but belong to five separate phyla; *e.g.,* Nematoda, Nematomorpha (class Gordiacea), Platyhelminthes (class Trematoda and class Cestoidea), Acanthocephala and Annelida (class Hirudinea).

Nematoda.—These true roundworms constitute an assemblage of many thousand species, of which probably the majority are free living, others are of considerable economic importance as parasites of vegetables, grains, flower bulbs and tubers and still others parasitize animals. They are typically cylindroidal, with a somewhat attenuated anterior end and a posterior end which is distinctly pointed in the female and ventrally turned or coiled in the male. There is a complete digestive tract, a body cavity which is not lined with mesothelium and an elaborate set of reproductive organs.

The males are typically somewhat smaller than the females; in a few species the male genitalia are parasitic in the female body (*e.g.,* syngonic), or males are wanting and the females produce progeny by parthenogenesis. The females are usually egg-laying (oviparous) but in some species they deposit living young (larviparous). There are characteristically four larval stages between egg and adult.

By far the largest number of parasitic nematodes inhabit the digestive tract. They may live free in the lumen (Ascaris), attached by their heads to the mucosa (Enterobius *vermicularis,* hookworms, *Trichocephalus trichiurus*), embedded in the glands and stroma (Strongyloides stercoralis) or live within tumours in the intestinal wall (*Oesophagostomum,* Cnathostoma in cats, Spirocerca in dogs). The majority enter the body by being swallowed in the fully embryonated egg stage or as free infective-stage larvae, but hookworms and Strongyloides actively penetrate the skin. Hookworms, Strongyloides and *Ascaris* have an obligatory migration through the lungs before they can settle down and develop into adults in the intestinal tract.

One type of nematode (*Gongylonema*) lives in the esophageal and buccal mucosa. another (Syngamus) is attached to the mucous membrane of the bronchi, trachea or Eustadhian tube; still another (Metastrongylus) inhabits the smaller bronchioles, and one giant species (*Dioctophyma* renale) inhabits the kidney and other viscera of the abdomen. A very important group, the filariae, live in a variety of extraintestinal locations. Bancroft's filaria (Wuchereria bancrofti) and the Malayan filaria (*W.* malayi) parasitize lymphatic vessels and lymph glands; Acanthocheilonema *perstans* and Mansonella ozzardi inhabit the body cavities; *Dirofilaria immitis* lives in the right heart cavity; Onchocerca volvulus is confined within subcutaneous tumours; and *Loa* loa migrates through subcutaneous tissues. These worms produce microscopic snakelike embryos. the microfilariae, which reach blood vessels or interstitial tissues of the skin, are taken up by sucking insects in which they mature into infective-stage larvae, are then deposited by the insect on the skin of the definitive host and actively enter its tissues to develop in several months into mature worms. The female Guinea worm, *Dracunculus* medinensis, upon becoming gravid, migrates from the viscera to the skin and produces a small blister. On contact with fresh water the blister bursts, discharging many active larvae. If these are eaten by a little water flea, Cyclops, they develop and serve as a source of infection for the next individual who drinks raw water containing the infected Cyclops. A few of the most important nematodes are described below.

Intestinal Roundworms.—Ascaris lumbricoides, the large intestinal roundworm of man, is about the size of a lead pencil. Under favourable conditions the fertile eggs, which have been evacuated in the feces onto the soil, require two to three weeks to mature. Thereafter, if taken into the mouth and swallowed, hatching occurs in the duodenum, the larva penetrates the gut wall, enters a mesenteric venule or lymphatic vessel and directly or indirectly migrates to the lungs, where it breaks out of a capillary into an air sac, ascends the respiratory tree to the epiglottis, is swallowed and on reaching the small intestine develops into the mature uorm. Although a single worm may at times produce acute intestinal symptoms, at other times hundreds of them may occasion only a drain on the nourishment of the host. However, where several worms are present, a careful check on the patient's history will usually reveal that a few weeks previously there was a severe, deep-seated "cold" or bronchopneumonia corresponding to the period when the larvae were migrating through the lungs. At times this same type of pneumonitis develops during the lung migration of Strongyloides and hookworm larvae. Even if *Ascaris* does not cause pneumonia, malnutrition or acute intestinal catastrophe, it is frequently responsible for allergic manifestations. The infection is cosmopolitan, is especially common in children living in warm climates, and is propagated by fecal contamination of the soil. It may be efficiently treated by oral administration of hexylresorcinol crystoids, but if children, as well as adults, are not taught to observe cleanly habits, specific medication is useless, since reinfection is bound to occur.

Hookworms.—Hookworms are strongyloid nematodes which are provided with a well-developed buccal capsule that is armed with teeth or cutting plates for purposes of attachment. The males have an umbrellalike extension of the caudal extremity, the copulatory bursa. They are moderately stout, threadlike forms varying in length from about 8 to 16 mm. The species of special interest are Ancylostoma duodenale (human). A. braziliense (canine, feline and human), *A.* caninum (canine and feline) and Necator *americanus* (human). Species of Ancylostoma have two or three pairs of cutting teeth, and Necator has paired cutting plates embedded in the buccal capsule, enabling the adult worms to become firmly anchored to the mucosa of the small intestine.

By trauma and secretion of esophageal gland ferments hookworms digest the tips of the intestinal villi and pump blood through their o n intestines far in excess of their maximum nutritional needs. This produces loss of blood at each site of attachment, varying from 0.1 to nearly 1.0 ml. each day. Thus the daily blood loss from 25 worms will not exceed 25 ml., which is usually low enough for complete compensation. From 200 worms, the loss is about zoo ml., or an amount sufficient to cause anemia, especially since most hookworm patients also suffer from nutritional deficiencies; while 500 to 1,000 worms will almost invariably produce

profound anemia, with associated severe pain in the epigastrium, diarrhea or tarry stools, loss of strength. dilatation of the chambers of the heart, rough parchmentlike skin and lustreless hair, a fishlike stare, physical, mental and sexual retardation, general dropsy and frequently death.

Frank hookworm disease may develop from a single exposure of the skin, usually of the bare feet, to a large number of infective-stage (filariform) larvae in the top layer of moist, sandy soil; or it may result from a number of lesser exposures. The mechanical loss of blood reduces the number, size and hemoglobin content of the circulating red blood corpuscles. producing a secondary anemia (microcytic hypochromic type). However, if it continues for a long period of time or if the patient has a constitutional tendency in that direction, a primary anemia may develop as a result of exhaustion of the blood-forming tissues.

The blood loss in the average hookworm patient can be compensated in 10 to 12 days by feeding rich protein diets supplemented by soluble iron salts such as ferrous sulfate. If the red cells number fewer than 1,000,000 (as compared with a normal of about 5,000,000) per millilitre of blood, one or more transfusions of whole blood are indicated. Only rarely is it helpful to give liver extract. Specific treatment may be accomplished by the administration of any one of several anthelmintics. Aiter about 1935 tetrachloroethylene, which is efficient and safe, became the drug of choice. Nevertheless, it is relatively useless from a public health point of view to treat isolated patients. In heavily endemic areas mass therapy for all infected persons is practised, accompanied by sanitary disposal of human feces and by educational campaigns. In the southern United States intensive hookworm campaigns beginning about 1915 resulted in eradication of the disease (Necator *americanus* infectionj from a majority of the population, but heavy residual infection persisted in some rural sections of the Carolinas. Georgia, Alabama, Mississippi and eastern Texas. In the tropics. hookworms, next to malaria, continued to produce widespread sickness and death.

Unlike *Ancylostoma* duodenale and *Necator americanus*, which are exclusively parasites of man. *A. braziliense* is a common helminth of dogs. cats and their wild relatives in warm climates, and only occasionally produces intestinal infection in man. The canine and feline varieties do, however, cause human disease. The infective filariform larvae penetrate human skin: but, unable to enter the cutaneous blood vessels and migrate via the lungs to the intestinal tract, they continue in serpiginous tunnels in the deeper layers of the skin. producing so-called "creeping eruption." (See also HOOKWORM.)

Trichinae.—The trichina worm, *Trichinella* spiralis, is primarily a parasite of hogs and rats, secondarily of man, dogs, cats, bears, etc. All stages in the life cycle of this minute nematode occur in the same host. but to continue the cycle an uninfected host must eat the infected flesh of another. The trichinous flesh contains the encysted larvae. On ingesting infected pork which has not been properly heated or otherwise processed, the organisms excyst in the duodenum and immediately enter the mucosa, where males and females mature in two to three days; they mate and the females begin discharging living young. These larvae enter intestinal venules or lymphatics and migrate into striated muscle, where they begin to encyst about the 20th day. Damage results from entry of the excysted larvae into the duodenal mucosa. migration of the larvae and the distribution of their toxic by-products through the body, as a-ell as the tissue reaction to the larvae. The first stage mimics acute food poisoning; the migratory stage is accompanied by acute muscular pain and frequently myocarditis suggestive of hypertension, and the intoxicative condition produces edema, especially around the eyes. as well as respiratory difficulties. The infection may be subclinical if meat is lightly infected. but death may ensue if it is heavily parasitized. There is no specific treatment. The source of human infection can be controlled by preventing hogs from eating garbage containing infected pork trimmings. (See also TRICHINOSIS.)

Filariae.—Bancroft's filaria (*Wuchereria* bancrofti) occurs throughout a broad band of the tropics. practically encircling the world. The threadlike parent worms live in subcutaneous and visceral lymphatic vessels and associated lymph nodes. Here the female worms give birth to delicate, elongated embryos provided with a sheath. They are actually the partially matured eggs which have stretched out so that they may travel through the lymphatic and blood capillaries. In most endemic areas these embryos, the microfilariae, remain in the viscera except at night, when they surge through cutaneous blood vessels. However, in the South Pacific islands they are continuously migrating through the peripheral circulation. The embryos are picked up by many species of mosquitoes (*Culex*, Aedes and Anopheles). in the thoracic muscles of which they undergo development and then migrate down the proboscis sheath and are discharged on the human skin when the mosquito alights to take a blood meal. The infective larvae burrow through the skin layers down to the peripheral lymphatics, gain entry to these vessels and proceed to migrate through the lymphatic system. About 12 months are required before the growing worms settle down and mate and the females begin to produce microfilariae.

Among native populations in endemic areas exposure begins in early childhood and 10 to 20 years may elapse before marked symptoms appear. In the meantime, microfilariae are present at night in the peripheral blood, repeated reinoculation (*e.g.*, superinfection) occurs, and there may be brief bouts of lymphangitis and lymphadenitis. In newcomers to an endemic area, with comparable exposure there may be dramatic manifestations within a few months (*e.g.*, during the biological incubation period), with acute attacks of lymphatic inflammation uherever the migrating adolescent worms are blocked by lymph nodes. This constituted a serious disability in about 15,000 U.S. troops in the Samoan region during 1942–44. The histological picture is that of a proliferation of the lining of the associated lymphatic vessels and of the macrophages in the lymph nodes immediately proximal to the norms, infiltration of macrophages around the worms in an attempt to strangulate them, and perilymphatic inflammation.

In persons in whom the worms develop to maturity there is fibrosis around the locations parasitized. This tends to produce stasis of the lymph retrograde to the blocked area. with a nonpitting edema and elephantiasis of the member. The groin and epididymal glands in the male are most frequently involved; groin gland varix and elephantiasis of a leg. the scrotum in the male and the labia of the vulva in the female are most commonly affected. With the death of the worm a marked increase in the symptoms typically occurs.

Diagnosis is made by recovery of the characteristic microfilariae in circulating blood, by puncture or biopsy of the infected region and, after calcification of the parent worms, by roentgenography. Antimonials showed some promise of cure, or at least of inhibiting egg laying by the female worms; but the later advent of Hetrazan for the first time provided genuine chemotherapeutic help. However, control of Bancroft's filariasis depends almost exclusively on mosquito control. With the advent of DDT and other insecticides there was no reason why the transmitters should not be eliminated from all endemic areas as soon as public health personnel were trained to this end. As a result of antimosquito campaigns the disease was eliminated from the region of Charleston, S.C., and was on the decline in Bahia state, Brazil. (*See* also FILARIASIS.)

Gordiacea.—The Gordiacea or "hair snakes" are parasitic in the hemocelic cavity of grasshoppers during their larval and adolescent stage but escape from their hosts into fresh water to complete development, to mate and lay eggs. There are several reports of gordiid worms which have been vomited or otherwise voided by man. Such temporary "parasitism" may be the result of accidental swallowing of the worms in raw drinking water. but there is no evidence that the adults are ever truly parasitic in habit. (See also NEMATOMORPHA.)

Trematoda.—Like other groups of the Platyhelminthes, the trematodes, or flukes, are more or less flattened, bilaterally symmetrical invertebrates, without true segmentation (*e.g.*, metamerism); similarly, they lack a body cavity. They possess suckers for purposes of attachment. All trematodes are parasitic, and the great majority are hermaphroditic. The Monogenea are es-

sentially ectoparasitic (*i.e.*, living on the exterior of the host), the Aspidogastrea are in the process of developing an endoparasitic mode of life. and the Digenea are exclusively endoparasitic (*i.e.*, living within the host). The former two groups have a simple type of life cycle, consisting of egg. larva and adult. The Digenea have a very complicated cycle: eggs are produced by the adult worms in the definitive host, reach water and produce infection of appropriate species of mollusks (usually snails). in which they metamorphose and multiply, with the eventual escape of tailed larvae (the cercariae), which. in turn, directly or indirectly are the source of infection for the definitive host. Forms of particular interest are Fasciola *hepatica* (sheep liver fluke), Clonorchis *sinensis* (Chinese liver fluke), Paragonimus westermani (oriental lung fluke) and species of *Schistosoma* (blood flukes).

Liver *Flukes.—Fasciola* hepatica is a rather fleshy, broadly elliptical worm measuring up to 30 mm. in length by 13 mm. in breadth. It causes liver disease of sheep throughout extensive areas of the world, is frequently parasitic in other herbivorous mammals and from time to time is diagnosed as a human parasite. The cercariae which escape from the snail (species of Lymnaea) encyst on vegetation in moist meadows. Ingestion of infested vegetation constitutes exposure. The larvae escape from their cysts in the duodenum, migrate through the intestinal wall, peritoneal cavity and Glisson's capsule into the liver and bore their way through to the larger bile ducts where they develop into adults. En route through the liver parenchyma the young worms produce marked mechanical and necrotic damage ("liver rot"), and in the biliary passages and gall bladder provoke proliferation of the epithelium, with fibrous encapsulation and pressure necrosis of the parenchyma, resulting in cholecystitis and cholelithiasis. Occasionally the worms in transit through the peritoneal cavity migrate into such locations as the abdominal wall, pleural cavity or brain. Diagnosis is made on recovery of the microscopically large hyaline, thin-shelled, operculate eggs in the feces or from aspiration of bile. In sheep and cattle hexachloroethane is very useful to kill worms which have arrived in the biliary passages; in man emetine hydrochloride has proved to be moderately effective. Control embodies destruction of the snail, as. for example, by the treatment of snail-inhabiting areas with solutions of copper sulfate or copper carbonate, but care must be exercised not to poison sheep or other grazing animals.

Clonorchis *sinensis*, the Asian liver fluke, is a delicate, transparent, lanceolate worm measuring 10 to 25 mm. long by 3 to 5 mm. in breadth. It lives primarily in the distalmost bile ducts toward the margins of the liver, but in infection with many hundreds of worms the more proximal bile passages, gall bladder and even the pancreatic duct may be parasitized. This infection is indigenous to Japan, Korea, China and Indochina, where all mammals which eat raw fresh-water fish are exposed. Man is most commonly and most heavily infected in south China and Indochina. Minute eggs of this fluke, when evacuated in excreta of man and other hosts into ponds. quiet streams and canals, are eaten by certain snails (*Bulimus, Parafossarulus*), in which the intramolluscan phase of the cyle develops. Cercariae discharged from the snails penetrate under the scales of fishes into their flesh, where encystation occurs. Frankly raw fish, fish heated only on the surface. salted, smoked, dried or preserved in wine or vinegar constitutes the sources of human infection. Upon being swallowed, the young larvae escape from the cysts in the duodenum and migrate directly through the ampulla of Vater up into the distal biliary ducts, where they mature. There is a proliferation of the epithelium in the infected bile passages, with fibrosis around the ducts and pressure necrosis of the liver parenchyma, accompanied by hepatic dysfunction and digestive disturbances.

Diagnosis is made by recovery of the typical minute ovoidal eggs in the feces. In early infections gentian violet and antimony compounds will eradicate the norms but in infections of long standing there is no satisfactory treatment. Man may remain free of Clonorchis if he eats only well-cooked fresh-water fish in endemic areas.

Lung Fluke.—Paragonimus westermani, the lung fluke, is a small fleshy worm measuring 7.5 to 12 mm. long by 4 to 6 mm. broad by 3.5 to 5 mm. thick. The adults live most frequently in little fibrous pockets opening into the bronchioles, but they have been recovered from the abdominal viscera and wall, the groin and, not infrequently. the brain. The infection is common in Japan, Korea, central and south China, Formosa and some of the islands of Indonesia. and it is also endemic in parts of Africa, Venezuela, Colombia. Peru and Ecuador. In Korea the infection results from eating raw soft tissues of fresh-water crayfish (Astacus), elsewhere of fresh- or brackish-water crabs. Related species of Paragonimus have been reported from rodents in south China (P. iloktsuenensis) and from crayfish-eating mammals in the United States (P. *kellicotti*). Eggs of these flukes are coughed up and discharged in sputum, or swallowed and evacuated in the feces. After hatching in fresh water the larvae escaping from the eggs penetrate certain snails of the genus *Melania*, where they multiply and from which they later escape as short-tailed cercariae, which penetrate the soft tissues of crayfishes and crabs, in which they encyst. Crayfishes or crabs, frankly raw (as eaten by the aborigines of Formosa) or preserved in brine or rice wine, constitute the sources of human infection. Once ingested, the young worms are digested out of the crustacean tissues, excyst and migrate through the intestinal wall. traverse the peritoneal cavity, penetrate through the diaphragm into the pleural cavity, then enter the lurgs and become localized near a bronchiole. Here they mature and begin oviposition. The devious route of larval migration explains why the worms so frequently become lodged in abnormal focuses. Pulmonary infection produces moderate to severe local inflammatory reaction, frequently with irritation causing coughing and rupture of near-by blood vessels, so that bloody sputum is relatively typical. Rupture of pulmonary lesions into the pleural cavity, with purulent effusion, occurs at times. In the abdomen the worms produce abscesses which may open into the intestinal tract or through the skin. The gravest damage appears when the worms become lodged in the brain or its envelopes, with associated Jacksonian type of epilepsy. Diagnosis is most frequently made from sputum, which grossly appears peppered with minute particles of iron rust (*e.g.*, the golden-brownish eggs) and is frequently blood-tinged; however. in about 40% of patients the eggs are first recovered in the feces, usually as a result of swallowing infected sputum. Emetine hydrochloride is helpful but not necessarily curative. Because there are so many nonhuman definitive hosts of P. westermani, control is not particularly practical. Man may remain uninfected by eating only thoroughly cooked crayfishes and crabs.

The species of *Schistosoma* and the disease they produce are treated separately under SCHISTOSOMIASIS.

Cestoidea.—The Cestoidea or tapeworms usually consist of a chain of many individual organisms, each of which is comparable with a trematode. This chain (*e.g.*, strobila) consists of a scolex, provided with suckers and frequently with hooklets for attachment to the host's tissues; a "neck," which is the region of growth of the individual organisms (proglottids) ; and proceeding distally a succession of immature, mature and gravid proglottids intergrading one into another. Mature proglottids contain a full complement of sexual organs; gravid ones are postmature and are crowded with eggs. Each fully developed egg contains an embryo, which in most species of tapeworms is provided with six hooklets (*e.g.*, it is a hexacanth embryo). On hatching from the egg it invades the tissues of the essential intermediate host and develops into a larva. In certain species a second larval stage in a second intermediate is required (*e.g.*, the fish tapeworm, Diphyllobothrium *latum*, and its relatives). The definitive host usually becomes infected from ingesting the larval host or its infected tissues. One notable exception is found in the dwarf tapeworm, Hymenolepis nana, which utilizes the same host for its larval and adult stages. Representative examples of disease produced by tapeworms are provided by *Hymenolepis* nana, Taenia *solium*, Echinococcus *granulosus* and Diphyllobothrium *latum*.

Dwarf *Tapeworm.—Hymenolepis* nana and its biological varieties are parasites of man. rats and mice. The worms are minute, as the specific name implies, being only a few centimetres in length. Spherical, thin-shelled eggs, fully matured, are voided in

the feces. When these eggs, directly or indirectly, get to the mouth and are swallowed, they hatch in the duodenum and the hexacanth embryo invades a duodenal villus, where it develops into a cercocystis larva. Thereupon it emerges from the tissues, attaches itself by its suckers and rostellar hooklets and matures into a complete worm. Man is normally infected only from human sources, rats only from infection previously in rats, and mice only from mouse infection. H. *nana* is common in man in the southern United States, Latin America, India and Mediterranean countries. It is particularly prevalent in children. Light infections usually produce little damage but occasionally in sensitized children there may be a profound systemic intoxication, with neurological manifestations, including epilepsy. Heavy infections almost invariably cause severe diarrhea and signs of systemic poisoning. Moreover, there is considerable evidence suggesting that, where a large number or worms is present, autoinfection (*e.g.*, from anus to mouth or even internally) occurs. H. *nana* is usually eliminated by the administration of oleoresin of *Aspidium*, or of quinacrine (atabrine). Control of the disease in a family or institutional group. as a children's asylum or mental hospital, is difficult because of the problem of personal and group hygiene.

Pork Tapeworm.—*Taenia solium* is one of the larger human tapeworms, with a length of two to seven metres and somewhat fewer than 1,000 proglottids. It is relatively uncommon in the United States and western Europe but frequently occurs in parts of China. India and Latin America. Eggs may be shed by gravid proglottids within the intestine, but more frequently they break off from the strobila singly or in groups and are evacuated in the stool, to disintegrate on the ground. They are usually picked up by scavenger hogs; the eggs hatch in the animal's duodenum, and the emerging embryos migrate through the tissues and settle down in the flesh. Here they develop in about three months into small, ovoidal. opalescent larvae, the cysticerci. When man consumes inadequately cooked pork. infection occurs. The adult worm causes a moderate nutritional drain on the host, resulting in diarrhea and dyspepsia. Absorption of the worm's by-products at times causes systemic intoxication. More serious, however, is the fact that man may serve in place of the hog as the larval host. When multiple cysticerci are present in the human tissues, some are likely to lodge in the brain or its envelopes, with resultant neurological pathology, manifestations of Jacksonian epilepsy and eventual death. Specific treatment of all infections with intestinal *Taenia solium* should be carried out to reduce its ill effects and prevent human cysticercus infection. Quinacrine (atabrine) is an effectivedrug for this purpose. Hogs should not be permitted access to human excreta, and all pork should be thoroughly cooked or frozen.

Echinococcus.—*Echinococcus granulosus* is one of few tapeworms parasitizing man in which the adult worm inhabits the intestine of the dog, while man is one of several hosts for the larval stage. Moreover, the adult worm is minute, measuring only three to six millimetres in length and possessing at one time only one immature, one mature and one or two gravid proglottids. In contrast, the larva, known as a hydatid cyst. may be as large as a football. Man acquires infection from contact aith the feces of infected dogs. Exposure most frequently occurs in childhood. During the 18th century Iceland had heavy humdn infection, but the disease in man was almost eliminated by the inculcation of personal hygiene. Hydatid disease is prevalent in the human population in Israel, Lebanon. Syria, north China, central and eastern Europe, Argentina, Uruguay, Chile, southern Australia and Tasmania. The eggs of E. *granulosus*, when swallowed, hatch in the duodenum. and the emerging embryos penetrate into the mesenteric venules. About 70% are filtered out in the liver, and lesser numbers reach other organs and tissues, including the lungs. brain and the stroma of long bones. The cyst grows slowly hut in five years may be as large as an orange or even a grapefruit. Internally there is a cavity filled with fluid. The wall consists of an inner germinative membrane. which produces fertile daughter cysts that become free in the fluid-filled cavity; an intermediate friable, laminated coat; and an outer fibrous capsule. At times germinal tissue migrates through the insulating layers and produces an unconfined alveolar hydatid. If the organism gains access to the inner structure of bones, it proceeds as an eroding stream, causing a weakening of the supporting structure and then fracture. Unilocular hydatid cyst causes disease as a result of pressure, by reason of its toxic metabolites and, on accidental rupture, anaphylactic shock. There is no medical treatment for hydatid cyst, but surgery is relatively satisfactory in removing the parasite. Control consists in care not to contaminate the mouth, directly or indirectly, with dog's feces and, in endemic areas, the destruction of dogs or periodic deworming of them with arecoline hydrobromide.

Fish Tapeworm.—*Diphyllobofhrium latum* measures three to ten metres in length. It differs from the majority of Cestoidea in having a scolex which is spatulate, with a ventral and a dorsal sucking groove, and a patent uterine port in each mature proglottid, so that eggs are shed in an immature stage and require development in fresh water. This worm occurs throughout a large part of the north temperate zone in the eastern hemisphere and is common in Canada and adjacent parts of Minnesota and Michigan. It is not proved to be indigenous in any part of the tropics, but is present in the lake districts of Chile and Argentina. In addition to man, dogs and sometimes bears harbour the parasite. When human or animal excreta containing eggs of *D. latum* are discharged into bodies of cool water, the eggs become fully matured, a little cap separates from the rest of the egg shell and a ciliated embryo swims out. This attracts the attention of water fleas. *Diaptomus* or *Cyclops*, which eat the active embryos. Instead of being digested, the embryos bore through the gut wall of the water flea and transform into first-stage larvae (procercoids). Then when a fish ingests the water fleas as food the larvae migrate into the musculature and become infective sparganum larvae. A smaller infected fish swallowed by a larger one transfers the infection to the latter. Man acquires the disease by eating infected fish. D. *latum* may produce no appreciable harm to the human host: it may cause mild digestive inconvenience and a low-grade secondary anemia or, in persons with a constitutional tendency, it may precipitate pernicious anemia. Fortunately, however, eradication of the worm by anthelmintic treatment usually restores the patient to the preinfection level of red blood cell production. Control of fish tapeworm infection depends on the thorough cooking of all fresh-water fish caught in endemic areas, but more specifically the elimination of all unprocessed human excreta from lakes and streams in which the fish breed. (*See* also TAPEWORMS.)

Acanthocephala.—The Xcanthocephala, or thorny-headed worms. have been regarded by some zoologists as relatives of the Nematoda, by others as akin to the Cestoidea. It seems wise, however, to reserve for them a special phylum position. They are more or less flattened, sacculate forms having a protrusible proboscis almost invariably armed with spines. They lack a digestive tract, possess a body cavity not lined with mesothelium and have separate sexes. The best-known species are *Macracanthorhynchus hirudinaceus* and *Moniliformis moniliformis,* intestinal parasites respectively of the hog and of the rat. Both species have been reported rarely from man. Infection is acquired from ingestion of beetles (the porcine form) and beetles or cockroaches (the rodent form) which serve as intermediate hosts. (*See* also ACANTHOCEPHALA.)

Hirudinea.—The Hirudinea, or leeches, are annelids and therefore are true segmented worms. They have one powerful sucker surrounding the mouth, and another at the aboral end, for purposes of attachment, and a digestive tract with 11 pairs of caeca vhich store blood sucked from their victims. Most leeches are aquatic and attach themselves to fishes, frogs, salamanders and turtles, but some are terrestrial like the notorious *Haemadipsa ceylonica* of Ceylon. India and Malaya, which may take blood from man or beast. Aquatic leeches, such as *Limnatis nilotica* of the North African coast and Bible lands, when taken into the mouth in unfiltered water, lodge in the throat, nasopharynx, larynx, upper esophagus or trachea and cause congestion, excruciating pain and at times death from suffocation. These leeches, like the medicinal species, *Hirudo medicinalis,* secrete hirudin from their buccal glands, thus preventing the coagulation of blood; this causes it to flow for some time after the leech has become engorged and

has abandoned its feeding site. DDT dusted into clothing and boots has considerable repellent properties. Internal leech infestation is a condition requiring the attention of a skilled surgeon. *(See* also LEECH.)

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PARASITISM AND PARASITOLOGY. Parasitology deals with parasites and the nature of parasitism and its effects on both the parasite and host. Broadly defined, a parasite is an organism which lives for all or part of its life on (ectoparasite) or in (endoparasite) another living organism (host) from which it derives some benefit such as food, shelter or protection. In general, the concept of parasitism is restricted to those associations in which the organisms differ in size—the parasite being the smaller and the host the larger.

Parasitism is largely concerned with securing food and is one type of the universal nutritional interdependence of living organisms. Most animals are directly dependent on the bodies of plants or other animals for food, and all living organisms are eventually dependent on other living organisms for essential components of their protoplasm. In general, parasites obtain their food directly from the tissues, waste products or partially digested food within the host.

Parasitism probably arose chiefly through three kinds of food habits, and its probable evolution can be indicated among modern species. The first type is that of saprophytism or saprozoism; *i.e.,* plants and animals, respectively. living on dead plants and animals. This habit may have led to the establishment of certain species within body cavities, such as the intestine, and finally to a true invasion of the body. A progressive series of such species may be seen in: (1) the free-living putrefactive bacteria living on decaying matter; (2) the putrefactive organisms living in the lower intestine of animals; (3) the tetanus organism, which is so poorly invasive that it lives on necrotic tissue resulting from injury and produces its ill effects by a toxin which diffuses into the body; and, finally. (4) the true parasites, such as the typhoid bacillus, which establish themselves in the tissues.

A second type of food habit leading to parasitism is probably that of predaceous animals, capturing and devouring living prey. There seems to be little difference between this mode of life by the free-living protozoa and the ingestion of the host's red blood cells by the parasitic amoeba *Endantoeba histolytica.*

A third type of food habit giving rise to parasitism involves feeding upon the fluids of plants and animals. Blood-feeding and bloodsucking are particularly interesting in this connection. Thus, among the Diptera, the common housefly, *Musca domestica,* feeds on many liquid materials, including serous exudates and blood. Other species of *Musca* live entirely on blood, which they cannot secure directly by bloodsucking because they do not possess piercing mouth parts, but which they secure from the exuding blood droplets left after they have pushed aside a bloodsucking fly. Some Diptera possess specialized mouth parts for bloodsucking. Finally, flies in the family Hippoboscidae have combined bloodsucking with ectoparasitism. Thus. the sheep ked, *Melophagus ovinus,* is wingless in the adult stage and completes its life cycle on the skin and in the wool of sheep. Many common ectoparasites. such as fleas (*q.v.*), lice *(see* LOUSE), mites (*q.v.*) and ticks (*q.v.*), are bloodsucking. They vary in their dependence on the host, as is indicated by the following series. The rat flea, *Xenopsylla cheopis,* completes its life cycle in the nest of the host, remains on the host only long enough to feed, and readily sucks blood from unusual hosts. Most bloodsucking lice are largely host-specific and soon die if removed from the host.

Some typical ectoparasites have become more or less endoparasites. Thus, the adult female of the chigoe flea. *Tunga penetrans,* burrows far enough into the skin of man or animals to cover most of its body, but extrudes eggs to the exterior. Sarcoptic mites. such as the itch mite of man, *Sarcoptes scabiei,* burrow into the skin and make long tunnels in which they feed and complete their life cycle. Finally, mites of the genera *Halarachne* and *Pneumonyssus* crawl down the trachea and invade the lungs of seals and old world monkeys. respectively. These habits represent unequivocal endoparasitism.

Many habits of free-living organisms may have led to or hastened the development of the parasitic habit. The habit of flies of laying their eggs or larvae in meat may easily have led to the deposition of larvae in wounds and in time to the larvae penetrating the skin and becoming true parasites as found in the myiasis-producing flies. A recently acquired habit of this type is seen in the important disease of sheep known as strike. It is produced by maggots from carrion-feeding flies which lay eggs in wool soiled by feces and urine. The maggots penetrate the flesh and are often fatal to the host.

Some free-living animals are cryptozoic and hide in various passages and cavities of other animals to which they have access. In addition. biotic associations *(see* ECOLOGY, ANIMAL) between free-living organisms grade into parasitism. Typically, the epiphytic plants grow on other plants without deriving food from them, as seen in orchids attached to trees. Similar epizoic animals are common. Various marine hydroids attach themselves to seaweeds without deriving any nutritive benefit. When epizoic animals attach themselves to mobile animals. the association may be termed phoresy or phoresis. Epiphytic, epizoic and phoretic associations grade into true parasitism as seen in mistletoe (q *v*). Parasitism, therefore, cannot be sharply demarcated from many associations of free-living species, nor can the parasitic method of obtaining food be separated unequivocally from the methods used by saprophytes, scavengers and predators.

Parasitism can. houever. be roughly divided into three types. In *commensalism* the association is highly beneficial to the parasite but is of indifference to the host An example is seen in the nonpathogenic amoebae of the human intestine, which feed on intestinal debris and other material but which. as far as is known, neither help nor harm the host. Parenthetically, it should be noted that the term commensalism is used by some authors in a different sense; *i.e.,* to designate mutualism in an external partnership such as seen in certain sea anemones attached to the hermit crab In *true parasitism* the parasite is potentially harmful. since it feeds on tissues or materials of value to the host. In general. hoaever, true parasites tend not to kill their hosts but to live in a more or less reciprocally adjusted balance with them. In *mutualism* (sometimes termed *symbiosis*), both host and parasite benefit from the association. The two partners in the association have become so highly adapted to each other that they are mutually dependent. The cellulose-digesting protozoa of certain wood-eating insects are examples of mutualism and will be considered below.

The metazoan parasites may be parasitic throughout the entire life cycle or only during parts of it *(see* the parasitoid wasp *Trichogramma* and the nematode *Nippostrongylus,* cited below).

Distribution of Parasitism.— The parasitic mode of life is widely distributed throughout the plant and animal kingdom. but parasites themselves are mainly lower plants and animals. Thus, most parasites belong to viruses, bacteria—including the spirochetes and rickettsias—and fungi among the plants; and to protozoa helminths and arthropods among the animals

The viruses are characterized by their inability to grow outside living cells Most of them are small enough to pass through filters that remove ordinary bacteria. They give rise to many diseases, such as smallpox, yellow fever and poliomyelitis of man; rabies and foot-and-mouth disease of animals: wilt disease of caterpillars; and various mosaic diseases of plants Parasitic bacteria likewise incite various diseases in man. animals and plants. In man, they cause such diseases as tuberculosis. leprosy, diphtheria, pneumonia, enteric fever, tetanus and plague. Spirochetes

cause, among other diseases, syphilis, relapsing fever and leptospirosis; and a rickettsia produces typhus fever. In addition, many saprophytic forms under unusual conditions may incite serious diseases. The entire class of fungi live either on dead or living organisms or organic matter derived from them. Parasitic fungi cause smuts and rusts of cereals. mildews of grapes and blights of potatoes. In animals and man they produce such infections as ringworm, actinomycosis and coccidioidomycosis.

Among the parasitic protozoa are included the causative agents of human malaria, amoebiasis and African sleeping sickness.

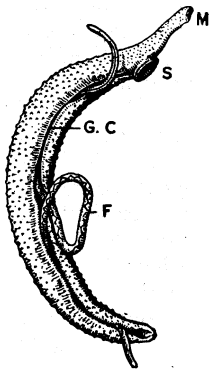
The helminths or worm parasites include the flukes, tapeworms and nematodes. A few representative species of these are: among the flukes, the blood fluke of man, Schistosoma haematobium (fig. 1), and the liver fluke of sheep, Fasciola hepatica, and of man, Clonorchis sinensis; among the tapeworms, the beef tapeworm of man, Taenie saginata, and the larval stage of Echinococcus *granulosus*, which produces hydatid disease in man, sheep and pigs; among the nematodes, various hookworms, such as *Necator americanus* and Ancylostoma duodenale of man, and various filarial worms of man, such as *Wuchereria* bancrofti.

Many arthropods parasitize plants (*e.g.*, scale insects) and animals (fleas, lice, etc.) as ectoparasites, and a few are endoparasites. Large numbers of insects, such as the chalcid and ichneumon flies (Hymenoptera) and the tachinid flies (Diptera), feed internally on the eggs or larvae of insect hosts and ultimately cause the death of the hosts. These are called parasitoids. In addition to these groups, numerous parasitic forms occur among the Crustacea, Coelenterata, Rotifera, Annelida and Mollusca. Even the vertebrates include phoretic forms such as the remoras which attach themselves to sharks and other large fish and turtles by a sucking disc, probably evolved from the spinous dorsal fin.

Among the flowering plants, some obligate parasites, such as mistletoe, are known as hemiparasites. They are autotrophic in that they manufacture their carbohydrates photosynthetically, but they are dependent on their hosts for water, mineral nutrients and certain organic materials.

Parasitism is so common in nature that most animals and plants harbour parasites of some sort. Parasites may even invade other parasites, a condition which is termed hyperparasitism. For example, members of the genus of parasitic ciliates *Opalina* may have their cytoplasm parasitized by amoebae. Other parasitic protozoa harbour nuclear parasites. Hyperparasitism is common among parasitic insects, parasitic crustaceans and helminths.

A parasite and its host are not necessarily of different species. Degenerate males may parasitize normal females in an association which is termed sexual parasitism. This type of association occurs as endoparasitism in the marine worm *Bonellia*. It is encountered as a form of hyperparasitism in the nematode *Trichosomoides* crassicauda. The female of this species lives as a parasite in the bladder of the rat, and the degenerate male lives inside the uterus of the female. Ectoparasitism occurs in certain of the angler fishes such as Photocorynus *spiniceps*. The female carries the greatly reduced male attached to her body. This is true parasitism, because the male establishes an organic connection with the blood vessels of the female. What might be termed sexual phoresis is seen in the blood fluke *Schistosoma* haematobium. The smaller female is carried in a ventral body wall fold of the male (fig. 1).



FROM SIR PATRICK MANSON, "TROPICAL DISEASES"

FIG. 1.—SCHISTOSOMA HAEMATOBIUM, X 5.5

The male is carrying the female (F) in a ventral groove (G C); (M) mouth and (S) ventral sucker of the male

Parasitism frequently occurs at a social level and thereby becomes social parasitism. Thus, some wasps, bees and ants have lost their worker castes. The fertilized female enters the nest of social insects, kills the host queen and usurps her place.

The size of parasites varies over a tremendous range. Among those that can infect man, the fish tapeworm, Dibothriocephalus latus, is from 0.4 to 0.8 in. wide and from 10 to 60 ft. long, whereas the virus of foot-and-mouth disease is about $\frac{1}{2,500,000}$ in. (10 mμ) in diameter.

The widespread occurrence and heterogeneity of parasites, together with their conspicuous economic and medical importance, have resulted in a somewhat artificial division of labour by scientists. Thus, in general. the bacteria, viruses and fungi parasitic on man and animals are studied by bacteriologists, medical scientists and veterinarians; the bacteria and fungi parasitic on plants are studied by plant pathologists; and the animal parasites, whether protozoa, helminths or insects, are studied by zoologists, medical and veterinary scientists and so-called parasitologists. Frequently. microbiologists cover all types of parasites.

Life Cycle of Parasites. — Complicated life cycles, sometimes involving more than one host, occur among the parasites, especially among the viruses. fungi, protozoa, helminths and insects. (*See* INSECT; ENTOMOLOGY; NEMATODA; PARASITIC DISEASES; PLATYHELMINTHES; PROTOZOA; TAPEWORMS; TREMATODES.) An example of a parasite which utilizes three hosts is the fish tapeworm, Dibothriocephalus latus. The adult tapeworm lives in the intestine of man, dog, cat, fox, bear or swine. Its eggs are discharged in large numbers in the host's feces and undergo the following development if suitable conditions occur: in fresh water, a free-swimming ciliated embryo (coracidium) hatches from the egg; if swallowed by one of several copepods, the coracidium develops into a procercoid and, if the infected copepod is swallowed by a susceptible fish, the procercoid in turn develops within the muscles into a plerocercoid. Man and other definitive hosts become infected from eating infected fish.

Morphology of Parasites. — Parasitic bacteria and some protozoa, such as the parasitic amoebae, are similar morphologically to their free-living relatives, whereas other protozoa have lost structures (*e.g.*, a mouth in the astomatous ciliates) or gained organelles (*e.g.*, an undulating membrane in the trypanosomes) supposedly as adaptations to the parasitic mode of life. Metazoan parasites, on the other hand, are usually markedly different from their free-living relatives. The changes are often degenerative in nature and are associated with the fact that parasites no longer have to do all the things their free-living relatives do. Organs of locomotion, such as wings, legs and other appendages, tend to disappear, and the alimentary canal may become less and less specialized or may entirely disappear as in the tapeworm. On the other hand, organs associated with attachment to the host, especially in ectoparasites and parasites in the intestine, tend to become highly developed, and reproductive functions increase because of the hazards of parasitic life. Thus, enormous numbers of eggs are laid by parasitic worms, and larval stages of many worms reproduce asexually by budding.

Metabolism of Parasites. — The habit of parasitism is sometimes transitory, sometimes optional and at other times obligatory. There is considerable ground for accepting the popular theory that, as organisms become more and more obligate in their parasitism, they tend to lose abilities to synthesize essential materials for their protoplasm and, as a consequence, become more and more dependent on their hosts for the substances they are no longer able to synthesize.

The loss of metabolic activity is carried farthest in the viruses. The true viruses are obligate intracellular parasites; *i.e.*, they reproduce only within a living cell. The living cells, however, may grow in a host or in tissue cultures. The simplest of the viruses consist only of nucleic acid and protein and are not living in the ordinary sense, but they can, in conjunction with the metabolic systems within the host, propagate themselves and behave as organized living parasites.

Sometimes the infected cell is killed by the virus; *e.g.*, the lytic or virulent bacteriophages and most of the disease-producing plant and animal viruses. At other times, the infected cell is not noticeably harmed. Thus, the temperate or latent viruses after entering a cell become practically indistinguishable from the cell components and reproduce with them. The temperate phages may exist as prophages in a stable parasitic equilibrium and appear to be incorporated into the genetic structure (chromosome?) of

the host cell. Occasionally when the parasitic equilibrium is disturbed, the virus rapidly reproduces and kills the host cell. Often a virus that is latent and produces no disease in one organism produces a disease in another. For example, the virus paracrinkle, when it infects the King Edward potato, can be detected only when the infected King Edward stock is grafted onto a susceptible potato stock.

Host-Endoparasite Relationships. — Every known parasite is limited in its range of hosts and, within the range of susceptible hosts, is more or less restricted in its site of colonization and in its power to invade, reproduce and survive. A part of this host limitation is attributable to purely ecological factors. which keep parasite and potential host apart. The protozoan parasite *Trypanosoma gambiense,* which causes African sleeping sickness in man, cannot naturally infect man outside Africa because its obligatory insect host and vector, certain species of the fly Glossina, occurs only in Africa. Other peculiar factors also effectively limit parasitism. The larva of the small parasitoid wasp *Trichogramma* evanescens parasitizes and eventually completely devours the eggs of other insects, especially moths, after it has been deposited there by an adult female. The female wasp does not attack moth eggs at random. It usually avoids parasitizing an egg a second time by being able to recognize a previously parasitized one. Thus, when a female wasp walks on a moth egg. it leaves an odour which inhibits other wasps from attacking the egg a second time. When the odour is removed. the wasp recognizes that the egg is parasitized after it has inserted its ovipositor into it and generally withdraws its ovipositor without depositing an egg.

Assuming effective contact between endoparasite and potential host. biochemical and physiological aspects of the host-parasite relationship fall into two main categories. These are: (1) factors of parasite invasiveness which are aimed at penetration of the host and maintenance within the host. and (2) factors of host immunity. both innate and acquired, which tend to prevent invasion and colonization by the parasite. Although invasiveness is associated with parasite factors and immunity with the host, the reciprocal relationship between the two often makes impossible clear-cut differentiations. Thus, certain pantothenic-acid-deficient hosts do not suffer from malaria as do normal hosts. Assuming that the parasites need this vitamin, the situation can be considered either as an athreptic host immunity (*i.e.,* immunity as a result of unfavourable conditions of nutrition for the parasite) or as a lack of virulence of the parasite resulting from its inability to synthesize the vitamin.

The interplay of such diverse factors results in all degrees of parasitism between a given parasite and a potential host. At one extreme, there are unquestionably many cases of absolute innate immunity in which the parasite cannot make the initial invasion of the potential host. These may arise from any number of physical or chemical barriers of the host or from some deficiency of the parasite. At the other extreme, there are a few cases, especially in experimental infections, in which not only can the parasite invade and reproduce at its maximum capacity but almost all its progeny can survive. Such associations cannot last long, as they inevitably result in the death of both host and parasite. In fact, no host infected with any endoparasite or with most ectoparasites can continue to survive in the absence of some mechanism limiting increase of the parasites.

Most endoparasitism falls within an intermediate zone in which host immunity and parasite invasiveness hold each other in check. The net result is that neither the host nor all of the parasites are killed — or, at least, the association is greatly prolonged. Although these successful host-parasite relationships may appear static, they actually rest on a complex, shifting, dynamic balance between the factors of parasite invasiveness and host immunity. Some of these factors will be considered below.

The nonlethal type of host-parasite equilibrium would be expected to have evolved through natural selection because of its survival value to the host and the parasite. It is hastened because once a parasite invades a specific host it becomes more or less isolated, just as free-living species become geographically isolated when they are segregated on islands or behind other ecological barriers. The effective isolation of a parasite generally increases as parasitism becomes obligatory and as it involves the entire life cycle of the parasite. In this sense the host becomes equivalent to the biotope of the free-living species. The biotope is peculiar, however, in that it involves a living organism which would be expected to respond specifically to parasitism provided the latter is widespread. As a corollary, it is probably safe to assume that the longer a given parasite is associated with a host in geological time the less pathogenic it becomes. It does not follow, however, that because a parasite is nonpathogenic it must have been associated with its host for a long time. Experience indicates that first contacts may show all degrees of parasite virulence. Hence, a presently nonpathogenic parasite may never have been pathogenic.

Invasiveness.—Parasite invasiveness arises from the summation of a heterogeneous collection of factors involving specialized structures and specific biochemical entities produced by the parasite. Frequently, however, a single factor may be eliminated without markedly modifying invasiveness. and therefore. specific factors are often difficult to associate with a specific activity of a parasite. Among the more likely invasive factors are the following:

1. The association of invasiveness by certain bacteria and their power to encapsulate has long been recognized. The best-known capsules are polysaccharide in nature, although some contain amino acids The possession of a capsule inhibits phagocytosis of the organisms by leucocytes or prevents digestion after phagocytosis. Also. injection of capsular material, by inhibiting phagocytosis, may allow invasion by the ordinarily noninvasive unencapsulated organism. On the other hand. immunization with the capsular material gives rise to antibodies as does infection and protects against infection by the encapsulated organism. That the prevention of phagocytosis and digestion by leucocytes is the important factor is further indicated by the fact that an unencapsulated noninvasive organism becomes invasive if the host is deprived of its leucocytes.

2. Toxins, which will be considered below in greater detail under Disease of the Host, probably increase invasiveness by breaking down various physiological mechanisms involved in immunity.

3. Leucocidins are produced by a number of bacteria and kill the circulating leucocytes. but their activity in increasing invasiveness, although likely, is obscure.

4. Passage of most parasites through the external barriers and spread through the denser tissues is generally believed to be a matter more of enzymatic activity than of mechanical force. The best known of the enzymes involved is hyaluronidase or the "spreading factor," which decreases one of the carbohydrate cement substances of connective tissue, known as hyaluronic acid. Another enzyme, collagenase, may split the protein collagen which occurs in the collagenous fibres of the connective tissue. (See CONNECTIVE AND SUPPORTING TISSUES.)

5. Once antibodies have become operative (see below), parasites are frequently able to overcome their effects either by producing new heritable antigens or by continuing to produce enough phenotypically resistant individuals to keep the infection alive (see discussion of trypanosome infections and malaria, below).

6. Inability of parasites to synthesize vitamins may be a limiting factor in invasiveness. In the case of the malaria parasite Plasmodium *gallinaceum* it has been found that the blood stages need pantothenic acid, one of the B-complex vitamins, for survival in vitro. Blood infections in chickens are suppressed by feeding the host a diet deficient in pantothenic acid and are restored to normal intensity by adding pantothenic acid to the deficient diet.

Localization of *Parasites Within the* Host. — Invasiveness is closely related to the elective localization of endoparasites in certain cells, tissues or organs within the host. Thus, among the fungi, the parasite of loose smut of wheat, *Ustilago* tritici, is localized in the embryo and growing points of the developing plant. For most of their development in man, the parasites of malaria (*Plasmodium*) live within red blood cells. The parasite of human kala azar, Leishmania *donovani,* lives in macrophages widely dispersed over the body. Adult hookworms of man are largely local-

ized to the small intestine. Such predilections are almost certainly associated in part with the availability of suitable nutrients or specific enzyme systems which the parasite can utilize. In spite of much speculation, little is known about the fundamental mechanisms involved.

Highly potent factors in invasiveness are the genetic mechanisms whereby parasites acquire new heritable characteristics which permit them to invade hosts which were previously immune to them or which allow them to become resistant to the immune factors which the host acquires during the infection. The extent to which even an exceedingly small and structurally simple parasite may vary is shown by the virus which produces tobacco mosaic disease. About 400 strains have been recognized which differ in such mays as symptoms and severity of the disease they produce, invasiveness, host range, serological reactions and amounts and kinds of amino acids they contain.

All parasites have to a greater or lesser degree the power to mutate and produce heritable variations. Genetic variability is further increased in parasites which undergo sexual reproduction by the constant mixing of different parental strains, as has been shown to occur in certain strains of malarial parasites during their sexual development in the mosquito. This variability is also of great economic importance in the rust-producing fungus of wheat, which undergoes its sexual cycle in the barberry and a purely vegetative phase in wheat. The fungus cannot be controlled by developing rust-resistant strains of wheat because new hybrids may arise in the barberry.

Although mating was once assumed not to occur in the supposedly asexually reproducing bacteria and viruses, sexual recombination and several other mechanisms of genetic exchange later were found to occur. Thus, the common enteric bacterium of man, Eschericlzia coli, mates not only with other strains of the same species, but also with several species of the genus Shigella, a group of dysentery-producing bacteria. The offspring of the various matings show features of both parents. Genetic exchange can also occur between bacteria by tranduction; *i.e.,* by the transfer of genetic material from one host cell to another by a suitable virus. In some organisms, such as the pneumococcus, genetic exchange by transformation occurs when the genetic material, deoxyribonucleic acid, is isolated from one strain and added to another. Apparently, the donor deoxyribonucleic acid enters into the recipient cell and becomes incorporated into its genetic apparatus. Mating and genetic exchange are known to occur in the viruses, such as the bacteriophage, the virus producing influenza in man and certain plant viruses.

Disease of the Host.—Even when a parasite gives rise to a serious disease, some hosts may harbour the parasite without noticeable symptoms or with few ill effects. Such persons are often termed "carriers" (*q.v.*), and they are particularly important in public health because they frequently disseminate disease-producing organisms without being aware of it.

Some, but by no means all, of the methods by which parasites injure or produce symptoms in the host are known. A few parasites, particularly among the bacteria, elaborate poisons, so-called toxins (*q.v.*), which have the specific effect of inducing antibodies known as antitoxins (*q.v.*) within the host. Examples of organisms producing true toxins are the diphtheria organism, the gas gangrene organism and the streptococcus producing scarlet fever. In addition to true soluble toxins, sometimes called exotoxins, cell substances of certain parasites seem to be toxic but are liberated only when the parasites break up. These so-called endotoxins are difficult to distinguish from the proteins of the parasites themselves. Many symptoms produced by them may be the result of a hypersensitivity, similar to the sensitivity to pollen in asthma and hay fever. Aside from poisoning, many parasites affect the host adversely by destroying tissues or cells. Thus, the malarial organisms live largely within red blood cells and destroy large numbers of them. This activity produces anemia and, if extensive, unquestionably breaks down the oxygen-carrying mechanism. Similarly, Endamoeba histolytica, the parasite of amoebic dysentery, destroys the tissue of the intestinal mucosa and ingests blood cells. Such tissue destruction undoubtedly plays a dominant role in the dysenteric symptoms and leads to concurrent and intercurrent infections with other intestinal forms. The hemolytic streptococci exemplify a combination of directly destroying tissue and producing toxic substances. Likewise, the pronounced anemia in hookworm disease apparently results from the worms' sucking blood from the intestinal mucosa. The parasite (Plasmodium falciparum) of malignant tertian malaria in man frequently agglutinates in the small vessels of such organs as the brain. Consequently, intravascular plugs (thrombi) form and tissue necrosis (infarction) takes place. In addition to injuring the hosts directly, many parasites probably deprive their hosts of essential food material. Certain endoparasites which produce overwhelming infections before death probably compete with the host for essential metabolic substances.

An analysis of the examples given indicates that parasitic virulence or the capacity to produce disease depends upon (1) various factors of invasiveness which increase the number and spread of the parasites and (2) the toxigenicity of the parasites.

Highly virulent parasites may show varying degrees of toxigenicity and invasiveness. The free-living saprophyte producing the frequently fatal food poisoning, botulism. of man is rarely invasive and ordinarily produces no infection at all. It is classed as highly virulent, however, because in improperly canned foods it produces an exotoxin which is highly poisonous when ingested. Only slightly more invasive is the bacillus *Clostridium tetani,* which produces lockjaw in man and is extremely toxigenic. It generally gains admission to tissues in deep, dirty wounds, where it is accompanied by common saprophytic bacteria and frequently by irritant chemicals. Under such conditions, it germinates (which it cannot do in healthy tissue) and locally secretes a powerful toxin which diffuses into the body and produces the disease symptoms.

At the other extreme, the virulent parasite Plasmodium *falciparum,* which produces subtertian malaria in man, is extremely invasive and practically nontoxigenic. This parasite seems to produce no significantly active toxin but is so invasive that the majority of the red blood cells in a fatal infection may be parasitized just before the host dies. When the parasite is nontoxigenic, a moderate invasiveness may be associated with low virulence. The essentially nonpathogenic blood parasite of the rat, Trypanosoma lewisi, is moderately invasive (see below) but rarely produces symptoms except in very young hosts.

Reactions of the Host.—The host resists infection by reacting passively and actively against the invasion and proliferation of the parasite. These capacities to react are collectively termed immunity (*q.v.*). Immunity may be innate (*i.e.,* a natural characteristic of the host) or acquired as the result of infection or immunizing procedure.

Upon initial contact of a parasite with an animal host and before acquired immunity develops, factors of innate immunity operate. The unbroken skin and the outward flow of mucus, urine, etc.. act as mechanical barriers to an initial invasion. After the mechanical barriers have been passed, many factors of the host acting together make the nonimmunized host an unsuitable medium in which a given parasite can achieve maximum reproductive and survival rates.

When infective stages or oöcysts of certain coccidia are fed nonsusceptible hosts, they often go through the alimentary tract without hatching or liberating their merozoites. Here it seems probable that the digestive juices of the nonsusceptible host are unsuited to induce hatching of the oocysts. Specific properties may exist in the serum which are inimical to the parasite. The reiistance of man to many trypanosomes which infect animals in Africa is almost certainly in part attributable to a nonantibody trypanocidal property of normal human serum. Thus, normal human serum is a potent curative agent for many of the trypanosomes of animals, but does not harm the commonest trypanosome, Trypanosoma garnbiense, producing sleeping sickness of man. Interestingly enough, it does not harm another trypanosome, Trypanosoma *rhodesiense* (which produces a sleeping sickness in man and which is probably an animal strain partially adapted to life in man), unless the strain has undergone several passages in

animals. In plants, innate immunity may be associated with the specific action of so-called antibiotic substances.

The absence of some necessary food component may give the host an innate athreptic immunity. This is probably true for certain vitamins (see *Host-Endoparasite* Relationships, above).

As would be expected, innate immunity is, to a large extent, genetically determined. This has been put to practical use in the development of resistant strains of plants. In addition, laboratory workers have developed many inbred strains of the smaller animals which possess the desired degree of susceptibility to a number of parasitic organisms.

During the progress of an infection of man or vertebrate animals, acquired immunity appears and owes its highly specific character to antigen-antibody reactions. Any given antigen (usually a protein) from a parasite induces the formation of a spectrum of antibodies by the host. These antibodies in general react specifically with the antigen which stimulated their production and react to varying degrees with antigens of related chemical structure. Antibodies are named according to how they react with the antigen or what effect they produce on the parasite. **As** a consequence, the same antibody may have several names. Although acquired immunity has been described in some plant infections, it is not associated with antibodies.

Antibodies fall into two groups, antitoxic and antiparasitic. The latter term can be further subdivided into antibacterial, antifungal, etc. When a parasite secretes a toxin, the resulting antibody or antitoxin which neutralizes the toxin may account for all or practically all of the acquired immunity. Whether or not a parasite secretes a toxin, each of its body proteins may stimulate an antibody which may produce antiparasitic effects depending upon the position of the antigen in the parasite. Thus, when the antigen is associated with some locomotor organ of the parasite, such as the flagella, the antibody acting as an agglutinin may agglutinate the organisms. When the antigen is on the surface of the parasite, the antibody acting as a lysin in conjunction with a normal component of serum, complement, may lyse the parasite (*i.e.,* injure the cell so that essential cellular constituents are lost) or, acting as an opsonin, may sensitize the parasite so that it is more easily eaten (*i.e.,* phagocytosed). Lysins are especially evident in the pathogenic trypanosomiases. When the antigen is a soluble material extruded from the parasite, the antibody acting as a precipitin may react with soluble parasitic materials to form precipitates. Precipitins are particularly common in metazoan infections and are probably involved in certain types of hypersensitivity which by producing inflammation speeds up the walling off of parasites.

Aside from mechanical barriers against infection, both antibody and nonspecific factors of immunity in an animal host are associated with cells of the blood and connective tissue. Some cells. particularly the polymorphonuclear leucocytes of the blood and the macrophages of the connective tissue, phagocytose small organisms and various debris resulting from the destruction of host

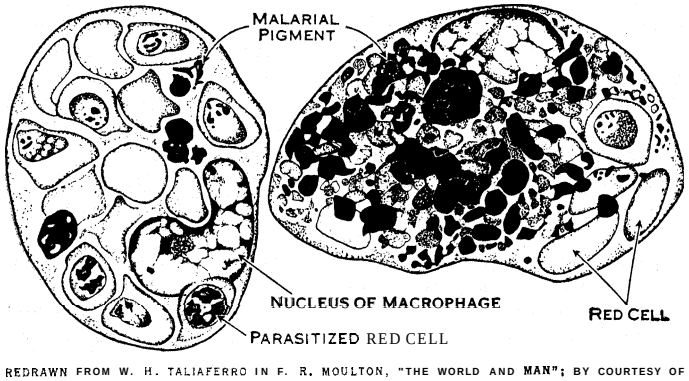


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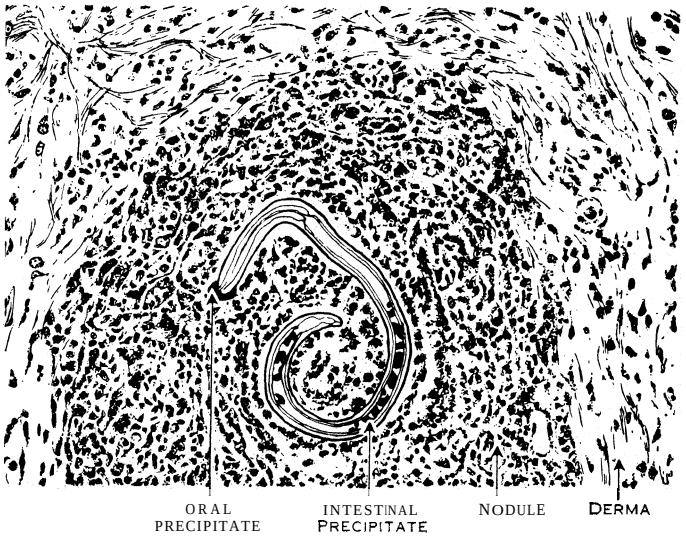
FIG. 2.—**ANTIBODY-INDUCED PHAGOCYTOSIS** IN MALARIA. X 2.300
Macrophage on left has phagocytosed both infected and noninfected red cells during the initial crisis of the infection; macrophage on right has digested most of the red cells and parasites, leaving malarial pigment (Plasmodium *brasilianum* in Cebus capucinus)



ADAPTED FROM W. H. TALIAFERRO AND M. P. SARLES, "THE CELLULAR REACTIONS IN THE SKIN, LUNGS AND INTESTINE OF NORMAL AND IMMUNE RATS AFTER INFECTION WITH NIP. POSTRONGYLUS MURIS," "JOURNAL OF INFECTIOUS DISEASES"; BY COURTESY OF THE UNIVERSITY OF CHICAGO PRESS

FIG. 3.—**A** LARVA OF NIPPOSTRONGYLUS MURIS IN THE **SKIN** OF AN IMMUNE RAT. X 165
Antibody has immobilized the larva and reacted with larval antigens to form a cap of precipitate over the mouth and masses of it in the intestine. Inflammatory processes have resulted in the formation of a granulomatous nodule around the larva

tissue. Macrophages and fibroblasts wall off large parasites or other material which cannot be phagocytosed. In addition, many cells of the blood and connective tissue have embryonic (*i.e.,* mesenchyinal) potencies which permit them to develop into other cells. This characteristic permits them to assume an important role in the regeneration of destroyed connective tissue. The activities involved in removing parasites and repairing injuries are closely connected with the process of inflammation. Inflammation, which is often evident superficially by a reddening and swelling of the skin, is a complicated reaction involving edema and the migration, transformation, division and phagocytic activity of certain cells of the blood and connective tissue. At the first contact of a parasite with its host, the parasite generally moves more or less rapidly through the tissues of the host, and inflammation with its mobilization of phagocytic cells is comparatively mild. At a second, third or later contact of the same parasite with the host, specific antibodies, such as precipitins and agglutinins, localize the parasite or its noxious materials, and opsonins make the smaller parasites more easily phagocytosed. In addition, more intense inflammation mobilizes more cells which phagocytose or wall off the localized parasites.

The interplay of antibody and cellular factors is clearly seen in the suppression of many bacterial infections by opsonin-induced phagocytosis and has been studied in detail in malaria (fig. 2 and 7). Agglutinins also assist in localizing various organisms and thereby probably aid in phagocytosis.

Acquired immunity to the small, hookwormlike nematode of the rat, *Nippostrongylus muris,* illustrates the direct antiparasitic action of antibodies acting as precipitins with the secondary cooperation of inflammatory cells. Eggs of this nematode are passed out of an infected host with the feces and develop into infective larvae after about a week or less. The infective larvae may then penetrate the skin of nonimmune rats. There they feed and develop. After about 20 hours they migrate and reach the lungs via the blood stream. In the lungs, they further feed and develop and then migrate to the mouth. After being swallowed, they reach the intestine between the second and third day. There they develop to sexual maturity by about the end of the first week and lay large numbers of eggs, but many worms are expelled from the gut after another week as a result of the development of acquired immunity.

Acquired immunity increases as successive reinfections take place. It is mainly associated with antibodies which are pro-

duced by the host in response to the secretions and excretions which pass from the mouth, anus and excretory pore of the worm. As the larvae feed in the skin or lung, these precipitins cause precipitates to form at all orifices and throughout the gut. The larvae are stunted and more or less immobilized by antibodies, probably as a secondary result of the precipitate formation. Furthermore, intense antigen-antibody reactions in the tissues produce tissue damage and set up inflammation which in turn results in the formation of nodules around the immobilized parasites (fig. 3). Some worms die in these nodules and the disintegrating worms are removed by macrophages.

Others may escape from the nodules and resume their migration but are stunted, and the females, if they reach the intestine, lay fewer eggs than normally. In the intestine, the worm feeds by piercing the mucosa and extracting materials from the lamina propria. Just as in the skin and lungs, little inflammation occurs at first. When acquired immunity supervenes, however, materials extruded from the mouth of the worm set up inflammatory processes within the rat tissue, and ingestion of antibody probably immobilize$ the worm to the extent that it cannot withstand peristalsis and is forced out of the rat gut.

Certain of the pathogenic trypanosomes (*e.g.*, Trypanosoma *equiperdum*, T. *brucei*, *T. gambiense*, etc.) reproduce at a constant rate in a series of experimental hosts and increase in number essentially logarithmically in mice and sometimes in rats until death occurs (see control mouse in fig. 4). In such infections there seems to be no evidence of antibody formation. In other hosts. such as the guinea pig, the parasitemia periodically decreases as a result of the production of typical trypanolysins (fig. 4). Lysins rarely eradicate the infection, however, because after each trypanolytic crisis, a few trypanosomes are resistant, continue to reproduce and repopulate the blood stream (see experimental mouse in fig. 4).

A unique antibody mechanism specifically inhibits growth and reproduction in the Trypanosoma *lewisi* group of nonpathogenic trypanosomes. Trypanosoma *lewisi* undergoes reproduction by division only in the first part of its infection and thereafter remains in the blood in the nonreproducing adult form (fig. ;). This seemingly inherent life cycle results from the formation of an antibody, ablastin, which inhibits reproduction of the parasites without any apparent effect on their general vitality, mobility or infectivity. Biochemical investigations indicate that the inhibited parasites are prevented from oxidatively assimilating glucose for the synthesis of new protoplasm but are able to oxidize glucose for maintenance as nonreproducing organisms. Nonreproducing trypanosomes may persist for varying lengths of time up to more than a year but are destroyed by specific lysins. Any trypanosomes resistant to lysins, however, do not repopulate the

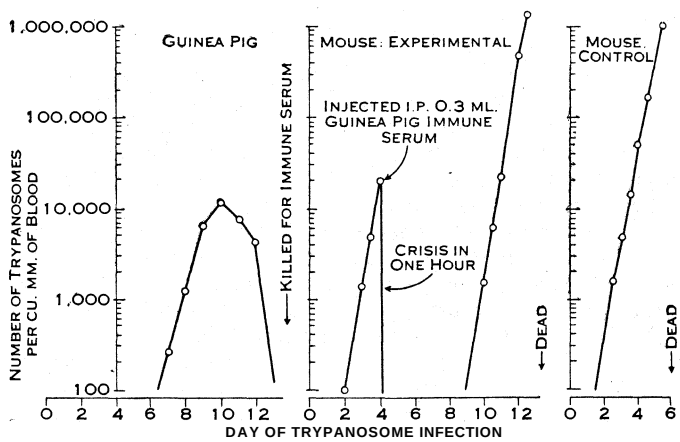


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FIG. 4.— ANTIBODY-INDUCED LYSIS IN AN INFECTION WITH TRYPANOSOMA EQUINUM

After the trypanosomes largely disappeared because of a lysin formed in the guinea pig, its serum was injected intraperitonealiy to induce a similar population decrease in a mouse, which nevertheless suffered a fatal relapse

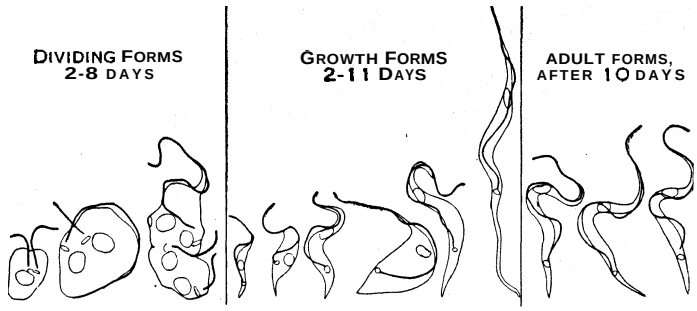

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FIG. 5.—TRYPANOSOMA LEWISI IN THE RAT. × 1.100

blood because they cannot reproduce in the presence of ablastin. Ablastin-resistant organisms have not as yet been found.

Host-Ectoparasite Relationships.— The ectoparasite is obviously less closely associated with its host than is the endoparasite. Xevertheless, there is a high degree of host specificity in ectoparasitism, and more and more examples are being found showing an interplay of invasive factors of the parasite and immune reactions of the host. An interesting situation is seen in the unionid clams. The larval stages of these mollusks, known as glochidia, are expelled in large masses into the water and fix themselves to various parts of fish. Because of the respiratory currents produced by the fish, many find their way to and attach themselves to the gills. This attachment is effected by a closing of the valves and is reinforced by hooks or spines in some species. The host epidermis responds by growing over and completely covering the parasite. Each enclosed glochidium then undergoes a complete metamorphosis into a young mussel, which breaks out of its cyst and falls to the bottom to begin its growth into an adult clam. The glochidia require a specific fish host for normal development. When they attach themselves to other species of fish. innate immunity operates to cause the sloughing off of the parasite before metamorphosis is complete. In addition, under experimental conditions, repeated infestations result in an acquired immunity which also causes the glochidia to be sloughed off prematurely. This antiparasitic action is associated with a lytic antibody in the serum.

Ticks are firmly attached by their mouth parts, which are inserted into the skin. Immunologically, they behave in the same manner as a nematode worm which lives in the intestine and pierces the mucosa to feed. Both inject antigens, which stimulate specific antiparasitic antibodies during the process of feeding. It has been shown that guinea pigs acquire an immunity to ticks. In solidly immune animals, fewer ticks attach themselves and, of those which do, many are prevented from engorging themselves and some die. This immunity can be passively transferred to normal animals by injecting blood serum from immune animals.

The female of the dipterous fly Cordylobia *anthropophaga* deposits its eggs preferably in sand. The first-stage larva burrows into the skin of man or animals and after attaining the third stage drops to the ground and pupates. The infected area of the skin looks like a boil. Heavy infestation of these maggots on guinea pigs results in a high degree of acquired immunity in which antibodies affect the larvae in much the same way as has been described for the larvae of *Nippostrongylus muris*. Immune precipitates are formed throughout the gut and at the ends of the larvae, and the maggots eventually die before they complete their development.

Mutualistic Host-Parasite Relationships.— In true mutualism, where host and parasite are benefited, an optimal invasion may have survival value for the host as well as for the parasite. A remarkable example is seen in certain termites whose intestines contain a teeming menagerie of protozoa, mostly flagellates. Experimental studies by L. R. Cleveland, R. E. Hungate and others indicate that from the termites the flagellates receive shelter, an optimal oxygen tension, wood particles finely enough divided to be eaten and utilizable nitrogenous materials. They in turn

furnish their host with various degradation products of cellulose which can be utilized metabolically by the host. Even in these ideal host-parasite relationships there must be some mechanism for preventing an unlimited increase in the parasite population. Three phases of flagellate infection have been recognized in the

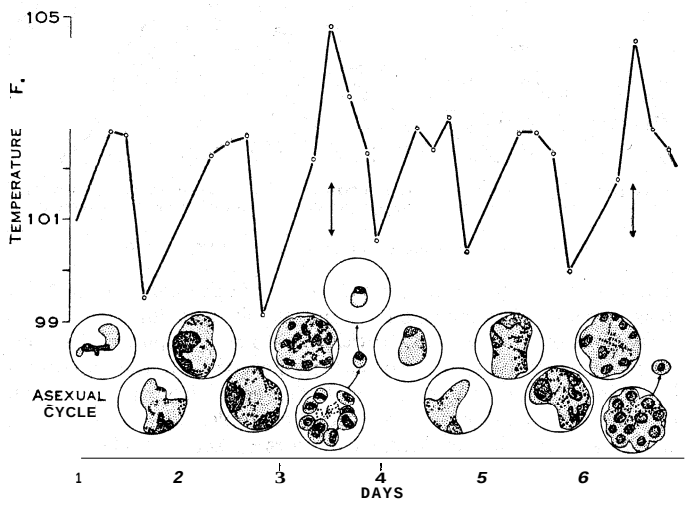

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FIG 6.— SYNCHRONOUS ASEXUAL CYCLE OF PLASMODIUM BRASILIANUM IN THE RED BLOOD CELLS OF CEBUS CAPUCINUS AND THE CORRELATION OF PARASITE SEGMENTATION WITH FEVER IN THE HOST

case of *Termopsis angusticollis:* (1) infection of a recently molted termite followed by a period of rapid flagellate multiplication; (2) a long period between molts when reproduction and death of the flagellates is low or practically nil; and (3) the end of the infection during molting when the flagellates are eliminated or die. It has been suggested that the lack of reproduction between molts and the rapid reproduction just after molting is attributable to the availability of the nitrogenous materials necessary for protozoan growth. The restraint of the flagellates during the intermolting periods by a lack of nitrogenous food would represent an athreptic immunity.

Molting may have other profound effects on the protozoan partner in these mutualistic associations. Thus, in one of the wood-feeding roaches. *Cryptocercus punctulatus,* molting is associated with sexual cycles in several of the flagellates of its hind gut. The sexual behaviour of the flagellates varies but is apparently induced by the molting hormone secreted by the prothoracic glands of the roach.

Population Ecology.-p he statistical study of parasites has proceeded chiefly along two lines involving: (1) changes in the population census of single species of parasites within a single host; and (2) the interaction between parasite population and host population. The first of these considers the changes in parasite population resulting from the interaction of parasite virulence and host immunity, whereas the second considers the reciprocal relation that is established when host and parasite populations interact through time.

Certain blood-induced malarias are ideal for studying the net result of the interplay of host immunity and parasite invasiveness on the parasite population. In the malarial infection of monkeys with *Plasmodium brasilianum,* the parasites are more or less evenly distributed in the red blood cells and can, therefore, be studied by means of frequent blood samples without injuring the host. The asexual parasites reproduce synchronously (*i.e.,* they develop almost simultaneously) and ordinarily take three days to grow and segment into approximately ten merozoites (fig. 6). This sequence permits a remarkably accurate determination of the rate of reproduction.

Thus, the length of this cycle together with statistical counts.. of the number of progeny (merozoites) formed at each segmentation give an absolute measure of the rate of reproduction which is independent of the number of organisms destroyed (fig. 7, "merozoites produced"). Examination of fig. 7 indicates that the population curve during the first four segmentations of the parasite in this particular infection rises and falls in a regular steplike fashion and is the net result of the rate of reproduction by one brood of parasites minus its death rate. Analysis of this curve indicates that only three of the ten merozoites produced per segmenter live, while four die during segmentation and three during growth.

Decrease in the population of parasites between the 13th and 19th day (fig. 7) is apparently composed of two phases. The first part of the drop is the expected intracorpuscular death of the parasites, whereas the second precipitous decrease results from the first evidences of acquired immunity. During this so-called crisis, parasitic reproduction is markedly deranged. The asexual cycle is lengthened, the number of merozoites produced is decreased, and many of the circulating parasites are markedly damaged. Within a few days, horn-ever. the surviving parasites become normal in appearance and produce their normal quota of merozoites. Interestingly, though not cogent to the present discussion, the parasites rearrange themselves after the crisis into two broods instead of one brood, each with a typical three-day asexual cycle (*see* arrows in fig. 7). For a long time there is a net survival of only one parasite per segmenter with a resultant static population. The parasites are resistant to the circulating antibodies producing the crisis. This resistance, however, is phenotypic and is not inherited because most of the parasites continue to be susceptible at each segmentation and no resistant strain arises as in the trypanosome infections noted previously.

The epidemiological aspects of the interaction between human populations and parasites comprise one branch of medicine (*see* EPIDEMIOLOGY). The epidemiological effects of parasites on subhuman host populations have been studied by entomologists and ecologists (*see* POPULATION ECOLOGY). This type of study is exemplified by the work on the interspecies competition of two flour beetles, *Tribolium confusum* and *T. castaneum,* as influenced by parasitism with the sporozoon *Adelina tribolii.* Each parasitized host species studied individually eventually reaches an equilibrium under certain standard environmental conditions. Of the two species, however, T. *castaneum* is much more susceptible to the parasite and the population of the host markedly decreases and then recovers about the 300th day. When the two beetles and the parasite were studied together over a four-year period, one host species alaays became extinct and the surviving one assumed a population trend statistically identical to that found in the particular parasitized species when studied individually. The same species, however, did not always survive when various environmental conditions were modified.

Prevention of Disease. — Innate immunity has been used by plant pathologists to great advantage in controlling plant diseases. Strains of economic plants which are specifically resistant to certain infectious diseases are deliberately bred.

Artificially produced acquired immunity has been highly successful in controlling some viral and bacterial diseases of man and animals. It can be produced passively by the injection of serum from an immunized animal (or man) or actively by the injection of parts of or entire dead organisms. Passive immunity is acquired almost immediately but lasts only a short time. When quick acquisition is not important, active immunity is employed because it is much more enduring and is generally stronger. Antitetanic serum is frequently administered as soon as possible after deep wounds to prevent the possible occurrence of lockjaw. Toxoid, a preparation of toxin which has lost its toxicity but retained its antigenicity, is widely used to protect against diphtheria. A vaccine of killed bacteria produces an artificial immunity against typhoid fever. Attenuated strains of viruses induce artificial active immunization against such viral diseases of man as smallpox, rabies and yellow fever. On the other hand, attempts to immunize against most protozoan and helminth infections have been, on the whole. disappointing. (*See* also IMMUNITY; TOXIN; VACCINATION.)

Many diseases can be controlled by preventing contact between the invading organism and its host. Diseases such as tuberculosis, diphtheria. measles. scarlet fever, whooping cough, mumps, colds

and related respiratory infections are spread by discharges from the mouth and nose. Such infectious discharges may be directly transmitted to uninfected persons by kissing and by the contamination of eating and drinking utensils, or may be transmitted indirectly as droplets dispersed in the air by coughing and sneezing. These methods of transmission are difficult to control.

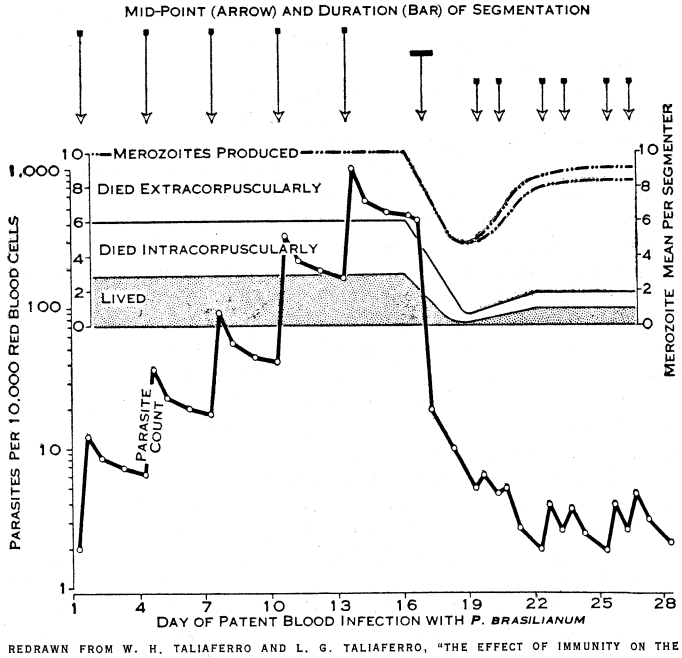
Other diseases are transmitted from man to man by intestinal discharges. Among these are typhoid fever, cholera and amoebic dysentery. The organisms of these diseases are generally acquired through water, milk or food that have been contaminated with the feces of infected persons or by soiling hands with fecal material. At times, they are mechanically transmitted by houseflies and other insects carrying the fecal material to food or drink. Some have been successfully controlled by isolating sick persons and carriers, properly disposing of fecal material, purifying water and pasteurizing milk.

Many parasites are transmitted by insects and other arthropods, either mechanically or after they develop in the body of the vector. Certain diseases in this category have been checked with remarkable success by controlling the arthropod host. Thus, Texas fever in cattle has been eradicated in many areas by dipping the cattle and thereby destroying the adult ticks.

Urban epidemic yellow fever was temporarily largely eliminated from the western hemisphere by controlling the mosquito *Aëdes aegypti,* but vaccination is becoming increasingly important in control. Malaria has been eliminated in certain areas by an attack on anopheline mosquitoes.

Chemotherapy.—An increasing number of drugs which cure or suppress parasitic diseases of man and animals are becoming known. A few specifics were known earlier, but beginning in 1909, and especially since the 1940s, more and more have been synthesized or, in the case of the antibiotics, formed in controlled cultures of microorganisms. Many of the specific remedies affect various parasites.

Emetine, the purified alkaloid from ipecac root, is helpful against amoebic dysentery. Tetrachloroethylene successfully eradicates hookworm. Quinine from cinchona bark, which was discovered by the South American Indians, is still used for malaria, but is supplemented by synthetic compounds such as primaquine, chloroquine and pyrimethamine. Several arsenicals and other synthetic compounds are effective against trypanosomes that produce diseases of man and animals in Africa. Various arsenicals and especially the antibiotic, penicillin, are used to treat the spirochete diseases such as relapsing fever and syphilis.



REDRAWN FROM W. H. TALIAFERRO AND L. G. TALIAFERRO, "THE EFFECT OF IMMUNITY ON THE ASEXUAL REPRODUCTION OF PLASMODIUM BRASILIANUM," "JOURNAL OF INFECTIOUS DISEASES"

FIG. 7.—POPULATION CURVE OF PLASMODIUM BRASILIANUM IN THE BLOOD OF CEBUS CAPUCINUS

The "merozoites produced" shows the number of progeny formed at each segmentation. The number of parasites in the blood indicates what proportion of the progeny dies extracorpuscularly and intracorpuscularly, and what proportion survives

Sulfonamides and particularly the antibiotics cure a wide range of bacterial infections. Certain antibiotics are effective against the rickettsial diseases, but none so far is satisfactory against any virus except the group producing psittacosis, lymphogranuloma venereum and trachoma. Penicillin, the first successfully developed antibiotic with low toxicity and high effectiveness, is supplemented by streptomycin, aureomycin, terramycin and others.

The genetic versatility of parasites in overcoming the action of antibodies is also frequently encountered in drug and antibiotic treatment. In work on the first synthetic drugs, the arsenicals which were developed against the trypanosomes, arsenic-resistant strains of parasites were noted. Similar sulfonamide- and antibiotic-resistant strains of bacteria are also encountered. A remarkable situation occurs occasionally. Certain mutant strains of bacteria have been found to be both streptomycin-resistant and streptomycin-dependent. They grow sparsely in culture media ideal for the parent stock or in animals, but luxuriantly in media to which the antibiotic is added or in animals treated with it. (W. H. T.)

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PARASITIC PLANTS

The parasitic habit is found in widely differing plant groups, from the simplest bacteria to trees such as the much-valued sandalwoods. It is very common among the bacteria and the fungi. In man, parasitic bacteria cause tuberculosis, abscesses, gangrene and many other diseases, while in plants they give rise to leaf spots, blights, wilts, soft rots, cankers and galls or tumours. Because of some resemblances to cancer tissue in human beings, the tumours of crown gall, induced by *Agrobacterium tumefaciens,* have been a subject of considerable research. Most parasitic fungi inhabit other plants, including algae, but a few parasitize nematodes, insects, crustaceans, fish and the higher animals. The dead forms of houseflies, surrounded by a whitish halo of spores, may often be seen fixed to the glass of unused windows in the

fall, victims of Entomophthora muscae. Another fungus of this group is very destructive to grasshoppers. Fish, especially if injured in any way, may be attacked by *Saprolegnia parasitica* or related water molds, and in man such well-known disorders as ringworm and tinea *pedis,* or "athlete's foot," are caused by parasitic fungi (*Microsporon* and Trichophyton species). Fungus parasites of higher plants cause many types of diseases, including blights, rusts, smuts, mildews, root rots and tree decays, that are of great economic importance because of the damage they do to crops and timber.

Relatively few seed plants are parasites, but the few include very interesting forms. All are parasitic on other plants, some being limited to specific hosts and others with a wide host range. The parasitism may be either partial, as in the common leafy mistletoes (*Viscum* album in Europe; Phoradendron species in North America), or complete or nearly so, as in dodder (Cuscuta). The green leaves and stems of the mistletoe are well supplied with chlorophyll, which enables it to produce its own organic nutrients by photosynthesis. Only water and minerals are required from the host. These the mistletoe obtains from the water-conducting vessels of the host through haustoria, or "sinkers," that have gradually become embedded in the host wood by the growth of layers of new wood around them.

In contrast with the mistletoe, the common dodder, with its twining leafless stems that clamber over and fix themselves to a variety of host plants, contain very little chlorophyll, and the parasite must depend almost completely on its hosts for food and water. The broom rapes, parasitic on roots of many plants, contain no chlorophyll and are totally dependent on their hosts for organic foods, but develop roots for the uptake of water and dissolved minerals.

Some plants, exemplified by the sandalwood tree and the brightly tipped Indian paintbrush (*Castilleja*), contain chlorophyll and develop roots, but maintain a root connection with a host plant. In these cases the actual parasitism is minor, for if the host connection is severed the plants are able to live for several months without aid from the host. Conversely, partial parasites, especially mistletoes, may occasionally exist for years embedded in the host in a wholly parasitic state, without external green shoots. Cases in which parasites are in turn parasitized are not uncommon, chiefly between fungi, or between a fungus and a parasitic higher plant.

Parasitism is often accompanied by a reduction in plant parts, a simplification which has reached an extreme in species of tropical *Rafflesia,* in which the only external part is the flower. This springs from undifferentiated filaments in the roots of the host (species of *Cissus*). In R. *arnoldi* it attains a spread of three feet or more, larger than any other known flower, but with a nauseous odour of decaying flesh, attractive to insects on which it must depend for pollination.

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PARASNATH, a hill (4,481 ft.) and place of Jain pilgrimage in Hazaribagh district, Bihar, India, 18 mi. from Giridih station on the Eastern railway. It derives its name from the last of the 24 Jain saints, who is believed to have attained there the nirvana.

PARATHYROID GLANDS. The parathyroid glands occur in all species from amphibia upward. In man they are tiny, brownish-red structures (approximately 6 × 4 × 2 mm.), usually situated behind the lateral thyroid lobes, two on each side. However, there may be as few as two, and as many as eight parathyroids have been found, sometimes in atypical locations anywhere in the deeper tissues of the neck or upper chest. Their embryonic origin is from the third and fourth pharyngeal pouches. Microscopically they are made up of closely packed epithelial cells separated by thin fibrous bands; occasionally the cells are arranged in circles with an open centre (alveolar arrangement) which may contain a colloid material.

In the latter half of the 19th century the parathyroids were recognized to play an important physiological role when it became apparent that the convulsive seizures and death which sometimes followed experimental thyroid operations were due to the inadvertent removal of the parathyroid glands. In 1908 their relationship to calcium metabolism was discovered when W. G. MacCallum and C. Voegtlin demonstrated that removal of these structures was followed by a fall in the calcium concentration of the blood serum, and that administration of calcium salts prevented or corrected the ill effects of the operation. In 1925 J. B. Collip developed a method of preparing a physiologically active extract of the parathyroid with which experimental animals could be tested.

The exact action of the internal secretion of these glands is not clear. It is believed that the parathyroid hormone plays an important role in stabilizing the calcium concentration of the body fluids—a very important function, since a lowering of the calcium ion concentration results in a condition of increased excitability of nerves and muscles known as tetany, in which there occur muscular spasms, convulsions and sometimes dementia. Under normal conditions a small drop in the calcium concentration of the body fluids results in increased activity of the parathyroid glands, which raises the calcium concentration by mobilizing some of the skeletal calcium. On the other hand, a rise in body fluid calcium concentration above the normal is counteracted by a reduction or cessation of secretion of parathyroid hormone. The internal secretion of the parathyroids also affects the metabolism of phosphorus. an excess of the hormone resulting in a lowering of inorganic phosphate concentration in the blood serum and an increased excretion of phosphate in the urine. Reduced parathyroid function is accompanied by a rise in the inorganic phosphate of the serum and a lessened urinary output of phosphate.

In medical practice both overfunction and underfunction of the parathyroid glands produce important disease entities. *See* 'ENDOCRINE GLANDS; ENDOCRINOLOGY; HORMONES. (J. E. HD.)

PARATHYROID GLANDS, DISEASES OF, comprise hyperparathyroidism (production of excessive amounts of parathyroid hormone) and hypoparathyroidism (underactivity of the glands.) The symptoms they produce result from disturbances in metabolism of calcium and phosphorus which is regulated by the parathyroid glands (*q.v.*).

The calcium in the body is confined for the most part (99%) to the bones and teeth and is excreted through the urine and feces. Under conditions of pregnancy and lactation it is excreted also through the placenta and breast. Since the amount in the body fluids is small and relatively constant, the difference between the calcium intake and output is represented by the calcium deposited or withdrawn from the bony structure. Ordinarily there is a constant movement of calcium between the blood and skeleton which is regulated by the difference between calcium intake and output. The normal level of blood calcium is 9–11 mg. per 100 c.c. Phosphorus is likewise found largely in the bones. Its blood level is 3–5 mg. per 100 c.c., and it exists in both inorganic (as a mineral) and organic forms (combined with other compounds), so that the relationship between intake and output is not so direct as with calcium.

Hyperparathyroidism. — Hyperparathyroidism is usually due to a tumour in one or more of the glands or to generalized overactivity of the parathyroid tissue. The characteristic features of the disease are elevation of the blood calcium level with lowering of the blood phosphorus level, together with increased excretion of both calcium and phosphorus in the urine. This condition results in symptoms and signs of three types: (1) those due to bone disease, such as softening of the bones with collapse of the spinal vertebrae or fracture of the long bones; (2) those due to kidney disease, such as the formation of kidney stones; (3) those due to the effect of the increase in blood calcium level per se, among them decreased neuromuscular excitability, fatigue, drowsiness, loss of appetite and constipation. The treatment is the removal of the tumour or of most of the overactive parathyroid tissue, with a consequent tendency for most of the disease process to be reversed by healing.

Hypoparathyroidism. — -Hypoparathyroidism usually occurs as a result of removal of excessive amounts of parathyroid tissue

during thyroid operations. It results in a low blood calcium and a high blood phosphorus. The condition produces tetany, a state of hyperexcitable neuromuscular activity with localized or generalized muscular spasms or convulsions. The bones become more dense and cataracts form in the lenses of the eyes. The treatment is to raise the blood calcium by a high calcium diet, by the administration of vitamin D or dihydrotachysterol by mouth or by the injection of parathyroid hormone.

See F. Albright and E. C. Reifenstein, Jr., *The Parathyroid Glands and Metabolic Bone Disease (1945).* (HY. F.)

PARATROOPS, soldiers specially trained and equipped to enter combat by making parachute jumps from airplanes. The term came into common use during World War II. Paratroops (or parachute troops as they were sometimes called) proved valuable for making surprise attacks on the enemy's flank or rear. Because their tactics mere akin to those of cavalry, paratroops and other airborne troops were later referred to as "cavalry of the sky."

See AIR-BORNE TROOPS.

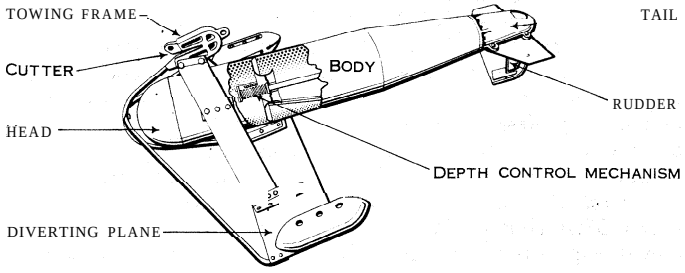
PARATYPHOID FEVER: *see* TYPHOID AND PARATYPHOID FEVERS.

PARAVANE, a type of water kite which was developed during World War I by Lieut (later Comdr) C D. Burney of the Royal Navy as an antisubmarine and antimine weapon. It consists of a buoyant body. towing frame, diverting plane, cutter, horizontal and vertical tail fins. a rudder and a depth-control mechanism. When towed the water plane diverts the paravane normal to the ship's course. The hydrostatically actuated rudder maintains the paravane at a preset depth.

Paravanes are employed primarily to protect ships against moored mines Towed on each side by means of a mire towrope attached to a fitting at the forefoot of the ship, paravanes and their towropes form a protective wedge which contacts the mine mooring, deflects it from the ship's path and severs it with the cutter. The mine then rises to the surface, where it may be destroyed by gunfire.

Paravanes operate from 5 to 15 ft. below the depth of the keel. The area swept depends upon speed, length of the towrope and the type of paravane employed. The two-speed paravane, employed in high-speed minesweeping during World War II, differed from the standard paravane by a speed adjustment feature which automatically shifted the angle of the diverting plane to either a high- or low-speed position. as determined by the speed of the paravane through the water.

Depth Control Mechanism. — An important part of the paravane is the depth control mechanism, consisting of a hydrostatic valve and a mercury oscillator. The hydrostatic valve is a rubber diaphragm held between the tail housing and the body, and connected at its centre to the valve rod which is linked to the rudder. A compressed spring opposes the hydrostatic pressure applied to the diaphragm. The desired operating depth is obtained by compressing the spring, thus moving the rudder to the diving position. Upon reaching the proper depth. hydrostatic pressure overcomes the spring and shifts the rudder, causing the paravane to rise. From this action the paravane follows a sinusoidal path through the water. At high speeds this motion becomes excessive; therefore, a damping device (mercury oscillator) is provided to reduce depth variation. The mercury oscillator consists of a column of mercury enclosed in a steel tube by a diaphragm at each end connected to the valve rod. When the paravane is inclined by action of the hydrostatic valve, the column of mercury applies pressure to the appropriate diaphragm. This pressure is transmitted to the rudder through the valve rod to restore the paravane to the horizontal. In this manner the mercury oscillator anticipates the action of the hydrostatic valve and prevents excessive changes in depth.



PARAVANE SHOWING DEPTH CONTROL MECHANISM

Paravanes were used extensively during World Wars I and II both for bow protection and minesweeping, but by the second half of the 20th century they were rapidly becoming obsolescent. (R. T. C.)

PARAZOA, the name sometimes used in zoology to denote the grade of organization represented by the sponges (*q.v.*), in contradiitinction to Protozoa and Metazoa (*qq.v.*).

PARCEL POST: *see* POST AND POSTAL SERVICES.

PARCENARY: see LAWS OF REAL PROPERTY AND CONVEYANCING.

PARCHIM or PARCHEM, a town of Germany, in the district of Schwerin, on the Elde, 23 mi. S.E. from the city of Schwerin, on the railway from Ludwigslust to Neubrandenburg. Pop. (1959 est.) 18.986. Founded about 1210, it was the residence of one branch of the family of the dukes of Mecklenburg during part of the 14th century. Parchim became an industrial town during the 16th century, but its prosperity was destroyed by the Thirty Years' War. It is a walled town, with a Gothic town hall. There Moltke was born. It now manufactures machinery, cloth, chicory and cigars, and is a gardening centre.

PARCHMENT. Skins of certain animals, prepared after particular methods, have supplied writing material on which has been inscribed the literature of centuries. The preparation of such skins. in a manner which gave the material the name it possesses today (Gr. *pergamene,* Lat. *charta pergamena,* Fr. *parchemin),* was traditionally attributed to Eumenes II of Pergamum, 197–158 B.C.

The principal improvement in the new manufacture was the dressing of the skins in such a way as to render them capable of receiving writing on both sides, the older methods probably treating only one side for the purpose, a practice which was sufficient in times when the roll was the ordinary form of book and when it was not customary to write on the back as well as on the face of the material. The invention of parchment, with its two surfaces, ensured the development of the codex.

The animals whose skins nere found appropriate for the manufacture of the new parchment were chiefly sheep, goats and calves. But in the course of time there has arisen a distinction between the coarser and finer qualities of the material; and while parchment made from ordinary skins of sheep and goats continued to bear the name, the finer kinds of manufacture produced from the more delicate skins of the calf or kid, or of stillborn or newly-born calves or lambs, came to be generally known as vellum (Fr. *velin*). The skin codices of the early and middle ages being for the most part composed of the finer kinds of material, it has become the custom to describe them as of vellum, although in some instances it would be more correct to call the material parchment.

The ordinary modern process of preparing the skins is by bashing, liming, unhairing, scraping, washing a second time, stretching evenly on a frame, scraping a second time and paring down inequalities, dusting with sifted chalk and rubbing with pumice. Similar methods must have been employed from the first.

The comparatively large number of ancient and mediaeval mss. that have survived enables us to gather some knowledge of the varieties of the material in different periods and in different countries. We know from references in Roman authors that parchment or vellum was entering into competition with papyrus as a writing material as early as the 2nd century A.D. (*see* ILLUMINATED MANUSCRIPTS), though at that time it was probably not so skilfully prepared as to be a dangerous rival. But the surviving examples of the 3rd and 4th centuries show that a rapid improvement must almost at once have been effected, for the vellum of that age is generally of a thin and delicate texture, firm and crisp, smooth and glossy. There was always a difference in colour between the surface of the skin from which the hair had been re-

moved and the surface next to the flesh of the animal, the latter being whiter than the other. This difference is generally more noticeable in the older examples, those of a later period having usually been treated more thoroughly with chalk and pumice. To obviate any unsightly contrast, it was customary, when making up the quires for a volume, to lay hairside next to hairside and fleshside to fleshside, so that, at whatever place the codex was opened, the tint of the open pages should be uniform.

As a rule, the vellum of early mss., down to and including the 6th century, is of good quality and well prepared. After this, the demand increasing, a greater amount of inferior material came into the market. The manufacture necessarily varied in different countries. In Ireland and England the vellum of the early mss. is usually of a stouter quality than that of foreign examples. In Italy and Greece and in the European countries generally bordering on the Mediterranean, a highly polished surface came into favour in the middle ages, with the ill effect that the hardness of the material resisted absorption, and that there was always a tendency for ink and paint to flake off. On the other hand, in western Europe a soft pliant vellum was in vogue for the better classes of mss., from the 12th century onward. In the Italian Renaissance a material of extreme whiteness was affected.

Examples of uterine vellum, prepared from stillborn or newly-born young, are met with in choice volumes. A remarkable instance of a codex composed of this delicate substance is the Additional ms. 23935, of the 13th and 14th centuries, in the British Museum, which is made up of as many as 579 leaves, without being a volume of abnormal bulk.

In conclusion, we must briefly notice the employment of vellum of a sumptuous character to add splendour to specially choice codices of the early middle ages. The art of dyeing the material with a rich purple colour was practised both in Constantinople and in Rome; and, at least as far back as the 3rd century, mss., generally of the Scriptures, were produced written in silver and gold on the precious stained vellum; a useless luxury, denounced by St. Jerome in a well-known passage in his preface to the Book of Job. A certain number of early examples still survive, in a more or less perfect condition: such as the mss. of the Gospels in the Old Latin version at Verona of the 4th or 5th century; the celebrated codex of Genesis in the Imperial Library at Vienna; the Rossano ms. and the Patmos ms. of the Gospels in Greek; the Gothic Gospels of Ulfilas at Uppsala, and others of the 6th century, besides a few somewhat later specimens. In the revival of learning under Charlemagne a further encouragement was given to the production of such codices; but soon afterward the art of purple-staining appears to have been lost or abandoned. A last trace of it is found in a few instances of stained vellum leaves inserted for ornament in mss. of the period of the Renaissance.

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PARDO BAZÁN, EMILIA (1851–1921), Spanish author, was born at Corunna. Her first novel, *Pascual López* (1879), was a simple exercise in fantasy of no remarkable promise; it was followed by a more striking story, *Un Viaje de novios* (1881), in which a discreet attempt was made to introduce into Spain the methods of French realism. The sensation caused by this book among the literary cliques was increased by the appearance of another naturalistic tale, La *Tribuna* (1885), wherein the influence of Zola is unmistakable. Meanwhile, the writer's reply to her critics was issued under the title of La *Cuestidn palpitante* (1883), a clever piece of rhetoric, but of no special value in regard to criticism or dialectics. Probably the best of Emilia Pardo Bazán's work is embodied in *Los Pazos de Ulloa* (1886), the painfully exact history of a decadent aristocratic family, as notable for its portraits of types like Nucha and Julian as for its creation of characters like those of the political bravos, Barbacana and Trampeta. Yet perhaps its most abiding merit lies in its pictures of country life, its poetic realization of Galician scenery set down in an elaborate, highly-coloured style, which, if not always academically correct, is invariably effective. A sequel, with the significant title of *La Madre naturaleza* (1887), marks a further advance in the path of naturalism, and henceforward Emilia Pardo Bazán was universally recognized as one of the chiefs of the new naturalistic movement in Spain. The title was confirmed by the publication of *Insolación* and *Morriña,* both issued in 1889. In this year her reputation as a novelist reached its highest point. Her later stories, *La Cristiana* (1890), *Cuentos de amor* (1894), *Arco Iris* (1895), *Misterio* (1903), *La Quimera* (1905), *Dulce Dueño* (1911), and *Cuentos de la Tierra* (1922), though not wanting in charm, awakened less interest.

PARDON, the release of guilt or the remission of punishment by an authoritative body. In criminal law the power of pardon is generally exercised by the chief executive officer of the state. So in England pardons are granted by the crown, in the United States by the president and in the states of the U.S. by the governors. They may be granted also, however, by the legislature and this is not uncommon in the form of an act of indemnity, a form of anticipatory pardon for acts done in the public interest that might be illegal and the subject of prosecution.

In England the pardon was formerly made under the great seal, but now a sign manual warrant countersigned by a principal secretary of state is effective. In practice the crown acts on the advice of the home secretary with respect to England and Wales and on the advice of the secretary of state for Scotland with respect to that country. The power to pardon is usually delegated in the commonwealth to governors general and colonial governors. As a result of the 17th-century struggle between crown and parliament, the crown is by statute deprived of its power to pardon for the offense of sending a subject to prison outside the kingdom and in the case of an impeachment by parliament (3 Charles II, ch. 2 and 12, and 13 William III, ch. 2).

A pardon may be full or conditional. It is conditional when its effectiveness depends on the fulfillment of a condition by the offender, usually the serving of a lesser substituted punishment, as in the commutation of the death sentence. The effect of a full pardon, where the punishment is unconditionally remitted, is unclear in some jurisdictions and has given rise to difficulties. In England it is said that the effect of a full pardon is to clear the person from all infamy and to remove all disqualifications and other obloquy attending on a conviction. So it has been held that a pardoned person may maintain an action for defamation against anyone who thereafter refers to him as a convict. In the United States the matter is much less clear in spite of a pronouncement by the supreme court that a pardon blots out guilt and makes the offender "as innocent as if he had never committed the offense" (Ex *Parte Garland 4* Wall. 333,380 [1866]).

Some states have held that a pardon does not remove the disqualification from office resulting from a conviction and that the pardoned offender may still be refused a licence to engage in a business or profession. In 1941 a New York court held that a pardoned conviction may count as a previous offense for the purpose of sentencing the offender under a habitual criminal statute *(People ex rel. Prisament* v. *Brophy* 287 N.Y. 132). Other states (Iowa, Massachusetts, New Hampshire, Rhode Island and Utah) provide expressly against this. The difficulty stems from the lack of any differentiation between pardons granted for reasons of clemency and those granted from a belief in the accused's innocence. New York attempted to solve this dilemma by providing that where a governor's pardon is based on a finding of innocence the court must upon motion set aside the judgment of conviction (New York Laws 1946, c. 60), but this solution presents the constitutional difficulty of being construed as executive interference with the independence of the courts.

Another problem is presented by the question of compensating the person who has served all or part of his sentence and is then pardoned on the ground of innocence. In England there is no right of compensation, though a small *ex gratia* payment is commonly made. In the United States the federal jurisdiction gives a right of suit in the court of claims for compensation up to a maximum of $5.000. California. North Dakota and Wisconsin give similar rights with similar ceilings. New York is the only state

that gives a right of compensation without a fixed maximum. No other state offers any right of compensation, and in such states a special statute would be necessary in each case to give redress. Continental European and Latin-American countries generally have detailed statutory provisions governing the law of pardon and providing for compensation in proper cases.

The granting of a pardon is a matter between the offender and the state and has no adverse effect on any civil actions that might be brought against the one pardoned. *See* also PROBATION.

See D. Weihofen, "The Effect of a Pardon," *University of Pennsylvania Law Review,* 88:177 (1939); R. C. Donnelly, "Unconvicting the Innocent," *Vanderbilt Law Review,* 6:20 (1932). (G. B. J. H.)

PARÉ, AMBROISE (1510–1590). French surgeon, ranked by the medical historian F. H. Garrison as one of the three (with John Hunter and Lord Lister) greatest surgeons of all time. is noted for his contributions to surgery in general, to military surgery and to the aseptic care of wounds. He was born at Laval in 1510, and, as a rustic barber's apprentice, went to Paris in 1529 at the age of 19 to work at the Hôtel Dieu, probably the world's oldest hospital. His lack of scholarly training forced him to write in his native tongue, rather than in Latin, and thus he was ridiculed by his more educated but less practically schooled confrères. The campaigns in Italy from 1.536 to 1545 gave him a great experience in military surgery and led to the classic *La Méthode de trnicter les playes fuetes par les arquebuses et aultres bastons à feu* (Paris, 1545 and 1552). He became surgeon to Henry II, Francis II, Charles IX (who is said to have protected him, a Huguenot, during the Massacre of St. Bartholemew by hiding him in his bedchamber) and also to Henry III.

Much of surgery in the day of Paré was wound surgery, and much of that was war wound surgery. While use of the ligature in tying arteries for the control of hemorrhage had been introduced earlier, it was Paré who first put his technique on a firm. systematic and practical basis. This contribution. hen-ever, is overshadowed by his disruption of the false doctrine of Renaissance surgery that gunshot wounds because of their supposedly poisonous nature should be routinely cauterized with boiling oil. It is said that one night in camp. Paré's supply of burning oil gave out and that he was quick to notice that the wounds treated without the oil did better than those treated with it.

The statement of Paré most often quoted is his reply when he was congratulated on the outcome of a successful case: "Je *le pansay, Dieu le guarit" ("I* treated him. God cured him"). This is inscribed on his statue and reflects the humility of one who. although of humble origin, attained the position of the greatest surgeon of his day. "nor yet lost the common touch." He died at Paris on Dec. 20, 1590.

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(H. N. Hs.)

PAREJA, JUAN DE (called EL ESCLAVO) (*c.* 1605–*c.* 1670), Spanish painter, native of Seville, was a mulatto. The legend that he was Velázquez' slave has been discredited by a letter from Seville dated May 12, 1630. asking permission to go to Madrid to continue his studies as a painter with his brother. Later, he probably became Velázquez' assistant and accompanied him on his second visit to Italy (1649–51), where Velázquez painted his portrait (Longford castle, Wiltshire), said to have been exhibited in the Pantheon to the admiration of all the painters in Rome. According to early writers. Pareja painted portraits in the manner of Velázquez, but his only known portrait. of José Rates (private collection. Granada), is a crude reflection of Velázquez' style. From other works, Pareja appears to have been a mediocre follower of the Madrid school. The "Calling of St. Matthew" (1661; Prado museum, Madrid) contains a self-portrait based on the portrait by Velázquez that made Pareja famous. (E Hs.)

PARENT, SIMON NAPOLEON (1855–1920), Canadian politician. son of Simon Polycarpe Parent, merchant. was born in the village of Beauport. in the province of Quebec, on Sept. 12, 1855. He was educated at Laval university, where he graduated in 1881. In the same year he was called to the bar of the province of Quebec.

Parent was mayor of Quebec from 1894 to 1906. From the year 1890 to 1905 he represented the county of Saint-Sauveur as a Liberal in the Quebec assembly, and was minister of lands in the Marchand administration of 1897. He was prime minister of Quebec from 1900 to 1905, when he became chairman of the Transcontinental railway of Canada.

Parent died in Sept. 1920.

PARENT EDUCATION, a voluntary co-operative effort on the part of parents studying under qualified leadership to increase their understanding of child growth and development, of parent-child relationships, of family life and of family-community relationships, and to improve their ability to perform their parts in these relationships with confidence and satisfaction. (Definition issued in 1934 by the United States office of education.) Included also is the field of parent-teacher, or home and school, reiationship.

THE UNITED STATES

Parent education was an early outgrowth of the adult education movement. It came about as parents in an increasingly complex and rapidly changing society felt the need for greater knowledge and understanding to help them in the wise guidance of their children. Moreover, the increasingly early age at which a child entered school—a situation in part created by the introduction of the kindergarten late in the 19th century—pointed up the need of co-operation between parents and teachers in child guidance and instruction.

The scattered pioneer parent education groups of the 1890s multiplied over and over in nation-wide programs. and it would be impossible to list here all of the institutions and organizations engaged in this activity at mid-20th century.

The largest of these organizations is the Xational Congress of Parents and Teachers, founded in 1897 as the Bational Congress of Mothers and broadened in 1908 to include teachers. In the early 1950s its membership had reached nearly 8,000,000 parents, teachers and other citizens organized in about 38,000 local associations throughout the U.S. Its purposes are to promote the welfare of children! to raise the standards of home life, to secure laws for care and protection of children and youth, to bring the home and the school into closer relationship and to develop plans for joint action along these lines by educators and the general public. Activities included participation in joint meetings with the American Association of School Administrators and other organizations. Publications which may be mentioned are *National Parent Teacher: The P.T.A. Magazine; Xational Congress Bulletin;* and *A Reading Guide for Parents.* In 1949 the congress undertook a five year nation-wide expanded parent education program in which five part-time professional consultants helped the various state congresses develop training programs for lay leaders of study-discussion groups.

The Child Study Association of America, organized in 1888, is devoted primarily to parent education through annual conferences, study groups, its magazine *Child Study* and other publications. The American Association of University Women promotes study programs for parents with materials for various periods and phases of child development. Numerous private and public organizations and agencies also sponsor or conduct a great variety of programs, through study-discussion groups, conferences, lectures, televised and radio talks for parent "listening groups," film forums and published materials.

Outstanding work has for years been carried on in many universities and colleges. Universities with special institutes devoted to research in child development or child welfare, with nursery schools or with extension services to parents provide extensive programs in parent education.

Government agencies—federal, state and occasionally municipal—played important roles in the parent education movement. Out-

standing among these were the U.S. office of education, the U.S. children's bureau, the U.S. bureau of human nutrition and home economics and the U.S. department of agriculture. Among the states, much of this work is carried on through state departments of education and by agricultural or farm bureaus which reach parents in rural areas. Federal and state health departments, especially through their mental health services, often conduct extensive parent education programs.

Professional leaders in parent education are for the most part recruited from diverse disciplines and fields—primarily from child development and welfare. education, psychology, home economics, social work. mental health, pediatrics and psychiatry. Lay leaders may or may not have had any formal type of training. The National Council of Parent Education. established about 1924 with a grant from the Laura Spelman Rockefeller memorial and now called the National Committee for Parent Education, represented an effort to consolidate the scattered efforts of professional workers in this field.

A special Parent Education project, designed "to help parents create for their children the kind of environment conducive to the development of mature, responsible citizens, able to build. to function in, and to maintain a free, democratic society." was set up at the University of Chicago in 1953 with a grant from the Fund for Adult Education established by the Ford foundation. This was another indication of the growing recognition of parent education as an important area of the vast field of adult education.

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(EL. K.; X.)

GREAT BRITAIN

Toward the end of the 19th century Mandell Creighton, bishop of London, could say with some truth that the only part in the educational system assigned to the parent was to be available for prosecution if his child did not attend school regularly. The relationship between school and the home in Great Britain had, however, become much closer by the 1950s. Many parents' associations were established and, during the primary stage especially, teachers began to attach much importance to co-operation with the home. This attitude was not, however, confined to the primary stage. Secondary schools made a prominent feature of open days to which parents are invited. not only to see the pupils' work but also to discuss with the teachers questions affecting their children's welfare. The encouragement of such co-operation became a marked feature of official policy. For example, the first report of the Advisory Council for Education in England, established under the Education act of 1944, devoted a chapter to home and school (School and Life, H.M.S.O. [London, 1947]); the Advisory Council on Education in Scotland included in its report on primary education a chapter on home and school relations (*Primary Education,* H.M.S.O. [Edinburgh. 1946]); and in its pamphlet *Education in Rural Wales* (H.M.S.O. [London, 1949]), the Welsh department of the ministry of education laid special emphasis on the value of good home training, opening its first chapter with the words: "The first school of every child is his home, and his mother is his first. teacher." Those days in the 19th century when the school attendance officer was much in evidence as an official enforcing the law of compulsory school attendance have been left far behind. Few children now go unwillingly to school and although attendance officers still have to deal with a small number of unco-operative parents, they are known as school welfare officers, a title that better describes their duties.

There are many reasons for the improved relationship between school and home. Some credit should be given to pioneers like Charlotte Mason, who, in 1888, founded the Parents' National Educational union, better known as the P.N.E.U.; and to organizations like the Home and School council of Great Britain. But the principal cause has been the development of child study and of teaching methods which focus attention on the individual child. In nursery and infant schools especially, such methods are now usual and teachers in these schools make a practice of enlisting the co-operation of parents. During the early years of school life it is natural for the relations between school and home to be particularly close, but this co-operation is tending more and more to continue throughout the primary stage and. in a varying degree, during the secondary stage. There has been much emphasis upon the education of the "whole child" and, when this view prevails, the relationship of home and school, both influencing the growth of the child's personality, assumes much importance. The smooth working of home and school relations inevitably makes certain demands on both parent and teacher. and depends to some extent on mutual respect and the recognition by each of the rights and duties of the other. Parents' visits to the school are becoming more frequent and there are also various formal arrangements designed to encourage co-operation between home and school; many nursery and infant schools have mothers' clubs and a usual feature in both primary and secondary schools is a parents' guild or parent-teacher association, an organization that has long been customary in the United States. There are more than 2,000 parent-teacher associations in England. Further evidence of parental interest is the increasing attention given by the press and the British Broadcasting corporation to problems of child upbringing.

See J. H. Newsom, The Child at School (1950); M. and F. K. Lawrence, How to Help Your Child in School (1950); C. W. Valentine, Parents and Children (1953); H. C. A. Gaunt, School: a Book for Parents (1953).

(W. O. L. S.; X.)

PARENTS AND TEACHERS, NATIONAL CONGRESS OF, commonly knonn as the P.T.A., was founded on Feb. 17, 1897, as the National Congress of Mothers. Later broadened to include both parents and teachers, the organization by 1936 had attracted to its ranks about 2,000,000 adults. Ten years later the membership was nearly doubled, and by 1960 more than 11,500,000 individuals were organized in more than 45,000 local P.T.A. organizations.

With the general objective of uniting "the forces of home, school and community in behalf of children and youth," the P.T.A. carried on programs in many fields of endeavour, such as parent education, health, juvenile protection, music, art, safety, mental hygiene and recreation. The P.T.A. also advocated enactment of measures to provide federal aid to education.

A major P.T.A. project in many communities was the sponsoring of school lunches.

Publications include *National* Parent Teacher: The P.T.A. *Magazine; National Congress* Bulletin; National Congress *Proceedings* (annual) and other publications of special interest to members.

Legislation **Program.**—The legislation program of the P.T.A. as adopted in Sept. 1952 by the National Board of Managers was, in part, as follows:

Federal Aid for *Education.*—"The federal government should appropriate funds to supplement those raised by local and state governments to provide adequate educational opportunities for all children and youth. . . . Such funds should go to publicly controlled. tax-supported schools only . . . with provisions ensuring . . . minimum federal and maximum local control and encouragement to the states to put forth their best efforts to equalize educational opportunities within their own boundaries."

Child Care Centers.—"Child care centers should be made available to children of employed mothers; adequately staffed and supervised by appropriate agencies; and jointly financed by public funds and parents' fees or by funds from public or private agencies."

Surplus Materials.—"Educational, medical and recreational materials and supplies purchased but no longer used by the armed forces should be released to the proper public, agencies . . . for use in developing programs of education, health and recreation throughout the United States."

Library Service.—"Public library service should be extended to all people on an equitable basis with special emphasis on needs in rural areas . . ."

Merit System.—"Child welfare services should be administered

by persons qualified to do so. Accordingly we support the extension of the merit system for public employees."

Child Labour.—"Federal legislation should give necessary protection to child workers, with special emphasis on the establishment of (a) a basic minimum age of sixteen for employment; (b) a higher minimum age for employment in hazardous occupations; and (c) a minimum wage provision for minors."

See also PARENT EDUCATION: *United States.*

PARESIS, GENERAL (DEMENTIA PARALYTICA, GENERAL PARESIS OF THE INSANE or SYPHILITIC MENINGOENCEPHALITIS), is an organic disease of the brain produced by *Treponema pallidum,* the causative agent of syphilis (*see* VENEREAL DISEASES). This organism destroys or seriously disturbs the function of the cerebral cortex and ultimately produces a general dissolution of mental and physical capacities. The disease is of historical importance because it is one of the first mental disorders for which a definite pathology was established.

General paresis was first described in 1798 and, until the advent of penicillin therapy for primary syphilis, accounted for 10% of first admissions to hospitals for mental disease. Penicillin caused it to become a rarity. The symptoms of general paresis usually appear 5 to 20 years after infection with syphilis. It occurs about five times more frequently in the male than in the female and is commoner in white persons than in Negroes. The onset is usually in the fourth to sixth decades of life, but in patients with congenital syphilis it may be in the early or late teens. The disease practically never develops in a patient who receives adequate treatment of the primary syphilitic infection.

The pathological changes are concentrated in the frontal lobes of the cerebral hemispheres. In the initial stage there is an inflammatory reaction. soon followed by degeneration of the nerve cells and proliferation of the supportive glial cells. Spirochetes are present in the brains of untreated patients.

The presenting symptoms are usually mental, with changes in the personality. irritability. fatigability and a mild degree of impairment of the intellectual faculties. The course of the disease, if untreated, is punctuated by psychotic episodes, convulsive seizures and transient paralyses. In the final stage there is complete dementia and paralysis of all extremities. Death usually occurs within five years of the onset of the symptoms.

The diagnosis of general paresis is considered when mental symptoms or convulsive seizures develop in a young or middle-aged adult, particularly if there is a history of a previous infection with syphilis. The diagnosis is established by examination of the cerebrospinal fluid, characteristic changes in which include an excess of cells, an increase in the protein content and a positive serological test for syphilis.

Former methods of treatment with arsenicals and artificially induced fever have been replaced by penicillin. Penicillin is injected intramuscularly in daily doses for a period of three to four weeks. With this therapy the disease can be arrested in practically all cases, and the patient restored to his premorbid physical and mental state. if the treatment is instituted before there is an extensive degree of damage to the brain. (H. H. M.)

PARETO, VILFREDO (1848–1923), Italian economist and sociologist, was born on July 15, 1848, in Paris, where his father, a Genoese nobleman and member of Mazzini's party, had been obliged to emigrate because of his revolutionary activities. The Paretos returned to Italy in 1858 under the political amnesty of that year. After his graduation from the University of Turin, Pareto became an engineer and later a director of the *Ferrovie Italiane.* Residing in Florence, he found time and inspiration not only to write many valuable periodical articles on economic subjects; applying therein his mathematical training: but also to study classics, philosophy and politics and thus equip himself to deal critically with sociological and humanitarian questions. Chosen to succeed Leon Walras (*q.v.*) in the chair of the political economy at Lausanne in 1893. Pareto carried on Walras's now famous mathematical approach to political economy, sharpening the latter's exposition. introducing concrete matter, distinguishing the role of abstract reasoning from that of empirical inquiry, and building economic systems upon monopolistic and collectivist as well as upon competitive assumptions.

I'areto's first work, *Cours d'Économie Politique* (1896–97), included. besides its sometimes original mathematical formulation of economic principles, Pareto's famous but much-criticized lam of income distribution. In his compact *Manuale d'e'conomia politic<* (1906), with its splendid mathematical appendix, he further developed his pure theory of economics and his analysis of ophelimity (power to give satisfaction); he also introduced "curves of indifference." analytical instruments that did not become popular until the 1930s. In 1911 he contributed a concise "Economie Mathematique" lo the *Encyclopédie des Sciences Mathématique.*

Realizing that there existed many concrete problems that could not be solved by economics, since it dealt only nith logical, want-satisfying action, Pareto turned to sociology, publishing in 1916 what he considered his greatest work, *Trattato di Sociologia generale.* Herein are developed ideas foreshadowed in his economic writings, in his critique of socialism, *Les systemes socialistes* (1902–03), and in *Le Myte vertuiste et la littérature immorale* (1911);—ideas that appear also in *Fatti e teorie* (1920) and *Trasformazioni della dsmocrazia* (1921). In the *Trattato* he inquired into the nature and bases of individual and social action, the methodology of economics and sociology, and the degree to which physical-science methods are applicable in the study of man's behaviour. He distinguished ideal or social ends from the individual wants of economics, thereby contributing importantly to the analysis of "welfare." He also developed a cyclical theory of social change to explain what was happening and a sociological case for protectionism. Pareto died in Geneva on Aug. 20, 1923.

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PARGA, a seaport of southern Epirus, in Greece, on the Ionian sea. Parga has a rock-built citadel and a harbour formed by a mole which the Venetians constructed in 1572. It is perhaps the site of the ancient Toryne, a short distance to the west; Parga was moved to its present position after the Turkish invasion in the 15th century. Under Venetian protection, freely accepted in 1401, the inhabitants maintained their municipal independence and commercial prosperity down to the destruction of the Venetian republic in 1797. though on two occasions, in 1500 and 1560, their city was burned by the Turks. The attempts of Ali Pasha of Iannina to make himself master of the place were thwarted partly by the presence of a French garrison in the citadel and partly by the heroic attitude of the Pargiotes themselves, who were anxious to have their city incorporated with the Ionian republic. To secure their purpose they in 1814 expelled the French garrison and accepted British protection; but the British government in 1815 determined to go back to the convention of 1800 by which Parga was to be surrendered to Turkey. though no mosque was to be built or Moslem to settle within its territory. Rather than subject themselves to the tyranny of Ali Pasha. most of the Pargiotes, migrated to the Ionian islands in 1819. The town was largely rebuilt after that date.

PARHELION (MOCK SUN), a spot on a solar halo reflected at various angles near the sun. The most brilliant are situated at the intersections of the inner halo and the parhelic circle, and are particularly brilliant when the sun is setting. They are caused by refraction through a pair of alternate faces of a vertical prism. When the sun is on the horizon the rays fall from the principal section of the prisms and the parhelia are therefore not only on the inner halo but also on the parhelic circle. The different values of the angle of minimum deviation for differently coloured rays give rise to most effective colourings. *See* HALO.

PARIA, GULF OF, an inlet of the Atlantic ocean between the Venezuelan mainland and the western coast of Trinidad. It is separated from the Atlantic by the southwestern peninsula of Trinidad and the large delta of the Orinoco river and from the Caribbean sea by the long, mountainous Paria peninsula of Venezuela. It is about 100 mi. east-west and about 40 mi. north-south. Entrance is made from the Atlantic through a 10-mi.-wide strait, Serpent's Mouth, and from the Caribbean through a 10-mi.-wide,

island-strewn strait, Dragon's Mouth. The gulf is used for shipping petroleum (Venezuela, Trinidad), iron ore (Venezuela), bauxite and general cargo. Port-of-Spain, Trinidad, is the chief city. (D. R. D.)

PARIAH, in western usage the name for the outcastes of India, but many castes rank below them. The term *paraiyan* probably means "drummer" but became almost generic and the caste was split up into a number of subcastes pursuing many humble avocations. As a caste their touch pollutes men of high caste, yet they belong to the right-hand faction and their priests actually wear the sacred thread. The Paraiyans appear to have been either a pre-Dravidian group or a caste depressed in Dravidian times. Official abolishment of caste and educational measures helped this and other lower castes. *See* CASTE (INDIAN): UNTOUCHABLES.

PARIAH DOG, a dog of a domesticated breed that has reverted, in a greater or less degree, to a half-wild condition. Troops of such dngs have been found in eastern Europe. Asia and Africa. They probably interbreed with wolves and jackals.

PARIAN CHRONICLE, a marble tablet found in the Island of Paros in 1627, now among the Arundel marbles at Oxford. It originally embraced an outline of Greek history from the reign of Cecrops, legendary king of Athens, down to the archonship of Diognetus at Athens (264 B.C.). The author of the chronicle recorded the dates of the establishment of festivals, of the introduction of various kinds of poetry, the births and deaths of the poets, and their victories in contests of poetical skill. Important political and military events are often omitted. The chronicle consists of 93 lines in the Attic dialect.

PARIMA, SIERRA (Port. SERRA PARIMA) is the tabular upland that surmounts the Guiana highlands (*q.v.*) along the border between Brazil and Venezuela. It runs for approximately 200 mi. N.N.W. to S.S.E. along the divide between the headwaters of the Rio Branco and the head of the Orinoco (*q.v.*). At its northern end it connects with the Serra Pacaraima (*q.v.*), which it resembles in surface form and geologic structure. Its height is about 5,000 ft. The region is explored only along the international boundary. (P. E. J.)

PARINI, GIUSEPPE (1729–1799), Italian poet and moralist, esteemed as "the Pope or the Boileau of Italy," was born at Bosisio, in Brianza, on May 22 or 23, 1729, the son of a silk trader. As a boy he was sent to Milan and educated by the Barnabites (1740–52). *Alcune poesie di Ripano Eupilino* (1752) secured his admittance to intellectual circles. He entered the Accademia dei Trasformati (1753), took holy orders (1754) and became a tutor in the household of Duke Gabrio Serbelloni (1754–62). In 1768 Parini edited the *Gazzetta di Milano;* then, for about 30 years, he taught the humanities in the Palatine schools and the Brera *ginnasio*. After the creation of the Cisalpine republic (1796) he worked for three unhappy years in the municipality.

Parini is best known for *Il Giorno,* a satire in four parts—*Mattino* (1763), *Mezzogiorno* (1765), *Vespro* and *Notte* (1801)—in which, with exquisite irony, he presents a day in the life of a dissolute young nobleman and reveals the superficiality and profligacy of the life of fashion. The *Odi* (1757–95), about 20 in number, deal with civil, social and personal themes, and are among the classics of Italian poetry. His other works include *Ascanio in Alba* (1771)—a libretto set by Mozart—and various prose discourses: *Dialogo sopra la nobiltà* (1757) and *I principi delle Belle Lettere* (1801). Parini died at Milan on Aug. 15, 1799.

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PARIS, also called ALEXANDROS ("defender"), son of Priam and Hecuba (*qq.v.*). Before Paris' birth Hecuba dreamed that she gave birth to a firebrand which set fire to Troy, and the dream was interpreted as warning the Trojans about her child. The baby, then, was exposed immediately upon birth. However, a bear nursed it or shepherds found it; Paris was raised as a shepherd, unknown to his parents. As a young man he entered a boxing contest at a Trojan festival, defeated Priam's other sons and his identity became revealed. Priam received him home again.

As shepherd, Paris delivers the "judgment" which forms so popular a theme of ancient art. Rejecting offers of kingly power from Hera and military might from Minerva, he awards the "apple of discord" (*see* ERIS) to Aphrodite. According to her promise, Aphrodite helps Paris win the most beautiful woman alive, seducing Helen. When Paris refuses to restore Helen and the Trojans support him, the Greeks set out for the Trojan War. During the war, Homer assigns Paris a secondary role: a good warrior, but inferior to his brother Hector and to the Greek leaders whom he faces. Symbolically. Menelaus defeats Paris in single combat. but Aphrodite rescues him and the war continues. Hector, the opposite of Paris, an innocent victim of Paris' marital irresponsibility, must return to Troy, urge his brother to leave Helen and fight.

Near the end of the war, Paris shoots the arrow which, by Apollo's help, hits a vulnerable spot and causes Achilles' death. Paris himself, soon after, receives a fatal wound from Philoctetes' arrow. A later story tells how Oenone, once the beloved of Paris, and abandoned for Helen, could have cured the wound but refused. Paris died and Oenone killed herself. (WM. S. A.)

PARIS, ALEXIS PAULIN (1800–1881), French scholar, was born at Avenay (Marne) on March 25, 1800. He published in 1824 an *Apologie pour l'dcole romantique* and took an active part in Parisian journalism. His appointment in 1828 to the department of manuscripts in the Bibliothilque Royale left him leisure to pursue his studies in medieval French literature. Paulin Paris lived before minute methods of research had been generally applied to modern literature, and his chief merit is that by his numerous editions of early French poems he continued the work begun by Dominique Méon in arousing general interest in the then little-known epics of chivalry. Admitted to the Académie des Inscriptions et Belles Lettres in 1837, he was shortly afterward appointed to the commission entrusted with the continuation of the *Histoire litteraire de la France.* In 1853 a chair of medieval literature was founded at the Collilge de France and Paulin Paris became the first occupant. He retired in 1872 with the title of honorary professor. He died at Paris on Feb. 13, 1881.

PARIS, (BRUNO PAULIN) GASTON (1839–1903), French scholar, one of the founders of the modern science of philology, was born at Avenay (Marne), Aug. 9, 1839. Educated at Bonn (1856–57), Gottingen (1857–58) and the École des Chartres (1858–61), he specialized in language and medieval literature. He was appointed to the Bcole des hautes études (1868) and succeeded his father in the chair of medieval French literature at the Collège de France (1872), becoming director in 1895.

He was elected to the Académie des inscriptions (1876) and to the Académie française (1896). He died at Cannes on March 6, 1903. He helped found and direct the *Revue critique* (1866) and the *Romania* (1872) and made notable contributions to these periodicals, to the *Journal des savants* and to the *Histoire littéraire de la France.* By his high standards, vast erudition and exceptionally retentive mind, he established principles of exact research which won him many disciples and still dominate work in philology and medieval studies.

His numerous writings, listed by J. Bédier and M. Roques in *Bibliographie des travaux de Gaston Paris* (1904), include: *Le rôle de l'accent latin dans la langue française* (1862); *Les plus anciens monuments de la langue française* (1875); *La littérature française au moyen âge* (1888 *et seq.); François Villon* (1901); and *Mélanges linguistiques* (1906–09). (F. I. WE.)

PARIS, LOUIS PHILIPPE ALBERT D'ORLEANS, COMTE DE (1838–1894), son of the duc d'Orléans, the eldest son of King Louis Philippe, was born on Aug. 24, 1838. His mother was the princess Helen of Mecklenburg-Schwerin, a Protestant. By the death of his father in 1842, the count, then four years of age, became heir apparent to the French throne. On the deposition of Louis Philippe in 1848, the duchess took her sons, the comte de Paris and the duc de Chartres, first to Eisenach in Saxony and then to Claremont. In 1861 he and his brother were attached to the staff of General McClellan, commanding the Army of the Potomac. The count fought in the siege of Yorktown (April

1862), at Williamsburg (May 5) and at Gaines Mill (June 27). When difficulties arose between France and the United States with regard to Mexico. the Orléans princes returned to Europe. On May 30, 1864, the count married his cousin, the princess Marie Isabelle. daughter of the duc de Montpensier; and his son and heir, the duc d'Orléans, was born in 1869. He returned to France after the fall of Napoleon III and lived quietly on his estates.

In Aug. 1873, at Frohsdorf, the comte de Paris agreed to waive his claims to the throne in favour of those of the comte de Chambord. By the death of the latter in 1883 the count became undisputed head of the house of Bourbon; but he did not push his claims. The popularity of the Orléans family, however, was shown on the occasion of the marriage of the comte de Paris' eldest daughter with the duke of Braganza, son of the king of Portugal, in May 1886. This led to a new law of expulsion, by which direct claimants to the French throne and their heirs were banished from France (June 11. 1886). The comte de Paris again retired to England, and devoted his leisure to study. In addition to his work *Les Associations ouvrières en Angleterre* (1869, and Eng. trans.), the count edited the letters of his father and published at intervals *Histoire de la guerre civile en Amérique* (8 vol.). In his later years the count compromised the Royalist party by his relations with General Boulanger.

He died on Sept. 8. 1894.

PARIS, MATTHEW (d. 1259), English monk and chronicler, is known only through his voluminous writings, which constitute one of the most important sources of knowledge of European events between 1235 and 1259. He was admitted a monk at St. Albans in the year 1217, and in 1248 he was sent to Norway to reform the Benedictine monastery of St. Benet Holm on the Island of Nidarholm. Apart from this mission and occasional visits to the royal court at Westminster, Winchester and elsewhere, he remained at St. Albans, assiduously recording contemporary events. His *Chronica majora* incorporates Roger Wendover's *Flores historiarum* and continues it from 1235 to 1259. His other chronicles—the *Historia Anglorum,* the *Flores historiarum* (formerly attributed to the fictitious "Matthew of Westminster" and not to be confused with Roger Wendover's work) and the *Abbreviatio chronicorurn—are* all abridged from his *Chronica majora* but contain some additional matter. Matthew also wrote a history of his own house, the *Gesta abbatum monasterii Sancti Albani,* which, like the *Chronica majora,* embodies the work of a predecessor and which he prefaced with the lives of the two King Offas. Autograph manuscripts of all these works survive. Matthew also wrote lives of Saints Alban, Edward the Confessor, Thomas Becket and Edmund Rich, in Anglo-Norman verse, and of Stephen Langton and Edmund Rich, in Latin prose.

As a chronicler, Matthew is noteworthy for his detailed knowledge of events all over Europe; for his use of information obtained from the leading figures of his day, such as Henry III and Earl Richard of Cornwall, both of whom he knew well; for the large number of documents which he included either in his chronicle or in an appendix to it, the *Liber additamentorum;* and for the outspoken expression of his prejudices against, in particular, the king, the foreign favourites at court and the papacy. Matthew's chronicle, however, must be used with caution, for he is frequently careless; he sometimes tampers with the texts of the documents he transcribes, or wilfully misrepresents the facts; and his violent prejudices colour his whole work. It is partly because of this that he gives us a more vivid and readable picture of his age than any other medieval English chronicler. Matthew was also an artist of considerable skill and, besides inserting a number of lively line-and-wash drawings in the margins of his historical manuscripts, he illustrated his Anglo-Norman verse saints' lives. In the history of cartography, his remarkable maps of England and Palestine and his famous illustrated itinerary from London to Apulia have an important place. In addition he is the earliest source for English heraldry: some 130 shields are depicted in his manuscripts, many of them with correct heraldic descriptions.

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PARIS, capital of France and of the Seine *département,* is situated on the Seine river, 233 mi. upstream from the English channel, at lat. 48° 50′ 14″ N. and long. 2° 20′ 14″ E. The city occupies a central position in the rich agricultural country of the Paris basin (*see* FRANCE) and covers approximately 40 sq.mi. Its suburbs and satellite towns (*plus grand Paris)* occupy the whole of the *département,* an area of 147 sq.mi.

The Paris zone has a temperate maritime type of climate with warm summers and not too rigorous winters. Prevailing winds blow from the southwest, but are varied in winter and spring by northeasterly or easterly ones, which bring spells of cold dry weather. The mean temperature is around 50.5° F. Frost occurs roughly on half the nights between December and February, and snow falls about 15 days in the year. Average yearly rainfall is around 21 in.

The immediate topographical characteristics of the city's surroundings exercised an influence on its early development. Near the site of the ancient settlement the plateaus of Beauce, Brie and Valois converged upon the Seine valley. To the south the relief of the hills was moderate (150 to 200 ft.), but these hills approached close t~ the river, a fact which tended t~ hamper the expansion of the city's left bank, though to the west a flood plain did facilitate development. Today, the city area on this bank amounts to slightly more than one-third of the whole. On the right bank a semicircle of heights (reaching about 350 ft.), stretching from the Seine at what is now Charonne, wheeled from east to west through present-day Ménilmontant, Belleville, Montmartre and Chaillot to Passy, to constitute at first the boundary of the river. A change in course, however, created a bordering meander plain, which offered the city a better opportunity for expansion when it began to push out its foothold on the banks. The northern heights are breached on either side of Montmartre and gave at an early time easy communications to the north. (J. D. L.)

HISTORY

Gallic and Roman Periods.—Paris grew up at the intersection of two great natural highways, one of them leading from the Rhine district to the south by way of what became the Rue Saint-Martin on the right bank of the Seine and the Rue Saint-Jacques on the left bank, and the other being the river itself. The land route crossed the Seine at the point where it was most easily forded—the Île de la Cité. Paris thus sprang up on the natural stronghold of the island. It was at first a fortified town of the Gallic tribe of the Parisii. Called Lutetia, it was connected with the two banks of the river by two wooden bridges at the ends of the two highways where the Pont Notre-Dame and the Petit-Pont stand. Caesar describes in his *Commentaries* how it was burned during the Gallic War (52 B.C.).

During the 1st century A.D. Lutetia is mentioned as a Roman town. Its character has now changed. The original island was about half the size of the modern fle de la Cité and was liable to be flooded by the river; it was not a normal site for a town, and could only have been selected for defensive reasons. Under the *pax Romana* Lutetia spread beyond its island to the Montagne Sainte-Genevibve which lay opposite it on the left bank; on the right bank there was only low-lying and uninviting ground, bounded by a semicircle of hills—those of Charonne, Ménilmontant and Belleville to the east, Montmartre in the north and Chaillot to the west. A new Roman city grew up on the northern slopes of the Montagne Sainte-Geneviève, with the straight roads and the public buildings characteristic of all Roman towns—the thermae or public baths,

on the site of Musée de Cluny, the theatre, about where the Boulevard Saint-Michel crosses the Rue Racine, and the arena on the site of the square which now bears that name. The town nas supplied with water by the aqueduct of Arcueil. Lutetia was extended up the hillside and was unfortified; its cemetery was by the side of the Roman road later to become the Rue Saint-Jacques.

Lutetia, then, was not an important city. Administratively, it was subject to Sens. From the 3rd century onward, during the barbarian invasions, it suffered severely from conflagrations. etc. Consequently its inhabitants deserted the left bank and the new districts of the right (Saint-Jacques-de-la-Boucherie and Saint-Gervais), in order to gather again within the limits of the original island. They hemmed the island in with a wall $7\frac{1}{2}$ ft. thick, without any bastion or toner. at a distance of about 30 yd. from the river. Concentrated in this narrow space, the city possessed a few public buildings (probably a temple in the east and a *palatinum* in the west). It remained connected with the two banks by the bridges. At the same period its name was altered: a milestone dated from 307 standing on the way to Reims records Paris instead of Lutetia for the first time.

Christianity reached Paris in the middle of the 3rd century. A 10th-century sacramentary refers to St. Denis as having been the first bishop of the city c. 250 (he was afterward mistaken for Saint Paul's disciple, Dionysius the Areopagite). In very early times a community existed on the banks of the Bièvre, near what is now the Carrefour des Gobelins, where archaeology revealed remains of a graveyard; but it was probably during the episcopate of Saint Marcel, the 9th bishop of Paris (c. 360–436), that Christianity gained a footing in the island and that a humble wooden church was erected there.

THE MIDDLE AGES

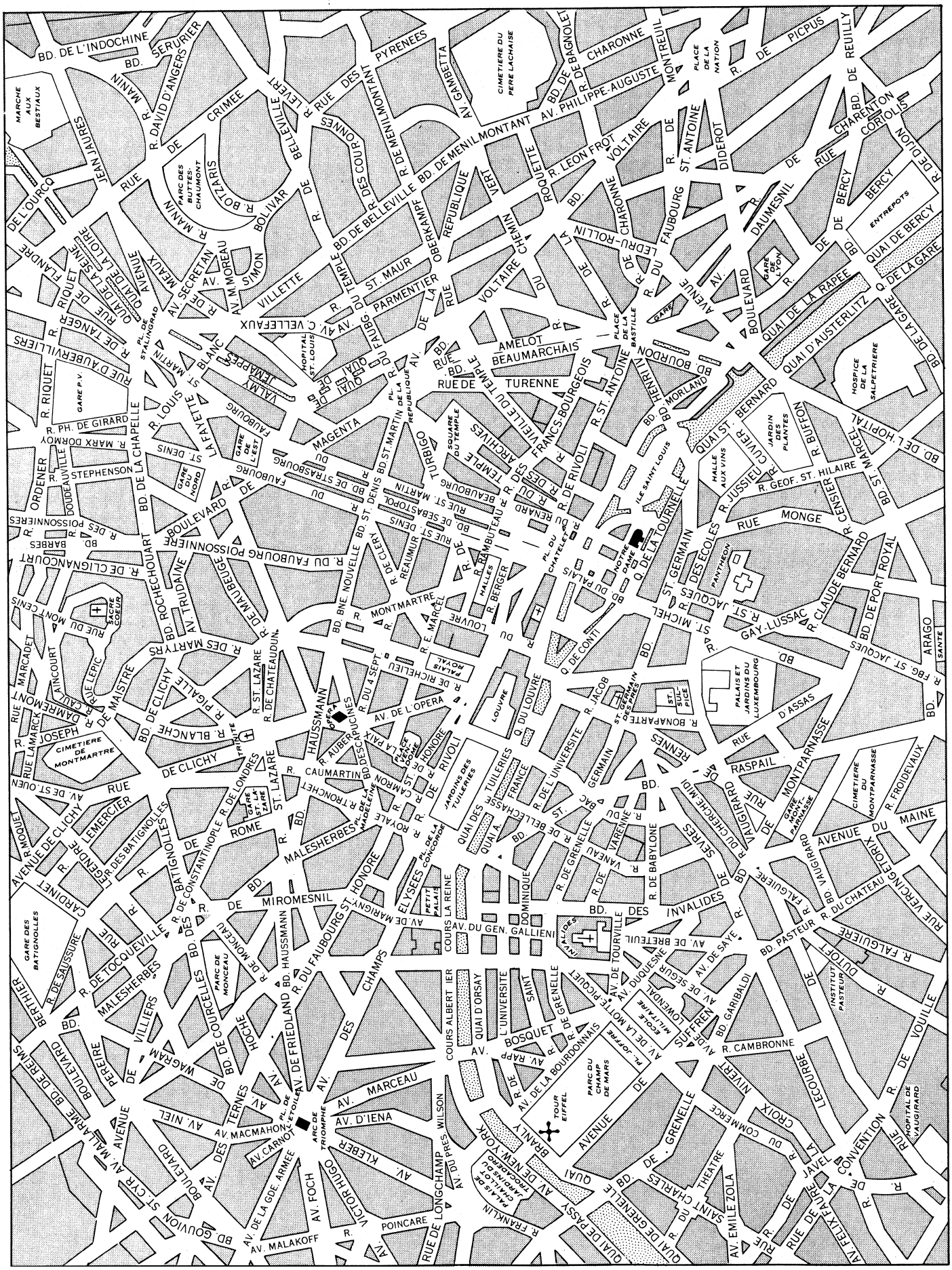
In the 5th century the Franks made themselves masters of Paris; they did not, however, destroy the Roman civilization. but were themselves influenced by its more advanced culture. Under Clovis they became converted to Christianity and thus came doubly under the influence of Rome. By his victory over the Visigoths in A.D. 507, the Frankish leader made himself the ruler of the south of France. He established his capital at Paris in order to bring the seat of his authority nearer to the newly conquered territories. Under Clovis and his Merovingian successors Paris was nothing more than a *castellum:* it was as yet neither a big market town nor an intellectual and commercial centre; and the kings usually resided elsewhere, on their estates of Clichy or of Chelles. However, several of the kings made Paris their capital: Clotaire in 558, Chilperic in 561, Caribert in 567. But the city was. above all, a centre of religious life hallowed by the memory of Saint Genevibve who watched over it at the time of the Hunnish invasions. Thus chapels and churches sprang up, and houses clustered around them amid the vineyards of the left bank and the reeds of the right: for instance the basilica dedicated to the apostles Peter and Paul and later to Saint Geneviève, on the site of what is now the Lycke Henri IV (behind the Panthéon); and the basilica dedicated to Saint Vincent in which Saint Germain, bishop of Paris, was buried (576) and which later became the abbey of Saint-Germain-des-Prks. The village on the banks of the Bièvre developed around the church where Saint Marcel was buried (later the collegiate church of Saint-Marcel). On the right bank stood the churches of Saints-Gervais-et-Protais and Saint-Laurent and, on the low-lying ground to the north: the basilica of Saint-Martin, on the site of which the priory of Saint-Martin-des-Champs was later erected. The old city, however, remained walled-in on the island. Its *palatinum,* formerly the palace of the Roman governors, served as the residence of the Merovingian king. Its cathedral was in the eastern quarter, slightly in front of the present site of Notre-Dame. A maze of bystreets wound through the city, on either side of the chief street, which joined the two bridges. Suburbs connected this centre to the blocks of houses surrounding the churches.

During the Carolingian period Paris once again lost most of its importance. The Holy Roman empire was centred much more to the east, and the royal dynasts moved from Metz to Aachen and from Reims to Cologne. However, to counterbalance the influence of the bishops, the king established counts as his representatives and these counts grew more and more independent.

The Norman invasions made havoc of the city. Mentioned for the first time in 837, the invaders besieged Paris in 885 and 886. Once more the inhabitants deserted the river banks to take shelter on the island, the defenses of which were organized anew. the Grand-Pont being rebuilt slightly farther downstream and fortified with a big tower, the Châtelet. Finally, in 911, by the treaty of Saint-Clair-sur-Epte, the boundary of Norman settlement was fixed at a distance of 20 leagues from its walls. Then, while the Robertian counts were gradually superseding the Carolingian kings. the land around the city was brought under cultivation. There were patches of woods or of swamp but few hamlets: Chaillot. where the woodcutters of the forest of Rouvre lived; Montmartre; and Charonne, where the early kings of Paris bred dogs and hawks for hunting. Paris at this time may be regarded as the juxtaposition of the centres of a number of great domains — principally ecclesiastical domains — and was, in fact, a sort of feudal mosaic. But after the accession of the Capetian dynasty in 987, the feudal suzerain was at the same time the king of the country, and the more the monarchy increased in power and extended its influence over France, the more Paris grew in importance.

Growth. — In the 11th century the channels of human intercourse began to be opened up once more and to exercise their life-giving influence. The population of Paris increased. The close organization of feudalism began to relax. It was at this time that the earliest of the guilds were formed in Paris, among them that of the river traders who plied up and down the Seine. With the growth of commerce during the 11th century there came into being a mercantile quarter near the Porte de Paris, bounded by the latter on the west, Saint-Merri on the north and Saint-Gervais on the east. This mercantile quarter might be regarded as deriving its origin from the intersection of the course of the river and the land route represented by the two streets of the Rue Saint-Martin and the Rue Saint-Denis. In the 12th century it was surrounded by a rampart and contained the market! situated on the Greve, where the Hôtel de Ville stands. Louis VI (1108–37) transferred the market to the site near the Rue Saint-Denis now occupied by the Halles Centrales. The Grand-Pont, on which the money-changers had their shops, became the Pont-au-Change in 1142.

Paris then began to grow rapidly. A parish was formed near the priory of Saint-Martin-des-Champs: about 1080 the priory church was also the parish church, but early in the following century the functions of parish church were transferred to the neighbouring chapel of Saint-Nicolas-des-Champs. The road to Saint-Denis, of which the street of that name forms part, increased in importance; from early in the 12th century the Lendit fair was held along this road. between Saint-Denis and Paris. The Paris leper hospital. which bore the name of Saint-Lazare, was on this road; its existence is first mentioned in 1122. It occupied the site of the modern prison of the same name. Farther to the south the church of the Innocents, which was built about 1150, and the abbey of Saint-Magloire, founded at about the same period, bear witness to the increasing population in the neighbourhood of Louis VI's new market. To the east, a new centre of activity was created toward the end of the 12th century by the foundation of the temple, south of the site now occupied by the Place de la République. The Couture du Temple is mentioned in 1184, and the Ville Neuve du Temple came into existence in the following century. The church of Saint-Paul. near the corner of the street of that name and the Rue Saint-Antoine, is first mentioned in 1136, and the township (bourg) of Saint-Paul came into being in the next century. Rural settlements gathered around the churches and abbeys. The small village of La Villette-Saint-Ladre, for example, grew up in the second half of the 12th century on the land of the Paris leper hospital. This is the origin of the modern district of La Villette. About the middle of the century the land which lies beyond where the chief boulevards are today and almost as far as Chaillot, which had been used as public pasturage, was brought under cultivation and formed the beginning of the ring


BD. DE L'INDOCHINE
MARCHE AUX BESTIAUX
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R. DAVID D'ANGERS
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AV. SECRETAN
AV. M. MOREAU
SIMON BOLIVAR
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AV. GAMBETTA
CIMETIERE DU PERE LACHAISE
BD. DE BAGNOLET
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AV. PHILIPPE-AUGUSTE
MONTREUIL
PLACE DE LA NATION
R. DE PICPUS
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REPUBLIQUE
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ROQUETTE
R. LEON FROT
VOLTAIRE
R. DE ST. ANTOINE
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CHARENTON
CORIOLIS
DE BERCY
BERCY
ENTREPOTS
QUAI DE BERCY
R. DE CHARONNE
R. DU FAUBOURG
LEDRU-ROLLIN
BD. DE LA
DAUMESNIL
AVENUE
GARE DE LYON
BOULEVARD
QUAI DE LA RAPEE
QUAI D'AUSTERLITZ
Q. DE LA GARE
BD. DE CLAYE
HOSPICE DE LA SALPETRIERE
PL. DE STALINGRAD
R. RIQUET
R. DE TANGER
RUE D'AUBERVILLIERS
GARE P.L.M.
R. PH. DE GIRARD
R. MARX DORMOY
R. STEPHENSON
DOUDEAUVILLE
ORDENER
R. DES POISSONNIERS
BD. DE LA CHAPELLE
R. LOUIS BLANC
ST. MARTIN
R. LA FAYETTE
GARE DU NORD
GARE DE L'EST
ST. DENIS
TAUBOURG
JEMMAPES
VALMY
QUAI DE JEMMAPES
HOPITAL ST. LOUIS
AV. C. VELLEFAUX
R. DU FAUBG. DU TEMPLE
PARMENTIER
DE LA RUE
VOLTAIRE
CHEMIN
DU
PL. DE LA REPUBLIQUE
AV.
BD.
RUE DE TURENNE
AMELOT
BEAUMARCHAIS
PLACE DE LA BASTILLE
GARE
AVENUE
BD. BOURDON
HENRI IV
R. ST. ANTOINE
FRANCS-BOURGEOIS
R. DE RIVOLI
BD. MORLAND
QUAI ST. BERNARD
JARDIN DES PLANTES
R. BUFFON
BD. DE L'HOPITAL
BD. ST. MARCEL
CUVIER
R. JUSSIEU
HALLE AUX VINS
R. GEOF. ST. HILAIRE
CENSIER
RUE MONGE
R. DES ECOLES
ST. GERMAIN
Q. DE LA TOURNELLE
ILE SAINT LOUIS
PONT DE LA TOURNELLE
MAGENTA
DU FAUBOURG
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R. DU FAUBOURG POISSONNIERE
BD. DE CLIGNANCOURT
BD. BARBES
R. DES MARTYRS
AV. TRUDAINE
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R. DAMREMONT
RUE JOSEPH
RUE LAMARCK
CIMETIERE DE MONTMARTRE
AV. DE ST. OUEN
R. DE MAISTRE
BD. DE CLICHY
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R. BLANCHE
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R. ST. LAZARE
R. DE CHATEAUDUN
R. DE CLICHY
R. DE LONDRES
GARE ST. LAZARE
R. CAUMARTIN
HAUSSMANN
R. AUBER
OPERA
R. DU 4 SEPT.
AV. DE L'OPERA
PALAIS ROYAL
R. DE RICHELIEU
R. MONTMARTRE
R. E. MARCEL
LOUVRE
R. BERGER
HALLES
R. DE RAMBUTEAU
PL. DU CHATELET
PONT NOTRE DAME
Q. DE CONTI
BD.
Q. DU LOUVRE
R. JACOB
ST. GERMAIN DES PRES
ST. SULPICE
R. BONAPARTE
PALAIS ET JARDINS DU LUXEMBOURG
PANTHEON
R. ST. JACQUES
R. ST. MICHEL
R. GAY-LUSSAC
R. CLAUDE BERNARD
BD. DE PORT ROYAL
FBG. ST. JACQUES
ARAGO
SANTE
BD.
D'ASSAS
RUE
RENNES
R. DE VAUGIRARD
MONTPARNASSE
CIMETIERE DU MONTPARNASSE
GARE MONT-PARNASSE
R. FROIDEVAUX
AVENUE DU MAINE
RASPAIL
R. DE SEVRES
DUCHERCHE MIDI
R. DE BABYLONE
R. DE VANEAU
R. DE GRENELLE
R. DE VARENNE
R. DE BELLECHASSE
QUAI A. FRANCE
QUAI DES TUILERIES
JARDINS DES TUILERIES
R. DE RIVOLI
PLACE VENDOME
R. CAMBON
R. ROYALE
R. TRONCHET
MADELEINE
PL. DE LA CONCORDE
CAMBON
R. DE LA PAIX
R. DES CAPUCINES
OPERA
HAUSSMANN
R. DU FBG. ST. HONORE
R. DE CONSTANTINOPLE
R. DE LONDRES
GARE ST. LAZARE
ROME
R. DE
BD.
MALESHERBES
R. DES BATIGNOLLES
R. LEMERCIER
AVENUE DE CLICHY
R. MOLIET
CARDINET
GARE DES BATIGNOLLES
R. DE SAUSSURE
R. DE TOCQUEVILLE
MALESHERBES
BERTHIER
BD. DE REIMS
BOULEVARD
PEREIRE
DE WAGRAM
AV. DES TERNES
AV. NIEL
AV. MACMAHON
PL. DE L'ETOILE
ARC DE TRIOMPHE
AV. CARNOT
AV. DE LA GDE. ARMEE
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AV. D'IENA
AV. MARCEAU
AV. DU PRES. WILSON
POINCARE
R. DE LONGCHAMP
BD. GOUVION ST. CYR
AV. MAL. LYAUTEY
BD. DE COURCELLES
PARC DE MONCEAU
R. DE MONCEAU
R. DE FRIEDLAND
AV. DE FRIEDLAND
BD. HAUSSMANN
R. DU FAUBOURG ST. HONORE
ELYSEES
PETIT PALAIS
PL. DE LA CONCORDE
AV. DE MARIGNY
COURS LA REINE
AV. DU GEN. GALLIENI
DOMINIQUE
R. DE MIROMESNIL
BD.
DES CHAMPS
COURS ALBERT IER
QUAI D'ORSAY
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R. DE GRENELLE
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R. FALGUIERE
RUE VERCINGETORIX
R. DE VOUILLE
DUTOT
INSTITUT PASTEUR
R. DE LECOURBE
CAMBRONNE
R. CAMBRONNE
AV. DE SUFFREN
BD. GARIBALDI
ECOLE MILITAIRE
AV. DE LA MOTTE-PICQUET
AV. DE LA BOURDONNAIS
PL. JOFFRE
PARC DU CHAMP DE MARS
TOUR EIFFEL
AVENUE DE
BRANLY
DE GRENELLE
R. DU COMMERCE
CROIX NIVERT
R. DE JAVEL
CONVENTION
R. DE LA
RUE DE LA FEDERATION
AV. FELIX FAURE
AV. EMILE ZOLA
R. DU THEATRE
BD. DE GRENELLE
QUAI DE PASSY
QUAI DE GRENELLE
R. FRANKLIN
PALAIS DE CHAILLOT TROCADERO
AV. DE NEW-YORK
HOPITAL DE VAUGIRARD

of vegetable gardens that still surrounds Paris but has been driven farther and farther out with the growth of the city. By about 1110 there was a township around the church of Saint-Germain-l'Auxerrois which, like the church itself, was dependent on the bishop of Paris. About 100 years later there was in addition to the old Bourg de Saint-Germain-l'Auxerrois or Fourg de l'Evêque, prolonged toward the west, a new Bourg de l'Evêque.

It was, however, to the mercantile quarter near the island city that the right bank principally owed its development; it thus acquired the character of the central business quarter which it still has. This was, strictly speaking, the town, as opposed to the left bank which came to be called the university. The latter (*see* PARIS UNIVERSITY) was formed by the masters and students who used to meet on the Montagne Sainte-Geneviève and whose association was recognized by Philip Xugustus in 1200. Thus there is an organic division, corresponding to the natural division of the site of Paris, which accounts for the old expression "the town, city and university of Paris."

About 1175 there existed at the foot of the Châtelet of the Petit-Pont a township which was a fief of the abbey of Saint-Germain-des-Prés. Another township clustered around the abbey itself. The district to the west of the Petit-Pont came under the feudal overlordship of the same abbey, while the district to the east was subject to the abbey of Sainte-Geneviève, which also had a township gathering around it. On the bank of the Bièvre was the village of Saint-Médard, and still farther to the south the township centring around the collegiate church of Saint-Marcel. The abbey of Saint-Victor, founded during the reign of Louis VI, formed yet another nucleus of rural population in the neighbourhood of what became the Halle aux Vins. The church of Notre-Dame-des-Champs, situated in the cultivated land on the plateau by the road which continued the Rue Saint-Jacques, also formed the centre of a small cluster of rustic houses. This bank of the river was mainly devoted to the cultivation of the vine.

It was in the reign of Philip II Xugustus (1180–1223) that the city, ever expanding, came to be organized as a unit. The king settled its limits by erecting a rampart (on the right hank in 1190, on the left in 1209). To describe its course in terms of present-day Paris, the wall on the right bank started from the end of the Pont-des-Arts in front of the Louvre, reached the Rue Saint-Honoré opposite the Oratoire and then ran parallel to the Rue Jean-Jacques Rousseau as far as the Rue Montmartre, from where, following the direction of the Rue Etienne-Marcel, it reached the Rue Saint-Martin. Then it bent in the direction of the Rue des Francs-Bourgeois and thus, passing by the southern end of the Rue de Sévigne, reached the Rue Saint-Antoine and the Seine. The gates were situated at the position of the modern Rue Saint-Antoine, Rue Vieille-du-Temple, Rue Saint-Martin, Rue Saint-Denis, Rue Saint-Honor6 and Quai du Louvre. Outside the rampart, in the southwestern part of what is now the courtyard of the Louvre, was a toner of defense which Philip Augustus called "our tower of the Louvre." This is the origin of the palace of that name. The wall on the left bank ran in the direction of the Rue des Fossks-Saint-Bernard, touched the Place du Panthkon on the south, cut through the Rue Soufflot and ran parallel to the Rue Monsieur-le-Prince, Rue de l'Ancienne Comédie and Rue Mazarine, to the east of those streets.

Within this surrounding wall new buildings sprang up: on the right bank the churches of Saint-Honork and Saint-Eustache (1223); on the left bank those of Saint-Sulpice (1211), Saint-André-des-Arts (c. 1215), Saint-Étienne-du-Mont (1222) and Saint-Sicolas-du-Chardonnet (1243); and, on the island, one of the great masterpieces of Gothic architecture, Notre-Dame, which was begun in 1163 and completed a century later. The left bank was more particularly the domain of the church, on which the university was dependent. It was there that the four mendicant orders established themselves: the Preaching Friars or Jacobins in 1219 near the corner of the Rue Saint-Jacques and the modern Rue Soufflot; the Cordeliers in 1230 in what is now the Rue de l'École-de-Médecine; the Austin Friars in 1293 on the Quai des hugustins, named after them; the Carmelites in 1319 in the Place Maubert. The Carthusians settled in 1259 on the site of the modern Avenue de l'Observatoire. A large number of colleges were established on the left bank of the river in the second half of the 13th century and in the 14th century, among them the college founded in 1257 by Robert de Sorbon and named after him the Sorbonne.

The right bank, as far as the hillock of Chaumont (where the gibbet of Montfaucon stood) was given rather to commercial activity. Some of the merchants' guilds were already in existence. The most famous of these, together with that of the butchers, was that of the river traders who as early as 1121 had been granted the privilege of navigation on the Seine from Corbeil up to Mantes. Louis VII confirmed this monopoly in 1170 and recognized the *prévôt des marchands de l'eau* as head of the river trading; and soon the latter, elected by his equals, was to be known simply as *prévôt des marchands*. Though the townships won privileges, the king still kept control of the city, and his representative the provost of Paris (mentioned as early as 1050) was responsible for order as well as for justice. The *prévôt des marchands* left the Parloir-aux-Bourgeois (near the Châtelet) and settled on the Grève, where later the town hall was to stand. The provost of Paris settled in the Châtelet and established a court of justice and a prison there.

The kings went on building. Charles V (1364–80) built the Hôtel Saint-Paul, which was his favourite residence, south of the Rue Saint-Xntoine. No trace of it remains. From that time onward the kings no longer made the palace in the city (now the Palais de Justice), which had been rebuilt by Philip the Fair, their habitual residence. Charles VI lived in the Hôtel Saint-Paul, and his successors in the Hôtel des Tournelles, near the modern Place des Vosges. After the death of Henry II (1559) the kings took up their residence in the Louvre, thus transferring their favour from the east of Paris to the west—a fact to which the development of the west of Paris is entirely due. The fortunes of Paris were closely bound up with those of the French monarchy; Paris was the royal capital which, from the 12th century onward, conferred on it a peculiar lustre, Manners became more refined, and the city came to be an intellectual and artistic centre in which crafts of all kinds flourished.

Political Struggles.— The Black Death and the Hundred Years' War interrupted the prosperity of Paris in the 13th and early 14th centuries. The political life of the city began in the 14th century. In the time of Étienne Marcel it was for a time a revolutionary commune; and it subsequently felt the effects of the reconstruction policy of Charles V. This king rebuilt the Louvre, which he made into a magnificent palace, though he still preferred to live in the Hôtel Saint-Paul. He also built a new line of fortifications to contain the part of the town on the right bank which had outgrown that on the left. The number of gates in the old rampart had already been increased because the town on the right bank had spread beyond it. The new fortification, described in terms of modern Paris, started from the Pont du Carrousel, crossed the square of that name, and cut through the southeast of the Palais-Royal to reach the Place des Victoires. From there it ran almost in a straight line to the Porte Saint-Denis, and then to the Place de la Bastille, following the direction of the main boulevards but a little farther to the west. It had six gates: Saint-Honork, Montmartre, Saint-Denis, Saint-Martin, Temple and Saint-Antoine, where there was a large bastide or fortress to protect the gate. This was the Bastille: built in 1370 on the western part of what is now the Place de la Bastille, captured by the populace on July 14, 1789, and then destroyed. In the east the rampart enclosed the marshes of the Temple, and consequently this part of Paris was formerly known as the Marais (marsh). Other bridges were built in addition to the l'ont-au-Change and the Petit-Pont: the Pont Saint-Niche1 about 1380, and in 1413 the Pont Notre-Dame, so-called by Charles VI.

Paris was again troubled by revolutionary agitation in 1382 as a result of the imposition of taxes; the revolt of the Maillotins was repressed with great severity in Jan. 1363. As a result, Paris lost its municipal regime, which was not restored until 1412. Further disturbances were caused by the struggle between the Burgundians and the Armagnacs. Paris fell into the hands of each

party in turn, was subjected to the violent rule of the butchers and skinners under Simon Caboche, became involved in revolution, called in Capeluche and his bands and fell into a state of starvation. The English invasion and the Anglo-Burgundian alliance made matters worse The English entered Paris, and the duke of Bedford, at the Hôtel des Tournelles, acted as regent for the young Henry VI, king of England and France (1422). Joan of Arc attempted in vain to recapture Paris in 1429. It was not until 1436 that the capital once more came into the possession of the king of France, Charles VII. These successive disturbances resulted in greatly reducing the population of Paris and in introducing foreign elements. Its prosperity suffered greatly. Several districts, on either bank of the Seine, had become ill-famed and infested by bandits and robbers nho made it dangerous to walk through them at night. This shons that pauperism had spread, as these people were reduced to living on their wits.

FROM **FRANCIS I TO** LOUIS XVI

Francis I made extensive alterations in the Louvre to make it suitable for the royal palace (1528). In his reign the town increased in size, and it began to be adorned with buildings in the Renaissance style (a new Hôtel de Ville). The population of the suburbs increased. The Faubourg Saint-Germain, under the influence of the neighbourhood of the Louvre, became an aristocratic quarter. The need of a new enclosing wall made itself felt; the lines of this were laid down in the 16th century, but it was not built until the reign of Louis XIII, and then only on the right bank of the river. It was in the reign of Francis I that Protestantism was introduced into Paris and the royal authority made its first efforts to stamp it out.

Renaissance and Reformation. — Henry II's solemn entry into his capital in 1549 marks the triumph of the Renaissance in Paris. The aristocracy built more mansions (as they had begun to do in the preceding century), particularly on the right bank. Jean Goujon's *Fontuine des Innocents* dates from the same year. Modern Paris now came into existence. Work on the Louvre was continued, and Catherine de Medici began the construction of the Tuileries in 1564. It was as though temples were being built to the new divinity, the monarch. Toward the end of the 16th century the gardens of the Tuileries began to be the meeting place of the polite world; this was a custom of Renaissance origin. The influence of the court spread over Paris, and with it the Renaissance spirit. Increased refinement of manners was the result. The Pont-Neuf, which was begun in 1j77 and completed under Henry IV, was the first classical bridge to be built in Paris. Quays were constructed in the 16th century, and an effort began to be made to set out the streets in line. It was the king's wish that new houses should have their façades made of stone and not of wooden beams and plaster. Paris began to wear the external characteristics of the capital of the absolute monarchy. The first theatre was built in 1548; it was known as the Théâtre de l'Hôtel de Bourgogne, in the Rue Française.

The wars of religion did not spare the capital. On the Day of Barricades (May 12. 1588) it parted company with Henry III. It was besieged by Henry IV. Under the influence of the ultramontane clergy, the city came to be controlled by the league. Famished and weary, it was given over to the terrorism of the "Sixteen" (representatives of the 16 districts). Then, on March 22, 1594, it once more came under the authority of its sovereign; and the monarchical era, which coincides with the classical age, entered upon its course. Henry IV built the Place Royale (Place des Vosges) and the Place Dauphine, as well as the Quai de l'Horloge and the Quai des Orfèvres. The building of the Place Royale resulted, under Louis XIII, in the building-over of the marshes which formerly lay to the north of it; the whole became the aristocratic quarter of Paris during the 17th century. The Pont-Neuf, on which a statue of Henry IV (the first statue to be erected in a public place in Paris) was set up in 1614, became one of the centres of the life of the city. It was also in the reign of Henry IV that the work of joining the Louvre to the Tuileries, begun in 1566, was completed; the hospital of Saint-Louis was built for plague patients; and a supply of spring water, which had been brought to the right bank at the end of the 12th century, was carried over to the Île de la Cité. The left bank was not supplied with spring water until the reign of Louis XIII.

Under Louis XIII, Paris increased still further in size. Straight streets were laid out toward the edge of the town. Two uninhabited islands in the river were built over and became the Île Saint-Louis. It was connected with the two banks of the Seine by the Pont de la Tournelle and the Pont-Marie. In 1631 the western suburbs on the right bank were attached to the town, and a new line of fortifications with bastions was constructed. It followed the line of the old rampart until the Porte Saint-Denis; from there it was carried westward to what is now the corner of the Rue Royale and the Rue Saint-Honor4 and then ran along the western side of the Tuileries garden. It thus shons how the centre of the town had been extended westward; but it did not enclose the districts that were springing up all the time to the north and to the south. After Henry IV's death the regent Marie de' Medici had laid out, to the west of the Tuileries garden, the Cours-la-Reine, where the carriages of the fashionable world used to drive. The same queen had built the Luxembourg palace (161j), and Cardinal Richelieu was to build the Palais-Royal (1636); both of these palaces had gardens which were frequented by fashionable society. The Jardin des Plantes had also been laid out during the reign of Louis XIII.

Louis XIV.—The *Fronde* was a leading event of the minority of Louis XIV. Paris was in such a disturbed state that the court was obliged to leave the town in Jan. 1649. The king returned in Oct. 1652. In the period following Mazarin's death in 1661, Paris became the triumphant capital of a victorious and all-powerful monarch. The Louvre, work on which had been resumed in 1624, was completed by the magnificent colonnade (1667–74). The Tuileries palace was altered, completed and sumptuously decorated; its gardens. transformed by André Le Nôtre. were prolonged beyond the Paris boundaries by the tree-planted avenues of the Champs-Élysées (1667). The line of fortifications, with its bastions, was replaced by a rampart along which were planted trees so as to form a walk; this was the origin of the grand boulevards (1670). The rampart was pierced by the Porte Saint-Denis (1672) and the Porte Saint-Martin (1674) in the form of Roman triumphal arches. Both arches still exist. Other triumphal monuments were the Place des Victoires (1686) and the Place Vendôme (1699), each containing a statue of Louis XIV. On the left bank, the Collège des Quatre-Nations (1662–74; the modern institute), endowed by Mazarin's will and open to young men from four recently conquered countries, and the Hôtel des Invalides (1670) formed a counterpart to the Louvre and the Tuileries opposite and were yet another testimony to the glory of the king of France. The Faubourg Saint-Germain was adorned with a stately line of *quais*, and in 1685 the Pont-Royal was built to take the place of the wooden bridge opposite the Kue de Beaune. On the left bank the Cours was laid out, corresponding to the line of the great boulevards on the other side; thus the southern part of Paris, which had remained within the limits of Philip Augustus' fortifications, was enlarged. The Quai Peletier was built along the Seine between the Pont Notre-Dame and the Grève (1673). Many of the streets were widened. The first barracks were constructed. The observatory was built in 1667–72. In 1667 the Gobelins manufactory was organized. Various academies were added to the Académie Française, reflecting the increasing centralization which was taking place around the monarchy. Everything tended to gravitate toward the *Roi Soleil*. But Louis XIV transferred the seat of the monarchy to the palace which he built at Versailles. Nevertheless, Paris had by now reached considerable proportions; and in 1702 the marquis d'Argenson, who, as *lieutenant général de police*, was the successor of the former provosts of Paris, raised the number of districts from 16 to 20 (15 on the right bank, 5 on the left). The town then had about 600,000 inhabitants and from the left bank new suburbs were advancing toward the villages of the surrounding hills.

The 18th Century. — During the 18th century Paris enjoyed peace and quiet for more than eight decades, and in that time the town was much embellished. In the nonage of Louis XV the

Tuileries, now the royal residence in Paris, was occupied for a few years. This encouraged urban development near the Tuileries. The Faubourg Saint-Honor6 increased in size and became, like the Faubourg Saint-Germain, an aristocratic quarter. The Rue Royale was made in 1732, and the Place Louis XV was laid out around the statue of that king which was set up in 1763. This later became the Place de la Concorde. The construction of the parish church of the Madeleine was begun in 1764 at the end of the Rue Royale, and the Pont Louis XVI, now the Pont de la Concorde, was built in 1787. 'The great boulevards now began to be bordered with houses, including some fine mansions. and the eastern part of them became a fashionable promenade. Small theatres and cafes added to the animation of this part of the boulevards. Paris now spread even beyond this limit; the Rues de Provence and d'Artois (or Laffitte) were laid out in 1770, the Rue Taitbout in 1773, the Rue Chauchat in 1779, the Rue Richer in 1782 and the Rue Le Peletier in 1786. Villas built by nobles and financiers were scattered about this outlying part of Paris. On the left bank the work of laying out the Cours and planting it with trees was continued: and houses mere soon built along it. This was the beginning of the line of boulevards which was only completed under the Second Empire. The École Nilitaire. with the Champ-de-Mars, dates from 1; 51. Germain Soufflot built a new church (now the Panthéon) for the abbey of Sainte-Geneviève. and Saint-Sulpice, which had been begun about 1640. was completed. The Petit-Châtelet was demolished and replaced by a quay (1782) on the left bank; the Grand-Châtelet on the opposite bank did not disappear until early in the 19th century. The houses on the bridges were demolished in 1786–88; some. however, remained until 1808. Water was supplied to both banks by the two fire pumps of the brothers J. C. and A. C. Périer (1779 and 1787) which were the precursors of steam-driven machinery. The garden of the Palais-Royal, around which the duke of Orléans built arcades in the reign of Louis XVI. became a centre of Parisian life. The octroi wall of the *fermiers généraux,* built about the same time, bore witness to the growth of Paris. Just as the rampart of Philip Augustus had borne witness to the existence of a city standing astride the Seine, so this octroi wall denoted at once the extension and the unity of Paris. On the modern map of Paris this wall would run from the Etoile northeastward to the Place Clichy and La Villette. then southeastward to the Place de la Nation, returning to the Étoile via Denfert and the Trocadéro. It would thus enclose the greater part of the modern town.

PARIS AFTER THE REVOLUTION

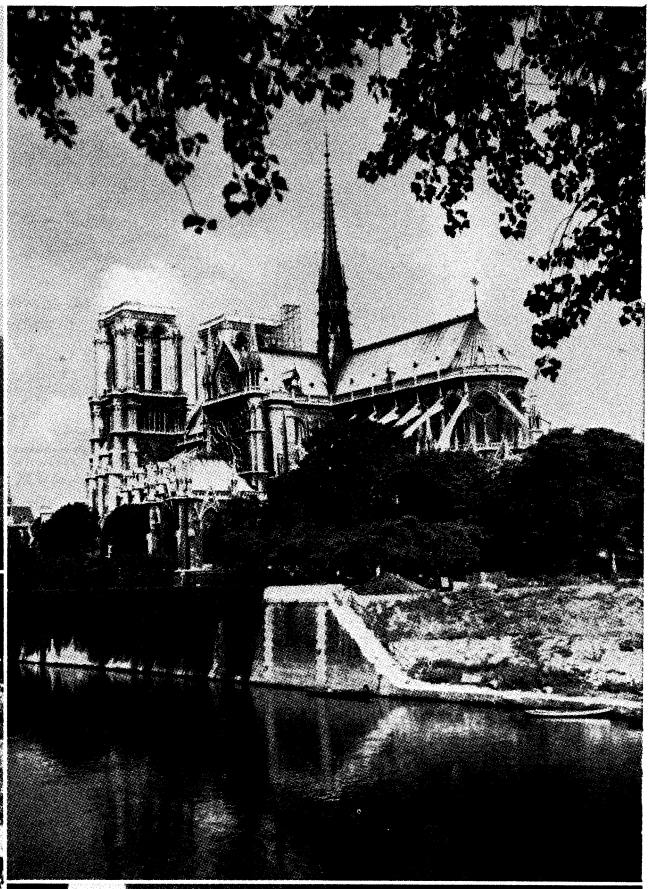
The Revolution brought about the unification of Paris. in which traces of the old feudal domains had survived until that time. It set the seal on the age-long tendency toward centralization in France and thus increased the importance of the capital. The Parisians, indeed, were at the head of the Revolution and, through their street-fighting or through their commune and their clubs, brought about the political changes. On July 13 and 14, 1789, they set up an insurrectional town council and stormed the Bastille, thus ensuring, from the social point of view. the overthrow of the *ancien régime.* On Oct. 5 and 6 they brought the king back to Paris, thus reasserting the capital's status against Versailles: thenceforth the assembly sat in the Rue de Rivoli. The Jacobin's club met in the old convent of the order of Jacobin friars; the Cordeliers', in the Rue de l'École de Médecine. On Aug. 10, 1792, a new Parisian revolt led to the proclamation of the republic. Louis XVI was guillotined on the Place de la Révolution (Place de la Concorde) on Jan. 21, 1793. The Terror prevailed until it was ended by 9 Thermidor (July 27, 1794). The love of amusement then began to revive; the Boulevard des Italiens began to be a haunt of the fashionable world (it continued to be so until the reign of Napoleon III). The Boulevard du Temple. on the other hand. where most of the small theatres were found: was the resort of the populace.

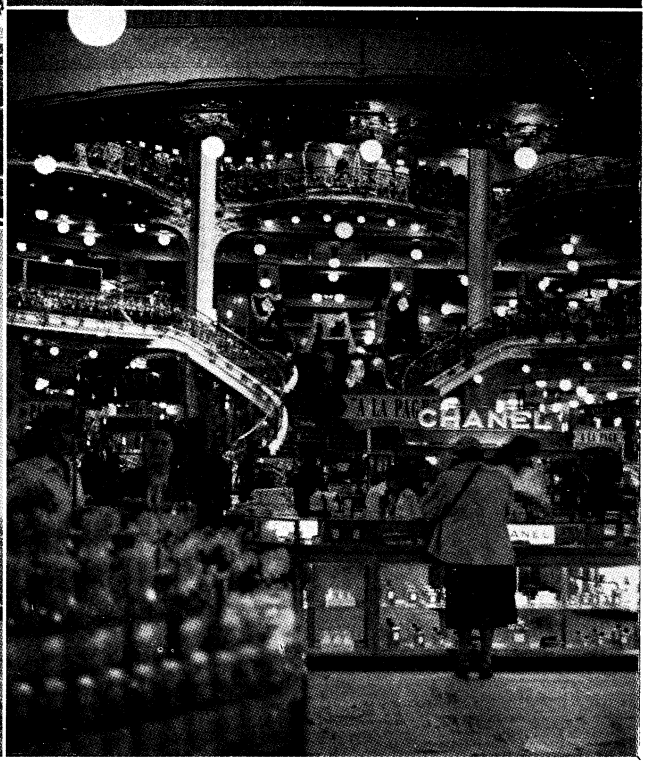
The consulate was now established, and Bonaparte. as first consul, took up his residence in the Tuileries. This was the reason for the construction oi the Rue de Rivoli with its arcades (1801). In 1806 Napoleon ordered the triumphal arches oi the Carrousel and of the Étoile to be set up; the latter was not completed until 1836. 'The Madeleine was completed to serve as a temple to glory. The neoclassical style began to give Paris an antique aspect; the city became, so to speak, the imperial Rome of a new Caesar. The first public slaughterhouses were established. Large cemeteries mere laid out beyond the boundaries of the town. Machinery and other new processes and products now began to come into use.

Large-scale industries began to grow up under the Restoration; the earliest social effects of this development made themselves felt in the reign of Louis Philippe and may explain the Revolution of 1848. Economic centralization began to take place. Paris received its first railway in 1837; it ran to Le Pecq. near Saint-Germain. The use of gas for lighting purposes also began under the Restoration. At this period and under Louis Philippe there was a great deal of building on the outskirts of Paris — the districts of François I (1823) and Beaujon (1825–42), that of l'Europe (1826–47) and. that of Notre-Dame-de-Lorette came into existence. This was the time when covered passages. the first of which was that of the Panoramas (1800), were in fashion. Many bridges were built. Omnibuses began to run in 1828. In 1840 fortifications were constructed beyond the octroi mall of the *fermiers généraux,* though the latter wall continued to form the limit of the town. A column commemorating the Revolution of 1830 was set up in the Place de la Bastille, and in 1836 the Luxor obelisk was erected in the Place de la Concorde.

Paris had in many respects retained the characteristics of a mediaeval city. It was Napoleon III who, with the help of Baron Georges Haussmann (*q.v.*), the prefect of the Seine. made it into a modern town. He was the creator of Paris as it exists today. The railway stations. which were by then the real gates of the city, were provided with the main streets necessary to give access to them. These included the Boulevard de Strasbourg and the Rues de Rennes. Auber and de Lyon. A new intersection of routes was created between the Boulevards de Strasbourg, Sébastopol, du Palais and Saint-Michel and the Rue de Rivoli. The Halles Centrales were constructed and provided with the necessary means of access. The great crossroads of the Place de la République mere created. The Opéra became another great meeting place of roads. The Étoile, with its great system of radiating main roads, was laid out. and a corresponding system of radiating roads. starting from the Place de la Nation, was planned at the other end of Paris. The Louvre was completed. The houses of the cite' gave place to public buildings. Wide streets were cut through the town on the left bank of the river. The population was provided with open spaces in the form of the Bois de Boulogne and the Bois de Vincennes and the Parcs des Buttes-Chaumont, de Montsouris and Monceau. Many squares were laid out on the English model. An immense system of sewers was created. The water of the Dhuys and the Vanne was brought to Paris. The Ponts National, de Solférino and de l'Alma and the viaduct of Auteuil were constructed. New parish churches were built. including those of La Trinité, Saint-Augustin and Sainte-Clotilde. Paris entered on a period of great brilliance. Universal exhibitions were held in 1855 and 1867. The town spread up to the fortifications (1860) and the old octroi wall was replaced by the outer boulevards.

The Tuileries palace was burned in the Commune which followed on the war and siege of 1870–71 (*see* FRANCO-GERMAN WAR). .The third republic carried on the work of Napoleon III, directing its attention mainly to the quarters added to the town in 1860. Further universal exhibitions were held in 1878. 1889, 1900 and 1937, and these were the occasion for the building of the Trocadéro (reconstructed as the Palais de Chaillot after 1937 and used occasionally after World War 11 for general assemblies of the United Nations), the Eiffel tower and the Grand and I'etit Palais des Champs-Elysées. The church of the Sacré-Coeur was erected in Montmartre. The Métropolitain railway was constructed. Conditions of life were radically altered by various modern inventions. Paris has no rival in France as a centre of material and intellectual interests. Commercial establishments took the place of dwelling houses in the centre of the city, and the population moved farther out, thus greatly increasing the extent of the suburbs. The upper part of the Champs-Elysées, like the





BY COURTESY OF (BOTTOM LEFT) BRITISH EUROPEAN AIRWAYS. PHOTOGRAPHS. (TOP LEFT) LOU LANDAUER FROM SLACK STAR. (TOP RIGHT, CENTRE LEFT) EWING GALLOWAY, (BOTTOM RIGHT) HERBERT LOEBEL— PIX FROM PUBLIX

FAMILIAR SIGHTS IN PARIS

Top left: "La Renommée" by C. A. Coysevox, in the Tuileries gardens. In the background is the Place de la Concorde with the obelisk erected by Rameses II at Luxor, Egy., c. 1250 B.C. and transported to Paris in 1831

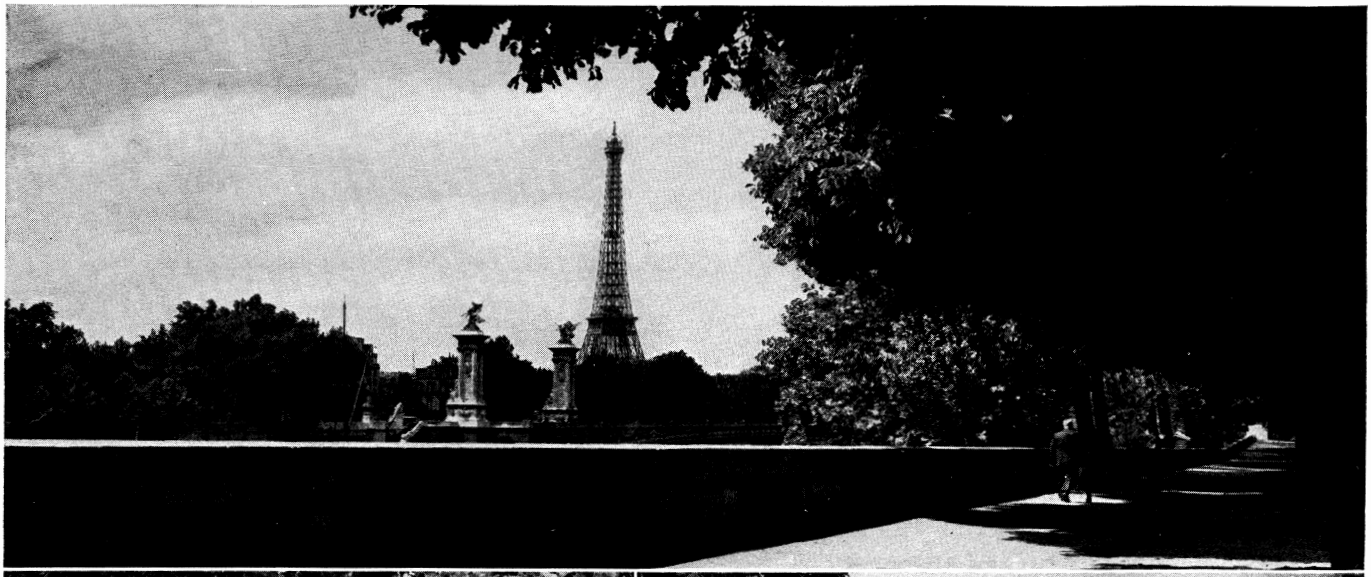
Top right: Notre Dame cathedral, on the Île de la Cite

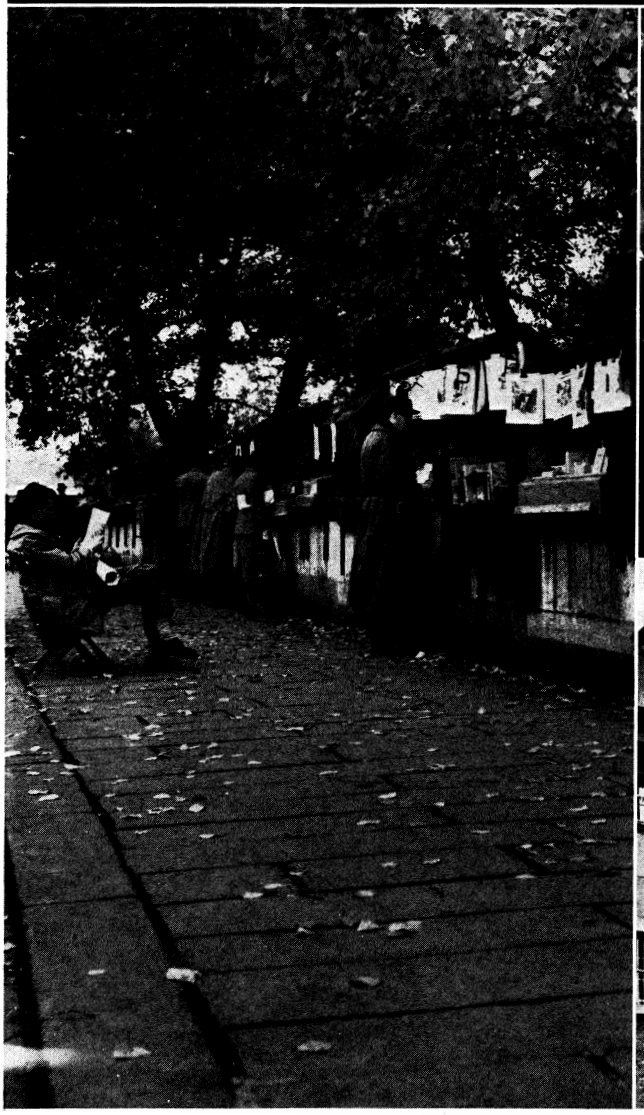
Centre left: A typical sidewalk cafe

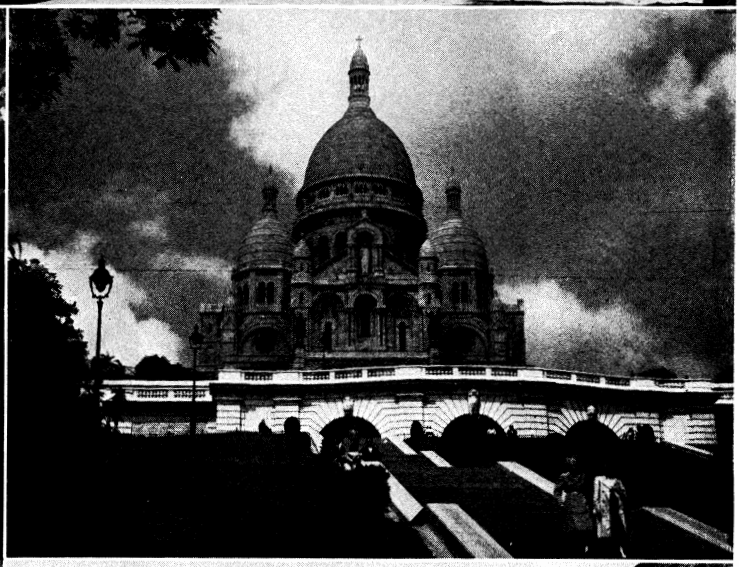
Bottom left: Arc de Triomphe, on the west end of the Champs Élysées

Bottom right: Interior of Les Galeries Lafayette, one of the largesi department stores of Paris

PARIS







PHOTOGRAPHS, (TOP, BOTTOM RIGHT) EWING GALLOWAY, (LEFT) MAX TATCH FROM BLACK STIR, (CENTRE RIGHT) T. AND V. JOHNSON FROM BLACK STAR

MONTMARTRE AND THE BANKS OF THE SEINE

Top: View of the Eiffel tower from across the Seine near the Pont d'lena
Left: Booksellers' stalls along the Seine river
Centre right: Sacré Coeur cathedral, Montrnartre, highest point in Paris
Bottom right: Street of shops and old buildings, Montrnartre

great boulevards, was given over to commerce. World War I transformed Paris into a great industrial centre, town and suburbs being no longer distinguishable. The fortifications of 1840 were demolished after the law of April 19, 1919.

During World War II Paris was occupied by the Germans, from June 14, 1940, to Aug. 24, 1944. The town suffered little from the war materially and was never the seat of very severe street-fighting. But for four pears it lived shut up, dull and cold. preparing for liberation by resistance to the occupying army. Then the people, under the direction of the civil police, rose against the Germans, and French troops under Gen. Jacques Leclerc entered from without.

In 1951 the 2,000th anniversary of the founding of the city was celebrated in a series of festivals.

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TOPOGRAPHY AND MONUMENTS

In considering the topography of the city of Paris itself, it is essential to remember the history of its development *(see* above). The nucleus of the city lay on the Île de la Cité in the Seine, and for many centuries this island provided protection for the seats of royal and ecclesiastical power. It is here, therefore, that the most ancient sites and some of the oldest architectural monuments of Paris or their remains are found. In addition, however, ancient religious foundations were established both on the right and left banks, and around these sprang up small but growing communities which subsequently formed the core of later quarters. The left bank opposite the ile de la CitC became at an early date the professional quarter through the establishment of places of study such as colleges and convents. Scribes, booksellers. printers, etc., were attracted to these areas. The right bank, on the other hand, became the commercial and industrial area of the city, with individual trades often tending to predominate in certain quarters. Thus. there was an early division of Paris into three parts: the official and religious centre on the Île de la CitC, the university on the left bank, and the "town" on the right. The characteristics of each persisted, though inevitably modified and overlaid with the passage of time.

When eventually the kings transferred their residence to the right bank. moving in various centuries to differing spots not far from the river, they attracted an aristocracy which erected several temporarily fashionable districts, many of whose architectural features survived though the areas themselves were largely adapted to commercial uses or fell into a certain degree of meanness. To the west sprang up newer quarters, but the area within the malls nas never completely built over. and open spaces gave opportunity ior the bold replanning of Baron Georges Haussmann (*q* v.). Haussmann's works transformed the face of Paris considerably and fashioned it into its present appearance. The fundamental principles were. the creation of spacious squares from which radiated broad avenues to various parts of the city; the transformation of the external fortifications into a ring of surrounding boulevards; the construction of wide and straight transversal thoroughfares; the addition in the west of nem well-planned quarters: and the provision oi open spaces such as parks and gardens. The result was to give the city in its main outlines and particularly in the nest and centre an appearance of impressive beauty and sometimes grandeur nithout destroying the more precious inheritances of the past and at the same time to make its internal communications easy. This conscientious and effective planning contrasts advantageously with the haphazard incorporation of existing suburbs and the creation of the new ones beyond the city proper.

The Paris area was subsequently divided into 20 *arrondissements* (there had previously been 12). The first seven in numerical order roughly cover the three historic parts of old Paris, the *cité,* the town and the university.

General Plan.— The Seine itseli, whose breadth (except where it divides into two arms around the Île de la CitC and the Île Saint-Louis) varies between 446 and 540 ft., forms one of the most attractive and useful highways of the capital. It sweeps in a pronounced loop of nearly eight miles from the Pont-National, its eastern limit within the city. to the Pont d'Auteuil in the west, passing in its course under 32 bridges. Of these the oldest is the Pont-Neuf (1571) at the western tongue of the Île de la CitC, with its equestrian statue of Henry IV. Other famous bridges are the Pont d'Austerlitz. on which are inscribed the names of the principal officers to fall at Austerlitz, the Pont Alexandre III, the Pont du Carrousel and the Pont d'Alma, all noteworthy for their sculpture.

The more easterly quays of the river, which is flanked by landing stages and towpaths, are used for receiving and dispatching merchandise brought from or sent to the north by canal and to and from the south by rail. The river then divides about the ancient part of Paris, the Île de la CitC and the Île Saint-Louis (joined together by the Pont Saint-Louis)! though the Île Saint-Louis was only extensively built on during the 17th century. Their quays and those of the adjacent and immediately westerly banks used to be lined with the shops of craftsmen — goldsmiths, watchmakers, etc.—but are now more usually occupied by traders. or booksellers. The parapets of the river walls are occupied by boxes for second-hand books. paintings and prints, and their tree-lined walks form a pleasant locality both ior the bibliophile and the saunterer. The river quays are then bordered by the Palais du Louvre and the Jardin des Tuileries to the north and various official buildings on the south. The river later begins to curve

Arrondissements and Quarters of Paris

Arrondissements	Quarters	Population 1906	Population 1931	Population 1936	Population 1946
I. Louvre	Saint-Germain-l'Auxerrois, Halles, Palais-Royal, Place Vendôme	60,906	41,461	42,166	36,478
II. Bourse	Gaillon, Vivienne, Mail, Bonne-Nouvelle	61,116	44,297	44,311	41,419
III. Temple	Arts-et-Métiers, Enfants-Rouges, Archives, Sainte-Avoie	86,152	70,971	70,971	64,393
IV. Hôtel-de-Ville	Saint-Merri, Saint-Gerrais, Arsenal, Notre-Dame	96,490	81,286	83,063	60,082
V Pantheon	Saint-Victor, Jardin-des-Plantes, Val-de-Grâce, Sorbonne	117,666	114,272	117,770	102,608
VI. Luxembourg	Monnaie, Odéon, Notre-Dame-des-Champs, Saint Germain-des-Prés	97,055	96,282	100,046	83,963
VII. Palais-Bourbon	Saint-Thomas-d'Aquin, Invalides, École-Militaire, Gros-Caillou	97,375	102,372	107,567	102,559
VIII. Élysée	Champs-Élysées, Faubourg du Roule, La Madeleine, L'Europe	99,769	84,259	84,854	72,438
IS. Opéra	Saint-Georges, Chaussée d'Antin, Faubourg Montmartre, Rochechouart	118,818	102,677	102,797	96,666
X. Saint-Laurent	Saint-Vincent-de-Paul, Porte Saint-Denis, Porte Saint-Martin, Hôpital Saint-Louis	151,697	129,701	131,150	123,939
XI. Popincourt	Folie-Méricourt, Saint-Ambroise, La Roquette, Sainte-Marguerite	232,050	218,678	219,471	188,547
XII Reuilly	Bel-Air, Picpus, Bercy, Quinze-Vingts	138,648	150,876	157,277	153,033
XIII Gobelins	Salpêtrière, Gare. Maison-Blanche. Croulebarbe	133,133	160,182	164,671	159,722
XIV Obscrvatoire	Montparnasse, Santé, Petit-Montrouge, Plaisance	150,136	173,395	178,230	175,584
X i Vaugirard	Saint-Lnmbert, Necker, Grenelle, Javel	168,190	236,223	238,797	244,981
ST I Passy	Auteuil, La Muette, Porte-Dauphine, Chaillot	130,719	173,289	176,868	197,732
XVII Batignolles-Monceau	Ternes, Plaine-Monceau, Batignolles, Epinette	207,127	219,933	220,716	218,341
XVIII Montmartre	Grandes-Carrières, Clignancourt, Goutte-d'Or, La Chapelle	256,174	287,286	288,810	259,589
XIS. Buttes-Chaumont	La Villette, Pont-de-Flandre, Amérique, Combat	148,081	165,359	165,757	149,297
XX. Ménilmontant	Belleville, Saint-Farneau., Père-Lachaise, Charonne	169,429	194,124	195,731	193,406

southwest with the Trocadéro and its gardens on the right bank and the Eiffel tower and the Champ-de-Mars on the left and passes through the western suburbs. The quays of the left bank constitute a downstream port for river craft. Upon the river sails a variety of craft, and there are huge floating swimming-baths moored to the banks. Less conspicuous is the optimistic angler who reels his rod on the broad towpath below.

On the north bank, roughly parallel to the river's course, runs another central artery of Paris, the east-to-west thoroughfare planned by Haussmann to give easy access across it. Beginning in the east at the Place de la Nation, this strikes as the Rue du Faubourg Saint-Antoine to the Place de la Bastille. Both the Faubourg Saint-Antoine and the quarter of Sainte-Marguerite just to the north of it are working-class districts in which are concentrated numerous small establishments specializing in such occupations as furniture making and metalwork. On the riverside the area is chiefly devoted to the needs of traffic to the quays. From the Place de la Bastille, where it intersects with a major north-to-south artery, the thoroughfare continues westward along the Rue Saint-Antoine and the magnificent colonnaded Rue de Rivoli in a long straight line to the Place de la Concorde. North of the Rue Saint-Antoine lies the ancient district of the Marais, formerly an area of fashion but now degraded into one of commerce and small industries, though retaining many of its 17th-century architectural beauties. Northwest of the Marais lies the district of the Temple. The Rue de Rivoli cuts across a second north-to-south artery formed by the Boulevards de Strasbourg and de Sébastopol on the right bank and continued by the Boulevards du Palais (on the Île de la Cité) and Saint-Michel (on the left bank); close to this intersection stand the Hôtel de Ville and the Châtelet. The first part of the western half of the Rue de Rivoli is bordered on the north by yet another former quarter of fashion, that of the Palais-Royal, now occupied by such buildings as the Halles, the Théâtre Français (the Comédie Française) and various banking establishments; farther west, it is also one of the centres of *haute couture*. On the south of the Rue de Rivoli are the Louvre and the Jardin des Tuileries.

The transversal westward thrust continues from the spacious Place de la Concorde along the tree-lined Champs-Élysées to the Place de l'Étoile and finally on to the extremity of Paris proper, the Porte Maillot. The western districts, both to the north (Faubourg Saint-Honoré, Monceau, Courcelles) and the southern along the now curving river (Passy and Auteuil), are areas of fashionable hotels, apartments and residences.

North of the Place de la Concorde is the Place de la Madeleine, a terminal point in the system of the grand boulevards, which strike northeastward from it (Boulevards de la Madeleine, des Capucines, des Italiens) to run eventually parallel to the Rue de Rivoli as far as the Place de la République (Boulevards Montmartre, Poissonnière, Bonne-Nouvelle, Saint-Denis, Saint-Martin), after which they turn southward to join the main east-to-west axis at the Place de la Bastille (Boulevards du Temple, des Filles-du-Calvaire, Beaumarchais).

The Théâtre de l'Opéra, the masterpiece of the famous architect Charles Garnier, now just off the Boulevard des Capucines, was chosen as the nodal point of a new fashionable quarter by the 19th-century planners. From it broad tree-lined avenues were constructed to other centres, which in their turn were connected with points in the city's circumference, thus joining up with an inner and an outer arc of boulevards and using the city gates as exits. The Avenue de l'Opéra itself runs south to the Louvre and the Tuileries, the Rue du Quatre-Septembre east toward the Bourse, the Boulevard Haussmann west past the Gare Saint-Lazare and the Rue Lafayette toward the Gares du Nord and de l'Est. These thoroughfares were supplemented by others. The area is now one of restaurants and open cafes, smart shops and also large stores, theatres and cinemas, catering for the tourists in particular. Toward the Place de la République, however, the working-class Faubourg Saint-Martin begins, lying between the district of the Temple and La Villette.

The arc of the outer districts on the right bank begins in the west with Les Batignolles, principally a middle-class residential area. Montmartre, to the east of it, is a varied area: there is the Montmartre of night clubs and dance resorts around the Place Clichy and Place Pigalle; and the Montmartre of the poets and painters leavened with the workers of the Butte and the Tertre with their narrow, hilly and picturesque streets dominated by the white basilica of the Sacré-Coeur. Further east, along the heights of the city, are the working-class districts of La Chapelle and La Villette, with Belleville to the southeast and, beyond it, Ménilmontant, in which are industries, abattoirs and warehouses. Through these outer districts runs an arc of inner boulevards that form lateral communications through the middle areas of Paris.

The left bank has neither any vista so imposing as the Rue de Rivoli and the Champs-Elysées nor any system of avenues so impressive as the grand boulevards. But it contains many fine thoroughfares and is set out with the same arcs of inner and outer boulevards as is the right bank, with probably a more adequate system of north-to-south routes. Its central north-to-south axis is the Boulevard Saint-Michel. This continues the line of the Boulevard de Sébastopol (with which it is connected by the Boulevard du Palais across the Île de la Cité) as far south as Montparnasse, a quarter that was formerly the rival of Montmartre as a "village" for painters and artists but is now less favoured by them though tourists and foreigners still like it. To the east of the Boulevard Saint-Michel and spilling over to the west is the Quartier Latin, originally the site of the component places of study that became the University of Paris and still the seat of many faculties. Farther east lie the commercial and industrial districts along the eastern quays of the left bank and the railways. The area west of the Quartier Latin is occupied by the Faubourg Saint-Germain, which was developed as a fashionable residential suburb during the 18th century and is full of noble mansions (many of them became official buildings) and monuments but is now increasingly haunted in its eastern localities by artists and littérateurs. Still farther west lie the more open and modern areas of fine avenues and gardens, in which are situated the Hôtel des Invalides, the Eiffel tower and the École Militaire. The east-to-west belt of outer southern districts, La Gare, Petit-Montrouge, Plaisance, Vaugirard and Grenelle, are less dense and somewhat more pleasant editions of the working-class areas of the north and northeast.

An essential feature in the planning of Paris was the utilization or adaptation of existing squares and the creation of new ones to serve as focal points in the system of boulevards and roads. Some reference to the more prominent of these assists in giving a clearer picture of the general layout of the city, while certain of them merit attention from an architectural and historical point of view. The northern east-to-west axis is marked by a succession of these squares. Almost at its terminal point in the extreme east is the Place de la Nation with its monument dedicated to the achievements of the First Republic. Roads connect it to the eastern outer boulevards, through it runs the inner arc of northern boulevards, and from it strike various routes, northwest to the extensions of the grand boulevards and to the northern suburbs, south or southwest to the river. The next square of the east-west axis is the Place de la Bastille, originally the site of the ancient fortress of Charles V that was converted into the state prison and eventually destroyed by the revolutionary mob in 1789. In its centre rises the Bastille column, erected in memory of the victims of the 1830 revolution. It, again, is the hub of a system similar to that of the previous *place*. Further west along the east-west axis is the Place de l'Hôtel de Ville and the adjacent Place du Châtelet and gardens, at the point of its intersection with the north-south axis of the Boulevards de Sébastopol, du Palais and Saint-Michel. At the end of the long Rue de Rivoli lies the Place de la Concorde, one of the largest and most impressive squares in the world, bounded on the north by buildings, the east by the Tuileries gardens, the south by the Seine and the west by the Champs-Élysées. In its centre is an obelisk and, around, monuments representing the chief cities of France. There was set up the guillotine on which suffered Louis XVI, Marie Antoinette, Robespierre, Danton and others. From the square, roads strike north to the grand boulevards and south to the river. Westward, the march of the city's

artery continues along the Champs-Élysées to the Place de l'Étoile: there is the Arc de Triomphe (begun in 1806) under nhich lies the body of France's Unknown Soldier; and from it radiate the spokes of numerous broad and beautiful avenues in all directions, making it the western counterpart of the Place de la Nation.

Other squares, most of them forming important focal points. lie in the north centre. The Place de la Madeleine, occupied by the large classical Corinthian-pillared church of that name, has been noticed already. A little to the east lies the more secluded Place Vendôme. with its column in memory of the Grande Armée, on which are bas-reliefs made of Austrian cannon captured at Austerlitz and depicting the campaigns of 1805–07; it offers an example of excellent 17th-century tonn planning and is now one of the centres of the luxury trade The Place de l'Opéra, a little further north, is the chief nodal point of the system of grand boulevards from which stem the broad tree-lined busy avenues leading to the more immediate city centres many of which themselves constitute the hubs of new netnorks. In the exterior suburbs the same use of squares is made, they serve as foci to connect the inner ring of boulevards with roads to the centre and with roads leading out of Paris.

The squares of the left bank arc are less impressive and less notable. In the east. balancing the Places de la Nation and de la Bastille is the busy Place d'Italie. which distributes arteries in all directions. The Place Denfert-Rochereau lies near the southern end of the north-south axis of nhich the Boulevard Saint-Michel is part. Further nest again, the planning of streets is dictated more by the extensive rectilinear gardens and enclosures of the Hbtel des Invalides and the Champ-de-Mars.

Public Buildings. — The chambers of both houses of the French parliament are situated some distance apart on the right bank of the river. The national assembly or loner house (formerly the chamber of deputies) sits in the Palais Bourbon overlooking the river on the Quai d'Orsay and opposite the Place de la Concorde. It is a mansion in classical style, with Corinthian columns. begun in 1722 by the dowager duchess of Bourbon and later extended by her grandson, the prince of Condé. It became the property of the nation in 1790 and was readapted to serve as a seat of legislature The council of the republic (formerly the senate) sits in the Palais du Luxembourg in the Jardin du Luxembourg on the nest side of the Boulevard Saint-Michel. This palace uas built betneen 161j and 1627 by Marie de' Medici. Turned into a prison on the outbreak of the Revolution. it became the seat of the Directory and later, under the 19th-century monarchs, of the upper house of parliament; its galleries contain the works of more modern artists and of distinguished sculptors. The official residence of the president of the republic, the Palais de l'Élysée, in the Faubourg Saint-Honoré, was built in 1718 and later acquired by Madame de Pompadour; it was the temporary residence of many other famous personages.

The headquarters of the municipal authorities is the Hôtel de Ville on the right bank opposite the Île de la Cité. The original building. begun in 1535, was largely destroyed by the Communards in *1871;* the present one is constructed in French Renaissance style with elaborate sculptures. Occupying most of the western end of the Île de la Cité itself stands the Palais de Justice (law courts). The site was occupied in Gallo-Roman times by a citadel and later by the palace of the Merovingian arid Capetian kings. It nas handed over to the *parlement* of Paris by Charles V but was destroyed by successive fires so that little is left of the mediaeval buildings save the Sainte-Chapelle, the Conciergerie (the old prison in nhich Marie Antoinette was confined) and some 1jth-century halls and kitchens. The western end of the present buildings has a fine façade in the Greek style on the Place Dauphine. The northern side, overlooking the wider branch of the Seine, embodies four towers which partly date from the Capetian era; the Tour de l'Horloge at the eastern angle is reputed to contain the oldest public clock (1370) in France.

Pre-eminent among other public buildings. as being the most ancient except for Notre-Dame and the most impressive monument of the city, is the Louvre, which extends between the Seine and the Rue de Rivoli for about half.a mile. On its site was originally a keep erected by Philip Augustus, which Charles V enlarged as a fortress and which Francis I transformed into a palace. Under Francis and his successors were built portions of the wings to the south and west courtyard, which rank among the finest examples of Renaissance architecture. The remaining buildings of the courtyard date from Louis XIII and XIV. The two wings projecting westward, each consisting of two parallel galleries with pavilions at intervals, were completed under Napoleon III (though the Grande Galerie and. at right angles to it, the pavilion of Henry IV, had been erected on the river front by Catherine de Medici and Henry IV). The adjacent palace of the Tuileries was begun by Catherine de Medici and Henry IV .constructed a wing (rebuilt by Napoleon III), uniting it with the Grande Galerie of the Louvre (a corresponding wing on the north side dated from various periods of the 19th century). The palace of the Tuileries was burned down by the Coinmunards in 1871, except for the terminal Pavillon de Flore. The corresponding Pavillon de Marsan was later rebuilt. The site of the destroyed palace. for three centuries the residence of French monarchs. is now occupied by the Jardin des Tuileries. The Louvre itself houses one of the most celebrated museums in the world; it contains in particular some of the best paintings of Italian, Spanish and French schools and fine specimens of ancient, mediaeval and modern sculpture. Just north of the Louvre is the smaller but magnificent Palais-Royal, built by Richelieu and given by him to Louis XIII: the Comédie Française is now housed in the Théâtre Français at its southwestern angle, and official bodies such as the Conseil d'État occupy the main body.

The Hôtel de Invalides, on the left bank a little way to the west. was founded by Louis XIV in 1670 as a retreat for infirm soldiers. It contains museums of military history and weapons. Within its courts are the parish church of Saint-Louis. with various marshals of France buried in its vaults. and the *dôme,* in the central crypt of which are the sarcophagus and the remains of Napoleon I. The Panthéon is now another civil building. Situated off the Boulevard Saint-Michel. it was intended to replace the abbey sanctuary of Sainte-Geneviève. Begun in 17j7, it was secularized on the Revolution and dedicated to the memory of great Frenchmen. During the 19th century it was several times reconsecrated and resecularized. The Panthéon is an imposing domed building in the form of a Greek cross, its facade adorned with Corinthian pillars. Inside are pictures and inosaics representing scenes of French history.

The Palais de Chaillot was built in 1937 on the site of the old Trocadéro, on the right bank opposite the Eiffel tower and now contains museums illustrating various aspects of civilization.

Centres of Commerce. — The principal financial and commercial district is around La Bourse. a huge building modelled on the Temple of Vespasian a little way east of the Ilace de l'Opéra. Just east of the Palais Royal is the Banque de France.

The slaughterhouses. cattleyards and most of the markets belong to the municipality. The chief abattoirs are in La Villette (near the Marché aux Bestiaux) and in Vaugirard. The principal market is the Halles Centrales (between the Palais-Royal and the Boulevard de Skbastopol), called by Zola the "bowels of Paris." They were first established there by Philip Augustus. The modern series of buildings was planned to number 12 in 1841; but only 10 were finished by 1868, and thereafter. 2 more were erected but not serviced. Into them come every day about 30,000 tons of edible merchandise of all types, and they give occupation to about 50,000 traders, carters, etc. At the western end of the Halles Centrales is the Bourse de Commerce, the centre for the sale of spirits, grain, oils, sugar, etc. The vast Halle aux Vins, for wines, is on the left bank opposite the eastern end of the Île Saint-Louis. There are other provision markets owned by the municipality in other quarters of the city, as well as numerous flower, bird and live-animal markets. Fairs held in Paris are: the Foire aux Jambons. in the Boulevard Richard-Lenoir (which runs north from the Place de la Bastille) during Holy Week; the Foire du Pain d'Épices, in the Place de la Nation at Easter time; and the industrial and commercial Foire de Paris, held in May every year in the Parc des Expositions near the Porte de Versailles.

Hospitals. — Paris has about 25 principal hospitals and the whole of the Seine *département* around 60. These are supplemented by special institutions for the mentally disordered, for the congenitally disabled. for children and for the aged.

The Hôtel-Dieu on the Île de la Cité is the Parisian hospital with the longest tradition (the generic name *hôtel-Dieu* was applied from the earliest times to hospitals in cathedral cities): an *hôtel-Dieu* near Notre-Dame is mentioned in 829. but since then there have been several demolitions and reconstructions: the present building dates from 1868. The Hospice des Quinze-Vingts. for the blind. founded by Louis IX in 1260. was moved in 1780 from the Faubourg Saint-Honor6 to the Faubourg Saint-Xntoine; its ophthalmological clinic dates from 1880. The Hôpital Saint-Louis. in the Faubourg Saint-Martin. founded by Henry IV for victims of the plague, now specializes in diseases of the skin and in syphilis and has a dermatological, syphiligraphic and surgical museum. The Hôpital Beaujon at the end of the Boulevard Haussmann in the Faubourg Saint-Honor6 was opened for foundlings in 17S4 and converted into a general hospital in 1795; it has magnificent new buildings (1935) just outside Paris, in Clichy. The Hôpital Bretonneau (1901) for children, in Montmartre. is also notable for its pleasing architecture. The major isolation hospital is the Hôpital Claude-Bernard (1905), the buildings of which extend from the old Porte d'Aubervilliers to the Canal Saint-Denis in La Villette.

A great number of the major hospitals are on the left bank. La Salpêtrière, a large establishment beyond the Jardin des Plantes and the Gnre d'Austerlitz. was founded as a hospice for beggars in 1656 and then assigned to sick or fallen women. and is now particularly devoted to the insane; it is specially associated with the name oi J. M. Charcot. Adjacent to it is La Pitié, founded for like purposes (hut nearer what is now the Jardin des Plantes) in 1612. converted to general purposes in 1809 and rebuilt on its present site in 1912. Farther to the west. around the southern end of the Boulevard Saint-Michel, are clustered the Hôpital du Val-de-Grhce, originally a nunnery (1621) with a splendid church (1645–1710) but converted into a military hospital in 1793; the Hôpital Cochin. originally a hospice for the poor of the parish of Saint-Jacques-du-Haut-Pas (1780); the Baudelocque maternity hospitnl; and the Hospice des Enfants Assistés (1814), which has an *annexe* at Antony (Seine). To the southwest, in the Plaisance district. are the contiguous Hôpital Saint-Joseph (Sisters of Saint-Vincent-de-Paul, 1884) and Hôpital Broussais (1888). In Montparnasse is the Institut Pasteur, with the Hôpital Pasteur and the Hôpital Saint-Jacques adjacent. The Hôpital Necker (1776; general and urinary). contiguous n-ith the Hôpital des Enfants Malades (1802), stands a little way to the north; and farther north again is the Hôpital Laënnec, so named in 1878 hut founded as the Hospice des Incurables in 1625 (it is now a general hospital specializing in tuberculosis).

Various other institutions are found in the I'aris vicinity, notably the Hospice Bicêtre, outside the southern fortifications; for the aged and infirm. for consumptives and also for the insane. There are also many privately endowed institutions, some subsidized by a particular profession or trade.

Religious Buildings. — The cathedral church of Notre-Dame is the most famous and impressive of the city's religious establishments. Situated on the Île de la Cité, the present building, which occupies the site of earlier foundations (the first dating from the 4th century), was begun in 1163. During succeeding centuries there have been extensive renovations and alterations. Now measuring 139 yd. in length and 52 yd. in breadth, the building consists of a choir and apse. a short transept and a nave flanked by double aisles and square chapels. Its central spire was added during 19th-century restoration. The two massive square towers crown the western façade, which is divided into tliree stories and has its doors adorned with fine early Gothic carvings and surmounted by a row oi figures of Old Testament kings. Above the central door is a rose window.

The Sainte-Chapelle is a smaller exquisite piece of ecclesiastical architecture situated near to Notre-Dame and now within the precincts of the Palais de Justice. It was built by Louis IX to shelter holy relics brought from the crusade and represents one of the finest existing specimens of Gothic art, richly decorated and filled with beautiful stained glass. Other famous churches include those of Saint-Germain-des-Prés (11th century), oldest church in Paris; of Saint-Germain-l'Auxerrois (12th century); of Saint-Pierre-de-Montmartre (12th century); of Saint-Étienne-du-Mont (13th century), containing Saint Genevieve's sarcophagus; of Saint-Sulpice (17th century), a large baroque building in classical style. with frescoes by Eugène Delacroix; of the Madeleine, built on the lines of a Roman temple by Napoleon I in honour of the French armies; and of the Sacré-Coeur (19th century), a spacious basilica in Roman-Byzantine style on the heights of Montmartre, n-here. according to legend. Saint Denis was martyred,

Centres of Learning and Libraries. — Parisuniversity (*q.v.*) is by far the largest of France's universities, with 53,427 students in 1951 out of a total of 123,058 for the whole of France. Residential accommodation for 3.000 of these students is provided in the Cité Universiraire erected in the southernmost part of I'aris, opposite Gentilly, on a site once occupied by the fortifications. The university comprises the faculties of law, medicine, letters, sciences and pharmacy. The faculty of law (21,632 students in 1951) is established in a separate building near to the Sorbonne. The Sorbonne itself, off the Boulevard Saint-Michel. houses the faculties of letters (13,137 students in 1951) and of science (7,569) and is also the administrative quarters of the educational district (*académie*) of which Paris is the centre. The faculty of medicine (8,117 students) and that of pharmacy (2,977) occupy various buildings in the Quartier Latin or adjacent areas of Saint-Germain-des-Prés. To the Collège de France, founded by Francis I in 1530 and situated opposite the Sorbonne. are elected distinguished scholars who give public lectures; it now has physical and chemical laboratories attached. Other institutes of higher education in all its branches found incorporated within the university are: the École des Chartes (research in literature. history, etc.), the École Pratique des Hautes Études and the École des Langues Orientales Vivantes. Specialized institutes for training in industry or government service are numerous, and a great proportion come under the various ministries: *e.g.*, the École Polytechnique. the Institut Agronomique. the École Militaire de Saint-Cyr, the École Nationale des Mines, etc. These are upplemented by other state institutions for music and acting (Conservatoire National de Musique et de Déclamation), painting, sculpture, architecture (Ecole Kationale et Spéciale des Beaux-Arts). etc.

The Institut de France was founded in 1795 for the encouragement of research. arts and science.,. It comprises the Académie Française, the Académie des Sciences Morales et Politiques, the Académie des Science., the Académie des Beaux-Arts and the Académie des Inscriptions et Belles-Lettres. Other smaller independent academies include the Académie Goncourt (literary), the Académie Mallarmé (modern poetry), the Académie Ronsard (French poets), the Académie d'Agriculture, the Académie de Droit International. etc.

The Académie Française was founded by Louis XIII in 163 j for the purpose of acting as the arbiter of the French language and literature, for which purpose it began the compilation of its celebrated dictionary. Suppressed under the Revolution. it was refounded as a section of the Institut in 1803. On the Restoration its former title nas restored to it. It has 40 members. who are elected, and, in addition to its linguistic duties. awards a number of literary prizes.

Secondary education is provided by free (*i.e.*, nonstate) colleges and by nonfree state *lycées* or alternative institutions. By the middle of the 20th century the former, mostly run by the Roman Catholic Church. were meeting with increasing financial difficulties and were being more and more subsidized by the state in one way or another. Some of the ancient colleges that survived the Revolution have been reconstructed as *lycées; e.g.*, the Collège d'Harcourt (1220), now the Lycée Saint-Louis. and the Collège de Clermont (1 j50), now the Lycde Louis-le-Grand. Loner education was provided by the usual hierarchy of schools, both free and stale, down to the kindergarten *écoles maternelles*.

The national library or Bibliothèque Nationale is housed in the former palace of Mazarin in the Rue de Richelieu near the Palais-Royal; the national archives are in the former Hbtel Soubise. Other libraries include the Bibliothkque Historique. the Bibliothèque Mazarine, the Bibliothkque Thiers and the Bibliothèque Forney *(see* also LIBRARIES).

Theatres. — The Opéra (National Academy of Music), whose name is the central landmark of the right bank at the Place de l'Opéra, was founded in the years 1669–71. It is operated by the state and produces the more serious type of opera; it also possesses a ballet. which has acquired great prestige. Less serious musical productions are played at the Opéra Comique (founded in the early 18th century and also run by the state), a little to the east, off the Boulevard des Italiens. The Théâtre Français or Comédie Française mas formed in 1681 under the latter name by the union of Molière's company with two others. Now housed in part of the Palais-Royal and run by the state, it has a repertory consisting chiefly of the French classical drama. The Théâtre Franqais also has a company uhich plays at the Odéon, just north of the Luxembourg gardens. Numerous smaller theatres specializing in modern productions are to be found in the vicinity of the grand boulevards. More popular music-hall shows exist in the amusement quarter of Montmartre (Place Pigalle). There are expensive night clubs off the Champs-Élysées and of a more popular type in Montmartre and also, though not in such numbers, in Montparnasse.

Hotels (**Mansions**).—Numerous examples of beautiful old *hôtels* (the mansions of former aristocracies) are to be found throughout the older quarters of Paris. Many of them still retain some dignity as museums or as the residences of embassies or other official bodies. Others have been put to more commercial uses. The fle Saint-Louis still preserves within its quiet leafy sanctuary many specimens of 17th-century mansions untouched and unsurrounded by modern progress. including the Hbtel Lambert, where at one time or another Voltaire. George Sand and Prince Czartoryski lived (it now houses many works of art), and the Hôtel Lauzun. The Marais district to the north of the Rue Saint-Antoine, with the right bank north of the Île Saint-Louis, has become an area of shabby commercialism. but there are still many architectural beauties: for instance the Rue Saint-Antoine itself, full of formerly splendid private houses with beautiful courtyards (such as the Hôtel Sully); and the Place des Vosges with its 17th-century red brick houses (this was formerly a courtyard of the Hbtel Royal des Tournelles. in n-hich Henry II was killed while tilting; later it became the duelling ground of the city). Also in this quarter is the Hbtel Carnavalet. once the home of Madame de Sévigné, now a museum illustrating the history of Paris. The Hbtel Soubise is now the Archives Nationales. Two mansions on the left bank now turned into museums are the Hbtel Biron (Musée Rodin) and the Musée de Cluny with its objects of art, furniture, porcelain and glass illustrative of mediaeval culture.

Parks, Gardens and Cemeteries. — In the centre of Paris are the public gardens of the Tuileries designed for Louis XIV and later enlarged when the palace of that name was destroyed. Further westward beyond the Place de la Concorde stretch the open spaces of the Champs-Élysées. In front of the Hbtel des Invalides and running down to the Seine is the Esplanade des Invalides. A little westward is the Champ-de-Mars (laid out *c.* 1770), with the Eiffel tower standing at one end by the river and the Ecole Militaire at the other. Across the river is the Jardin du Trocadéro in front of the Palais de Chaillot. On the west of the Boulevard Saint-Michel is the Jardin du Luxembourg. On the river bank, immediately south and east of the Halle aux Vins. lies the Jardin des Plantes (founded early in the 17th century), which contains a museum of natural history. zoological gardens and an important collection of plants in nurseries. hothouses and greenhouses. On the way from the Etoile to Les Batignolles is the Parc Monceau. Between La Villette and Belleville is the Parc des Buttes-Chaumont. Other larger open spaces are the Bois de Boulogne (2.200 ac.), west of the old fortifications beyond Passy and Auteuil, once the hunting ground of the Valois kings, given to the municipality by Napoleon III; and the Bois de Vincennes (2.300 ac.), beyond Bercy, the extreme southeastern quarter of the right bank, with its open-air zoo. Well-known cemeteries are the Cimetikre Montparnasse (with the graves of Baudelaire. Maupassant. Saint-Saens and Sainte-Beuve), the Cimetikre Montmartre (with Heine, Stendhal, Théophile Gautier. Dumas fils, Zola and the brothers Goncourt) and the Cimetikre du Père-Lachaise (between Ménilmontant and the Place de la Nation; with Abélard and Héloïse, Molière. Racine. Balzac, Chopin, Rossini and Wilde).

Sport. — The principal sports of Paris are racing, football and bicycling. Race meetings are held at Auteuil and Longchamp in the Bois de Boulogne and at the more distant courses of Saint-Cloud. Vincennes and Enghien and at those, still more distant, of Chantilly and Le Tremblay. Association and rugby football take place at the Stade de Colombes (across the Seine. to the northwest), at the Parc des Princes, etc. At the latter also and at the Vélodrome d'Hiver is held bicycle racing. Motor racing takes place at Montlhéry to the south of Paris; athletics at the Stade de Colombes, tennis at the Stade Roland-Garros.

The Press. — The Paris press in the years after World War II suffered in its circulation from the increasing competition of the provincial newspapers, and this drop was accelerated by the tendency of the public to make the press one object of their minor economies. Several journals went altogether out of circulation. The chief Parisian daily papers and their approximate circulation in Jan. 1953 nere: *France-Soir,* 940,000; *Le Parisien Libéré,* 667,000; *Le Figaro,* 489,000; *L'Aurore,* 349,000; *Paris-Presse,* 217.000; *Le Monde,* 154,000; *La Croix,* 150,000; *Franc-Tireur,* 130,000; *Ccmbat,* 61,000; and *Le Populaire,* 25,000. These reflected opinions from the right to the left centre, with *Le Figaro* and *Le Monde* representing nonparty. moderate and independent views. Communist papers were *L'Humanité* (177,000) and *Libération* (122,000).

ECONOMIC ASPECTS

Population. — In the 14th century the estimated population of Paris; already the largest city of France. was around 290,000. Under Louis XIV in the 17th century it had exceeded 500,000, but for some time thereafter the rate of growth was slow—524,000 in 1789 and 547,000 in 1801. Progress was rapid during the 19th century, particularly in the decade after the Franco-German War, but levelled off during the 20th century. Indeed the population was tending to decline (as throughout the whole of France) in the years between World Wars I and II. Figures (to nearest thousand) for representative years since the beginning of the 19th century are: 548,000 in 1801; 786,000 in 1831; 1,053,000 in 1851; 1,851,000 in 1872; 2,447,000 in 1891; 2,888,000 in 1911; 2,906,000 in 1921; 2,830,000 in 1936; 2,725,000 in 1946; and 2,820,534 in 1954.

The large growth of population during the 19th century was chiefly due to immigration from the provinces and to the incorporation of outer suburbs with the city proper during reconstruction. This accounted. for example, for 96.5% of the city's increase between 1846 and 1856 and for 92% between 1876 and 1881. Paris is, therefore, a place whose population derives largely from the immediate provincial sources.

Because of the relatively restricted area of the city itself, the density of its population, particularly since the end of the 19th century, has been very high. However, with the migration of certain industries into the industrial belt beyond the city boundaries there came a lowering of this density. In addition there has been some attempt to clear slum areas in the densely populated quarters and to settle the occupants in dormitory towns.

Administration. — Greater Paris occupies most of the Seine *département,* which is, therefore, in a large degree amalgamated with Paris proper for the purposes of administration. The *préfet* of the Seine is the administrative head of both areas and, as other *préfets,* is appointed by the minister of the interior and responsible to him. Police duties, however, are entrusted, not to him (as to *préfets* of other *départements*) but to a special and independent *préfet de police,* responsible to the minister of the interior.

The 20 arrondissements of Paris itself are grouped in varying

numbers into nine sectors. each of which return every six years a number of councillors proportionate to the size of their joint electorate. The council, which comprises 90 members in all, elects its own president and four vice-presidents, and its main business is to vote the city budget and to advise the *préfet* in his administration. Its decisions may be overruled or its recommendations ignored by the *préfet*, who has effective control of all subjects (finance, education. highways, markets, etc.). All the municipal councillors are of right members of the *conseil général* (roughly equivalent to a county council) of the Seine. To this body 60 *conseillers généraux* are also elected by the communes of the *département*, grouped into five sectors. The *conseil général*, being thus quite distinct from the Paris municipal council, is concerned with departmental business and has its own president and vice-presidents. Each *arrondissement* of Paris (but not Paris as a whole) and each commune of the outer area has its own mayor who is responsible for minor duties such as the registration of births, marriages and deaths.

Justice.—Courts of more or less local competence. sitting in each arrondissement, are the Tribunaux de Simple Police de Paris, over which preside the *juges* de *paix* for the city's *arrondissements* who deal with the minor infractions in their own areas. The Tribunal de Première Instance de La Seine has jurisdiction running throughout the whole *département* and is divided into a number of chambers, civil, criminal and juvenile; the Cour d'Appel de Paris hears appeals from the two former courts, both in civil and in criminal cases; and the Cour d'Assise. serves the Seine and surrounding *départements* for the hearing of more serious cases. These sit in the Palais de Justice.

Besides these courts. however, Paris is the seat of central judicatures for the whole of France. These are: the Cour de Cassation, sitting in the Palais de Justice; the Conseil d'Etat, sitting in the Palais-Royal; and the Cours des Comptes, with competence over the expenditure of the public *départements* and the larger communes situated by the northeastern corner of the Place de la Concorde.

Other tribunals for settling by arbitration commercial, industrial and professional disputes are: the Tribunal de Commerce de la Seine, composed of prominent businessmen; and the Conseils des Prud'hommes de la Seine, joint bodies of employers and workers.

Police.—Before 1800, the police in Paris were essentially a body used to control the political activities of the citizens, though *officiers de paix* mere created in 1791. In 1800, the preiecture of police was created, but public order was entrusted for some time to the *gendarmerie*, a military body. under the orders of the *préfet* de police. A hundred uniformed *sergents* de *ville* were appointed in 1829. They became the 1,500 municipal guards in 1830 and were renamed in 1848 for a short time *gardiens* de Paris (nicknamed *montagnards*). In 1870, the force was again baptized as *gardiens* de la *paix*. At the end of the century the police strength was 7,500 and the bases of the present organization were being established.

The jurisdiction of the *préfet* de police extends over the whole Seine *département*, and its chief divisions are municipal and judicial police. The former are divided into nine divisions under *commissaires* and number about 19,000. Their principal functions are to maintain general public order (in which they are assisted hy the *garde républicaine*, a military reserve body); to control traffic (for which there exist specially trained companies); to prevent criminal acts; and to execute immediate arrests (foot, cycle and motorized squads). The judicial police, whose headquarters are on the Quai des Orfèvres, intervene when criminal investigation is required. More serious crimes and those difficult to detect are usually handled by the specialist services at headquarters; minor ones may be tackled by the local *commissaires* who rank both as municipal and judicial police. After World War II there was an increase in the number of crimes of violence requiring swift action. against which local territorial brigades of the judicial police were created. The centralized brigades include la *brigade criminelle* (for the most serious crimes). *la brigade de voie publique* (offenses on the highway, particularly of violence), la brigade *mondaine* (prostitution. public morals, drugs) and la brigade *financière* (fraud, etc.). These are reinforced by more technical and scientific branches for indoor investigation. Also members of the judicial police are the *juges d'instruction* and other investigating officials, who prepare the case for the courts. Figures for the numbers of more serious criminal acts (*crimes* and *délits*) have been: 82.1 j j in 1938; 146,448 in 1945; 102,00 j in 1948; and 87,553 in 1949.

Juvenile cases are handled by specially trained policewomen, known as *assistantes de* police, who, however, numbered only 30 for the whole *département* of the Seine in 1950, so that one had to take care of several *arrondissements* or groups of communes. These *assistantes* rank as members of the judicial police but are linked up with the social-security system. the hospitals and the local town halls. They also brief the tribunals when proceedings are initiated.

Communications.—Paris developed as the country's outstanding centre of inland communications both because of its general geographical position and because of the policy of extreme centralization adopted by the state. Certain physical features assisted in this development. The flat plateaus of Brie to the east and Beauce to the south were easily covered by roads and later by railways. The hills further to the east are pierced by the rivers Seine, Marne, Aisne and Oise. To the west the plain of the Seine is broad. and the land rises gradually to the hills of Perche and eastern Normandy.

Roads.—Since the 17th century the nation's roads have been chiefly designed to converge on the capital. The main ones are: Paris-Laon-Mauberge, to Belgium; Paris-Chblons-Verdun and Jletz, to Luxembourg and Germany; Paris-Sézanne-Nancy-Strasbourg; Paris-Troyes-Chaumont-Belfort, to Switzerland (Basle); Paris-Sens-Dijon, to Switzerland (Geneva); Paris-Sens-Lyons and the Rhône valley: Paris-Orléans-Toulouse, to Spain; Paris-Chartres-Le Mans-Nantes; Paris-Chartres-Tours-Bordeaux. to Spain; Paris-Caen-Cherbourg; I'aris-Rouen-Le Havre; Paris-Beauvais-Boulogne; Paris-Amiens-Dunkirk.

For internal thoroughfares see above. General Plan.

Railways.—As with the roads, Paris is the outstanding hub of the national and continental system, and a deviation via Paris is often much better than relying upon cross-country services. blain line stations in the capital are: the Gare du Nord, the Gare de l'Est. the Gare de Lyon (serving the south and southeast), the Gare d'Austerlitz (serving the southwest and Spain). the Gare hfontparnasse (serving the west and southwest) and the Gare Saint-Lazare (serving Normandy). The city also has certain terminal stations for local traffic.

The Métro, essentially an underground railway, though a certain part is carried overhead. has been constructed at only a little depth. First opened in 1900 with a line from the Porte Vincennes in the east to the Porte Maillot in the west, the system now comprises about 80 stations and covers about roo mi.

Airports.—The two principal airports for Paris are Le Bourget (6 mi. N.) and Orly (12 mi. S.). The latter specializes particularly in transcontinental traffic and is also used by Air France for inter-European and domestic movements. During 1951 the two airports were served by 100 different companies belonging to 33 countries. Le Bourget still possessed 52.3% of the traffic flow, but Orly was in process of expansion. The average daily joint total of aircraft arrivals and departures was around 200; and the number of passengers in Sept. 1951 was 144,479.

Waterways and the Port of Paris.—Paris is served by an excellent system of waterways. The lower Seine connects it with the channel coast. Its area is linked up to northwestern France and Belgium, through the Oise and to eastern France and Germany through the Marne. The upper Seine is connected by canal with the Rhône and so with the Mediterranean. Moreover, three canals supplement the rivers and provide places for ports within the immediate area in or about the city: the Saint-Denis canal from a northern point on the Seine to La Villette and the Saint-Martin canal irom La Villette to a southern point obviate the journey along the large western loop of the Seine; and the Canal de l'Ourcq runs from La Villette eastward to Meaux (thus short-circuiting

the southward loops of the Marne) and then proceeds in a northward direction to link up with the Ourcq river itself.

The economic life of Paris and its suburbs has since the beginning of the 19th century been more closely associated with the Seine. though the river was always the cheapest and safest means of transporting goods. Paris has long been the largest inland port in France. thanks to this advantage of a system of waterways converging from all parts of the country. The idea of putting the river to a greater use by making the city a seaport was conceived in the 1860s. and work was subsequently begun on dredging a deep channel to Le Hnvre. A channel 14 ft. deep now exists, capahle of taking large barges (many self-propelled) and tugs.

Paris. in its widest geographical sense. has now become the third port of France. surpassed only by blarseilles and Le Havre in the amount of merchandise. Its port possesses about roo mi. of quays along the Seine and the Marne and the canals of Saint-blartin. of Saint-Denis and of the Ourcq. Besides the *quais* in the city and greater Paris. a port area was begun in 1926 to cover 978 ac.. with 8 mi. of additional quays at Gennevilliers. Barges could thus reach the edge of the great western industrial region without having to pass through the lock at Suresnes. In 1950, the Port of Paris handled 8,400,000 tons of merchandise (*cf.* Marseilles 12,200,000 and Le Havre 9,900,000) of which 6,800,000 were imports. Craft discharged amounted to around 30.000, chiefly plying between England. Belgium and the Netherlands.

Industry. — Paris is not only by far the most important administrative and cultural centre of France but also its leading industrial and commercial city. though it is not situated near to any sources of mineral wealth. It possessed, however. considerable sources of labour and turned initially to a variety of luxury and secondary industries. With the development of railways and canals early in the 19th century the resources of the northern coal fields were made more accessible, and the city began to develop heavier industries (*e.g.*, engineering and chemicals). The outer quarters. which had grown rapidly during the middle decades of the century under the impetus of this industrialization and been incorporated within the municipality itself. proved insufficient to contain the new industries. Thus. Paris rapidly overflowed beyond encircling heights which were its natural boundaries to become greater Paris. During the 20th century there was an increasing tendency for new industries to be concentrated in the outer districts and in the satellite towns. to which moreover the heavier industries were inclined to migrate.

The chief industry of the city itself is that which caters for the tourist trade, with hotels. restaurants and entertainment: foreign tourists alone numbered 1,500,000 in 1950. A second type of industry is the manufacture of luxury articles demanding highly skilled workmanship and capable of being produced in small establishments or even within the home. These luxury articles comprise precious metalware. leather articles, gloves, china and *haute couture*. Such occupations are usually concentrated within the central *arrondissements* as for example in the Faubourg Saint-Honoré and around the Place Vendôme. In addition, the outlying *arrondissements* often specialize in particular trades such as furniture making around the Place de la Bastille. heavier metalwork in the Marais and Temple quarters, tanning in the southeast, shoemaking at Belleville and a variety of lighter industries. such as the making of precision tools. optical instruments, wireless apparatus and office equipment. in other *arrondissements*. Printing and publishing are found in the Quartier Latin. A fair proportion of the Paris population is also concerned with importing food. liquor and other commodities either by canal or by rail.

The development of greater Paris took place first along the lines of communication and spread in all directions. The area it now occupies is the whole of the Seine *département* and, more ambiguously. certain communes of adjacent *départements* which. in 1932. were stated to fall within a radius of 22 mi. of Paris. Industrial suburbs comprise Saint-Ouen, Saint-Denis and Aubervilliers in the north and Pantin in the northeast. The inspiration for their development was the Saint-Denis canal. Saint-Denis (*q.v.*) now has heavy industries producing locomotives and rolling stock and marine and factory equipment and also makes light metal and electrical equipment, chemical by-products, etc. Saint-Ouen has more diversified and lighter trades. Aubervilliers and Pantin (*qq.v.*) concentrate on the production of both heavy and light kinds of chemicals. Minor industries in the area include glass and pottery. In the west and in the northwest progress has been made chiefly along the valley of the Seine. The west is the centre of the motor and aircraft industries. including the Citroën works at Grenelle within Paris itself and the Renault works at Boulogne-Billancourt. Farther northwest. along the Seine loop from Suresnes (opposite the Bois de Boulogne) to Gennevilliers. extend the armament factories. heavy engineering works. oil refineries and chemical industries. Among these industrial areas. however. are growing residential suburbs such as Neuilly-sur-Seine. Nanterre and Colombes. The southeastern suhurhs repeat on a somewhat smaller scale those of the Seine valley in the west. To the south and southwest along the valley of the Bièvre river are tanneries, cement works, breweries and tobacco factories. The eastern area has been left relatively untouched by industrialization and remains rather a residential area.

Water Supply. — The growth of the city has naturally been accompanied by improvements in its water supply. The earliest water supply was initiated by the Romans. who built an aqueduct from Rungis into the city. Until the 19th century. domestic water was obtained chiefly from wells and from the Seine. A pump (called La Samaritaine) was built by Henry IV on the Pont-Neuf, and in the 17th century another was erected at Notre-Dame. Public fountains obtained supplies from the construction of other aqueducts. Early in the 19th century the newly constructed Canal de l'Ourcq served as an aqueduct. and others were constructed from neighbouring rivers. During the Second Empire the foundations of the present system were laid by the engineer Eugène Belgrand. Earlier sources were used for public and industrial purposes. and purer domestic water was obtained by tapping the sources of distant streams. whose supplies were led to reservoirs in the higher suburbs. Modern pumping and filtering stations to supplement them with water from the Marne and from the Seine were also constructed (Saint-Maur and Ivry-sur-Seine).

The development of the Paris sewers began under Louis XIII but the present system is relatively modern. The sewers serve also as conduits for gas and water pipes, telephone and telegraph wires, etc. *(See* below.)

Sanitation. — The city was slow in developing any adequate system of sanitation. Streets were not paved until the time of Philip Xugustus, who also ordered the inhabitants to transport their refuse outside the city walls. Streams rising in the surrounding heights were used as primitive sewers. and their pollution gave rise to repeated infection. Under Henry IV the first covered sewer was constructed (1605), but later progress was slow: even in 1663 the city had less than 1.6 mi. of underground drainage and 5 mi, of open canals. In 1737 Turgot undertook the work of improving the city's sanitation. By 1800, however. underground sewers were only 16 mi. in length. and much water still drained into swamps and ponds within the city area. An outbreak of cholera inspired a further development of various kinds of drainage, particularly in the 1860s and 1870s under the planning of Belgrand, who undertook extensive improvements covering the whole area. By 1878 a network of 385 mi. of sewers had been constructed, other accessories created and the Seine freed from pollution.

By the 1950s the underground sewers of Paris extended for about 807 mi.. and those of the outer suburbs for 683 mi.

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PARIS, the commercial and industrial centre for much of northeast Texas; U.S., and seat of Lamar county. located 100 mi. N.E. of Dallas. It was settled in 1841, incorporated as a town in 1874, and chartered in 1905. The city was replanned after a

disastrous fire in 1916. Paris Junior college (municipally owned, founded 19243 is located there. Manufactures include lamps, furniture, boilers. business forms. garments, crates, vinegar. stock feed. cottonseed oil and dairy products. Paris is also a shipping point for cotton, grain and livestock.

For comparative population figures see table in TEXAS: *Population.* (C. A. W.)

PARIS, CONFERENCE OF. The conference for framing the treaties which ended World War I was held in Paris in 1919–20.

PRELIMINARIES

The Pre-Armistice Agreement. — Germany faced complete defeat and unconditional surrender when, one after the other. its allies Bulgaria. Turkey and Austria-Hungary broke under the strain of war in Sept. and Oct. 1918, and sought terms with the enemy. Germany saw its best chance in overtures to the president of the United States, whose speeches during months past had underlined the principles necessary to the restoration and preservation of world peace (*see* FOURTEEN POINTS). Accordingly. on Oct. 4 the German government dispatched a note to Woodrow Wilson through the Swiss government requesting an armistice.

In reply. President Wilson laid down the stipulations that must be complied with before negotiations for peace could be opened: (1) Germany must accept without qualification the principles of the fourteen points. leaving for discussion only the practical details of their application; (2) the German armies must be withdrawn from all territories of the Allies under the direction of the Allied military authorities; (3) Germany must cease all illegal and inhuman practices and abandon unlimited submarine warfare; (4) the German nation must free itself oi the arbitrary government which had conducted the war. Gen. Erich Ludendorff resigned rather than accede to those conditions. but the civil government, although it protested against the charges of illegal and inhuman practices. dispatched a note on Oct. 20 accepting the stipulations of President Wilson as preliminary to the Armistice. Wilson then presented the matter to the Allies. The president had already sent Col. Edn-ard M. House to Paris as C.S. representative on the Supreme War council. He met the Allied leaders, David Lloyd George. Georges Clemenceau and Vittorio Orlando, to discuss, first, whether an armistice should be granted, and second, whether Germany's request that the fourteen points be used as the basis of peace should be accepted.

President Wilson has been much criticized on the ground that he was responsible for too early a peace. and that had it not been for him terms would have been dictated in Berlin. This is far from the truth. The Allied council agreed to grant the Armistice on the recommendation of the military leaders; the Americans were in fact less eager than the French and the British for the cessation of hostilities. To he certain of Allied sentiment regarding the Armistice. House asked Marshal Ferdinand Foch directly whether or not from a purely military point of view he would prefer hostilities to cease on the terms proposed. Foch replied that, since the terms demanded of Germany were practically the same as those that would be demanded at Berlin, he was opposed to the useless sacrifice of even one more life.

The Allied leaders were niore doubtful whether President Wilson's fourteen points should be taken as the basis of the peace, as Germany asked. Clemenceau. Lloyd George. Paul Hymans and Orlando each raised objections. They finally agreed, however, upon the strong insistence of House. to accept the fourteen points with tn·o reservations regarding the freedom of the seas and restoration of invaded territory. Acknowledging these reservations, Wilson on Nov. j communicated the reply of the Allies to the German government. This note is of vital importance. "It constitutes the formal and written offer of the Xllied and Associated States to conclude with Germany (*a*) an armistice convention and (*b*) a treaty of peace. This offer. it is conceived, was accepted by Germany by the act of sending representatives. through military channels, to meet Marshal Foch for the purpose of arranging an armistice

By the acceptance of the offer a solemn Agreement was reached which served both morally and legally as the basis of the armistice convention and the treaty of peace." [1]

The note of Nov. 5, in which Wilson stated that Marshal Foch would communicate the conditions of the Armistice. contained the text of the memorandum of observations by the Allied governments on the correspondence between President Wilson and Germany. In this memorandum those governments "declare their willingness to make peace with the government of Germany on the terms of peace laid down in the President's address of Jan. 8, 1918 (the Fourteen Points). and the principles of settlement enunciated in his subsequent Addresses," subject to two qualifications. These reserved complete liberty, as regards the "freedom of the seas," and interpreted "restoration of invaded territory" as meaning that "compensation will be made by Germany for all damage done to the civilian population of the Allies and their property by the aggression of Germany by land. by sea and from the air."

Both the Allied and associated powers and the Germans accepted this pre-Armistice agreement as the basis of the peace. The protests of the German delegation against the Versailles treaty in May 1919 were based upon their allegation that the treaty was not in accord with the principles of the agreement. The Allied and associated powers, although they denied the validity of the allegation. explicitly acknowledged the validity of the basis: "The Allied and Associated Powers are in complete accord with the German delegation in their insistence that the basis for the negotiation of the treaty of peace is to be found in the correspondence which immediately preceded the signing of the Armistice of Nov. 11, 1918."

ORGANIZATION OF THE PEACE CONFERENCE

Representatives of the Chief Allied Powers. — Representatives of the chief Allied powers and associated powers — France, Great Britain. Italy. Japan and the Cnited States — held consultations in December and the first plenary session of the peace conference did not take place until Jan. 18. 1919. President Wilson did not reach Europe until Dec. 13, 1918. The British prime minister. Lloyd George, was detained at home by the political uncertainties of a general election until after the new year. So important to any negotiations was the participation of these two heads of governments that nothing definite could be attempted until their arrival. In the meantime, the smaller powers which had hcen overrun by the armies of Germany had time to reorganize their governments and to send plenipotentiaries to the conference.

The peace conference was called by the five principal powers mentioned above to assemble at Paris.

The Council of Ten.—Upon the arrival of Lloyd George in Paris, a meeting of the Supreme War council was held, Jan. 12, at the Quai d'Orsay. France was represented by Clemenceau and S. Pichnn, Great Britain by Lloyd George and A. J. Balfour, Italy by Orlando and Baron Sidney Sonnino, the United States by Wilson and Robert Lansing. Though ostensibly an informal conversation among plenipotentiaries of the four leading powers, the meeting was the occasion of the significant decision to add only the representatives of Japan to the Supreme council and to exclude all others from the major decisions of the peace conference. Thus the Supreme council (*q.v.*) of the conference, or Council of Ten, sprang from the Supreme War council.

Other Delegations. — There also came to Paris the representatives of Belgium. Serbia. Rumania! Greece and the other states— 32 in all—which had fought against the Central Powers or had broken off diplomatic relations with them. Obviously it was impossible ior all to have equal part in determining the conditions ot peace. To each, seats and a vote were allotted in the plenary sessions of the conference. Representatives of those states which had remained neutral during the war, and yet had interests to safeguard or to advance at the peace conference. were permitted to attend only those sessions which were arranged for discussion of their claims, whenever they were specially summoned by the five chief powers. It had been the intention of the latter at first to put on the same footing the new states which were rising from the ruins of the Central Powers. Before the iirst plenary session,

[1] H. W. V. Temperley, *A History of the Peace Conference of Paris*, i, 382 (1920).

Poland and Czechoslovakia were conceded representation in the conference; but Yugoslavia—including Serbia, Montenegro and the South Slav provinces of Austria-Hungary—was not officially recognized until the end of May, chiefly because of the opposition of Italy.

The Delegates.—Outstanding among the delegates from the smaller powers were Paul Hymans, foreign minister of Belgium; I. J. Paderewski, premier of Poland, and Roman Dmowski, president of the Polish National committee in Paris; and Ion C. Bratianu, premier of Rumania. For Serbia and the South Slavs came N. Pasic, M. Vesnic and A. Trumbic. E. Venizelos came to speak for Greece. For Czechoslovakia came its premier, K. Kramar and its foreign minister. E. Benes. The new kingdom of the Hejaz was represented by the Emir Faisal.

But there was considerable dispute before the five principal powers finally assigned places in the conference to each state in accordance with its military strength and its share in the war. Five seats were given to each of the five chief powers; three apiece were assigned to Belgium, Serbia and Brazil; two each to Canada, Australia. South Africa. India, China, Czechoslovakia, Poland, Greece, the Hejaz. Portugal, Rumania and Siam; one each to New Zealand, Bolivia, Cuba, Ecuador, Guatemala, Haiti, Honduras, Liberia, Nicaragua, Panama, Peru and Uruguay. Many delegates were thus left out, but the panel system was adopted so that all powers could use their plenipotentiaries in rotation if they desired. Representatives of the British dominions. for example, more than once shared in important decisions of the Supreme council by reason of their membership in the panel of the British empire. Other work was found for excess members of several delegations on commissions and subcommittees.

When the plenary assembly of the conference met for the first time on Jan. 18 it proved to be only a body of approval merely passing upon actions that had already been determined in the Supreme council. Clemenceau was elected president of the conference. A secretary-general previously selected by the Supreme council was appointed. A drafting committee was approved, on which had been placed only representatives of the five chief powers. The smaller powers endeavoured to protest against such rigid control by the five. But at the second plenary session on Jan. 25 Clemenceau bluntly dismissed their objections with allusion to the 12,000,000 soldiers behind the five powers.

Administrative **Work.**—With this matter of authority arbitrarily arranged. the peace conference settled to the work of constructing a peace. Peacemaking, however, was not to be its sole task. It was obliged also to assume executive duties of tremendous consequence. It was to direct the .Allied Armistice commission at Spa. It was to set up and control the Supreme Economic council at Paris. It had to maintain its own authority over Poland. Germany, Hungary, Czechoslovakia and Rumania. The Supreme council of the conference administered the Armistice by instructions to Marshal Foch, who in turn forwarded them to the international commission at Spa. The Allied members of the commission consequently had no authority to make any decision beyond their instructions. They had full power to explain and to stress important points in the Allied interpretation of the Armistice and, by personal intercourse, to prevail upon the German representatives to accept the decisions of the Supreme council at Paris. The matters that chiefly concerned the Armistice commission were: the withdrawal of German forces from the territory of the Allies and their demobilization; the repatriation of prisoners interned in Germany; surrender by Germany of the required amounts of arms, aeroplanes, mercantile and agricultural machinery. railroad equipment; and the delivery of other commodities stipulated in the Armistice.

Supreme Economic Council.—At the instance of President Wilson. on Feb. 8 the Supreme council resolved to create a Supreme Economic council of five members each from interested powers to advise the conference on the temporary economic measures necessary pending the completion of peace negotiations.

At its first meeting on Feb. 17 the Supreme Economic council decided to co-ordinate the work of all the former war boards and to direct them as sections of its own organization. As a result, matters of food and relief were placed under Herbert Hoover of the United States as director-general; matters of finance. under Norman Davis of the United States; the problems of communications were ultimately assigned to Brig. Gen. H. O. Mance of Great Britain; ram materials, to Louis Loucheur of France; problems of blockade, to Vance McCormick of the United States; and shipping to Kimball Cooke of Great Britain.

The Supreme Economic council endeavoured to supply devastated areas with materials necessary for reconstruction and to revive the economic activity of those countries which were victims of the war. It mas especially concerned with the problem of relieving the famine-stricken areas of eastern Europe—a situation recognized as dangerous to political stability and likely to encourage the spread of Bolshevism. It arranged the Brussels agreement by which Germany was provided with foodstuffs, to carry out that provision in the armistice which pledged the Allies to revictual Germany in return for cash payments. It delegated to a subcommittee the special task of economic administration in the territories of Germany occupied by Allied armies. It carried on direct negotiations with the German finance commission, studied the economic effects of the Allied blockades of Bolshevik Russia and Hungary, and urged the Supreme council of the conference to relax those blockades for the benefit of the peoples of other states near by. It relaxed the blockade against Germany and reorganized the transportation systems of Austria; Hungary and Poland.

In short, the Supreme Economic council under the efficient chairmanship of Lord Robert Cecil, established only as a temporary commission to administer economic affairs until the advent of peace, became one of the most important international bodies directing the reorganization of Europe. After the treaty of Versailles had been signed, it continued to act as agent for the Allies. The last meeting was held in Feb. 1920.

Official Language and **Publication.**—Two preliminary questions of procedure for a time disturbed the plenipotentiaries at Paris. What was to be the official language of the conference? Should its proceedings be made public? It was decided that French and English texts. of equal authority, should be presented in the treaty with Germany, which included the covenant. Italian texts, along with English and French, were presented in the Austrian, Hungarian and Bulgarian treaties; and in all these the French version was declared to prevail in case of divergence. The languages of the enemy states were denied admission to the texts of the treaties. The decision was reached to withhold details of discussions as much as possible until definite understandings had been secured.

THE WORK OF THE PEACE CONFERENCE

Problems in Eastern Europe.—The authority of the peace conference was menaced seriously not only by the hostility of Germany, but by the resistance of Rumania and the new governments of Poland and Czechoslovakia. Early in Nov. 1918 hostilities had broken out between the Poles and the Ruthenians in east Galicia where Polish proprietors constituted a landed minority, and Ruthenian peasants—closely related to the Ukrainians in Russia—were a majority. During Feb. 1919 an Allied mission intervened. but the Ukrainian commander refused to accept the proposed truce. In March the Supreme council of the peace conference arranged another truce with the Ukrainian commander, and on April 2 set up an inter-Allied commission at Paris to arrange the terms of an armistice concerning east Galicia. The Polish delegation rejected this armistice on the ground that Poland's safety required military occupation of east Galicia. The Supreme council sanctioned the Polish occupation. The status of east Galicia was left for later decision. (See POLAND: *History.*)

To safeguard Poland on its western border, the peace conference imposed an obligation upon Germany that had not been stipulated in the armistice. In Poznania the Poles rose against the German garrisons at the end of Dec. 1918. In January the Supreme council dispatched an inter-Allied commission to stop these hostilities and served notice of that intention upon Germany through Marshal Foch. Germany protested, but practically accepted the provisional line of demarcation as laid down by the Allied commission

until the boundaries of Germany and Poland were determined by treaty. Germany also objected to the transport of Gen. Jozef Haller's Polish army from France to Poland via Danzig on the ground that its presence would prejudice the ultimate disposition of Danzig. The conference forced Germany to admit the technical right of the Allies to use Danzig as such a port of entry to Poland, but allowed Germany to route Haller's army via railway without touching Danzig.

Still more vexatious to the peace conference, perhaps, was the situation that developed in Hungary after the establishment of a Bolshevik regime under Béla Kun and the conflict between Hungary and Rumania. (See HUNGARY: History.) Other matters to distract the Supreme council of the peace conference from its major task of peacemaking were the sharp controversies between Czechoslovakia and Poland over Teschen and between Austria and Yugoslavia over Klagenfurt. The situation in Russia caused much discussion during the first days. Decision was reached on Jan. 22 that all the Russian factions should be summoned into consultation on the island of Prinkipo, in order to determine who was to be responsible for Russian interests at the peace conference. But nothing came of the effort. Neither the old tsarist order, the revolutionary government of Alexander Kerensky, nor the Bolshevik regime of Nicolai Lenin were represented at the peace conference. Nor were the new Baltic states — Finland, Estonia, Latvia, Lithuania — which were breaking away from the old Russian empire.

Special **Commissions.**—Among the special agents established to assist in making a peace were commissions on: (1) responsibility for war and guarantees, with Robert Lansing of the United States as president and subcommittees on criminal acts. responsibility for war, responsibility for violation of laws and customs of war; (2) reparation for damage, with L. L. Klotz of France presiding and subcommittees on estimation of damages, financial capacity of the enemy, and means of payment and reparation; (3) international labour legislation, with S. Gompers of the United States presiding (see INTERNATIONAL LABOCR ORGANIZATION); (4) international control of ports, waterways and railways, with F. Crespi of Italy as president and subcommittees on transit and control of routes of communication; (5) financial questions, with E. S. Montagu of Great Britain presiding and subcommittees on financial problems preliminary to peace, on monetary questions. enemy debts and so on; (6) economic questions, with Etienne Clémentel of France as president and subcommittees on permanent commercial relations, tariifs and customs, navigation, industrial property and others; (7) aeronautics, with Colonel Dhé of France as president; (8) inter-Allied naval and military affairs, under the presidency of Marshal Foch. which with other associated committees constructed the military and naval and air terms for presentation to the enemy; (9) the central commission on territorial questions, over which André Tardieu of France presided, to coordinate the work of the committees and commissions examining the complex problems of Czechoslovakia, Poland. Rumania. Yugoslavia, Greece, Albania, Belgium, Denmark, the Saar territory and Alsace-Lorraine.

In all these agencies of the peace conference the five associated powers kept for themselves either the entire membership or at least a majority over the smaller powers.

League of Nations Commission. — First and most important of all was the commission on the League of Nations, chosen on Jan. 25 at the iecond plenary session of the conference upon the recommendation of the Supreme council. The membership of this commission was drawn from the political leaders of 14 nations. Among them were Lord Robert Cecil and Gen. J. C. Smuts of the British empire, Léon Bourgeois of France: Orlando of Italy. Hymans of Belgium, Venizelos of Greece, M. Vesnic of Serbia, Wilson and House of the United States. The commission met on Feb. 3, and after daily sessions in the Hôtel Crillon (held at hours that did not conflict with the meetings of the Council of Ten) presented to the plenary session of the conference on Feb. 14 the first draft of the covenant. The usual procedure at the conference. of translating into French when English was used and into English when French was spoken, lengthened the sittings twofold and, though necessary, consumed much time. On the other hand, at the meetings of the commission to form the covenant for the League of Nations: interpreters, sitting by those who did not speak both languages, kept them informed in an undertone of the progress of the discussion. It was agreed by the commission to use as a basis for discussion the U.S. plan for the covenant prepared by Wilson and House, which had, by consent, been put into legal phraseology by Sir Cecil Hurst and David Hunter Miller, legal advisers respectively of the British and U.S. delegations. There were difficult problems to solve. The question of political equality and that of having a league with an army at its command to enforce its decisions, advocated by the Japanese and French respectively, caused acrimonious debates.

The debate in the plenary session — the one important discussion in that body throughout the period of the conference — resulted in approval of the principle of the covenant and brought forward various suggestions for amendment. President Wilson left on the following day for the United States. The covenant was revised by the commission and finally approved by the fifth plenary session of the conference on April 28, without change of a single word. The covenant specifically provided for safeguarding the Monroe Doctrine against actions by the League; it contained a clause to permit any state to withdraw upon giving notice of its intention two years in advance. The chief objection to the covenant raised in the United States was passed over. With the full support of President Wilson. article 10 was retained in the covenant. (See also LEAGUE OF NATIONS.)

Council **of** Four. — Four days after President Wilson left for the United States (Feb. 15), Clemenceau was shot at by a fanatic. Although not dangerously wounded, he was confined to his home. House, who had been delegated to take Wilson's place, came to meet him there and, with the return of Lloyd George from England, the same group was again formed which had worked with celerity and success during the Armistice proceedings. Thus the Council of Four took iorm. The Japanese plenipotentiary, K. Saionji, held to the policy of standing off when Japanese interests were not concerned, especially when the matters under discussion pertained purely to a European problem.

Cpon Wilson's return to Paris (March 14) he replaced House in these informal conferences. The four heads of states abandoned the Council of Ten. It mas reduced to the five foreign ministers. Whenever they desired: the four assumed the authority of the ten as the Supreme council of the peace conference and drew apart to confer in private. The ministers of foreign affairs continued to sit as a Council of Five, although they were concerned chiefly with minor executive duties and other matters of routine. But, while the four were still engrossed in negotiation with the recalcitrant German delegation, the five went ahead with discussion of the terms to be given to Austria. The power of the peace conference had been drawn into the hands of four men: and the Italian, Orlando, found that final decision belonged really to the three— Clemenceau. Lloyd George and Wilson.

S o one heard the arguments of the four except their interpreter, Paul Mantoux. and later their secretary. Sir Maurice Hankey, who kept the minutes of their discussions and drafted the resolutions upon which they agreed. On occasion, experts were summoned to give data and technical advice. Inter-Allied commissions were formed directly by the four and ordered to report to them.

Claims of France and **Poland.**—When Wilson returned to Paris. the problem of meeting the claims of France, Italy, Belgium and Japan immediately became acute. The French asked for continued occupation by the Allies of the Rhineland and the bridgeheads of Cologne, Coblenz and Mainz. Unauthorized demands were made for the permanent separation from the reich of German territory on the left bank of the Khine. France asked further ior complete sovereignty over the Saar territory, as compensation for its own mines which had been deliberately ruined by the German forces. The French representatives pressed vehemently for "integral reparation," assessment of actual damages done by the enemy and exaction of the total amount in reparation. France supported Poland's claim to complete sovereignty over Danzig and the approaches to that city.

.Although at one time (April 7) President Wilson threatened to break off negotiations over these questions and return to the United States without finishing the task of peacemaking, compromises that he could accept were found one aiter another. The scheme for a republic on the Rhine was repudiated. but agreement was reached that the left bank of the Rhine and a wide strip on the right bank should be demilitarized and all fortifications razed, and that the Allies should maintain their joint military occupation for 15 years. It was to be continued if France, in the opinion of the Allies. was not then sufficiently secured against an unprovoked attack. The decision to prohibit union of Germany with Austria, described by André Tardieu as one of Clemenceau's fundamentals, was inserted in the first draft of the German treaty in May and remained there in the definite text of June 28.

As for the French claim to the Saar territory, the compromise was reached that France should have full ownership of the coal mines but that, because of the 650,000 German inhabitants, government of the region should not be given to France but should be put under the control of the League for 15 years. At the end of that time, the inhabitants resident before this arrangement should vote for one of three settlements: the *status quo* under the League, union with France or return to Germany. In case they voted for return to Germany, France was to give back the mines and to receive compensation from Germany.

The problem of reparation was not effectively solved by the Council of Four. Many English and U.S. advisers, thinking of Germany's exhaustion, the danger of making the German people desperate and the mistaken policy of asking that a blank cheque be signed and handed over for the Allies to fill in, urged that Germany be cleared of charges for reparation by payment at once of whatever amount it could produce. The debate ramified into the uncertainties of Germany's capacity to pay and the largest sum for which Germany might be held liable. The French view prevailed. It was agreed that Germany should be held liable to pay to the limit of its capacity. The demands oi the British and French that pensions should be included in the reparations bill were first opposed by Wilson, but he finally yielded. (*See* REPARATIONS.)

The deadlock over Danzig was broken by Lloyd George, who 'sought and found a complicated compromise between Wilson's thirteenth point that Poland should have free and secure access to the sea and British fears that a *Germania irredenta* might be created. Danzig was to be a iree city under the protection oi the League of Nations, but Poland was to have access through I'olish territory to the Baltic sea and virtual control over Danzig's interests abroad. Within a week after President Wilson had threatened to leave the conference, these differences had been ironed out so well that the representatives of Germany were invited to appear at Versailles on April 2j.

Claims of Italy, Belgium, Yugoslavia and Japan. — But another crisis suddenly appeared. The Italians threatened to withdraw from the conference unless their claims to Austro-Hungarian territories were met before the Germans signed the treaty. These claims were grounded upon promises given by France and Great Britain in the secret treaty of London (April 26, 1915). Orlando went further, however. to claim the city and port of Fiume (*q.v.*) which had not been allotted to Italy by the secret treaty. In this case he argued for the principle of self-determination, although he had opposed the application of that principle to the German population in the Tyrol south of the Brenner pass. Wilson gave way to Orlando's contention to the extent of agreeing that Italy's northern frontier should be extended to the Brenner. But he resisted the Italian pretensions on the eastern shore of the Adriatic because they were advanced at the expense of Yugoslavia and Albania. Fiume had a large Croat population and a purely Croat hinterland. It was the natural seaport of the Slavonic and hlagyar regions to the east. Wilson rejected the suggestion that Fiume should be given to Italy in exchange for the Italian renunciation of claims upon Dalmatia under the treaty of London. On April 23 Wilson publicly declared his reasons for opposing Italian claims. Orlando and his foreign minister. Sonnino, left Paris for Rome, but returned when the conference determined to proceed with the German treaty. They reached Paris on May 7, a day too late for the sixth plenary session which approved the draft of the treaty, and only a few hours before it was handed to the Germans at Versailles. The Italians n-ere hack in the conference, but the question of the Adriatic was not settled.

Meanwhile the claims of Belgium. Yugoslavia and Japan further complicated the situation for the Council of Four. Paul Hymans appeared on April 29 to demand that, since Belgium had been first to suffer in the war. it should be first to receive compensation for war costs. It had been promised as much in the Armistice. He asked that Belgium be given a prior lien upon $500,000,000 of the first cash receipts from Germany and complete settlement of the Belgian account within ten years.

Eventually the U.S. view prevailed — that Belgium's case was different from all others. Belgium mas practically assured payment of its war costs by receiving a special issue of German bonds and priority on the cash receipts. Serbia immediately asked for $400,000,000, but the Council of Four dismissed that claim summarily.

The Japanese issue, however. could not be settled so easily as the Belgian or the Serbian claims. The Japanese representatives took exception to the suggestion that the German area in Shantung should be handed back directly to the Chinese. Japan claimed Shantung on several grounds. and a secret agreement in 1917 with the Allies had assured Japan that they would offer no objection to Japanese claims in Shantung, although the United States had never been a party to the agreement. Wilson resisted the Japanese claims. but finally accepted a compromise on April 30.

The Italian crisis was threatening to disrupt the conference. and an understanding with Japan was more than ever necessary. It was to the effect that the Japanese were to keep Kiaochow and its adjacent district. with rights also to exploit the mines and railways in the peninsula: but that Chinese sovereignty would he restored over the peninsula of Shantung "as soon as possible." The U.S. president expressed faith in the oral promise of the Japanese that Japan would eventually evacuatc Shantung in favour of China and retain there only commercial concessions. The Chinese representatives at the peace conference had no such faith. They refused to sign the treaty with Germany, but they gained a place for China in the League of Nations by signing the subsequent treaty with Austria.

TREATY OF VERSAILLES

The draft of the treaty with Germany was handed to Germany's chief representative, Count Ulrich von Brockdorff-Rantzau, on May 7, 1919. at the Trianon. Without rising from his chair the German hurled sharp words at the representatives or' the Allies for their dilatory methods. In the past six months, he declared, the blockade had caused the deaths of hundreds of thousands in Germany, "Think of that." he said. "when you speak of guilt and punishment." He and his countrymen would accept the liabilities to which they were committed by the Armistice, would share in restoring Belgium and the devastated areas of France. But they and their nation did not hope for a just peace. "We know," he said. "the poner of the hatred that we encounter here."

German Objections. — The Germans protested that the Allied plan for reparations was too severe and that the treaty as a whole was inconsistent with the terms of the pre-Armistice agreement. The Allies rejected this imputation, and a movement for revision led by Lloyd George came to an end on June 13. The only consequence was that some concessions were made to Germany on minor points (see VERSAILLES, TREATY OF).

The treaty of Versailles was ratified on July 9 by Germany, and by October Great Britain, France, Italy and Japan also had ratified. The exchange of ratifications was delayed for two reasons. First, it was hoped that the senate of the Cnited States would ratify at least with reservations. Second, Germany must make amends for the destruction of its fleet in violation of the Armistice.

On Nov. 19, 1919. the U.S. senate failed to ratify; but on Jan. 10, 1920, Germany finally signed a protocol to give compensation for scuttling the fleet. Then the exchange of ratifications was made at Paris between the European Allies and Germany, and on Jan. 16,

1920, the League of Nations was formally inaugurated.

Other Treaties. — After the Germans had signed the treaty of Versailles on June 28, 1919, the peace conference turned to the problems of Austria (*see* SAINT-GERMAIN, TREATY OF), Hungary (*see* TRIAXON. TREATY OF THE), Bulgaria (*see* NEUILLY. TREATY OF) and Turkey (*see* SÈVRES. TREATY OF).

Mandates.—The acceptance of the principle of mandates was one of the most far-reaching decisions of the conference. It was a new venture in the government of backward peoples, and one destined to play a large part in the affairs of many nations. It gave an excuse and a method for taking over the German colonies by the several countries interested.

The German colonial empire vanished overnight. It was one of the hardest blows which German pride received, and one resented with passionate fervour.

Until the Paris conference there had been no attempt to reach a general understanding or fixed policy between the more powerful civilized nations regarding the control or betterment of such states or territories.

However, the system hitherto practised was admittedly so bad that when the conference came to the disposition of the former German colonies. there was general agreement that a more enlightened policy should be inaugurated. In furtherance of this desire article 22 was incorporated in the covenant of the League of Nations, and subsequently a commission was appointed to sit in London during the summer of 1919 for the purpose of preparing the terms of the mandates. Upon this commission were Lord Milner, who had as his adviser Lord Robert Cecil; Henri Simon. French minister for the colonies; Viscount Chinda of Japan; Signor Marconi for Italy; and Col. House for the Cnited States, with George Louis Beer as adviser (*see* MAXDATE).

(E. M. H.; R. B. McC.)

SUMMARY

Few treaties of peace have had such severe criticism from victor and vanquished alike as the treaty of Versailles and the treaties subordinate to it. The first criticism is with regard to time and method. It has often been argued reasonably enough that the conference should have begun earlier than the second half of Jan. 1918 and that there should have been a preliminary peace which would have enabled Europe to begin the work of reconstruction. But this argument ignores the difficulties which the Allied Powers had in organizing their delegations and preparing to meet the intricate questions which the exhausting efforts of war work had caused them to delay. Moreover, President Wilson had to face the biennial mid-term elections in November and would have found it difficult to he in Paris sooner, and so great was his prestige at that time that the conference would have been useless without him. In Great Britain the prime minister judged it necessary to hold a general election, a step which has been much criticized, but this criticism overlooks the fact that the parliament in existence had exceeded its normal span by three years and had become in some respects unrepresentative.

It has also been said that not enough forethought had been given to the methods of working the conierence and that more should have been left to the professional diplomats of the Allied countries who would have worked more skilfully and speedily if left to themselves. But the three dominant statesmen, Wilson, Lloyd George and Clemenceau, were men of such outstanding personality and men with such a suspicion and contempt for conventional diplomatic methods that they naturally expected and were expected by their countries to be in the centre of the peacemaking from the first. Their political power outweighed the diplomatic skill of their most experienced advisers.

French opinion was not satisfied with the treaty, for it did not provide them in a clear enough manner with either the military security which the French naturally desired, nor the material compensation for the destruction of so much of their country. The guarantee of security through the League of Nations covenant, incorporated in the treaty, was unconvincśng to the French and smacked of misty Anglo-Saxon idealism. The pact which mould have bound Great Britain and the United States to give military support to France foundered with the failure of the treaty to secure ratification in the U.S. senate. On the other hand the French well understood that the Germans were unlikely to accept the treaty in spirit and were certain to resent its severe conditions. The judgment of Jacques Bainville that the treaty was "too harsh for its lenity" expressed very well French uneasiness.

In Great Britain and the United States opinion began rapidly to turn against the treaty. In the United States this was a double reaction of the isolationists who could not accept the League of Nations and of many liberals who felt that Wilson had renounced his higher idealism in being party to such a severe document. In Great Britain opinion at first was on balance favourable; only two English members of parliament voted in the commons against its acceptance and the act of Ring George V in meeting Lloyd George personally at Victoria station on his return from the conference was in tune mith popular feeling. But already much Liberal and Labour opinion mas anxious and indignant and had made itself felt. Later in the year this opinion was stimulated by one oi the most effective political pamphlets of modern times, J. M. Keynes's *The Economic Consequences of the Peace* (London, 1919). This book, which enjoyed at once great celebrity, painted a picture of the conierence and of the peace which came to be accepted by most Liberals and Radicals in Britain and the United States although it was widely denounced at the time in Conservative organs. Its main purpose was to demonstrate that the provisions of the treaty with regard to reparations were absurd and cruel but more generally it poured scorn on the principal actors at the conierence, the conduct of the election in 1918, and the supposedly odious character of the new parliament.

In the course of time Conservative opinion began to turn against the settlement, less on humanitarian and economic grounds than because it was "unrealistic." Conservative opinion did not seriously accept the covenant of the League as a great boon and the passing of the old Austro-Hungarian empire now replaced by smaller and new states was regretted without much reflection on the fact that the Austro-Hungarian empire had disappeared by the time the hostilities had ceased in 1918.

By insisting on including the full cost of the war as a basis for reparations, the British and French delegations had aroused expectations which were not iulfilled. The reparations commission which was charged with arranging the amount and manner of the payments was a source of much dispute between Britain and France in postwar years and the collapse of the German currency added to the difficulties. A more moderate demand for a fixed sum might have been more successful. In time Keynes's criticism of the economic consequences of the treaty came to be generally accepted although it was later challenged, notably by the work of Etienne Mantoux, *The Carthaginian Peace* (Oxford, 1946).

The attempt to settle Europe on the principle of self-determination has also been vigorously assailed and many examples of unjust drawing of frontiers were quoted as revealing either folly or vindictiveness. In each instance a case can be made out for the frontier lines chosen. But the severe limitation of the frontiers of Hungary appeared unduly oppressive. The inclusion of the southern Tyrol in Italy was a concession to the Italian claims of a strategic frontier and a defiance of national considerations. The frontiers of Poland in the west were vigorously assailed, most of all the strip which gave access to the sea, the so-called Polish corridor, becoming especially notorious. Yet it was the violation of Poland's western frontier by Germany which mas the occasion of the British and French declaration of war in 1939. The Turkish treaty was severely attacked and probably with most reason. The extension of the Greek kingdom into Thrace and into Asia Minor proved to be politically untenable and militarily indefensible and the reviving power oi Turkey under Mustafa Kemal Ataturk enabled the Turks to return to Constantinople and to Smyrna. The British mandate for Palestine (which enabled the Jews to find a home in their ancient land) attracted little attention at the time but later produced the gravest difficulties; by Jews, however, it is remembered as the beginning of the new state oi Israel. There is a certain irony in the reflection that while the principle of self-determination was essentially a Liberal principle, the Liberals in Great Britain and elsewhere, with a few exceptions, were unable to greet its practical applications mith approval; they were much influenced by the fact that the treaty had been carried out by their political enemies and in an atmosphere of chauvinism and nationalistic excitement repugnant to their taste and conscience.

The view may be taken that the treaty was unsound in its general principles, that it injured Germany too severely without, at the same time, providing guarantees against its future aggression. On the other hand, it may be held that the treaty was the best obtainable in the circumstances and that the new frontiers of Europe, for all the difficulties which they presented, mere more just to the various peoples of Europe than the previous state of affairs which left all Europe east of the Rhine under the control of three despotic empires — Germany, Austria and Russia. What was deiective was not the treaty itself but the will of the victors to enforce it. The Bolshevik revolution and the outbreak of class warfare in all countries presented problems which attracted attention away from national problems. The challenge of Marxist socialism produced a new form of counter-revolutionary demagogy which under the name of fascism or naziism threatened the peace of Europe in a way which no one in 1919 could possibly have predicted.

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PARIS, DECLARATION OF (1856) owes its origin to the diametrically opposing views of Great Britain and France on the carriage of property at sea at the time of the Crimean War. In 1854 France allowed enemy goods in neutral vessels to go free but confiscated neutral goods in enemy vessels. Great Britain confiscated enemy goods in neutral vessels but respected neutral goods in enemy vessels. The situation was an impossible one for neutrals. Accordingly each power abandoned part of its doctrines and accepted part of its ally's doctrines. This compromise was expressed in Art. 2 and 3 of the Declaration of Paris, which stated four principles of international law:

1. Privateering continues to be illegal. 2. The neutral flag covers enemy's goods. with the exception of contrahand of war. 3. Neutral goods. with the exception of contraband of war, are not liable to capture under the enemy's flag. 4. Blockades in order to be binding must be effective. *i.e.,* maintained by a force sufficient to prevent access to the coast of the enemy.

The declaration was signed by Austria. France. Great Britain, Prussia. Russia. Sardinia and Turkey, and was acceded to by all the powers except Bolivia, Spain, United States. Uruguay and Venezuela. Spain acceded in 1908. The United States withheld formal adherence on the ground that. not possessing a large navy. it was obliged to rely upon privateers in time of war. The U.S. government would not agree to give up the right to commission privateers unless the principle of the immunity of private property at sea was generally accepted. At the beginning of the American Civil War and again in the Spanish-American War of 1898 the United States declared its adherence to the declaration for the duration of hostilities only. Spain in the latter war. while repudiating any obligation to the declaration, announced that it would take a similar course.

During World War I the British prize court declared that it would regard the declaration not only in the light of rules binding in the conduct of war but also as a recognized and acknowledged part of the law of nations. But Art. 2 became almost wholly nullified by a series of developments: the disappearance of the "Free List"; the extension of the term "contraband" to include all commodities of use, directly or indirectly. to the enemy in the conduct of the war: the presumption of hostile destination; and the application of the doctrine of continuous voyage. Art. 3 was also rendered almost wholly nugatory by the German submarine method of indiscriminate destruction. While the neutral owner of goods on board an enemy vessel was entitled to have them restored or paid for when brought in for adjudication, he took the risk of all necessary acts of war. It was held by the French and German prize courts that in the case of lawful destruction of an enemy merchant vessel compensation for loss of neutral goods on board could not be claimed. Sinking at sight. without putting passengers and crew in a place of safety, although forbidden by the London naval treaty of 1930 (Art. 22) and the London protocol of 1936. was resorted to by the principal belligerents on both sides in World War II. (See Niirnberg judgments on Donitz and Raeder. *International Military Tribunal,* pp. 304. 308 [1946]). Art. 4 mas .repeated in the Declaration of London (1909) but "paper blockades" were complained of in World War I. Conditions of war against enemy commerce had so changed that the Declaration of Paris had little applicability during or after World War II.

(H. H. L. B.; Q. W.)

PARIS, TREATIES OF. When this term is used without qualification it refers either to the treaties signed at Paris on May 30, 1814. and on Nov. 20. 1815, at the end of the Napoleonic wars. or to the treaty of March 30, 1856, that ended the Crimean War.

Many other treaties and conventions have been signed at Paris. They are most readily identified by their dates and by the names of the wars they ended. The treaty of Paris signed by Great Britain and France on Feb. 10, 1763. for example, ended the Seven Years' A'ar. Other notable examples are the treaty of alliance between France and the United States signed at Paris on Feb. 6, 1778; the treaty of Sept. 3, 1783, which ended the War of American Independence; and the treaty of Dec. 10, 1898, ending the Spanish-American War.

The treaties signed at various Parisian suhurhs, such as Versailles. in 1919 and 1920 at the end of World War I are sometimes referred to collectively as the treaties of I'aris (*see* PARIS, CONFERENCE OF).

The treaties of Paris signed on May 30, 1814, were between France on the one side and Austria, Great Britain. Portugal. Prussia. Russia and Sweden on the other. Spain made the same treaty with France on July 20. Napoleon had abdicated in April and the victors, even after nearly a quarter century of n·ar. gave generous terms to France under the restored Bourbon dynasty. France was allowed to retain her boundaries of Jan. 1, 1702. keeping possession of the enclaves annexed in the early years of the revolution; the most substantial was the papal territory around Avignon. Outside this frontier. France kept some small territories of which the most important were the fortress of Landau and, in the southwest. Savoy. Most of the French colonies were given back to France. hut Tobago and St. Lucia in the West Indies and the Ile-de-France (now Mauritius) and its dependencies in the Indian ocean were ceded to Great Britain; San Domingo went to Spain; and France recognized the British possession of Malta. France received most-favoured-nation trading rights in British India and her old fishing rights at Newfoundland and the Gulf of St. Lawrence.

This treaty dealt only in general terms with the disposal of the European territories taken from the French empire and ended with the provision that all of the powers engaged on either side in the war should send plenipotentiaries to Vienna to complete the arrangements. In "additional, separate, and secret articles." however. France agreed to accept the principles to be determined at the Vienna conference by the allied powers, Austria, Great Britain, Prussia and Russia. The articles formed the basis for much of the subsequent treaty of Vienna. Other supplementary treaties dealt with the abolition of the slave trade. the expenses of prisoners of war and private claims against France.

The second treaty (Nov. 20. 1815) and its dependent instruments were signed in an altogether diiferent spirit. Napoleon had returned from Elba and had met with no resistance and with much welcome from the French. War was resumed and continued until Napoleon was defeated at Waterloo. The preamble of the treaty stated that the allied powers had preserved France and Europe from the disturbances with which they had been menaced by Napoleon's last enterprise. They had decided. therefore. for the sake of future security to exact indemnities from France. partly in territory and partly in money. The French frontier was chanced from that of 1792 to that of Jan. 1, 1790. The enclaves remained French hut a number of bits of territory along the Belgian border. the fortress of Landau. and Savoy were taken away. France had to pay an indemnity of 700,000,000 fr. and to support an army of occupation of 150,000 men for not more than five years nor less than three years. In supplementary treaties. the provisions for the settlement of public and private claims were more detailed and more severe than in the treaty oi 1814. The treaty abolishing the slave trade was renewed and strengthened.

On the same day, a treaty commonly known as the Quadruple Xlliance was signed by Austria. Great Britain. Prussia and Russia. The four powers declared their intention to enforce the treaties signed with France, to exclude the Bonaparte family from the throne and to continue their alliance after the military occupation of France was ended. The sixth article stated that in order to facilitate and to secure the execution of the present treaty, the sovereigns or their ministers would meet at fixed periods to consider measures that might be useiul for the repose and prosperity of nations and the peace of Europe. In accordance with this last article the congresses of Aix-la-Chapelle (1818), Troppau (1820), Laibach (1821) and Verona (1822) were held (*qq.v.*).

The treaty of 1856 dealt with problems that had not been included in the settlement of 1814–15: the Near East and the influ-

ence of Russia in the Ottoman empire. The terms of the treaty were worked out at a congress that met in Paris from Feb. 25 to April 30 on principles that had been agreed on under Austrian mediation. The congress convened to make peace between the belligerents of the Crimean War: Russia on the one side, France, Great Britain, Sardinia-Piedmont and Turkey. Austria, which had maintained formal neutrality during the war but had leaned towards the western powers, was represented throughout the congress; Prussia was invited to attend to help revise certain existing treaties.

As the principal occasion for the war against Russia had been the protection of Turkey, the treaty gave special attention to this problem. Turkey was for the first time formally admitted into the system of the public law of Europe and the other powers agreed to respect and to guarantee her independence and territorial integrity. In turn. the Sultan promised to improve the condition of his subjects without distinction of religion or race. The Black sea was neutralized: its ports and waters were opened to merchant ships of all nations but were closed to all warships, and its shores were to be forever without fortifications or naval bases. The Danube river was opened to free navigation and an international commission was created to regulate this and to keep the channel free of obstacles. Russia was removed from direct contact with the delta of the river by the cession of part of Bessarabia to Moldavia. The principalities of Moldavia and Wallachia (later joined as Rumania) n-ere reorganized as autonomous states under the suzerainty of the Sultan.

An additional convention reaffirmed the "ancient rule" that the Straits of the Bosphorus and Dardanelles were closed to all foreign warships while Turkey was at peace. A declaration on the maritime law of war, which was generally accepted as international law, abolished privateering; declared that enemy goods; except contraband, were protected by a neutral flag; that neutral goods, except contraband, were not subject to capture even on enemy ships; and required that blockade. to be effective, must be maintained by a force sufficient really to prevent access to the enemy coast.

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PARIS COMMUNE: see COMMUNE (OF PARIS, 1871).

PARISH. In the early Christian Church each district was administered by a bishop and his attendant presbyters and deacons, and the word *parochia* was frequently applied to such a district. Scattered congregations or churches within the *parochia* were served by itinerant presbyters. Toward the close of the 4th century it had become usual for the bishop to appoint resident presbyters to defined districts or territories. to which the term parish came gradually to be applied. (*See* also DIOCESE.)

Parish. in English ecclesiastical law, may be defined as the township or cluster of townships assigned to the ministration of a single priest, to whom its tithes and other ecclesiastical dues are paid: but the word has now acquired several distinct meanings. After the abolition of compulsory church rates in 1868 the old ecclesiastical parish ceased to be of importance as an instrument of local government. Its officers. however, have still important duties to perform. The rector, vicar or incumbent is a corporation-sole, in whom is vested the freehold of the church and churchyard, subject to the parishioners' rights of user. The other officials are the parish clerk and sexton. They have freeholds in their offices and are paid by customary fees, but can be dismissed by a joint act of the incumbent and the parochial church council. Church parochial councils were created by the Parochial Church Councils (Power) Measure of 1921. The primary duty of the council is to co-operate with the incumbent. It is a body corporate with perpetual succession. The powers of the vestry and church trustees were mostly transferred to it, and it has power to levy a voluntary church rate.

About the beginning of the 13th century the whole, or almost the whole. of the kingdom of Scotland was divided into parishes. After the Reformation the power of altering parishes was assumed by the legislature. The existing parochial districts being found unsuited to the ecclesiastical requirements of the time, a general act was passed in 1581. which made provision for the parochial clergy. and. *inter alia,* directed that "a sufficient and competent" district should be appropriated to each church as a parish (1581, cap. 100). Thereafter, by a series of special acts in the first place, and, subsequent to the year 1617, by the decrees of parliamentary commissions. the creation of suitable parochial districts proceeded. In the year 1707 the powers exercised by the commissioners were permanently transferred to the court of session. whose judges were appointed to act in future as "commissioners for the Plantation of Kirks and Valuation of Teinds." Under this statute the areas of parishes continued to be altered and defined down to 1843. when the act commonly known as Graham's act was passed. This act. which applied to the disjunction and erection of parishes. introduced a more simple procedure. The main division of parishes in Scotland was into civil and ecclesiastical. or. to speak more accurately, into parishes proper (*i.e.,* for all purposes, civil and ecclesiastical) and ecclesiastical parishes.

In the United States the term parish is not in use as a territorial designation except in Louisiana. the 64 parishes of which correspond to the counties of the other states. Various U.S. religious denominations frequently use the word to denote the area or congregation served by a single church.

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PARISITE, a rare mineral. consisting of the cerium group of rare earths (cerium. lanthanum. didymiurn) and calcium fluocarbonate. For many years the only known occurrence of the mineral was in the famous emerald mine at Muzo in the eastern Andes in Colombia found by J. J. Paris, who rediscovered the mine. It has been found in Norway. Italy and Madagascar, at Quincy, Mass., and in Montana. The composition of parisite is $(CeF)_2Ca(CO_3)_3$. It is found only as crystals, which belong to the hexagonal system and usually have the form of acute double pyramids terminated by the basal planes; parallel to the basal plane there is a perfect cleavage. The crystals are hair brown in colour and are translucent. Light which has traversed a crystal of parisite exhibits a characteristic absorption spectrum. (L. J. S.; X.)

PARIS UNIVERSITY. The University of Paris had its beginnings in the early 13th century. As was the case with most other universities in the middle ages, it was a kind of corporate company including both professors nnd students. Before it came into existence, the already famous Paris schools were divided into two categories: on the one hand, the École de Notre-Dame, dependent on the chapter of the cathedral, was administered by the chancellor of Notre-Dame; on the other, the abbatial schools were organized in famous ecclesiastical institutions, often outside the town. Such were Ste.-Geneviève's and St.-Victor's, the most celebrated among them.

The chancellor of Notre-Dame tried to enforce his control of all education within his jurisdiction. Thus he alone bestowed the *licentia docendi; i.e.,* the right of teaching. Both professors and students opposed this state of affairs and tried to gain autonomy so as to organize education in their own way. Among other things. they wanted to give the right of teaching to all those who showed adequate intellectual ability and to this end they joined in a *conjuratio,* a community of professors and students. which was given the name of *universitas,* and sought the pope's favour against the chancellor.

It is impossible to assign a precise date of birth to the university. However, in 1200, King Philip II Augustus granted the university authorities certain privileges and toward the end of 1208, Pope Innocent III gave them freedom in the planning of their own regulations; in 1215, the papal legate, Robert de Courçon, presented them with a statute. Finally. a bull of 1231 defined the relations between the university and the bishop, to the dis-

advantage of the latter. Such were the first real manifestations of the existence of the university.

Like the schools that preceded it in the 12th century, the university continued to attract the most celebrated professors in Europe, all of whom were ecclesiastics, as were the students themselves. The freedom from episcopal jurisdiction, which made the university directly answerable to Rome. both widened the scope of the curriculum and allowed a greater control by the pope of its orthodoxy, which was further increased by the entry of the mendicant orders — Dominicans and Franciscans both began teaching during the 1220s. Their intrusion provoked some discontent and a serious conflict broke out between the secular and the regular teaching clergy during the years 1252–57 and 1265–71; the conflict was settled by the pope in favour of the mendicant regulars who from then onward taught without hindrance.

So, at the end of the 13th and in the 14th century, the University of Paris was the most celebrated teaching centre of all Christendom, particularly in theological studies. Among the famous professors were St. Bonaventura, Albertus Magnus and St. Thomas Aquinas. Students poured in from all countries and never more than in those days was the international character of education, deeply Christian in inspiration, more in evidence. The pupils were divided into four "nations" according to their origin: French. Picards, Normans and English. The university included four faculties: the faculty of arts where the arts of trivium (grammar, rhetoric and logic) and quadrivium (arithmetic, geometry, astronomy and music) were taught together with scientific, literary and general culture; the faculty of theology, the most famous of the faculties; the faculty of law (civil and canonic); and the faculty of medicine. A dean was elected at the head of each faculty, and the dean of the faculty of arts was the nominal chief of the university with the title of rector. Many colleges were built to accommodate the students; one which was to be the best-known in later years was founded in the middle of the 13th century by the legate Robert de Sorbon and was called the Sorbonne. Mont-Ste-Genevieve became the district of studies. the Latin Quarter.

The University of Paris played an important part in the history of the time. It was. so to speak, a tribunal for orthodoxy and its pronouncements had great influence. During the Great Schism (1378–1418) its advice and decisions were of the highest importance; it detailed the various solutions capable of bringing the church crisis to an end (its professors were Pierre d'Ailly and Jean Gerson). The university also sometimes took part in politics; for example, during the quarrel between the Armagnacs and the Burgundians (at the beginning of the 15th century), it upheld the cause of the duke of Burgundy. John the Fearless.

Such activities, however. somewhat detracted from its prestige. In addition. education founded essentially on the scholastic method became rigidly fixed. As a result, the university made little contribution to the humanism of the Renaissance, in spite of the presence of as great a Renaissance scholar as Jacques Lefèvre d'Étaples (Jacobus Faber). Finally it was torn by the conflicts arising out of the Reformation.

The university's reluctance to accept advanced theories explained its critical situation at the end of the 16th century. Its resources had been severely reduced after the wars of religion; its authority had been reduced and its discipline relaxed; and, moreover, academic studies had been abandoned by a generation more attracted by martial glory than by the pleasures of the mind. The kings therefore undertook reforms. In 1598 Henry IV promulgated new statutes which specified the functions of teachers. reenforced discipline and established new programs. Cardinal Richelieu further clarified these rules and proceeded with the construction of colleges. The new Sorbonne was completed in 1627 on its present site and Richelieu wished to be buried in the chapel. the first stone of which he laid in 1635. The statutes of 1598 were in operation throughout the 17th and 18th centuries. They gave the university a solid foundation, and its members always enjoyed high repute. They took part in the quarrels of the Quietists, Jansenists and Gallicans (for the professors were opposed to the Jesuits whose teaching flourished in many colleges, particularly that of Clermont, founded in 1611).

The French Revolution aimed at sweeping away all institutions of the ancien *régime* (and of the Roman Catholic Church) and at reorganizing education; accordingly the colleges and the four faculties of the university were abolished on Sept. 15, 1793. For 13 years, they were replaced by institutions of learning specializing in different fields — the Polytechnic school, the Ecole Normale, the school of medicine and the museum. In 1806 Napoleon, with a view to higher education, founded the University of France which was granted the monopoly of teaching in France. It was organized according to a decree of March 17, 1808, and gave birth to a new University of Paris.

The latter reunited the establishments for higher education within the Academy of Paris. which was a territorial district inside the University of France, and had a rector appointed by the government at its head. Once more it included several faculties, some of which were to disappear in the future (for example, that of theology in 1886), while other faculties were to be created, for example, those of science and pharmacy. Many specialized institutions were later to come under its sway; for example the École des Beaux-Arts and the Institut National des Sciences Politiques. Apart from small alterations in details, this organization still exists. Teaching was laic; *i.e.*, independent in regard to any political or religious doctrine. Professors were co-opted.

The University of Paris renewed its fame in modern times as one of the most distinguished scientific and intellectual centres throughout the world and the premier university of France. The most reputed professors lecture there and there are more than 400 chairs. The number of students in 1885 was nearly 12,000; in 1953 it exceeded 50,000. Students of both sexes come from all parts of France, territories of the French union and many foreign countries.

The curriculum of the University of Paris likewise underwent considerable changes. The faculties of letters, of the sciences and of law, it is true, were in the middle of the 20th century still granting the same degrees and setting the same examinations as previously (for the *baccalauréat*, for the licence and for the doctorat); but other faculties had an entirely different structure. A student of medicine, for instance, proceeded directly to his doctorate without any intervening change of status; students of pharmacy or at the various institutes took their own special diplomas; and the old examinations were being progressively superseded by competitions.

These developments, however, were not restricted to the University of Paris. They reflected; rather, the general tendency of higher education in contemporary France, which. in common with the rest of the educational system, seemed to be calling for a radical reform that would affect at once the range of studies and the methods of instruction.

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PARITY, LAW OF CONSERVATION OF. The law of the conservation of parity states that in every physical process a certain characteristic of the physical system, called its parity, remains unchanged. The lax belongs to the class of conservation laws (like that of energy) which are the most powerful principles of physics. The parity of a system, like its energy, is a relatively abstract property. Unlike energy, parity has no meaning in classical physics, and the law is thus not readily put into everyday language. But the basic concept of symmetry which underlies the law is old and familiar. and will be described in some detail below.

The conservation of parity was explicitly formulated in the early days of quantum mechanics by Eugene Wigner; it became an intrinsic part of the theory. In the summer of 1956. Tsung-Dao Lee and Chen Ning Yang of Columbia university and the Institute for Advanced Study, Princeton, Buggested that the law, however well verified in other parts of physics, might fail in certain inherently slow decay processes of various fundamental particles. A world-wide attack on the problem by many experimenters led to

a full confirmation of the proposal of Lee and Yang. In such decay processes it nas found that parity indeed is not conserved. Lee and Yang were jointly awarded the 193'7 Nobel prize for physics.

Parity is the formal expression of the behaviour of the wave function of any system when the spatial co-ordinates describing the system are inverted through the point at the origin; that the co-ordinates *x,* y and *z,* are sent into *-x, -y* and *-z.* Such an analytical transformation may be visualized by thinking of the relation between a right and a left hand or by viewing not the object directly but its optical image in an ordinary plane mirror. Since the time of Kant, at least, this distinction between object and image has concerned natural philosophy. Such a mirroring produces a counterpart to any given physical system; the full content of the lam of conservation of parity is simply that the "mirrored" system so produced is as fully physical as its original. The world of the looking glass is a possible real world—of course, it is an unfamiliar one. In Lenis Carroll's *Through the Looking-Glass,* Alice first thought the looking glass book was in a strange language, but it was a *possible* language. Only a particular historical sequence led to the form of our letters and the direction in which we read them on the page. It is the same for all artifacts; there can be no real distinction between object and mirror image. For each of them, a mirrored artifact is possible. Even in biology the off-centred heart beat and the coiling direction of snail shells are mere accidents of history Mirrored organisms are perfectly possible, and indeed occur. The asymmetry of chemical molecules lies deeper, but is no different *(see* STERCOCHEMISTRY). For every optically active form, its mirror counterpart is possible, and identical in stability and function. The ubiquity, for example, of L-amino acids in nature is simply a historical fact; evolution might equally well have given us a living norld made wholly with D-amino acids.

But the β-decay of radioactive nuclei, and related processes, such as the decay of a and μ mesons, can distinguish object from image. Experiment demonstrates that the emitted particles in such processes show a particular sense of spin direction around their directions of flight. The ordinary β-decay processes, emitting negative electrons, send out neutrinos all of which spin in the sense a left-handed screw would turn if advanced along the direction of flight of the neutrino. No stronger violation of the parity principle could be produced; the looking glass 0-decay process is reversed in neutrino spin sense, and unrealizable in our world. But such decay processes are intrinsically rare; in all specifically nuclear processes and in mechanical and electromagnetic processes, which span all of the physical and chemical changes of everyday life, the object and image are equally realizable in nature and parity is fully conserved. Only in the slow decays, caused by the so-called weak interactions, nas the proposal of Lee and Yang found to describe the case.

It is probable that even the distinction between object and image allowed by the weak interactions would fail if the "mirror" mere rather more broadly interpreted. If the mirrored system were not only spatially different, but if it were as well made of antimatter (substituting positron for electron, antinucleon for nucleon, and so on throughout) the antimatter mirrored system would become realizable. The looking glass positron emission would yield spin directions just like the ones we can observe. It is possible that this more general mirroring in fact eliminates the apparent distinction, and that what we see as the fundamental distinction between our matter and antimatter is only an accidental feature of the grand evolution of matter in our cosmic neighbourhood. But Alice could never enter the looking glass world of antimatter on pain of annihilation!

See also PARTICLES, ELEMENTARY; QUANTUM MECHANICS.

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PARK, MUNGO (1771–1806?), Scottish explorer of the Niger, was born in Selkirkshire at Foulshiels on Sept. 10, 1771. He was apprenticed to a surgeon and through the good offices of Sir Joseph Banks became assistant surgeon on an East Indiaman. Returning from his first voyage in 1793, he contributed a description of eight new Sumatran fishes to the *Transactions* of the Linnean society.

In 1794 Park offered his services to the African association to explore the Kiger. On June 21, 1795, he reached the Gambia and ascended that river 200 mi. to Pisania. a British trading station. On Dec. 2, he started for the unknown interior by crossing the upper Senegal basin. The journey was full of difficulties. At Ludamar he was imprisoned by an Arab chief for four months; he escaped alone on July 1, 1796, with nothing but his horse and a pocket compass. On July 21 he reached the long-sought Niger at Ségou. He followed the river downstream 80 mi. to Silla, where he was obliged to turn back, being without means and utterly exhausted. On his return journey he took a route more to the south, keeping close to the Kiger as far as Bamako. He reached Pisania again on June 10, 1797. A detailed narrative of his journey, *Travels* in *the Interior of Africa,* was published in 1799. It was extremely popular at the time and is still regarded as a classic.

In 1799 Park married and settled at Foulshiels. Two years later he moved to Peebles, where he practised medicine. In the autumn of 1803 he was invited by the government to lead another expedition to the Niger. Park accepted the offer, but the start of the expedition was delayed, so he went back to Foulshiels. He made the acquaintance of Sir Walter Scott, who was then living nearby at Ashestiel.

In September Park was summoned to London to leave on the new expedition. He sailed from Portsmouth for the Gambia on Jan. 31, 1805, having been given a captain's commission as head of the government expedition. Alexander Anderson, his brother-in-law, was second in command. Having picked up reinforcements at Goree; Park began to ascend the Gambia with a company of 40 Europeans. Only 11 of them were alive when the expedition reached the Niger in August; the rest had succumbed to fever or dysentery. From Bamako the journey to Ségou was made by canoe. He received permission from the ruler of that town to proceed and at Sansanding, a little below Ségou, Park prepared for his journey down the still unknown part of the river. With eight companions he set sail on Nov. 19, 1805.

Park wrote to his wife stating his intention not to stop or land anywhere until he reached the coast. where he expected to arrive about the end of Jan. 1806. No more was heard of the party until reports of disaster reached the settlements on the Gambia. As a result of inquiries made on behalf of the British government it was established that Park and his company reached the rapids at Bussa, about 1,000 mi. below Sansanding. There they were attacked by hostile natives and Park was drowned.

BIBLIOGRAPHY.—J. Thomson, *Mungo Park and the Niger* (1890), for a critical estimate. *See* aiso the biography by J. Wishaw prefixed to *Journal of a Mission into the Interior of Africa in 1805* (1815); H. B., *The Life of Mungo Park* (1835); S. L. Gwynn, *Mungo Park and the Quest of the Niger* (1934). (JA. S.)

PARK, ROBERT EZRA (1864–1944), U.S. sociologist, was born in Luzerne county. Pa., Feb. 14, 1864, and graduated from the University of Michigan. Ann Arbor, in 1887. His experiences as a newspaper reporter and editor in Minneapolis, Minn., Chicago, Ill., and Detroit, Mich. (1887–98) led him to study the mechanisms of individual and social behaviour with William James and Josiah Royce at Harvard university and with Georg Simmel and Wilhelm Windelband at Heidelberg university, where he received his Ph.D. in 1904.

Park was assistant in philosophy at Harvard, 1904–05, and later while secretary to Booker T. Washington, devoted himself to the study of the Negro. He was a member of the sociological staff of The University of Chicago, 1913–33, and after his retirement taught and conducted research at Fisk university, Nashville, Tenn., 1936–43.

Park conceived of sociology as a natural science of human behaviour. He defined its relations to other social sciences and developed its conceptual systems in terms of the processes of communication, conflict, accommodation and interaction. He made a clear distinction, which he believed to be fundamental, between the ecological community as an aggregate of individuals characterized by symbiosis, the division of labour. and competitive cooperation and society as an organization of persons through

communication, socialization and collective behaviour. These and other sociological concepts he regarded not as ends in themselves but as research instruments.

Among his writings are *Introduction to the Science of Sociology* (1921); The *Immigrant Press and Its Control* (1922); *The City, Suggestions for the study of the Urban Environment* (1925); *Race and Culture* (1950); *Human Communities, the City and Human Ecology* (1952).

See Edna Cooper, "Bibliography of Robert E. Park," Pylon, The *Atlanta University Review of Race and Culture,* 6:372–83 *(1945).*

(ET. W. B.)

PARK AND PLAYGROUND. The first parks mere grants of the royal lands for the enjoyment of people; modern parks are gifts from the people to themselves. They are paid for by public funds and are planned in an organized and functional way for the use and recreation of taxpayers. In the course of this development there have been many changes, increasing in numher each year. In some respects, the modern parks would hardly be recognizable to those accustomed to the parks of previous centuries.

In the parks of earlier times there were extensive woods. rectilinear *allées* stretching between one vantage point and another, raised galleries and, in many cases, elaborate aviaries and cages for wild beasts. attesting to the hunting proclivities of the lords. Later the concept of the public park was somewhat domesticated. An area devoted simply to green landscape, a saluhrious and healthful breathing space as a relief from the densely populated and industrialized city of the mid-19th century, became of vital importance. Examples of this type park are: Birkenhead park in England (1814) by Sir Joseph Paxton; Jean Charles Alphand's Bois de Boulogne; Central park in New York city by F. L. Olmsted and C. Vaux; Friedrich-il'ilhelmsgarten in Germany; the Botanic gardens in Melbourne, Aust.; and Akashi park in Kōbe, Japan. The design was generally romantic in character. The primary purpose was to provide for passive recreation—walking and taking the air in agreeable and natural surroundings reminiscent of the unspoiled country.

What primarily differentiates modem parks is their accommodation for active recreation. Park areas differ greatly from country to country, and their designs reflect differences in climate: cultural attitudes. social habits and pastimes. In the gardens of the Generalife. a Spanish family may enjoy its holiday outing in a shaded *bosque* near a cool fountain. On an evening in Venice a procession with banners and torches may sweep into one of the little piazzas. In the Buttes-Chaumont in Paris little boys reach out from wooden horses on the merry-go-round to spear a brass ring. During the bright summer week-ends in Stockholm residents cultivate vegetables in allotment gardens leased to them by the park department. In Israel. Iran and Pakistan. basketball: soccer and kabadei (a game like rugby) are played in parks; in Japan. volleyball, tennis and sumō (wrestling). Almost universally. there is recognition of the creative possibilities of leisure and of community responsibility to provide space and facilities for recreation.

The facilities include outdoor theatres, zoos, concert shells, historical exhibits, concessions for dining and dancing, amusement areas, boating and areas for sports of all kinds such as fly-casting pools and skating rinks. There is always the danger that the original reason for creating the park, *i.e.,* to bring a part of nature within reach of the city dweller. will be sacrificed to its specific recreational functions. It is difficult to keep the balance—the tempo of urban life is mounting and with it the requirements for intensive use.

Another danger to the public park has been the automobile. With the tremendous growth in automobile traffic. and consequently increasing pressure from traffic authorities for more land. there has been hardly a major city that has not lost some sections of its parks to highways. There has been a growing awareness, particularly in Europe, that large-scale urban planning should be carried out in such a way that traffic functions are clearly separate and do not encroach on other spheres. In the United States also; there have been victories for the park user against the automobile; in San Francisco, the state freeway was halted at the city limits, and in New York, Washington square was closed to traffic altogether.

It is unfortunate that the word park has come to connote almost exclusively the "romantic" style park or English garden of the 19th century, examples of which have been noted above. In truth. there are other traditions whose influence has been equally vital. How different from the Parisian Buttes-Chaumont. for instance. are the Tuilleries across the river. These were laid out under the supervision of Marie de Medici in the style of the Boboli gardens in Florence. Versailles, the Belvedere park in Vienna, the Vatican gardens in Rome, Hellbrun in Salzburg. Blenheim in England, Drottningsholm in Sweden and Peterhof in the U.S.S.R.—all these parks stem originally from the Italian baroque tradition. They were not intended to be a foil or escape from the oppressive city. but rather to be its central dramatic focus—a display for the opulence of rulers, a piazza for the moving of great crowds, from the tournament and guild ceremonies of Florence in the 17th century to the formal pageantry of the court. It was in the baroque park that the handling, control and stimulation of crowds in the open air developed as one of the great arts of the urban designer.

A third park tradition which has had world-wide influence is that of Islam. In Teheran, Marrakesh, Seville, Lahore and Delhi, this tradition is the dominant one and. as with all parks. developed according to the climate, social custom and religious ethos. The original Moslem idea was to think of the garden as a paradise, a symbol of the afterlife as an oasis of beauty blooming in the earthly desert. Water and the cypress are the two main elements. Within the park then is water, the symbol of purity, in the four-way river of paradise, and trees (above all the cypress, symbolizing life), surrounded by high walls to keep out the dry wind. Everywhere: in keeping with the religious view. the design pattern is abstract rather than humanistic. The fundamental idea creates its own specific technical skills; nowhere is there more artful use of irrigation for plants. of jets of water to cool the air, of orchards for shade, of colour to break up the sun's glare or of the use of masonry patterns than in these Islamic gardens.

The Taj Mahal in India dates from the 17th century. when by the testament of Shah Jahan this area of 20 ac. was to be maintained as a public grounds in perpetuity, where the poor could walk and pick fruit. In China and Japan, a similar opening of the royal precinct for public enjoyment, as with the Winter palace or the Katsura Imperial Villa gardens in Kyōto, has been a more recent development. The great religious shrines, however. have always resembled western parks. The Horimonji temple in Tokyo, the Mimeguri shrine, the great Buddhist temple at Ise and the Inner (Shintō) shrine at Mieshima are examples of an age-old garden tradition in which man is but "one of a thousand things" and where nature is presented in an idealized and symbolic way as an object for contemplation and spiritual enjoyment. In their techniques of horticulture and in their use of stones, water and surface textures. the gardens of the far east are of a high level. This eastern tradition had its effect on European park design in the 18th century and again in the 20th century, as in the grounds for the USESCO building in Paris, designed by Isamu Noguchi.

PLAYGROUNDS

The playground is perhaps the most typical facility of the new park's recreational function. Active playground building programs are continually underway in almost all countries. The acquisition of lands, the most difficult of all problems, is approached in various ways. In London. for instance, lans have been enacted to permit conversion of ancient burial grounds in the city core to recreational use. In New Pork playground areas have been acquired in conjunction with traffic planning: playgrounds are often built as adjuncts to highway developments.

There have been changes in the educational philosophy behind playgrounds and immense changes in their design and methods of construction. At the beginning of the century the originators of the playground movement in western Europe and the United States were preoccupied with problems of health and safety. Ample statistics demonstrated that higher rates of tuberculosis. traffic accidents and delinquency occurred in areas aithout playground facilities. The typical playground of that day was an outdoor

gymnasium for body and character building through the development of athletic skills.

These goals have not changed but others have been added: new categories of childhood experience have been taken into consideration. There has been, for instance, much attention given by psychologists, child development specialists and educators generally to the preschool child. New attitudes toward play, developed first in nursery schools, have liberalized thinking toward all outdoor play areas and resulted in the design of highly distinctive equipment for public areas often called "tot-lots." The effects of this new spirit are seen in an awareness of the child's own scale, in an appreciation of materials that can be used by the active child emotionally and socially as well as physically. Much has been done with objects that stimulate the child's innate skills of improvisation. In addition to sand, water and simple building materials in abstract shapes, boats, trains, wagons and similar toys have been installed in playgrounds for children to use in dramatic play.

While playgrounds in the United States tend to have structural and mechanical equipment, European playgrounds, particularly those in the Scandinavian countries usually have more informal and natural materials; *e.g.,* the simple hardwood trees in Scandinavian playgrounds; the "junk playgrounds" in Denmark where children are encouraged to do their building out of odds and ends with their own tools. This is also a characteristic of the new state nurseries in the U.S.S.R., of the English "adventure" playgrounds and those of the "Pro Juvente" movement in Switzerland! one example of which is the famous Robinson Crusoe playground in Zurich. In the Netherlands there has been an attempt to adapt portions of residential streets for use as playgrounds.

Another influential development has been the amusement park or kiddie land, of which the most famous example is California's Disneyland where the old fairy tales and nursery rhymes are brought to life and animated mechanically. Though the child participates only as a spectator, and therefore passively, these storybook playgrounds are genuinely popular. They have introduced new materials. particularly plastics with their bright colours and resilient textures, to the construction of playground equipment and have brought new gaiety and liveliness into the design.

Indeed. design has become a major factor in the contemporary playground. Formerly the area mas considered as an open space to be outfitted with standard equipment from the manufacturers; it has now become a challenge to the landscape architect, the industrial designer and the sculptor. Moller-Nielsen in Sweden and Seebacher-Konzut in Vienna are two of the foremost designers of this new play sculpture; in the U.S., the foremost landscape architects are Eckbo and Royston. Almost everywhere where there are new playgrounds, exciting and original work is being produced.

STANDARDS

Park and playground standards vary from one country to another not simply because parks and playgrounds are planned in relation to varying population densities and diverse physical and cultural patterns. The idea of standards of any kind is a fairly recent one and an outgrowth of the prior notion that cities themselves can be planned for the health and recreation of their citizens; that is, in a rational way by responsible agencies with certain definite technical means at their disposal.

In the layout of the new planned towns and cities, Chandigarh in India. Kitimat in Alaska, Valingby in Sweden and Brasilia in Brazil, definite standards as to recreation space have been adhered to. In Chandigarh, communities of from 8,000 to 20,000 have been planned nithin a $\frac{1}{2}$-mi. radius of the local community centre or sports field, slightly less than a 15-min. walk. This agrees roughly with the standards of the other new towns.

In older cities, city planning must have been well established and effective over a relatively long period for standards to have any validity. In Zurich, there are playfields and social centres serving nell-defined neighbourhoods within an average walking distance of $\frac{5}{8}$ mi. from each residence. This pattern is the result of careful planning and a social outlook which is less in evidence in cities where development is in the hands of the uncontrolled speculative builder.

Standards throughout the United States and Canada have been perhaps the most widely publicized. The National Recreation association (N.R.A.) recommends for neighbourhood playgrounds from 3.25 to 6 ac. to serve a population of 2.000–6.000 or about 1 ac. for each 800 persons. The area should be located within an average of $\frac{1}{4}$ mi. walking distance from each residence. Playfields with recreation building should be from 12 to 20 ac. to serve a population of 20,000 or about 1 ac. for each 800 persons; it should be located within $\frac{1}{2}$ to 1 mi. walking distance. Standards set by the California committee for recreation park areas and facilities (with particular reference to high-density areas in Los Angeles) call for one playground serving a neighbourhood of from 2,000 to 4,000 persons, at an average walking distance of $\frac{1}{8}$ mi. Standards recommended by the Canadian Federation of Mayors and Municipalities agree generally with those of the N.R.A. The figure often quoted as the standard for total recreation space in cities (which would include larger parks, conservation areas, zoos, botanical gardens and concert grounds) is 1 ac. to every 100 persons.

According to the N.R.A. actual figures at mid-20th century for several U.S. cities are as follows:

In Los Angeles, there is 1 ac. total park space for each 500 persons and 1 playground under year-round leadership (including public school playgrounds) for each 11,000 persons. In Philadelphia there is 1 ac. total park space for each 200 persons and 1 playground under active year-round leadership for each 50,000 persons. In Seattle, there is 1 ac. total park space for each 160 persons and 1 playground for each 23,000 persons.

New facilities constructed in the United States are generally of high standard, but there is still a long way to go before coverage is adequate for most urban populations. Perhaps the most encouraging trend, particularly in western U.S., is the increasing use of the public school playground and its facilities (such as auditorium, gym and club rooms) as a community and neighbourhood centre throughout the year.

It is significant that in statistics published for certain European cities, in contrast to those for U.S. cities, relatively little emphasis is placed on small neighbourhood playgrounds, not because they do not exist, but because they are provided by other than public or governmental recreation agencies. In the newer urban sections particularly, the common building type is the large and openly landscaped housing estate, in which play spaces for the younger children are created as part of the original plan.

In France, where social patterns are again different, younger children's play is oriented more to the family group than to the wider peer group. Also, the quality of play depends less on motor activity and use of apparatus. There is consequently little provision for playgrounds of this type in the parks.

There are many other instances in mhich standards are almost inapplicable. In Spain, for instance, the private sports club, organized for football, soccer, rowing and other activities, performs a function provided elsewhere by the public authority; there is also the institution of the "Penas" or informal conversational club, in mhich the boulevard cafe becomes in a real sense a social centre.

In countries where the baroque design tradition predominates, particularly in the Mediterranean countries, there is more spontaneous and open social play and a sense of pageantry that makes use of public squares and boulevards in immeasurable ways.

After World War II, there was an almost world-wide dissemination of playgrounds and facilities of the western type. However, there has also been a growing appreciation of indigenous recreation forms such as folk music, gardening, wrestling or simply a quiet contemplation of nature as in the oriental gardens. Indeed there is implicit in the word playground a dissociation from both home and work that would be incomprehensible to certain cultures not overtaken by the march of industrialism. In part, the recreation movement has followed the industrial revolution, and has been in a sense an answer to certain problems and displacements which might not otherwise have been acute. See also CITY PLANNING; ZOSING.

See Talbot Hamlin, *Forms and Functions of 20th Century Architecture,* vol. *4,* ch. *48–49* (1952). (R. B. NI.)

PARKER, ALTON BROOKS (1852–1926). U.S. lawyer, was born at Cortland. N.Y., May 14, 1852. He graduated from Albany Law school in 1873. Admitted to the bar, he began to practise at Kingston, N.Y., and in 1877 was elected surrogate of Ulster county. In 1885 he mas appointed by the governor justice of the N.Y. supreme court to fill a vacancy, and the following year was regularly elected. He was appointed a member of the second division of the N.Y. court of appeals in 1889 and a member of the general term in 1893. In 1898 he was elected chief justice of the N.Y. court of appeals. In 1904 he resigned on being nominated by the Democrats for president, but he was defeated by Theodore Roosevelt. He then resumed the practice of laa in New York city. In 1913 he mas counsel for the managers of the impeachment of Governor Sulzer of New York. He died in New York city. May 10. 1926.

PARKER, FRANCIS WAYLAND (1837–1902), U.S. educator, a founder of what is commonly called the progressive education movement, was born in Bedford, N.H., Oct. 9, 1837. He started to teach at age 16 and five years later (1858) became school principal in Carrolton, Ill. After service in the Union army during the Civil War he resumed teaching until 1872 when he went to Germany to study the new educational practices pioneered by Pestalozzi. Herbart and Froebel.

Parker's main work was accomplished as school superintendent in Quincy, Mass., and as head of the Cook County Normal school in Chicago. Ill. His pedagogy was essentially progressive, advocating self-expression, activity and a humanized instruction that stressed the child's individuality and the teacher's artistry. Parker emphasized arts and crafts and urged the correlation of subjects around a common core. Much of this mas basically European, but Parker was no mere borrower. In an era when principals were tsars in their schools, Parker favoured the democratic process. To encourage understanding and cooperation, he convened his teachers in weekly discussions and organized the first parent-teacher group in Chicago. Parker died on March 2, 1902.

For Parker's views *see* his *Talks on Teaching* (1896) and *Talks on Pedagogics* (1894).

See Adolphe E. Meyer, *An Educational History of the American People* (1957). (A. E. M.)

PARKER, SIR (HORATIO) GILBERT (1860–1932), Canadian-born politician and writer of popular adventure fiction and historical romance, was born at Camden East, Ont., Nov. 23, 1860. He was educated at local schools, Ottawa Normal school and Trinity college, Toronto. In 1885 he went to Australia and traveled extensively in the South seas; in 1889 he moved to London and soon became known for his skill in weaving spirited stories out of energetic action, vivid characters and rich local colour. In politics he became a prominent imperialist and was a member of parliament for Gravesend from 1900 to 1918. Knighted in 1902, he was made a baronet in 1915 and a privy councilor in 1916. He died in London, Sept. 6, 1932, but was buried in Belleville, Ont.

Parker first made his mark as a writer with *Pierre and His People* (1892) and other dramatic tales of the Canadian northwest and of French Canada. The most widely read of his 33 volumes were *The Scats of the Mighty* (1896), a romance of the conquest of Quebec; *The Battle of the Strong* (1898), a historical tale of the Channel Islands during the Napoleonic Wars; *The Right of Way* (1901), a violent contemporary novel set in Quebec; and *The Weavers* (1907), a melodramatic story of imperialist intrigue in England and Egypt. His collected works were published in 23 volumes (1912–1923).

See C. F. Klinck and R. W. Watters, *Canadian Anthology* (1955). (G. H. Ro.)

PARKER, HORATIO WILLIAM (1863–1919), U.S. composer and musician, mas born at Auburndale, Mass., Sept. 15, 1863. He studied music first in Boston, later at the Royal Conservatoire, Munich. In 1894 he was appointed professor of the theory of music at Tale. His oratorio *Nora Novissima* was nidely performed in America and nas given in England in 1899 at Chester and at the "Three Choirs" festival at Worcester, the latter an honour never before paid an American composer. His opera *Mona* won the Metropolitan Opera company's $10,000 prize in 1911, and in 1914 his opera *Fairyland* gained the National Federation of Women's clubs' $10,000 prize. For the centenary celebration of the Handel and Haydn society of Boston in 1915 he wrote the cantata *Morven and the Grail.*

His other works include: the cantatas, *King Trojan* and *The Kobolds;* and the oratorios, *St. Christopher* and *A Wanderer's Psalm.* He died at Cedarhurst. L.I., Dec. 18. 1919.

PARKER, SIR HYDE, BART. (1739–1807). British admiral. second son of Sir Hyde Parker (1714–82), entered the navy at an early age, and became lieutenant in 1758. Five years later he became a post captain, and from 1766 served in the West Indies and in North American waters, particularly distinguishing himself in breaking the defences of the North river (N.Y.) in 1776. His services on this occasion earned him a knighthood in 1779. In 1778 he was engaged in the Savannah expedition. and in the following year his ship was wrecked on the hostile Cuban coast. His men, however, entrenched themselves, and were in the end brought off safely. Parker was with his father at the Dogger Bank. and with Howe in the two actions in the Straits of Gibraltar. In 1793. having just become rear admiral, he served under Lord Hood at Toulon and in Corsica, and two years later, now a vice-admiral, he took part, under Hotham, in the indecisive fleet actions of March 13, and July 13, 1795. From 1796 to 1800 he was in command at Jamaica. In 1801 he was appointed to command the fleet destined to break up the northern armed neutrality, with Nelson as his second-in-command. Copenhagen fell on April 2 to the fierce attack of Nelson's squadron, Parker with the heavier ships taking little part. Subsequently Parker hesitated to advance up the Baltic, a decision which was severely criticized. Soon afterward he was recalled and Nelson succeeded him. He died in 1807.

PARKER, MARTIN (c. 1600–*c.* 1652). English ballad writer whose best known song "The King enjoyes his own again" (1645?) was a favourite with royalists and Jasobites in the 17th and 18th centuries. He may have been a London tavern keeper and apparently began publishing ballads about 1625. Many, with his signature or initials, are preserved in the British museum. London.

Parker was acknowledged by his contemporaries as the "popular" poet laureate and by John Dryden as the best ballad writer of his time. His ballads were tuneful, topical and often amusing: one, "Saylors for my Money," inspired Thomas Campbell's "Ye mariners of England." Parker died *c.* 1652.

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PARKER, MATTHEW (1504–1575), archbishop of Canterbury, was born at Norwich, Aug. 6, 1504. Matthew was sent in 1522 to Corpus Christi college, Cambridge. He graduated B.X. in 1525, was ordained deacon in April and priest in June 1527, and was elected fellow of Corpus the following September. He commenced M.A. in 1528, and was one of the Cambridge scholars whom Wolsey wished to transplant to his newly founded Cardinal college at Oxford. Parker, like Cranmer, declined the invitation. He had come under the influence of the Cambridge reformers, and after Anne Boleyn's recognition as queen he was made her chaplain. Through her he was appointed dean of the college of secular canons at Stoke-by-Clare in 1535. In 1537 he was appointed chaplain to Henry VIII and in 1538 he mas threatened with prosecution by the reactionary party. But in 1541 he was appointed. to the second prebend in the reconstituted cathedral church of Ely. In 1544 on Hehry VIII's recommendation he was elected master of Corpus Christi college, and in 1545 vice-chancellor of the university. He got into some trouble with the chancellor, Gardiner, over a ribald play, "Pammachius," performed by the students, deriding the old ecclesiastical system, though Bonner wrote to Parker of the assured affection he bore him. On the passing of the act of parliament in 1545 enabling the king to dissolve chantries and colleges, Parker was appointed one of the commissioners for Cambridge, and their report saved its colleges, if there had ever been any intention to destroy them. Stoke however was dissolved in the following reign and Parker received a pension equivalent to £400 a year in modern currency. He took advantage of the new reign to marry Margaret, daughter of Robert Harlestonc, a

Norfolk squire in June 1547 before clerical marriages had been legalized by parliament and conxocation During Rett s rebellion he was allowed to preach in the rebel camp on Mousehold hill, but without much effect Later he encouraged his chaplain, Alexander Neville, to write his history of the rising His Protestantism advanced nith the times and he received higher promotion under Northumberland than under the moderate Somerset Bucer nas his friend at Cambridge. and he preached Bucer's funeral sermon in 1551. In 1552 he was promoted to the deanery of Lincoln and in July 1553 he supped with Northumberland at Cambridge when the duke marched north on his campaign against Mary.

As a supporter of Northumberland and a married man, Parker was naturally deprived of his preferments. But he was not cast in a heroic mold and had no desire to figure at the stake; he lived quietly in retirement throughout Mary's reign. He was elected archbishop of Canterbury on Aug. 1, 1.559; but it was not until Dec. 17 that four bishops were found willing and qualified to consecrate him. Parker's consecration was, however, only made legally valid by the royal supremacy, for the Edwardine Ordinal that was used had been repealed by Mary and not re-enacted by the parliament of 1559. Parker was a modest and moderate man of genuine piety and irreproachable morals. His historical research was exemplified in his *De antiquitate ecclesiae* and his editions of Asser, Matthew Paris, Walsingham and the compiler known as Matthew of Westminster; his liturgical skill was shown in his version of the psalter and the occasional prayers and thanksgivings which he was called upon to compose. He left a priceless collection of manuscripts to his college at Cambridge.

He was happier in these pursuits than in the exercise of his jurisdiction. lie was left to stem the rising tide of Puritan feeling with little support from parliament, convocation or the crown. The bishops' *Interpretations* and *Further Considerations,* issued in 1.5'60, tolerated a lower vestiarian standard than was prescribed by the rubric of 1559; the *Advertisements,* which Parker published in 1566 to check the Puritan descent had to appear without specific royal sanction; and the *Reformatio legum ecclesiasticarum,* which Foxe published with Parker's approval, received neither royal, parliamentary nor synodical authorization. Parker died on May 17, 1575, lamenting that Puritan ideas of "governance" would "undo the queen and all others that depended upon her."

John Strype's *Life of Parker,* originally published in 1711, and re-edited lor the Clarendon Press in 1821 (3 vol.), is the principal source for Parker's life. *See* also J. Bass Mullinger's scholarly life in *Dict. Nat. Biog.;* W. H. Frere's volume in Stephens and Hunt's *Church History;* Strype's *Works* (General Index); Gough's Index to *Parker Soc. Publ.* Fuller, Burnet, Collier and R. W. Dixon's Histories of the Church; Birt's *Elizabethan Settlement;* H. Gee, *Elizabethan Clergy* (1898); W. M. Kennedy, *Archbishop Parker* (1908).

PARKER, THEODORE (1810–1860), American preacher and social reformer, was horn at Lexington, Mass., Aug. 24, 1810, the grandson of Capt. John Parker, leader of the minutemen in the skirmish at Lexington. From his mother he learned the religion of love and good works; from his father the use of good books; and his formal training was secured in the district school and one term at Lexingtoc academy. At 17 he became a schoolmaster and at 20 he entered Harvard, working on his father's farm as usual while he followed his studies, going over to Cambridge for the examinations only. For the theological course he resided at the college, graduating in 1836. At the close of his college career he began his translation (published in 1843) of Wilhelm M. L. De Wette's *Beiträge zur Einleitung in das Alte Testament.* He found himself extremely antagonistic to the popular theology of the period. He was ordained in West Roxbury however in 1837 and preached there until 1846. His rationalistic views were slow in assuming form, but on May 19, 1841, he preached at Boston a sermon on "the transient and permanent in Christianity," which presented the main principles and ideas of his final theological position. The Boston Unitarian clergy denounced him and declared that the "young man must be silenced." Nevertheless he delivered in Masonic hall, in the winter of 1841–42, the lectures published as the *Discourse* of *Matters pertaining to Religion* (1842). Beginning in 1845 he preached to the Twenty-Eighth Congregational society of Boston. He took up the question of the emancipation of the slaves, fearlessly advocating in Boston and elsewhere, from the platform and through correspondence and the press, the cause of the Negroes. He assisted actively in the escape of fugitive slaves and aided John Brown (*q.v.*). But his days were numbered. In Jan. 1859 he suffered a violent hemorrhage of the lungs and vainly sought relief by retreating first to the West Indies and then to Europe. He died in Florence on May 10, 1860. A preacher rather than a thinker, a reformer rather than a philosopher, he spoke straight to men's intelligence and conscience and the goodness of their hearts.

Among his principal works are: *Ten Sermons of Religion* (1852) and *Theism, Atheism and the Popular Theology* (1853). A collected edition of his works was published in England by Frances P. Cobbe (1863–70) and another, the Centenary edition, in Boston, Mass.. by the American Unitarian Association (1907–11). A volume of *Theodore Parker's Prayers,* edited by Rufus Leighton and Matilda Goddard, was published in 1861 and a volume of Parker's *West Roxbury Sermons,* with a biographical sketch by F. B. Sanborn, in 1892. A German translation of part of his works was made by Ziethen (1854–57).

BIBLIOGRAPHY.—Biographies include John Weiss, *Life* and *Correspondence of Theodore Parker* (1864); O. B. Frothingham, *Theodore Parker: A Biography* (1874); J. W. Chadwick, *Theodore Parker, Preacher and Reformer* (1900), containing a bibliography; and H. S. Commager, *Theodore Parker, Yankee Crusader* (1936, reissued *1960).*

For Parker's religious and philosophical position, *see* J. E. Dirk, *Critical Theology of Theodore Parker* (1948).

PARKERSBURG, a city of West Virginia, U.S., and seat of Wood county, is located at the confluence of the Little Kanawha and Ohio rivers about midway between Pittsburgh and Cincinnati. Settled about 1785 as Neal's station on a land tract originally purchased by Alexander Parker, it was first chartered by Virginia in 1820, and rechartered by West Virginia in 1563.

The city is the marketing centre for a large agricultural and industrial area in the mid-Ohio and Little Kanawha regions. Raw materials anti natural resources include oil. natural gas, sand, gravel, clays. hardwoods and brines. Around these a diversified industry developed including oil well equipment, glass and porcelain products, rayon, shovels, iron and steel and chemicals.

Blennerhassett Island. once the property of Harman Blennerhassett. lies just below the city.

For comparative population figures *see* table in WEST VIRGINIA; *Population.* (S. R. SM.)

PARKES, SIR HARRY SMITH (1828–1855); British diplomatist. was horn at Bloxwich, near Walsall, Staffordshire, on Feb. 24, 1828. When only 14 he went to live at Macao and studied Chinese with such effect that in 1844 he entered the British consular service as interpreter. As consul in Canton in 1856 Parkes's dispatches on the seizure of the British-registered. Chinese-owned lorcha "Arrow" played no small part in the war with England and France. The treaty of Tientsin. 1858, nominally ended the war. But in 1860. when Lord Elgin was approaching Peking to ratify the treaty. Parkes was treacherously seized with three companions, imprisoned and saved from decapitation only by the Allies' arrival. Parkes became consul in Shanghai in 1862. Appointed minister to Japan in 1865, he narrowly escaped murder by reactionary samurai for his open support of the reformers.

In 1883 he was appointed jointly minister to China and the newly opened kingdom of Korea. He died on March 22, 1885, at Peking. (O. M. G.)

PARKES, SIR HENRY (1815–1896), Australian prime minister, who has been called the father of the Australian commonwealth, was born at Stoneleigh, in Warwickshire, on May 27, 1815. The son of parents in humble circumstances, he received only a rudimentary education. and at an early age was obliged to earn his living as a common labourer. Failing to make his way in England, he emigrated to Australia in 1839, and after a time settled in Sydney as an ivory turner. He took a prominent part in the movement against the transportation of convicts, and in 1849 started the *Empire* newspaper to inculcate his policy of

attacking abuses while remaining loyal to the crown. The paper appeared until 1858. One of the reforms for which Parkes fought most strenuously was the full introduction of responsible government. He was returned to the legislative council under the old constitution as member for Sydney. and on the establishment of a legislative assembly in 1856 mas elected for East Sydney. He was elected for East Sydney again in 1859 at the first general election under the new electoral act, and sat until 1861, when he was sent to England to promote emigration.

He made a prolonged stay in England, and described his impressions in a series of letters to the *Sydney Morning Herald,* some of which were reprinted in 1869 under the title of *Australian Views of England.* He returned to Australia in 1863. and became colonial secretary from 1866 to 1868. He passed the Public Schools act of 1866, which for the first time instituted an efficient system of primary education in the colony. His great chance came in 1872, when the Martin ministry resigned on the question of the sum payable by Victoria in lieu of border duties. Parkes had for several years persistently advocated free imports as a remedy for the financial distress of the colony. He now became prime minister and colonial secretary; and he threw the colony open to trade. He held office until 1875, and on the fall of the Robertson ministry again became premier and colonial secretary from March until Aug. 1877. At the end of this year he was made K.C.M.G.

Parkes formed a coalition with Sir John Robertson, and became premier and colonial secretary for the third time from Dec. 1878 to Jan. 1883. In 1887 he again took office as prime minister. His free trade policy was once more successful. Other important measures of his administration were the reform of the civil service. the prohibition of Chinese immigration, and the railways and public works acts. He fell from office in Jan. 1889, but in the following March became for the fifth time premier and colonial secretary. The remainder of his life was chiefly devoted to the question of Australian federation. The federal convention at Melbourne in 1890 was mainly his work; and he presided over the convention at Sydney in 1891, and was chiefly responsible for the draft constitution there carried. Defeated in Oct. 1891 on his refusal to accept an eight hours' day for coal miners. he remained in opposition for the rest of his career. He died at Sydney on April 27, 1896.

He published, in adtiition to the works already named and numerous volumes of verse, a collection of speeches on the *Federal Government of Australia* (1890), and an autobiography, *Fifty Years in the Making of Australian History* (1892).

PARK FOREST, a residential village in Cook county, 11 mi. S. of Chicago, in northeastern Illinois, U.S. Developed after World War II, Park Forest attracted widespread interest because its planners assumed responsibilities for all phases of community development.

The builders designed the village primarily for middle-income families, to include rental and privately owned dwellings, as well as schools. churches. shopping centres, municipal services and an industry park. Construction began in Aug. 1947. From its incorporation in 1949, the community has retained a village organization with a trustee-manager form of municipal government. Commuters are served by railway and bus lines. For comparative population figures *see* table in ILLINOIS: *Population.*

(AR. C. H.)

PARKINSON'S DISEASE: *see* PARALYSIS AGITANS.

PARKMAN, FRANCIS (1823–1893), U.S. historian, was born at Boston, Mass., on Sept. 16, 1823. He was the son of Francis Parkman, a graduate of Harvard in 1807.

Francis Parkman was the eldest of six children. As a boy his health was delicate, so that it was thought best for him to spend much of his time at his grandfather Hall's home in Medford on the border of the Middlesex Fells, a rough and rocky woodland, which was as wild in many places as the primaeval forest. This breezy life saved him from the artificial stupidity which is too often superinduced in boys by their school training. At the age of 14 Parkman began to show a strong taste for literary composition. In 1841, while a student at Harvard, he made a rough journey of exploration in the woods of northern New Hampshire, and at this time he determined to write a history of the last French war in America. which ended in the conquest of Canada, and some time afterward he enlarged the plan so as to include the whole course of the American conflict between France and Great Britain; or, to use his own words, "The history of the American forest; for this was the light in which I regarded it. My theme fascinated me, and I was haunted with wilderness images day and night." In the course of 1842 illness led to his making a journey to Italy. In 1844 he graduated at Harvard with high honours.

He now determined to study the real wilderness in its gloom and vastness. He had become an adept in woodcraft and a dead shot with the rifle, and could do such things with horses, tame or wild. as civilized people never see done except in a circus. In company with his iriend and classmate, Quincy Shaw, he passed several months with the Ogillalah band of Sioux. Knowledge, intrepidity and tact carried Parkman through these experience~ unscathed. and good luck kept him clear of encounters with hostile Indians. It was an important experience in relation to his life-work.

But outdoor life did not suffice to recruit Parkman's health, and by 1848. when he began writing *The Conspiracy of Pontiac,* he had reached a truly pitiable condition. The trouble seems to have been some form of nervous exhaustion, accompanied with such hypersensitiveness of the eyes that it was impossible to keep them open except in a dark room. Against these difficulties he struggled with characteristic obstinacy. He invented a machine which so supported his hand that he could write legibly with closed eyes. Books and documents were read aloud to him, while notes were made by him with eyes shut, and were afterward deciphered and read aloud to him until he had mastered them. After half an hour his strength would give out, and in these circumstances his rate of composition for a long time averaged scarcely six lines a day. The superb historical monograph composed under such difficulties was published in 1851. It had but a small sale, as the American public was then too ignorant to feel much interest in Xmerican history. But Parkman began his great work on *France and England in the New World,* to which the book just mentioned was in reality the sequel. This work involved several journeys to Europe, and was performed with a thoroughness approaching finality.

In 1865 the first volume appeared, with the title of *Pioneers of Frtwce in the New World;* 27 years elapsed before the final volumes came out in 1892. After the *Pioneers* the sequence is *The Jesuits in North America, La Salle and the Discovery of the Great West, The Old Régime in Canada, Frontenac and New France and Louis XIV, Montcalm and Wolfe, A Half Century of Conflict.* As one obstacle after another was surmounted, as one grand division of the work after another became an accomplished fact. the effect upon Parkman's condition seems to have been bracing, and he acquired fresh impetus as he approached the goal. His physical condition was much improved by his cultivating plants. He was an adept horticulturist and himself originated several new varieties of flowers. He was professor of horticulture in the agricultural school of Harvard in 1871–72, and published a few books on the subject of gardening. He died at Jamaica Plain on Nov. 8. 1893.

The significance of Parkman's work consists partly in the success with which he has depicted the North American Indians. Parkman was the first great writer who really understood the Indian's character and motives. Against this savage background of the forest he shows the rise, progress and dramatic termination of the colossal struggle between France and Great Britain for colonial empire. With all its instructiveness, his book is a narrative as entertaining as those of T. Macaulay or J. Froude. In judicial impartiality Parkman may be compared with S. R. Gardiner, and for accuracy of learning with W. Stubbs. (J. F.)

See G. H. Farnham, *Life of Francis Parkman,* 2nd ed. (1909); H. D. Sedgwick, *Francis Parkman* (1905); *H.* C. Lodge, "Francis Parkman," *Mass. Hist. Soc. Proc.,* vol. lvi., pp. 319–335 (1923); J. Russell, "What We Owe to Francis Parkman," *Dalhousie Review,* vol. iii., pp. 330–341 (1923); J. W. Oliver, "Francis Parkman," *Western Pa. Hist. Mag.,* vol. vii., pp. 1–9 (1924).

PARK RIDGE, a residential city in Cook county. 13 mi.

N.W. of Chicago, in northeastern Illinois, U.S. The town site developed around a brickyard founded by George Penny and Robert Meachem in 1854. Known first as Pennyville, then Brickton, the village was organized as a residential community and renamed Park Ridge in 1873. following the exhaustion of its clay deposits. Proximity to Chicago and location on the Chicago and North Western railway brought a steady growth without industry. It was incorporated as a city in 1910. The family home of John Alden Carpenter (*q.v.*), the U.S. composer, later became the city hall. Rapid expansion occurred after the 1940s with the suburban movement of business and the nearby construction of O'Hare field. Chicago's international airport. In 1950 the city adopted a council-manager form of government. For comparative population figures *see* table in ILLINOIS: *Population.* (AR. C. H.)

PARLEMENT, in O Fr. the name given to any meeting for discussion or debate (*parler*, to speak), a sense in which it was still used by Joinville, but from the latter half of the 13th century employed in France in a special sense to designate the sessions of the royal court *(curia regis)*. Finally, when the parlement of Paris had become a permanent court of justice, having the supreme authority in cases brought before it, and especially in appeals against the sentences of the *baillis* and seneschals, it retained this name, which was also given to the other supreme courts of the same nature which were created after its model in the provinces.

Early Usage.—The early Capetians had a custom, based upon ancient precedents, of summoning periodically to their court their principal vassals and the prelates of their kingdom. These gatherings took place on the occasion of one of the great festivals of the year, in the town in which the king was then in residence. Here they deliberated upon political matters and the vassals and prelates gave the king their advice. But the monarch also gave judgment here in those cases which were brought before him. These were few in number during the early days of the Capetian dynasty; for though the king always maintained the principle that he was judge, and even that his competence in this respect was general and unlimited, this competence was at the same time undefined and it was not compulsory to submit cases to the king At this period, too, appeals, strictly so called, did not exist. Nevertheless when a suit was brought before the king he judged it with the assistance of his prelates and vassals assembled around him, who formed his council. This was the *curia regis*. But in law the king was sole judge, the vassals and prelates being only advisers. During the 12th and at the beginning of the 13th centuries the *curia regis* continued to discharge these functions, except that its importance and actual competence continued to increase, and that we frequently find in it, in addition to the vassals and prelates who formed the council, *consiliarii,* who are evidently men whom the king had in his entourage, as his ordinary and professional councillors. Under the reign of St. Louis (which was also the period at which the name parlement began to be applied to these judicial sessions) the aspect of affairs changed. The judicial competence of the parlement developed and became more clearly defined; the system of appeals came into existence, and appeals against the judgments of the *baillis* and seneschals were brought before it; cases concerning the royal towns, the *bonnes villes,* were also decided by it. Again, in the old registers of the parlement at this period, the first *Olim* books, we see the names of the same councillors recurring from session to session. This suggests that a sufficient number of councillors was assured beforehand, and a list drawn up for each session; the vassals and prelates still figuring as a complementary body at the council.

Reforms.—Next came the series of ordinances regulating the tenure of the parlement, those of 1278, 1291, 1296 and 1308, and the institution was regularized. Not only were the persons who were to constitute each parlement named in advance, but those who were not placed on this list, even though vassals or prelates, were excluded from judging cases. The royal *baillis* had to attend the parlement, in order to answer for their judgments, and at an early date was fixed the order of the different *bailliages,* in which the cases coming from them were heard The *baillis,* when not interested in the case, formed part of the council, but were afterwards excluded from it. Before the middle of the 14th century the personnel of the parlement, both presidents and councillors, became fixed *de facto* if not *de iure.* Every year a list was drawn up of those who were to hold the session, and although this list was annual, it contains the same names year after year; they are as yet, however, only annual commissaries (*commissaires*). In 1344 they became officials (*officiers*) fixed but not yet irremovable. At the same time the parlement had become permanent; the number of the sessions had diminished, but their length had increased. In the course of the 14th century it became the rule for the parlement to sit from Martinmas (Nov. 11) till the end of May; later the session was prolonged till the middle of August, the rest of the year forming the vacation. The parlement had also become fixed at Paris, and, by a development which goes back to fairly early times, the presidents and councillors, instead of being merely the king's advisers, had acquired certain powers, though these were conferred by the monarch; they were, in fact, true magistrates. The king held his court in person less and less often, and it pronounced its decrees in his absence; we even find him pleading his cause before it as plaintiff or defendant. In the 14th century, however, we still find the parlement referring delicate affairs to the king; but in the 15th century it had acquired a jurisdiction independent in principle. As to its composition, it continued to preserve one notable feature which recalled its origin. It had originally been an assembly of lay vassals and prelates; when its composition became fixed and consisted of councillor-magistrates, a certain number of these offices were necessarily occupied by laymen, and others by ecclesiastics, the *conseillers leis* and the *conseillers clercs.*

The parlement was at the same time the court of peers (*cour des pairs*). This had as its origin the old principle according to which every vassal had the right to be tried by his peers, *i.e.,* by the vassals holding fiefs from the same lord, who sat in judgment with that lord as their president. This, it is well known, resulted in the formation of the ancient college of the peers of France, which consisted of six laymen and six ecclesiastics. But although in strict logic the feudal causes concerning them should have been judged by them alone, they could not maintain this right in the *curia regis*; the other persons sitting in it could also take part in judging causes which concerned the peers. Finally the peers of France, the number of whom was increased in course of time by fresh royal creations of peerages, became *ex officio* members of the parlement; they were the hereditary councillors, taking the oath as official magistrates, and, if they wished, sitting and having a deliberative function in the parlement. In suits brought against them personally or involving the rights of their peerage they had the right of being judged by the parlement, the other peers being present, or having been duly summoned.

Divisions.—While' maintaining its unity, the parlement had been subdivided into several *chambres* or sections. In the first place there was the *Grand Chambre,* which represented the primitive parlement. To it was reserved the judgment in certain important cases, and in it a peculiar procedure was followed, known as *oral,* though it admitted certain written documents. Even after the offices of the parlement had become legally saleable the councillors could only pass from the other chambers into the *grand chambre* by order of seniority. The *chambres des enquêtes* and *des requites* originated at the time when it became customary to draw up lists for each session of the parlement. The *enquêteurs* or *auditeurs* of the parlement had at first been an auxiliary staff of clerks to whom were entrusted the inquests ordered by the parlement. But later, when the institution of the appeal was fully developed, and the procedure before the various jurisdictions became a highly technical matter, above all when it admitted written evidence, the documents connected with other inquests also came before the parlement. A new form of appeal grew up side by side with the older form, which had been mainly an oral procedure, namely the appeal by writing (*appel par écrit*). In order to judge these new appeals the parlement had above all to study written documents, the inquests which had been made and written down under the jurisdiction of the court of first instance. The duty of the *enquêteurs* was to make an abstract of the written documents and report on them. Later the reporters *(rapporteurs)* were

admitted to judge these questions together with a certain number of members of the parlement, and from 1316 onwards these two kintls of members formed together a *chambre des enquêtes*. As yet, no doubt, the *rapporteur* only gave his opinion on the case which he had prepared. but after 1336 all those who formed part of the chamber were put on the same footing, taking it in turn to report and giving judgment as a whole. For a long time, however, the *grand charnbre* received all cases, then sent them to the *chambre des enquêtes* with directions; before it too were argued questions arising out of the inquiry made by the *chambre des enquêtes* to the decisions of which it gave effect and which it had the power to revise. But one by one it lost all these rights, and in the 16th century they are no longer heard of. Several *chambres des enquêtes* were created after the first one, and it was they who had the greater part of the work

The *chambre des requites* was of an entirely different nature. At the beginning of the 14th century a certain number of those who were to hold the session of the parlement were set apart to receive and judge the petitions *(requites)* on judicial questions which had been presented to the king and not yet dealt with. This eventually led to the formation of a chamber, in the strict sense of the word. the *requêtes du palais* But this became purely a jurisdiction for privileged persons; before it (or before the *requites de l'hôtel*, as the case might be) were brought the civil suits of those who enjoyed the right of *committimus* The *chambre des requêtes* had not supreme jurisdiction, but appeals from its decisions could be made to the parlement proper. The parlement had also a criminal chamber, that of *La Tournelle*, which was not legally created until the 16th century, but was active long before then It had no definite membership, but the *conseillers lais* served in it in turn

Provincial **Parlements.**—Originally there was only one parlement, that of Paris, as was indeed logical, considering that the parlement was simply a continuation of the *curia regis*, which, like the king. could only be one. But the exigencies of the administration of justice led to the successive creation of a certain number of provincial parlements. Their creation, moreover, was generally dictated by political circumstances, after the incorporation of a province in the domain of the Crown. Sometimes it was a question of a province which, before its annexation, possessed a superior and sovereign jurisdiction of its own, and to which it was desired to preserve this advantage. Or else it might be a province forming part of feudal France, which before the annexation had had a superior jurisdiction from which the Crown had endeavoured to institute an appeal to the parlement of Paris, but for which after the annexation it was no longer necessary to maintain this appeal, so that the province might now be given a supreme court, a parlement. Sometimes an intermediate régime was set up between the annexation of the province and the creation of its provincial parlement, under which delegates from the parlement of Paris went and held assizes there. Thus were created successively the parlements of Toulouse, Grenoble, Bordeaux, Dijon, Rouen, Aix, Rennes, Pau, Metz, Douai, Besançon and Nancy. From 1762 to 1771 there was even a parlement for the principality of Dombes. The provincial parlements reproduced on a smaller scale the organization of that of Paris; but they did not combine the functions of a court of peers. They each claimed to possess equal powers within their own province. There were also great judicial bodies exercising the same functions as the parlements, though without bearing the name, such as the *Conseil souverain* of Alsace at Colmar, the *Conseil supérieur* of Roussillon at Perpignan; the provincial council of Artois had not the supreme jurisdiction in all respects.

The parlements, besides their judicial functions, also possessed political rights; they claimed a share in the higher policy of the realm, and the position of guardians of its fundamental laws. In general the laws did not come into effect within their province until they had been registered by the parlements. This was the method of promulgation admitted by the ancient law of France, but the parlements verified the laws before registering them, *i.e.*, they examined them to see whether they were in conformity with the principles of law and justice, and with the interests of the king and his subjects; if they considered that this was not the case they refused their registration and addressed remonstrances (*remontrances*) to the king. In acting thus they were merely conforming to the duty of counselling *(devoir de conseil)* which all the superior authorities had towards the king, and the text of the ordinances *(ordonnances)* had often invited them to do so. It was natural, however, that in the end the royal will should seek to impose itself. In order to enforce the registration of edicts the king would send *lettres de cachet*, known as *lettres de jussion*, which were not, however, always obeyed. Or he could come in person to hold the parlement, and have the law registered in his presence in a *lit de justice*. This was explained in theory by the principle that if the king himself held his court, it lost. by the fact of his presence, all the authority which he had delegated to it; for the moment the only authority existing in it was that of the king, just as in the ancient *curia regis* there was the principle that *apparente rege cessat ntagistratus*. But, principally in the 18th century, the parlements maintained that only a voluntary registration, by the consent of the parlement, was valid. The parlements had also a wide power of administration. They could make regulations (*pouvoir réglementaire*) having the force of law within their province, upon all points not settled by law, when the matter with which they dealt fell within their judicial competence, and for this it was only necessary that their interference in the matter was not forbidden by law. These were what were called *arrête de règlement*. By this means the parlements took part in the administration, except in matters the cognizance of which was attributed to another supreme court as that of taxation was to the *cours des aides*. They could also, within the same limits, address injunctions *(injonctions)* to officials and individuals.

See La Roche-Flavin, *Treize livres des parlements de France* **(1617)**; Felix Aubert, *Histoire du parlement de Paris, des origines à François I.* (2 vols., **1894**); Ch. **V.** Langlois, *Textes relatifs à l'histoire du parlement depuis les origines jusqu'en 1314* **(1888)**; Glasson, **Le** *Parlement de Paris, son rôle politique depuis le règne de Charles VII. jusqu'à la révolution* (2 vols., **1901**). (J. P. E.)

PARLEY, PETER: *see* GOODRICH. SAMUEL GRISWOLD.

PARLIAMENT, the name given to the supreme legislature of the United Kingdom of Great Britain and Northern Ireland. (For the old French *parlement, see* PARLEMENT; and for other assemblies *see* the articles on the respective countries.) The word is found in English from the 13th century, first for a debate, then for a formal conference, and for the great councils of the Plantagenet kings; and the modern sense has come to be applied retrospectively. William the Conqueror is said in the Anglo-Saxon Chronicle to have had "very deep speech with his Witan"; this "deep speech" (in Latin *colloquium*, in French *parlement)* was the distinguishing feature of a meeting between king and people and thus gave its name to the national assembly itself. The Statute of Westminster (1275) first used "parlement" of the great council in England.

The British parliament consists of the king (or queen regnant), the lords spiritual and temporal, and the commons. and it meets in two houses, the house of lords (the upper or second chamber) and the house of commons.

The crown, pre-eminent in rank and dignity, is the legal source of parliamentary authority. The sovereign virtually appoints the lords spiritual, and all the peerages of the lords temporal have been created by the crown. The king summons parliament to meet, and prescribes the time and place of its meeting, prorogues and dissolves it and commands the issue of writs for the election of members of the house of commons. By several statutes, beginning with the 4 Edward III, c. 14, the annual meeting of parliament had been ordained; but these statutes, continually disregarded, were virtually repealed in the reigns of Charles II and William and Mary (16 Ch. II 31; 6 and 7 Will. and Mary, 32). The present statute law merely exacts the meeting of parliament once in three years; but the annual voting of supplies has long since superseded statutory provisions. When parliament is assembled it cannot proceed to business until the king has declared the causes of summons, in person or by commission, and though the veto of the crown on legislation has long been obsolete, bills passed by the two houses only become law on receiving the royal assent.

The house of lords is distinguished by peculiar dignities, privileges and jurisdictions. Peers individually enjoy the rank and precedence of their several dignities, and are hereditary councillors of the crown. Collectively with the lords spiritual they form a permanent council of the crown, and, when assembled in parliament, they form the highest court of judicature in the realm, and were, until the Parliament act of 1911, a coequal branch of the legislature, without whose consent no laws could be made. Their judicature is of various kinds, viz.. for the trial of peers; for determining claims of peerage and offices of honour, under references from the crown; for the trial of controverted elections of Scotch and Irish peers; for the final determination of appeals from courts in England and Scotland; and lastly, for the trial of impeachments.

The house of commons also has its own peculiar privileges and jurisdictions. Above all, it has the paramount right of originating the imposition of all taxes and the granting of supplies for the service of the state. It has also enjoyed, from early times, the right of determining all matters concerning the election of its own members and their right to sit and vote in parliament. This right, however, has been greatly abridged, as, in 1868, the trial of controverted elections was transferred to the courts of law; but its jurisdiction in matters of election. not otherwise provided for by statute, is still retained intact. As part of this jurisdiction the house directs the speaker to issue warrants to the clerk of the crown to make out new writs for the election of members to fill up such vacancies as occur during the sitting of parliament.

Privileges of Parliament. — Bothhouses are in the enjoyment of certain privileges, designed to maintain their authority, independence and dignity. These privileges are founded mainly upon the law and custom of parliament, while some have been confirmed and others abridged or abrogated by statute. The lords rely entirely upon their inherent right, as having "a place and voice in parliament"; but, by a custom dating from the 6th Henry VIII, the commons lay claim, by humble petition to the crown at the commencement of every parliament, "to their ancient and undoubted rights and privileges." Each house has its separate rights and jurisdictions; but privileges properly so-called, being founded upon the law and custom of parliament, are common to both houses. Each house adjudges whether any breach of privilege has been committed, and punishes offenders by censure or commitment. This right of commitment is incontestably established, and it extends to the protection of officers of the house, lawfully and properly executing its orders, who are also empowered to call in the assistance of the civil power. The causes of such commitments cannot be inquired into by courts of law, unless it be manifest that the cause of commitment is other than for contempt (Lord Ellenborough in *Burdett* v. *Abbott*, 1811, 14 East at p. 150), nor can prisoners be admitted to bail. Breaches of privilege may be summarized as disobedience to any orders or rules of the house, indignities offered to its character or proceedings, assaults: insults or libels upon members, or interference with officers of the house in discharge of their duty or tampering with witnesses. Such offenses are dealt with as contempts, according to the circumstances of the respective cases, of which numerous precedents are to be found in the journals of both houses. The lords may imprison for a fixed period and impose fines; the commons can only imprison generally, the commitment being concluded by the prorogation. and have long discontinued the imposition of fines.

Freedom of speech has been one of the most cherished privileges of parliament from early times. Constantly asserted and often violated, it was finally declared by the Bill of Rights "that the freedom of speech, and debates and proceedings in parliament, ought not to be impeached or questioned in any court or place out of parliament." Such a privilege is essential to the independence of parliament and to the protection of members in discharge of their duties. But, while it protects members from molestation elsewhere, it leaves them open to censure or other punishment by the house itself whenever they abuse their privilege and transgress the rules of orderly debate.

Freedom from arrest is a privilege of the highest antiquity. It was formerly of extended scope. but has been reduced, by Inter legislation, within very narrow limits. Formerly not only the persons of members but their goods were protected, and their privilege extended to their servants. At present members are themselves free from arrest, but otherwise they are liable to all the processes of the courts. If arrested, they will be immediately discharged, upon motion in the court whence the process issued. Peers and peeresses are, by the privilege of peerage, free from arrest at all times. Members of the house of commons are free only for 40 days after prorogation and 40 days before the next appointed meeting; but prorogations are so arranged as to ensure a continuance of the privilege. Formerly even suits against members were stayed, but this offensive privilege has been abolished by statute. Exemption from attending as witnesses upon subpoena, once an acknowledged privilege, is no longer insisted upon; but immunity from service upon juries is at once an ancient privilege and a statutory right. The privilege of freedom from arrest is limited to civil causes and has not been suffered to exempt members from the operation of the criminal law, nor even from commitments for contempt by other courts. But, uhenever the freedom of a member is so interfered with, the courts are required immediately to inform the house of the causes of his commitment. Witnesses, suitors, counsel and agents in attendance upon parliament are protected from arrest and molestation and from the consequences of statements made by them or other proceedings in the conduct of their cases.

As both houses, in enforcing their privileges. are obliged to commit offenders or otherwise interfere with the liberty of the subject, the exercise of these privileges has naturally been called in question before the courts. Each house is the sole judge of its own privileges; but the courts are bound to administer the law, and, where law and privilege have seemed to be at variance a conflict of jurisdiction has arisen between parliament and the courts. Many interesting controversies have arisen upon such occasions; but of late years privilege has been carefully restrained within the proper limits of the law and the courts have amply recognized the authority of parliament.

EARLY HISTORY OF THE BRITISH PARLIAMENT

The origin of parliament may be sought in the assemblies of the Anglo-Saxons known as the folkmoot or tribal assembly and in the shire moot or assembly of the freemen of the shire. The shire moot was also the general folkmoot of the tribe, assembled in arms, to whom their leaders referred the decision of questions of peace and war.

Superior to these local institutions was the witenagemot, or assembly of wise men, with whom the king took counsel in legislation and the government of the state. This national council has sometimes been regarded as the origin of parliament but to describe it as such is an unhistorical anticipation of modern usage. Its character has been the subject of much antiquarian investigation, notably by William Stubbs and Felix Liebermann. It must never be forgotten that in these early times, and indeed long after, the making of new laws was as abhorrent as it was rare. The cry of the nation, so often expressed in the charters, was not for the making of new laws but for the preservation of old ones, while the levying of taxes was almost unknown except for purposes of national defense. Such a council was originally held in each of the kingdoms commonly known as the heptarchy; and after their union in a single realm, under King Edgar, the witenagemot became the national assembly. The witenagemot concluded treaties, advised the king as to the disposal of public lands and the appointment and removal of officers of state, and even assumed to elect and depose the king himself. The king had now attained to greater power, and more royal dignities and prerogatives. He was unquestionably the chief power in the witenagemot; but the laws were already promulgated, as in later times, as having been agreed to with the advice and consent of the witan. The witan also exercised jurisdiction as a supreme court. These ancient customs present further examples of the continuity of English constitutional forms.

The constitution of the witenagemot, however, was necessarily less popular than that of the local moots in the hundred or the shire. The king himself was generally present, and at his sum-

mons came prelates, abbots, ealdormen, the king's gesiths and thegns, officers of state and of the royal household and leading tenants in chief of lands held from the crown. Crowds sometimes attended the meetings of the witan, and shouted their acclamations of approval or dissent; and, so far, the popular voice was associated with its deliberations; but it was at a distance from all but the inhabitants of the place in which it was assembled. and until a system of representation (*q.v.*) had slomly grown up there could be no further admission of the people to its deliberations.

The Norman Conquest.— The Anglo-Saxon polity was suddenly overthrown by the Norman Conquest. A stern foreign king had seized the crown, and was prepared to rule his conquered realm by the sword. He brought with him the absolutist principles of continental rulers, and the advanced feudal system of France and Normandy. Feudalism had been slowly gaining ground under the Saxon kings. and now it was firmly established as a military organization. William the Conqueror at once rewarded his warlike barons and folloners with enormous grants of land. The Saxon landowners and peasants were despoiled and the invaders settled in their homesteads. The king claimed the broad lands of England as his own, by right of conquest, and when he allowed his warriors to share the spoil he attached the strict condition of military service in return for every grant of land. An effective army of occupation of all ranks was thus quartered upon every province throughout the realm. England was held by the sword; a foreign king, foreign nobles and a foreign soldiery were in possession of the soil, and swore fealty to their master, from whom they held it. Saxon bishops were deposed and foreign prelates appointed to rule over the English church. Instead of calling a national witenagemot, the king took counsel with the officers of his state and household. the bishops. abbots earls. barons and knights by whom he was pleased to surround himself. Some of the forms of a national council were indeed maintained but the witenagemot was now transformed into a common council of tenants in chief. It was thus a purely feudal assembly.

In spite of the immense constitutional prestige enjoyed by Magna Carta, that historical document played little or no part in the development of parliament. It was there ordained that no scutage or aid, except the three regular feudal aids, should be imposed, save by the common council of the realm. To this council the archbishops, bishops, abbots. earls and greater barons were to be summoned personally by the king's letters, and the lesser tenants in chief by a general writ through the sheriff. The summons was required to appoint a certain place, to give 40 days' notice at least and to state the cause of meeting.

This council was in no sense a modern parliament nor was it intended to be. Magna Carta has been truly described as "a very feudal document," how feudal William Sharp McKechnie forcibly showed in his standard commentary. By these clauses the tenants in chief protected themselves from arbitrary taxation by the crown without their "common counsel." but they did not thereby preclude themselves from taxing their own mesne tenants. It mas only when later kings began, of their own initiative. to summon representatives of the shires and boroughs to attend meetings of the common council to grant a tax that the "commons" came into existence. And there can be no doubt that F. W. Maitland was right in tracing the origin of the commons, and the principle of representation which their summons implied to the adaptation of the pre-existing institution of the jury to that purpose. Originating as a fiscal instrument for valuation of land. as in Domesday Book, or for assessment to the first tax on personalty, as in the case of the Saladin tithe, the jury was extended to the presentment of crimes by Henry II and, as such, it represented the township, the borough and the hundred in the county court. It was originally elected and from this it was but a step to summoning elected representatives of the counties and boroughs to Westminster.

But it must be remembered that the idea that the consent of the local communities or communes of county and borough to taxation is necessary was of late growth. The juries of neighbours who were summoned to assess the people under the Saladin tithe were assessing a tax to which their consent was neither asked nor required. **A** definite departure was made when, in 1265, Simon de Montfort, the leader of the revolt against Henry III, summoned to Lewes a national assembly which was distinctive in that writs were issued not only to the knights of the shire, who had occasionally been summoned before, but to representatives of the boroughs. It was a revolutionary assembly but none the less it established a precedent.

The transition period between Simon de Montfort's parliament of 1265 and the Model parliament of 1295 was long a puzzle to historical students, since, except for two provincial councils in 1283, no traces were found in the records, between 1265 and 1295, of the representation of cities or boroughs, or of representation of the counties between 1275 and 1290. But in 1910 Hilary Jenkinson (see *English Historical* Review, for April) found in the record office some old documents which proved to be fragments of three writs and of returns of members for the Easter parliament in 1275. They made it certain that knights of the shire were then present. and that burgesses and citizens were summoned (not as in 1265 through the mayors, but as since 1295 through the sheriffs). The importance of the 1295 parliament thus appears to be smaller in English constitutional history, the full reforms appearing to have been adopted 20 years earlier. It is noteworthy, however, that in the writs of 1275 the instruction to the sheriff is "venire facias." not "elegi facias."

In 1295 these precedents were followed with a parliament summoned by Edward I which was long regarded as the first Model parliament. But as an institution it had yet to make its footing good as the exclusive authority on taxation. In legislation it was long subject to competition by the king's council and by the great council. (Seb PRIVY COUNCIL.) The great council continued to be summoned not infrequently without the issue of writs to the commons, and this became the test applied in peerage cases to determine whether the descendant of a baron summoned to a national assembly has made out his claim to be a "lord of parliament." (See the St. John Barony case, 1913 A.C. 305, where it was held that a national assembly of 1290 was not a parliament, in spite of its having passed the "statute" of *Quia Emptores*, because the commons were not summoned.)

Secession **of the** Clergy.— It formed part of Edward's policy to include the clergy in his scheme for the representation of all orders and classes of his subjects. They were summoned to attend the parliament of 1295 and succeeding parliaments of his reign, and their form of summons has been continued until the present time; but the clergy resolutely held aloof from the national council and insisted upon voting their subsidies in their own convocations of Canterbury and York. The bishops retained their high place among the earls and barons, but the clergy sacrificed to ecclesiastical jealousies the privilege of sharing in the political councils of the state. As yet, indeed, this privilege seemed little more than the voting of subsidies, but it was soon to embrace the redress of grievances and the framing of lams for the general welfare of the realm. By the 17th century the clergy definitely lost their power of separate taxation and were included in the grant made by the commons (1664).

Meanwhile the commons, unconscious of their future power, took their humble place in the great council of the realm. The knights of the shire, as lesser barons or landowners of good social standing, could sit beside the magnates of the land without constraint; but modest traders from the towns were overawed by the power and dignity of their new associates. They knew that they were summoned for no other purpose than the taxing of themselves and their fellow townsmen; their attendance was irksome; it interrupted their own business; and their journeys exposed them to many hardships and dangers. It is not surprising that they should have shrunk from the exercise of so doubtful a privilege. Considerable numbers absented themselves from a thankless service; and their constituents, far from exacting the attendance of their members as in modern times, begrudged the sorry stipend of *2s.* a day paid to their representatives while on duty and strove to evade the burden imposed upon them by the crown. Some even purchased charters, withdrawing franchises which they had not yet learned to value. Nor, in truth, did the

representation of towns at this period afford much protection to the rights and interests of the people. Towns were enfranchised at the will or caprice of the crown and the sheriffs; they could be excluded at pleasure; and the least show of independence would be followed by the omission of another writ of summons. But the principle of representation (*q.v.*), once established. was to be developed with the expansion of society; and the despised burgesses of Edward I, not having seceded. like the clergy! were destined to become a potential class in the parliaments of England. Eventually, in 1624, the principle that once a writ had been issued to a borough to send representatives to parliament, and obeyed, it could no longer be withheld was established and thereby the independence of the commons was secured. The crown, however, retained the prerogative to incorporate new boroughs with parliamentary representation and thus. in days when there was no such thing, except in the case of the counties. as a common franchise, the crown could by the charter of incorporation create what franchise for the borough it pleased. The Tudors made free use of this prerogative to pack the commons, but in the reign of Charles II it fell wholly into desuetude.

Another constitutional change during the reign of Edward I was the summoning of parliament to Westminster instead of to various towns in diiierent parts of the country. This custom invested parliament with the character of a settled institution and constituted it a high court for the hearing of petitions and the redress of grievances. The growth of its judicature, as a court of appeal. was also favoured by the fixity of its place of meeting.

Authority of Parliament Recognized by Law.—Great was the power of the crown, and the king himself was bold and statesmanlike; but the union of classes against him proved too strong for prerogative. In 1297, having outraged the church, the barons and the commons by illegal exactions, he was forced to confirm the Great charter and the Charter of the Forests, with further securities against the taxation of the people without their consent and, in return, obtained timely subsidies from the parliament. Henceforth the financial necessities of a succession of kings ensured the frequent assembling of parliaments. Nor were they long contented with the humble function of voting subsidies, but boldly insisted on the redress of grievances and further securities for national liberties. In 1322 it was declared by statute 1j Edw. II that "the matters to be established for the estate of the king and of his heirs, and for the estate of the realm and of the people, should be treated, accorded, and established in parliament. by the king, and by the assent of the prelates, earls and barons. and the commonalty of the realm, according as had been before accustomed." The constitutional powers of parliament as a legislature were here amply recognized—not by royal charter, or by the occasional exercise of prerogative, but by an authoritative statute. And these powers were soon to be exercised in a striking form. Already parliament had established the principle that the redress of grievances should have precedence of the grant of subsidies; it had maintained the right of approving councillors of the crown and punishing them for the abuse of their powers; and in 1327 the king himself was finally deposed, and the succession of his son, Edward III, declared by parliament.

At this period the constitutioii of parliament was also settling down to its later and permanent shape. Hitherto the different orders or estates had deliberated separately and agreed upon their several grants to the crown. The knights of the shire were naturally drawn, by social ties and class interests, into alliance with the barons; but at length they joined the citizens and burgesses and in the first parliament of Edward III they are found sitting together as "the commons." This may be taken as the turning point in the political history of England. If all the landowners of the country had become united as an order of nobles they might have proved too strong for the development of national liberties, while the union of the country gentlemen with the burgesses formed an estate of the realm which was destined to prevail over all other powers. The withdrawal of the clergy, who would probably have been led by the bishops to take part with themselves and the barons, further strengthened the united commons.

The reign of Edward III witnessed further advances in the authority of parliament and changes in its constitution. The king, being in continual need of subsidies. was forced to summon parliament every year, and in order to encourage its liberality he frequently sought its advice upon the most important issues of peace or war and readily entertained the petitions of the commons praying for the redress of grievances. During this reign also the advice and consent of the commons, as well as of the lords spiritual and temporal, was regularly recorded in the enacting part of every statute.

Separation of the Two Houses.—But a more important event is to be assigned to this reign—the formal separation of parliament into the two houses of lords and commons. There is no evidence—nor is it probable—that the different estates ever voted together as a single assembly. It appears from the rolls of parliament that in the early part of this reign, the causes of summons having been declared to the assembled estates, the three estates deliberated separately, but afterward delivered a collective answer to the king. While their deliberations were short they could be conducted apart, in the same chamber; but, in course of time, it was found convenient for the commons to have a chamber of their own, and they adjourned their sittings to the chapter house of the abbot of Westminster, where they continued to be held after the more formal and permanent separation had taken place. The date of this event is generally assigned to the 17th Edward III.

Parliament had now assumed its modem outward form. But it was far from enjoying the authority which it acquired in later times. The crown was still paramount; the small body of earls and barons—not exceeding 40—were connected with the royal family, or in the service of the king or under his influence; the prelates, once distinguished by their independence, were now seekers of royal favour; and the commons, though often able to extort concessions in return for their contributions to the royal exchequer! as yet held an inferior position among the estates of the realm. Instead of enjoying an equal share in the framing of laws, they appeared before the king in the humble guise of petitioners. Their petitions, together with the king's answers, were recorded in the rolls of parliament; but it was not until the parliament had been discharged from attendance that statutes were framed by the judges and entered on the statute rolls. Under such conditions legislation was, in truth, the prerogative of the crown rather than of parliament. Enactments were often found in the statutes at variance with the petitions and royal answers, and neither prayed for by the commons nor assented to by the lords. In vain the commons protested against so grave an abuse of royal authority; but the same practice was continued during this and succeeding reigns. Henry V, in the second year of his reign. promised "that nothing should be enacted to the petitions of the commons, contrary to their asking, whereby they should be bound without their assent"; but, so long as the old method of framing laws was adhered to there could be no security against abuse; and it was not until the reign of Henry VI that the introduction of the more regular system of legislating by bill and statute ensured the thorough agreement of all the estates in the several provisions of every statute.

The commons, however, notwithstanding these and other discouragements, were constantly growing bolder in the assertion of their rights. In 1377 the demands of a former parliament were reiterated with greater boldness and persistence, the evil councillors of the late reign were driven out and it was conceded that the principal officers of state should be appointed and removed. during the minority of Richard II, upon the advice of the lords. The commons also insisted upon the annual assembling of parliament under the stringent provisions of a binding law. They claimed the right, not only of voting subsidies, but of appropriating them and of examining public accounts. They inquired into public abuses and impeached ministers of the crown. Even the king himself was deposed by the parliament. Thus during this reign all the great powers of parliament were asserted and exercised. The foreign wars of Henry IV and Henry V, by continu-

ing the financial necessities of the crown, maintained for a while the powers which parliament had acquired.

Relapse of Parliamentary Influence. — But a period of civil wars and disputed successions was now at hand, which checked the further development of parliamentary liberties. With the close of the Wars of the Roses the life of parliament seems to have well-nigh expired.

To this constitutional relapse various causes contributed at the same period. The crown had recovered its absolute supremacy. The powerful baronage had been decimated on the battlefield and the scaffold; and vast estates had been confiscated to the crown. The commons had lost the liberal franchises of an early age. All freeholders, or suitors present at the county court, were formerly entitled to vote for a knight of the shire; but in the eighth year of Henry VI (1430) an act was passed (c. 37) by which this right was confined to 40*s*. freeholders. resident in the county. Large numbers of electors were thus disfranchised.

As for the cities and boroughs, they had virtually renounced their electoral privileges. As we have seen. they had never valued them very highly; and now by royal charters, or by the usurpation of small self-elected bodies of burgesses, the choice of members had fallen into the hands of town councils and neighbouring landowners. The anomalous system of close and nomination boroughs, which had arisen thus early in English history, was suffered to continue without a check for four centuries as a notorious blot upon a free constitution. Nonetheless during the period of what Stubbs called the "Lancastrian experiment" there was a marked, though premature, period of parliamentary ascendancy, resulting, no doubt, from the fact that the Lancastrian kings themselves reigned under a parliamentary title. The commons frequently asserted. and made good, a claim that the king's councillors should be named in parliament, although they were far from asserting the modern principle of responsible government.

The Three Estates of the Realm. — This check in the fortunes of parliament affords a fitting occasion for examining the composition of each of the three estates of the realm. The archbishops and bishops had held an eminent position in the councils of Saxon and Norman kings, and many priors and abbots were from time to time associated with them as lords spiritual until the suppression of the monasteries by Henry VIII. They generally outnumbered their brethren, the temporal peers, who sat with them in the same assembly. The king can create new bishoprics by order in council but his power to summon them to parliament was limited by the act of 1878 which restricted the number of lords spiritual to 26.

The lords temporal comprised several dignities. Of these the baron, though now the lowest in rank, was the most ancient. The title was familiar in Saxon times, but it was not until after the Norman Conquest that it was invested with a distinct feudal dignity. Next in antiquity was the earl, whose official title was known to Danes and Saxons, and who after the conquest obtained a dignity equivalent to that of count in foreign states. The highest dignity, that of duke, was not created until Edward III conferred it upon his son, Edward the Black Prince. The rank of marquess was first created by Richard II, with precedence after a duke. It was in the reign of Henry VI that the rank of viscount was created, to be placed between the earl and the baron. Thus the peerage consisted of five dignities of duke, marquess: earl, viscount and baron. During the 1 jth century the number of temporal peers summoned to parliament rarely exceeded 50, and no more than 29 received writs of summons to the first parliament of Henry VII. There were only 59 at the death of Queen Elizabeth I. At the accession of William III this nuinber had been increased to about 1jo. The most important step in the development of the independence of the lords was their successful assertion in the earl of Bristol's case! in the reign of Charles I, that once the king had issued a writ of summons to a subject to attend the house of lords and it had been obeyed, a hereditary right to the writ had been created and vested in his heirs. The crown's prerogative to create new peerages of the Cnited Kingdom remains unlimited, except as regards the "limitation" or definition of the mode of descent. (See PEERAGE.) In 1876 the crown acquired the power to create life peerages (nine) for lords of appeal in ordinary (*q.v.*)

The commons formed a more numerous body. In the reign of Edward I there were about 275 members. in that of Edward III 250, and in that of Henry VI 300. In the reign of Henry VIII parliament added 27 members for Wales and four for the county and city of Chester, and in the reign of Charles II four for the county and city of Durham. Between the reigns of Henry VIII and Charles II 130 members were also added by royal charter.

Parliament Under the Tudors. — To resume the history of parliament at a later period, let us glance at the reign of Henry VIII. Never had the power of the crown been greater than when this king succeeded to the throne, and never had a more imperious will been displayed by any king of England. Parliament was at his feet to do his bidding and the Reformation enormously Increased his power. He had become a pope to the bishops; the old nobles who had resisted his will had perished in the field or on the scaffold; the new nobles were his creatures; and he had the vast wealth of the church in his hands as largess to his adherents. Such was the dependence of parliament upon the crown and its advisers during the Reformation period that in less than 30 years four vital changes were decreed in the national faith. Each of the successive reigns inaugurated a new religion.

With the reign of Elizabeth I commenced a new era in the life of parliament. She had received the royal prerogatives unimpaired and her hand was strong enough to wield them. But in the long interval since Edward IV the entire framework of English society had been changed; it was a new England that the queen was called upon to govern. The coarse barons of feudal times had been succeeded by English country gentlemen. beyond the influence of the court and identified with all the interests and sympathies of their country neighbours. From this class were chosen nearly all the knights of the shire and a considerable proportion of the members for cities and boroughs. They were generally distinguished by a manly independence, and were prepared to uphold the rights and privileges of parliament and the interests of their constituents. In the country the yeomen and farmers were far superior to the cultivators of the soil in feudal times; and the towns and seaports had become important centres of commerce and manufactures.

The parliaments of Elizabeth I, though rarely summoned. displayed an unaccustomed spirit. They discussed the succession to the crown, the marriage of the queen and ecclesiastical abuses; they upheld the privileges of the commons and their right to advise the crown upon all matters of state; and they condemned the grant of monopolies. The bold words of the Wentworths and Yelvertons were such as had not been heard before in parliament. The conflicts between Elizabeth and the commons marked the revival of the independence of parliament and foreshadowed graver troubles at no distant period.

The Stuart Kings. — James I, with shortsighted pedantry, provoked a succession of conflicts with the commons in which abuses of prerogative were stoutly resisted and the rights and privileges of parliament resolutely asserted. The "remonstrance" of 1610 and the "protestation" of 1621 would have taught a politic ruler that the commons could no longer be trifled with; but those lessons were lost upon James and upon his ill-fated son.

The momentous struggles between Charles I and his parliaments cannot be followed in this place. The earlier parliaments of this reign fairly represented the earnest and temperate judgment of the country. They were determined to obtain the redress of grievances and to restrain undue prerogatives; but there was no taint of disloyalty to the crown; there were no dreams of revolution. But the contest at length became embittered. until there was no issue but the arbitrament of the sword. The period of the Great Rebellion and the Commonwealth proved the supreme power of the commons, when supported by popular forces. Everything gave way before them. They raised victorious armies in the field, they overthrew the church and the house of iords and they brought the king himself to the scaffold.

It is to this time of fierce political passions that we trace the origin of political agitation as an organized method of influencing

the deliberations of parliament. The whole country was then aroused by passionate exhortations from the pulpit and in the press. No fewer than 30,000 political tracts and newspapers published during this period have been preserved. Petitions to parliament were multiplied in order to strengthen the hands of the popular leaders. Clamorous meetings were held to stimulate or overawe parliament. Such methods, restrained after the Restoration, were revived in later times and came to form part of the acknowledged system of parliamentary government.

Parliament After the Restoration.— On the restoration of Charles II parliament was at once restored to its old constitution and its sittings were revived as if they had suffered no interruption. No outward change had been effected by the late revolution; but that a stronger spirit of resistance to abuses of prerogative had been aroused was soon to be disclosed in the deposition of James II and the Glorious Revolution of 1688. At this time the full rights of parliament were explicitly declared, and securities taken for the maintenance of public liberties. The end of the Stuart dynasty marked the final triumph of the principle of parliamentary sovereignty. Henceforth it was never again disputed that parliament might abolish the prerogatives and alter the common law. (*See* PREROGATIVE; COMMON LAW; PRIVY COUNCIL.) The theory of a constitutional monarchy and a free parliament was established; but after two revolutions it is curious to observe the indirect methods by which the commons were henceforth kept in subjection to the crown and the territorial aristocracy. The representation had long become an illusion. The knights of the shire were the nominees of nobles and great landowners; the borough members were returned by the crown, by noble patrons or close corporations; even the representation of cities, with greater pretensions to independence, was controlled by bribery. Nor were rulers content with their control of the representation, but, after the Restoration, the infamous system of bribing the members themselves became a recognized instrument of administration. The country gentlemen were not less attached to the principles of rational liberty than their fathers, and would have resisted further encroachments of prerogatives; but they were satisfied with the revolution settlement and the remedial laws of William III, and no new issue had yet arisen to awaken opposition. Accordingly, they ranged themselves with one or other of the political parties into which parliament was now beginning to be divided and bore their part in the more measured strifes of the 18th century. From the revolution till the reign of George III the effective power of the state was wielded by the crown, the church and the territorial aristocracy; but the influence of public opinion since the stirring events of the 17th century had greatly increased. Both parties were constrained to defer to it; and, notwithstanding the flagrant defects in the representation, parliament generally kept itself in accord with the general sentiments of the country.

On the union of Scotland in 1707 important changes were made in the constitution of parliament. The house of lords was reinforced by the addition of 16 peers, representing the peerage of Scotland and elected every parliament; and the Scottish peers, as a body, were admitted to all the privileges of peerage except the right of sitting in parliament or upon the trial of peers. No prerogative, however, was given to the crown to create new peerages after the union. To the house of commons were assigned 45 members, representing the shires and burghs of Scotland.

Parliament Under George III.—With the reign of George III there opened a new period in the history of parliament. Agitation in its various forms, an active and aggressive press, public meetings and political associations, the free use of the right of petition and a turbulent spirit among the people seriously changed the relations of parliament to the country. And the publication of debates, which was fully established in 1771, at once increased the direct responsibility of parliament to the people, and ultimately brought about other results, to which we shall presently advert.

In this reign another important change was effected in the constitution of parliament. Upon the union with Ireland! in 1801, four Irish bishops were added to the lords spiritual, who sat by rotation of sessions, and represented the episcopal body of the Church of Ireland. But those bishops were deprived of their seats in parliament in 1869, on the disestablishment of the Church of Ireland. Twenty-eight representative peers, elected for life by the peerage of Ireland, were admitted to the house of lords. All the Irish peers were also entitled to the privilege of peerage. In two particulars the Irish peerage was treated in a different manner from the peerage of Scotland. The crown was empowered to create a new Irish peerage whenever three Irish peerages in existence at the time of the union had become extinct or when the number of Irish peers, exclusive of those holding peerages of the United Kingdom, had been reduced to 100. And, further, Irish peers were permitted to sit in the house of commons for any place in Great Britain, forfeiting, however, the privilege of peerage while sitting in the lower house.

At the same time 100 representatives of Ireland were added to the house of commons. This addition raised the number of members to 658. Parliament now became the parliament of the United Kingdom. In 1922 (see below) the provisions of the Act of Union as to the representation of Ireland in the commons were, save in the case of Northern Ireland, repealed and the term United Kingdom is now restricted to Great Britain and Northern Ireland.

Schemes for Improving the Representation.—By the union of Scotland and Ireland the electoral abuses of those countries were combined with those of England. Notwithstanding a defective representation, however, parliament generally sustained its position as fairly embodying the political sentiments of its time. Public opinion had been awakened, and could not safely be ignored by any party in the state. Under a narrow and corrupt electoral system the ablest men in the country found an entrance into the house of commons; and their rivalry and ambition ensured the acceptance of popular principles and the passing of many remedial measures. As society expanded and new classes were called into existence the pressure of public opinion upon the legislature was assuming a more decisive character. The grave defects of the representation were notorious and some minor electoral abuses had been from time to time corrected. But the fundamental evils —nomination boroughs, limited rights of election, the sale of seats in parliament, the prevalence of bribery and the enormous expense of elections—though constantly exposed, long held their ground against all assailants. All moderate proposals were rejected till the concurrence of a dissolution, on the death of George IV, with the French Revolution in 1830, and an ill-timed declaration of the duke of Wellington that the representation was perfect and could not be improved suddenly precipitated the memorable crisis of parliamentary reform. (See also REFORM MOVEMENT.)

The Reform Acts of 1832.—The result of the memorable struggle which ensued may be briefly told. By the Reform acts of 1832 the representation of the United Kingdom was reconstructed. In England, 56 nomination boroughs returning 111 members were disfranchised; 30 boroughs were each deprived of one member, and Weymouth and Melcombe Regis, which had returned four members, were now reduced to two. Means were thus found for the enfranchisement of populous places. Twenty-two large towns, including metropolitan districts, became entitled to return two members, and 20 less considerable towns acquired the right of returning one member each. The number of county members was increased from 94 to 159, the larger counties being divided for the purposes of representation.

The elective franchise was also placed upon a new basis. In the boroughs a £10 household suffrage was substituted for the narrow and unequal franchises which had sprung up—the rights of freemen, in corporate towns, being alone respected. In the counties, copyholders and leaseholders for terms of years, and tenants at will paying a rent of £50 a year, were added to the 40*s*. freeholders. Reform acts, similar in character, were passed to deal with the franchise and constituencies in Ireland and Scotland respectively. The most decisive feature of these reform acts was not so much the extension of the franchise, as five-sixths of the male adult population were still left without a vote, the working classes being practically disfranchised. But what the acts did do, once and for all, was to take the control of the con-

stituencies, particularly by the disfranchisement of the rotten boroughs, out of the hands of the peers who had hitherto bought or sold the right of nomination of candidates. From henceforth the political balance of power was shifted from the lords to the commons.

The legislature was now brought into closer relations with the people, and became more sensitive to the pressure of popular forces. The immediate effects of this new spirit were perceptible in the increased legislative activity of the reformed parliament, its vigorous grappling with old abuses and its preference of the public uelfare to the narroner interests of classes. But several electoral evils still needed correction. Bribery and corruption, the undue influence of landlords and employers of labour, defective arrangements for registration, the high legal costs of election campaigns which restricted membership of parliament to the moneyed classes — these problems remained for the succeeding period and the need to solve them was felt with all the greater urgency because of the new spirit engendered in public life by the Reform act of 1832. (H. C.)

PARLIAMENT AFTER 1832

The history of parliament after 1832 has for its main theme a gradual readjustment of relations between the government, the house of commons and the electors. Within the flexible framework of government by the king in parliament, the Reform act of 1832 and still more the subsequent extensions of the franchise effected a new displacement in the balance of political power, which had hitherto been moving from the king and the house of lords to the house of commons. The 17th century had proved that government was impossible without the co-operation of the house of commons. The experience of the 18th century had shown that such co-operation could only be maintained by the selection of the king's ministers from the party for the time being in a majority in that house. This indirect power of selecting and dismissing ministers raised the status of the house of commons to a position of predominance in the constitution — a position the practical effects of which were, however, restricted by the influence which the crown and the territorial nobility had, through the defects of the representative system, secured over the composition of the house. The reform of 1832 rid the house of commons once and for all of this interference and opened the way to the full exercise of its potential powers. But the vast increase during the first half of the 20th century in the power of the cabinet, which accompanied the steady and successful drive towards universal suffrage, effected a new shift in the centre of gravity of political forces — this time away from the house of commons — and ended in depressing the status of parliament both in relation to the executive government and to the electorate.

This chapter in the long story of parliamentary development may be conveniently divided into the following sections: (1) the progress toward universal adult suffrage; (2) the decline of the house of lords; (3) the development of the party system and the tightening of party discipline in parliament; (4) the increasing deference of the house of commons to the wishes of the electorate; (5) (as a result of these tendencies) the growing ascendancy of the ministry in parliament; and (6) the rise in importance of the counterbalancing function of parliamentary opposition.

Progress Toward Universal Suffrage. — The progress, begun in 1832, of reforming the representative system was concerned with two main objects, the qualifications of electors and their grouping into constituencies. The old system, which had been designed to secure the representation of communities and interests, was gradually replaced by a new system, based on individual units of voting power, which preferred arithmetical equality to the maintenance of local community interests. This new system did not find its full development until the Representation of the People act of 1948, but its germ is to be discovered in the ,Reform act of 1832 which, however unwittingly, started a process that had no logical stopping-place short of universal adult suffrage and equal electoral districts.

The Representation Acts of 1867 *to* 1948. — Although the reforms of 1832 were intended by their authors to be a permanent solution, they were regarded as no more than an instalment by the Radicals and the politically conscious artisans who had actually suffered disfranchisement in certain boroughs, such as Westminster and Coventry, which had previously enjoyed what was practically manhood suffrage. The famous six points of the Chartist program included manhood suffrage and equal electoral districts. After the final defeat of Chartist agitation in 1848 the popular demand seemed to die out, and it mas in the house of commons itself that the question of reform was kept alive. Reform bills were introduced in 1852, 1856, 1859, 1860 and 1866 but it was impossible to secure agreement on the figure to which the property qualification in the boroughs should be reduced or on the compensatory suggestions for increasing the voting power of wealth and education which formed part of the schemes. After the defeat of the Liberal bill of 1866, a Tory reform bill was passed in 1867 which, after the excision of all the safeguards and "fancy franchises" which it had originally contained, proved to be a far more democratic measure than either of the great parties would have accepted without the competitive pressure of the other. The *Reform acts of* 1867 *(England) nnd* 1868 *(Scotland and Ireland)* abolished the property qualification for householders in boroughs and created a new £10 lodger franchise, thereby more than doubling the number of borough voters. In the counties it made comparatively minor changes — the reduction of the property qualification for long leaseholders and the creation of a new £12 occupational franchise — changes which stopped short of giving the vote to the agricultural labourers. The accompanying schemes of redistribution, less far-reaching than in 1832, partly or wholly disfranchised a number of small English boroughs and redistributed the bulk of the seats thus made available between English counties and boroughs (fohr large English cities receiving a third member each). In addition the University of London was given one member, Scottish universities two, and five other seats were allotted to Scotland so as to increase Scottish representation to 60.

It was only a question of time before the process of democratization applied in 1867 to the boroughs reached the counties. This step was taken by the Liberals through the *Reform act of* 1884, which extended the borough household and lodger franchise to the counties and thereby nearly tripled the county electorate. The *Redistribution act of 1885* made a great stride toward equal electoral districts by accepting a rough proportion of one seat for 54,000 inhabitants as a basis of representation. Taking advantage of the new uniform franchise, it deprived 79 small boroughs of independent representation, merging them in the counties, and took one member from 36 larger boroughs. The seats thus secured were distributed among the counties and great towns in proportion to their population. The whole country was carved up into single-member constituencies! about 20 double-member towns alone being left undivided. In adopting the system of artificially drawn single-member constituencies, the act of 1885 made a great change not only in the basis of representation but in the relations of members, on the one hand, with their constituents and, on the other, with the house of commons. Previously, a member had been regarded as the spokesman of a particular community; now he came to be accepted as the trustee of a certain amount of undifferentiated voting power measured in relation to a population quota.

The principal provisions of the *Representation act of 1918* (which was a redistribution act as well as a franchise act) were the final assimilation of the county and borough franchises and, more important, the enfranchisement of women over 30 years of age (reduced in 1928 to 21 years). The qualifications for men became either residence or the occupation of business premises of the annual value of £10. Plural voting was restricted to one vote for residence and one for the occupation of business premises or in virtue of a university qualification. For the distribution of seats the same principles were accepted as those laid down in the act of 1885, with the variations rendered necessary by changes of population, the quota of population per seat being raised to 70,000.

The effect of the long and comprehensive *Representation of the People act of 1948* was to give statutory authority to the findings of the boundary commissions previously set up to redistribute parliamentary seats (the act also substantially altered these find-

ings), and to consolidate and amend the electoral law.

In pursuit of the ideal of "one man one vote" the 12 university constituencies and the City of London constituency, as such. were abolished; and all plural voting, whether university or business. was swept away. In pursuit of the ideal of "one vote one value" the entire electoral map was recast into single-member constituencies coincident with local government boundaries, and equal in population so far as geography and local traditions allowed.

The boundary commissions, from whose purview the university and City of London constituencies were excluded, had recommended no change in the number of members to represent Scotland (71) and Sorthern Ireland (12). but an increase of one for Wales (making 36) and of five for England (making 489)—a total of 621 (including 12 university members and allowing one seat to the City of London) as opposed to the figure of 61j before 1945. The act of 1948. by excluding 12 university members and one member for the City of London and by adding 1; further members for England. on balance increased the boundary commissions' estimates by the net figure of four; the house of commons thus contained 625 members. Orders approved in 1955, giving effect to further recommendations of the boundary commissions, increased this number to 630.

The stages in the extension of the franchise and the progress toward adult suffrage are summarized in the following table:

England, Wales and Scotland

		Total electorate	Population aged 20 yr. and over	Electorate as percentage of population 20 yr. and over
1832 act	Before (1831)	509,391*	10,207,000	5.9%
	After (1832)	720,784	10,207,000	7.1
1867 act	Before (1864)	1,130,372	13,051,816	9 0
	After (1868)	2,231,030	13,625,658	16.4
1884 act	Before (1883)	2,955,190	16,526,233	18.0
	After (1886)	4,965,618	17,394,014	28 5
1918 act	Before (1914)	7,483,165	24,969,241	30 0
	After (1921)	19,984,037	26,846,785	74 0
1928 act	Before (1927)	21,895,347	29,654,721	74.0
	After (1931)	29,175,608	30,096,135	96 9
1948 act	Before (1946)	34,320,351†	34,566,000§	99 3
	After (1949)	33,545,221‡	34,981,000‖	95 9

*The figures relating to the 1832 act have been estimated as accurately as the available statistics allow.
†Register published on Oct. 15, 1946, based on qualifying date of June 30, 1956.
‡Register published on Oct. 1;, 1949, based on qualifying date of June 10, 1949.
§As estimated by the registrars general ior June 1946.
‖As estimated by the registrars general for June 1949.

Effect of Reform Acts on Composition of the House of Commons.—The various reform acts mentioned above did not affect the numerical composition of the house of commons to any great extent. After the union with Ireland in 1800 the figure stood at 658 which remained. unchanged by the Reform acts of 1832 and 1868. until 1885, when it was increased to 670. In 1918 the number was further increased to 707, but was reduced in 1920–22 to 615 by the reduction to 13 of the representatives of Ulster and by the creation of the Irish Free State. In 1948 it was raised to 62j and in 1955 to 630.

Electoral Corruption.—The widespread extension of the vote and the resulting increase in the number of contested elections intensified the demand that elections should be freely and fairly held. No reform of representation could ignore the twin evils of bribery and intimidation. One of the first results of increasing the number of electors was to increase the opportunities for corruption. In the period between 1832 and 1867 the reports of election commissioners disclosed open and wholesale bribery, and also intimidation by employers and large customers. Many small boroughs acquired notoriety. The number of election petitions increased and the cost of elections rose to a figure which excluded all but the richest candidates. It was only by stages that parliament found a remedy. The trial of election petitions was transferred from committees of the house of commons to the judges in 1868. The Ballot act of 1872, which made voting secret, put an end to the pressure which had been exercised by landlords and employers and, incidentally, brought into existence the Nationalist party in Ireland. Under the Corrupt and Illegal Practices act of 1883 candidates and agents were made liable to severe penalties; and the legitimate expenses of candidates were strictly limited.

Electorate and Elections.—All persons entitled to vote, that is, all persons male and female over the age of 21 not subject to any legal incapacity, must be registered before voting. This registration of voters is carried out by special officers under the Representation of the People act, 1948. No person is entitled to vote for more than one constituency. Elections are conducted by the returning officers in obedience to the king's writ and are determined by a majority of registered electors. All polls must be held on the same day and all nominations must also be received on one day. The day fixed by a returning officer for receiving nominations is, by statute, the eighth day after the proclamation calling a new parliament, and the poll must be taken the ninth day after the day fixed for receiving nominations.

Decline of the House of Lords.—The Reform act of 1832 opened a new chapter in the relations between the two houses. Previously the fact that the social and territorial influence of the peers controlled a majority of seats in the house of commons had secured co-ordination between the two houses. Now this control was transferred to an electorate becoming ever more democratic. Also, at a time when party organization began to acquire a new definiteness and rigidity, a single party had established a permanent majority in the house of lords. The foundations of a permanent Tory majority had been laid by William Pitt's lavish creations. but it was not yet irreversible—in 1832 the ratio of the two parties was about four to three and it was calculated that the creation of 50 or 60 Whig peers would have made the Reform bill safe. The long period of Whig and Liberal administrations. which lasted (with breaks aggregating less than 15 years) from 1832 to 1886, failed to reduce the Conservative majority. It continued to grow almost as rapidly as the peerage itself expanded. Between 1760 and 1830 the numbers of the house of lords had risen from 224 to 400. In 1881 they stood at 511. In 1911, when they were nearly 650, it was calculated that the creation of at least 400 new peerages would be needed to override the Conservative majority against the Parliament bill.

Differences were thus bound to arise with the prevailing Liberal majority in the house of commons. Until 1874 the discrimination of the lords against Liberal legislation could be defended on the ground that the Liberrtls were the party of progress and the house of lords was expected to act as a constitutional brake on progress. When, however, the Conservative party, under Benjamin Disraeli's lead. itself embarked on oolicies of change. the charge of partisanship became more difficult to rebut, since the lords almost invariably accepted the reforming legislation of the one party and continued to reject that of the other or to amend it out of recognition.

In fact, the intensification of party spirit and the elaboration of party machinery which accompanied the extension of the franchise ended by undermining the independent status of the house of lords as a co-ordinate branch of the legislature, and converted it in the eyes of a large section of the electorate into an auxiliary of one of the political parties in the struggle for the control of the house of commons. Without the power to force the resignation of ministers, since it was not to the house of lords that ministers were responsible, it could so paralyze their actions that their only recourse was to a dissolution of parliament. In claiming to resist measures on the ground that they had not been approved by the electorate, the lords were charged with using the mandate doctrine as a pretext for dictating both the moment at which, and the issue on which an appeal to the electorate should be made. After the general election of 1895 they seemed to be justified in this claim by the fact that their rejection of the Home Rule bill in the previous year had been endorsed by the electors.

During the ten years of Conservative government which followed. the lords forgot their scruples and continued to pass bills, such as the Licensing and Education bills introduced by the Conservatives. which had never been submitted to the electorate. When the Liberals returned to power (with a majority of 356) the house of lords resumed its policy of rejecting or mutilating their measures. It rejected the Licensing. the Land Values (Scotland) and the London Election bills, and wrecked the Education bill and several other bills by comprehensive amendment. On the

other hand; it accepted the Trades Disputes bill and the Old Age Pensions bill. in pursuance, it was believed. of the Conservative policy to avoid offending the workers. In short. it destroyed every bill against the third reading of which the official opposition had voted in the house of commons.

Struggle Over *the Parliament* **Bill,** *1911.*—Exercised so consistently to their disadvantage, the claim to refer particular measures to the judgment of the electorate could not fail to be intolerahle to the Liberals with their large and recent majority. In 1907 they secured a resolution of the commons in favour of restricting the powers of the lords so that "within the limits of a single parliament the final decision of the commons shall prevail." The final breach came when the lords rejected the Finance bill in 1909. The power of the lords to amend a "bill of aids and supplies" had been denied by the commons in resolutions passed in the 17th century which the lords had tacitly accepted. But their power to reject bills of this class (including finance bills) had been admitted in principle. Since the rejection by the lords of the paper duties in 1860, the commons had taken the precaution of including all the taxes of the year in a single bill, calculating that the lords would not take the drastic step of leaving the public services financially uncovered.

The provisions of the Finance bill of 1909 to which the lords most objected were the various duties on the capital value of land, and they maintained that the social changes, capable of wide extension, which the bill embodied took it out of the category of money bills. Accordingly, on the motion of Lord Lansdowne, the bill was rejected on the familiar plea that the lords could not consent to it until it had been submitted to the judgment of the country.

The struggle between the two houses and the two parties now shifted from the Finance bill (which the lords accepted in the following session) to the burning question of the powers of the house of lords itself. For this important chapter of national history see ENGLISH HISTORY. Suffice it to say here that after two general elections. in Jan. and Dec. 1910, which gave the Liberals and their Irish and Labour allies majorities of more than 120, the lords agreed under the threat of the creation of peers—but even so only by the small majority of 131 to 114—to the government measure which reduced their control over legislation to the imposition of a brief period of delay. Briefly, the Parliament act of 1911 provided that the house of lords should have no power to reject or amend a bill certified by the speaker to be a money bill as defined by the act itself; and that any public bill other than a money bill, passed by the commons in three successive sessions! should, if rejected each time by the lords: after its third rejection receive the royal assent, provided that a period of two years should have elapsed between the date of its second reading in the first session and the date of its passing the house of commons in the third session.

Subsequent Proposals ,for *Settlement.*—In the preamble to the Parliament act mention is made of the government's intention to substitute for the existing house of lords a second chamber on a popular instead of a hereditary basis. This reform. which "did not brook delay." was not implemented. In 1917 an dl-party conference, instituted under the chairmanship of Lord Bryce, recommended the substitution of a system of joint conferences for the suspensory veto of the lords in the case of disagreement over non-money bills. In place of the hereditary qualification! it proposed an elective basis for a smaller second chamber, three-quarters of which should be elected by the commons and the remaining quarter by a joint standing committee of both houses. This. the most far-reaching of the schemes of reform, pleased none of the parties. In 1927 proposals were submitted by Lord Cave on behalf of the government which, while leaving aside the question of the hereditary basis of the upper house, were directed to the possibilities of the abuse of the Parliament act. These proposals were not pursued.

The *Parliament* Bill, *1947–49.*—This bill was brought forward in 1947 to reduce the minimum period of delay before a bill (other than a money bill) could receive the royal assent without the consent of the lords under the provisions of the existing Parliament act. Instead of having to pass in each of three sessions in the commons with a minimum interval of two years between the second reading in the first session and the final passing in the commons, the period was to be two sessions and one year. This amending bill received a second reading in the commons on Nov. 11, 1947. Before the rejection of the bill by the lords, negotiations were undertaken between the parties for a compromise upon the reform of the composition and the powers of the upper chamber, but broke down. General agreement was obtained for a suggested reform of the composition of the house, contingent on agreement as to its powers. But, while it was agreed that the new time limit should run from the date of the passing of a bill on third reading in the commons instead of, as hitherto, the date of its second reading, agreement was not reached on the length of the new time limit. The minimum demand of the Conservative party was 12 months, while the maximum concession by the Labour government was 9 months. The Liberals adhered to the government's side. The small difference of three months concealed an underlying conflict of principle; the government claimed that a period longer than nine months would jeopardize legislation in the fourth as well as in the fifth year of any parliament. while the Conservatives maintained that anything less than one year might render nugatory that pause for consideration of a measure by the electorate, which they believed to be an essential safeguard.

In view of this deadlock the bill was rejected by the lords in June 1948, reintroduced and passed for the second time by the commons in a special new session in Sept. 1948 and again rejected by the lords in the same month. The bill was reintroduced and passed by the commons in Nov. 1949 and, being rejected for the third time by the lords on Nov. 29, received the royal assent under the provisions of the Parliament act of 1911 on Dec. 16. 1949.

The practical importance of the Parliament act of 1911 was difficult to assess. It was certainly not to be measured by the number of bills—no more than three—passed into law under its procedure. The Government of Ireland bill, 1912 to 1914, was suspended and overtaken by events before it came into operation. The Welsh Church bill was also suspended and replaced by a tech-' nically different bill. Otherwise, for 38 years the act remained without application—some would say because of the predominant Conservative majority in the house of commons during that period. By the end of 19jj. no bill had passed into law under the procedure of the 1949 act. but its impending enactment probably facilitated the passing in one session of the Iron and Steel act. 1949.

With the increasing hurriedness of legislation in the house of commons. the value of the house of lords as a revising chamber had become more appreciated. As a forum of public opinion. its reputation had not suffered. The level of its debates. conducted by the handful of distinguished men who attended, was normally higher than in the house of commons. Its prestige did not diminish —at any rate in proportion to the reduction of its legal power. The principal result of the removal of a potential check on the legislative function of the house of commons was a gain to the government, which had become the real legislative power.

The Party System.—Parliament is an engine which seems to require the fuel of party spirit to make it work. It is interesting to trace the stages by which the successive extensions of the electorate after 1832, by stimulating party organization in the constituencies. reacted on the party system in the house of commons so as to tighten the grip of the party machines on the rank and file and to subject the house as a whole to the increasing domination of the government, as leaders of the party for the time in the majority. Parties in their modern form date from 1832. Before that date the two great parties of Whigs and Tories had already had a history of 1jo years. Both parties were organized on the basis of personal and regional connections at least as much as on definite political principles. But by 1832 the Whigs had come to regard themselves as the party of reform, while the Tories stood for the defense of the established order. Henceforward, with some variations attributable to the personalities of leaders such as Sir Robert Peel, Lord Palmerston and Disraeli, the struggle between the two parties turned on this distinction of principle. The old meaningless names. which owed their content to history and tradition, were replaced by more significant labels. the Tories accepting, not without misgiving. the title of "Conservative" from Sir Robert

Peel, and the Whigs combining with the Radicals under William Gladstone's uplifted banner of "Liberalism." As for the new Labour party, it was not until the parliament of 1906, in which it held about jo seats. that it made its appearance as a third party. Through several successive general elections it barely maintained its position in the house of commons. But in 1922, because of the split in the Liberal ranks, it became the second party. In 1924 and again in 1929 (when it was the largest of the three parties) it held office as a minority government. After taking its turn as the official opposition, in 1945 it secured a large independent majority for its third period of office; it remained in office after the elections of Feb. 1950, although by a bare margin, until the Conservatives were returned in Oct. 1951.

The Two Party System.—No doubt because parliamentary parties had long stood for a method of government even more than for a means of representation, the natural tendency of parties to split into groups was subordinated in the British system to the need ior uniting to support or oppose the ministry. The arrangement of benches in the chamber facilitated the division of the house into two opposing sides confronting each other. Moreover, the retention of the majority system of voting (which normally exaggerates the representation of the most powerful party)! in spite of roo years of agitation for more scientific methods of securing numerical representation, tended to eliminate small parties except in the few localities where they have an absolute majority. Since Gladstone and Disraeli a general election has become a trial of strength between ministers and the leaders of the opposition, the alternative government. Thus the important question about a candidate became "which side does he support?" and electors showed themselves loath to throw away votes on the candidate of a party which had little hope of being strong enough to form an administration. After 1918, the risk of losing the deposit of £1 jo (forfeited if a candidate receives less than one-eighth of all the votes cast) tended to discourage third-party candidatures.

Party Organization and Discipline.— Democratization of the electorate was accompanied by a tightening up of party discipline in parliament which would have appeared intolerable to the haughty temper of the unreformed house of commons. Party loyalty in those days was sustained by material rewards and promises; later it came to depend chiefly on organized team spirit. A reminder that the one system passed gradually into the other is the fact that the head of the new machinery. the whips' office, continued to be the minister who under the old system was responsible for patronage. the patronage, or (as he was then alternatively called). the parliamentary secretary to the treasury. The whips' office consists of the chief whip, or parliamentary secretary aforesaid, five junior lords of the treasury who receive salaries (one of whom, paid at a slightly higher rate. is styled the deputy chief whip), besides two who are unpaid and three officers of the king's household. The opposition has a similar whips' office on a smaller scale manned by the surviving holders of such posts in its last administration. together with new men to complete the organization, none of whom receive payment from public funds. Any third party that may exist has its own whips' office on a still smaller scale. In close touch with the chief whip is the central office of the party which maintains contact with the local party organizations and the national union or federation into which they are merged. In addition to the primary function of shepherding their party members into the right division lobby it is the duty of the whips to keep a finger on the pulse of the party, to know the reactions of back-bench members to developments in party policy and to give the leaders timely warning of the growth of dissatisfaction.

The growing strictness of party control over the votes of members could be tested by the steady increase in the frequency with which government whips acted as tellers during the period between the first Reform act and the end of the 19th century. In the session of 1836 the proportion of the total number of divisions in which the government whips acted as tellers was less than half; from 1851 to 1860 the average was nearly 70%; from 1878 to 1887 it was nearly 82%. By mid-20th century it had become the general rule to "put on the whips" in every division in which a question on government business was to be decided. On the rare occasions when a majority government found it convenient to "permit a free vote," it was either because the question was of a nonpolitical character, like the prayer book measures of 1927 and 1928, or because the question cut across party divisions in parliament and in the country, like the inclusion of women's suffrage in the Representation bill of 1912 or the question of the death penalty in 1948, 1955 and 1956.

During this period the efforts and ultimate success of the whips in bringing increasing numbers of their party members into the right division lobby can be measured. Party divisions (*i.e.*, divisions in which at least nine-tenths of the members voting on each side found their way into their party lobbies) reckoned as percentages of all the divisions of a session were: in 1836. more than 22%; in 1850, nearly 16%; in 1860, about 6%; in 1871, 35%; in 1881, nearly 47%; in 1894, 76%. In the 20th century the figure probably rose to the neighbourhood of 100%.

Rarity of Government Defeat.— The risk of a government's being defeated by a vote of the house of commons progressively declined. Between 1850 and 1865 governments were defeated on an average ten times a session without resigning. In many of these cases a majority of the supporters of the government went into the lobby against them—as many as 12 times against Lord John Russell in 1850—and almost as often against Lord Palmerston at the height of his prestige in the early 1860s; and in many other cases ministers were saved through the support of their opponents from defeat at the hands of the majority of their own party. In the '90s, on the other hand, the average number of government defeats in a session had fallen to one. The Rosebery government in 1893 made a single defeat in a snap division an excuse for resigning.

An exception must be made for the unusual case of a government without a party majority. On taking office in 1924, Ramsay MacDonald announced that his government would only go out on a vote of no confidence, and that he would judge for himself what constituted such a vote. On this principle he felt justified in ignoring ten defeats in the first six months of his tenure of office.

The immunity of the modern government under normal conditions is the result not only of the strengthening of discipline within its party but also of the fact that the party system is so all-embracing that the floating vote, so decisive in the country, is negligible in parliament. With no hope of rallying unattached support, frontal attacks by opposition parties lost their former danger. It would be misleading, however, to suggest that this saves a government the need to keep watch on movements of parliamentary opinion—at any rate, within its own party. Refinements were introduced into the technique of incipient revolt within a party. Such crude tactics as to vote against one's leaders are resorted to, if at all, only when they are certain to be ineffective. Even abstention on a large scale may bring doun a government, as in 1940, when the Chamberlain ministry resigned because a critical division showed a drop of more than 150 in its nominal majority. Representations and warnings, made privately or at party meetings, took the place of demonstrations in the division lobby; and (on such a background) advice respectfully submitted in debate might be no less effective. For example, in the early sessions of the parliament elected in 1935 there were at least five occasions when the government, in response to pleas chiefly from the benches behind them. abandoned or completely recast measures dealing with such important matters as foreign policy (the Hoare-Laval treaty), unemployment, education and taxation.

Increasing Deference of the House of Commons to the Electorate.— From early times two distinct and somewhat incompatible theories have been implicit in the notion of representation. On the one hand, it has been regarded as a trust confided to chosen leaders of public opinion to treat with the government about affairs of state in the name of the whole country On the other view, the representative is commissioned to voice the discontent of his constituents and to secure the redress of their grievances. These two theories have been uppermost at diiferent periods. The former view was held well into the 19th century. After 1867, however, the working-class voters, who were beginning to swamp the registers, tended to look on their members less as national representatives than as delegates sent to redress local griev-

ances and further local interests. Payment of members (which had lapsed since the middle ages, but was restored in 1911, increased in 193; and 1945, and by mid-20th century stood at £1,000 a year) had some effect in the same direction. Although it is a payment from the national exchequer, the position of those members for whom the salary provides their main source of income is one of increasing dependence upon their constituents, or rather upon their local party machines.

Status of the House of Commons.—The admitted decline in the status of the house of commons after the second Reform act resulted from the clearer recognition of the fact that the real source of a government's authority was no longer parliament, the legal sovereign, but the electorate. The support of a majority of the house of commons was still necessary to the continued existence of a ministry: but the first and the last word—the installation and resignation of a ministry—had come to depend on the votes of the electors. Betneen 1832 and 1868 it was the regular practice for a ministry defeated in the house of commons to bow to the will of the house and to resign without seeking a dissolution. The parliament which sat from 1852 to 1856 supported. for the first half of its period, a coalition government under Lord Aberdeen and, for the second half, a Liberal government under Lord Palmerston. In the parliaments which were elected in 1857 and 1865. defeated Liberal governments were replaced by minority Conservative governments which maintained themselves for one and two years, respectively, without seeking a dissolution. But after 1868 an appeal to the country (except during war) promptly followed the loss by a ministry of the support of the house. Sometimes the defeated prime minister has left it to his successor to secure a dissolution; Lord Rosebery did so in 1895. But in 1924 when the minority government of Ramsay MacDonald uas defeated, parliament nas dissolved; no attempt was made to find another combination which could maintain itself in the same parliament.

In most changes of government, however, the electors have acted as a court of first instance and not as a court of appeal. They have dismissed a ministry coming to them with its parliamentary majority intact; and the house of commons has either played no part in the change or has merely registered the verdict of a general election. So clearly is the verdict of the electors accepted as conclusive that a ministry defeated at a general election resigns without going through the formality of meeting parliament. This was regarded as a novel and doubtful constitutional practice when adopted by Disraeli in 1868. But it was followed by Gladstone in 1874 and again by Disraeli in 1880. In 1886 Lord Salisbury, and in 1924 Stanley Baldwin, met parliament to be defeated on the address, because neither of the main parties had an absolute majority and it was not certain which would receive the support of the third party that then existed. But in 1905 Arthur Balfour resigned during the recess while in possession of a comfortable majority in the house of commons on the plea that a long series of by-elections showed he had lost the support of the electorate.

Growing appreciation of the transference of real power to the electorate has been shown by the gradual acceptance of the "mandate doctrine." In its positive aspect, the doctrine is that a government has the right and the duty to carry out the policy it has submitted to the electors who put it into office. Peel anticipated the doctrine in 1834 in his address to the electors of Tamworth; and after 1868 the leaders of all parties followed Peel's precedent in greater and greater detail. The negative corollary of the doctrine is that no new policy should be embarked on unless it has been endorsed by a general election. In 1829 Catholic emancipation. and in 1846 the repeal of the corn laws, were carried through without endorsement by the electors, and, indeed, by ministries which had committed themselves to opposing these policies. In 1868 Disraeli's protest that parliament had no moral competence to deal nith disestablishment without a previous appeal to the country was denounced by Gladstone as an ultrademocratic and anarchical doctrine. By 1904, however, the theory had become so generally accepted that Arthur Balfour could conscientiously refuse to introduce a measure of fiscal reform, or even discuss the question when raised by his opponents, on the ground that it had not been before the country at the general election of 1900. In 1923 Stanley Baldwin dissolved the parliament elected only in the previous year in order to secure a mandate for a policy of protection. When he wanted a free hand to treat the economic symptoms of the crisis of 1931, Ramsay MacDonald asked for, and received, a "doctor's mandate."

Growing Ascendancy of the Government in Parliament.—The tendencies which have been surveyed as resulting from the successive extensions of the franchise converged to produce one main result, the predominance of the government in parliament. To the vast administrative powers derived from the royal prerogative, ministers, as leaders of docile majorities in the house of commons, had now added a virtual monopoly of the parliamentary function of legislation. Further, they had succeeded largely in circumventing that control of government which it was the traditional function of the house of commons to provide; by enforcing party discipline on the majority of its members they were in a position to control the controllers.

Monopoly of the Initiative in Legislation.—A direct consequence of the progress toward democracy was the greatly increased importance attached to the function of legislation. Before the middle of the 19th century the primary duty of a government was to administer. Legislation was still regarded as the function of parliament, in which ministers took their share as members but had no recognized predominance. Most of the great political reforms of the first half of that century, such as the repeal of the Test acts and Catholic emancipation, and social reforms, such as the abolition of the slave trade and the reform of factory conditions, associated with the names of William Wilbcrforce and Lord Shaftesbury, were initiated and in many cases piloted to the statute book by private members unattached to the government. Ministers themselves often submitted preliminary resolutions to the house to secure the co-operation of members in settling the principles on which to draft their bills. The India bill of 1858 was shaped in this way. But when, in 1867, Disraeli proposed to follow the procedure of a preliminary consultation of the house before introducing his reform of representation, he found he had laid his government open to the charge of shirking its responsibility. After 1867 this procedure was followed only in the case of the Parliament bill of 1911. In 1865 the flood of legislation, pent up in Palmerston's lifetime. burst into spate with the Gladstonian reforms. It followed from the new conception of the comprehensive scope of legislation that only the government. through its departmental organization, could be regarded as having a central point of view which could give consistency to legal change; and only its command over the house could provide the momentum necessary to propel bills on to the statute book. A role, though a humble one, was still left for private members. Their bills and motions might still initiate small and uncontentious improvements, or occasionally test reactions to new ideas without compromising the government. But, as the volume of ministerial legislation increased, ministers easily convinced themselves that this role was hardly worth the expenditure of time involved. During the 20th century the share of private members in the initiation of legislation has tapered almost to vanishing point. From 1940 to 1948 it was suspended altogether.

Other Factors Creating *Ministerial Predominance*.—The great extension in the range of governmental activity, accepted by all parties, and the consequent increase in the complexity of the machinery of government put the house of commons at a growing disadvantage in exercising its functions of control. The social services—education, health. insurance, the regulation of labour, industry and agriculture—all involved the creation of new departments of state, whereby the administrative and clerical staffs of the civil service expanded fivefold in the first half of the 20th century, reaching a peak of nearly 750,000. The administrative ability and specialized experience concentrated in the upper ranks of the civil service gave ministers. at whose disposal they were, a great advantage over the house of commons, both defensively and constructively. After 1945 the policy of nationalization—involving transfer of industries such as coal mining, transport and aerial navigation. to centralized corporations loosely attached to the administration—raised new problems of parliamentary control,

solutions of which had yet to be found at mid-century. The practical need of rapid and flexible administrative action necessitated the delegation to ministers of powers to legislate by administrative orders which, but for the overstraining of the deliberative machine, would have been retained by parliament. This wide field of legislation, touching national life at countless points, is submitted by a very summary procedure to parliament, if it is not withheld altogether from its control. The practice grows of ministers seeking agreement directly with outside interests before the introduction of their hills, and presenting the house of commons with closely knit schemes which are difficult to alter by amendment. Finally, the multiplication of new departments bound a growingly disproportionate number of officeholders by ties of personal interest to unquestioning support of the government. Including the unpaid parliamentary private secretaries! attached to every minister, the total parliamentary personnel of a ministry rose to a figure amounting to between one-fourth and one-fifth of the whole membership of the house of commons.

Government Control of the Time of *the House.* — *A* result of the predominance of the government in parliament, particularly its practical monopoly of the legislative program, was the control which it secured of the time of the house. Before 1832 ministers had begun to make growing demands for their business but still had no recognized precedence over other members. Before the end of the century they had secured the disposal of three out of the five days of the parliamentary week. In 1906 a standing order provided that government business should have precedence throughout the session, except on two days a week during about two months after its commencement. This standing order had been preceded and was accompanied by others which prevented any interference with the arrangement of business or dilatoriness in its dispatch. Drastic powers were secured for curtailing debate by means of the closure, for excluding amendments at the discretion of the chair and, finally, for forcing bills through their stages in accordance with fixed timetables. More intensive use was later made of standing committees to relieve the pressure on the house. Beginning in 1945 further steps were devised to streamline procedure. The joint effect of all these devices was to speed up the legislative process. Since the beginning of the century the bulk of the statute book (*i.e.,* the public acts passed by parliament each session) had increased from an average of 350 to an average of more than 1,000 pages a session. As the time spent on legislation remained roughly constant, it follows that the speed of the legislative process had increased almost threefold. This meant that ministers could secure in a single session the passage of three or four major bills. each of which might have needed a session to itself jo years earlier.

Countercheck of Parliamentary Opposition. — The factors making for the ascendancy of the government over the house of commons gave additional importance to the countercheck which the parliamentary system provides in the existence of a responsible party organized for the criticism and review of government policy —the official opposition. The paradoxical term official, applied to a body which plays no part in government (in the strict sense), is revealing, because it marks appreciation of the fact that the provision of a check on power is a function of government (in the wide sense). Even before the Reform act of 1832 John Cam Hobhouse had coined the expression "His Majesty's Opposition." A wise prime minister is said to welcome a strong opposition, which by its criticism keeps his colleagues alert and by its pressure consolidates his following. The British parliamentary opposition is a united party with a common policy, which is prepared to take office when the existing government falls. This is a feature of the British system, whether at home or in the dominions, which distinguishes it from the system of a country, such as France, where no coherent opposition exists, but only a number of parties or groups, united solely in attack and representing such divergent policies that they are incapable of combining to form an alternative government.

Opposition has a long and honourable history in the house of commons. In the 17th century, opposition to the Stuart kings was the function of a large majority of the house as a body. Only when the cabinet system had made the majority the supporters of the government did the duty of opposition devolve on the minority. It still retains the prestige of a traditional parliamentary function. Respect for the rights of the minority is the chief element in the parliamentary spirit which, in spite of the governmental bias of the modern standing orders, still tempers the rule of the majority.

The same process which, by building up party machinery and party discipline, strengthened the government in parliament and put it into closer touch with the electors, had similar results in strengthening the opposition. Half the electorate supports it as the alternative government — its leaders are the shadow cabinet. An act of 1937 granted its leader a salary out of the consolidated fund — the fund on which the salaries of judges and other high officials is borne. Facing ministers seated on the treasury bench, the leaders of the opposition direct criticism of government measures, legislative and administrative, from the point of view of the party policy which they have had the chief influence in formulating. The opposition whips see to it that this policy is supported by members of the party in debate and in the division lobbies. It is principally through the efforts of the opposition that controversial questions are brought to an issue in debate. For this purpose the opposition is entitled by long-standing custom to receive from ministers all official information necessary for intelligent criticism and to enjoy certain rights over the time of the house for initiating debates on subjects of its own choice. The leader of the opposition can claim a day for a motion of censure on the government and is regularly accorded facilities for discussing newly arising questions of public interest. In addition, the 25 or more days a session on which annual expenditure is reviewed have come to be recognized as "opposition time." By long practice these days are used not for the purpose of scrutinizing finance but for the criticism of administrative policy; and after the beginning of the 20th century the opposition enjoyed the right to pillory the departments whose policy it disapproved on every day allotted to the consideration of expenditure — an arrangement which permits its leaders, whenever they choose, to challenge ministers on matters with regard to which they are then vulnerable. It is noteworthy that the total number of days which the government is, in these various ways, bound by convention to surrender for the use of the opposition slightly exceeds. on the average, one quarter of the whole 160 days (or so) of the session.

Opinions may differabout the value, as a check on government, of the facilities for criticism which parliamentary convention places at the disposal of the opposition. But, granted that party allegiance makes the government unassailable in the division lobby, sustained criticism may still have an effect in the country and influence votes at a general election. The appeal of both sides to public opinion is reflected in the daily publication of verbatim reports of speeches in both chambers and in the standing committees of the house of commons. It may be true that the technique of addressing constituents and courting the general public over the heads of members has a distorting effect on parliamentary debate. The house had acquired an instinctive distaste for modern methods of publicity such as the broadcasting of proceedings (adopted in the more democratic of the dominions). It still tried to hold the balance between two uses of debate which were both valuable but were falling out of equilibrium because of the progress toward full democracy which had taken place since the mid-19th century. The one was to bring the differing views of its members to a focus in order to reach the largest measure of agreement. The other was to appeal to public opinion outside. The one made for conciliation, the other for demagogy, and the only hope of reconciling the two purposes was by the spread of political education. Parliament was still the chief contributor to this end. For it is parliamentary debate that provides the forum in which spokesmen of the government and the opposition, acting like counsel for the prosecution and defense in a court of law, bring conflicting views to an issue and provide the material for the verdict of the nation.

Results of Democratization. — A survey of parliamentary development after 1832 shows that parliament continuously lost in political power, on the one hand, to the electorate and, on the other, to the government. The overriding of the lords' veto, though it

strengthened the relative position of the house of commons, inured principally to the benefit of the government, the real legislative power. The growth of party machinery in parliament had made ministers, as leaders of the majority party, the masters of the house of commons; and its spread throughout the country had increased the parliamentary ascendancy of the government, which controlled the local party machinery by increasing the dependence of members upon their constituents. The sole check on majority rule was the vigorous survival of the two-party system, based on a real division of political principles, or perhaps rather popular instincts. While this system deprived the house of commons of the power of making and unmaking governments which the multiparty system gives some European legislatures, it removed the danger, to which party government is exposed, of the permanent surrender of power to a single set of leaders. The rule of the majority is tolerable because it is at any time a temporary and replaceable majority. The fact that the temporary minority has almost equal support in the country gives reality to the function of opposition and is a guarantee of moderation. It is the stubborn refusal of the country to do without an alternative government in reserve that gives the opposition its strength; and it is the function of opposition in the house of commons to keep parliamentary government parliamentary.

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PARLIAMENTARY PROCEDURE

Basis of Procedure.— The existing rules of procedure are based upon: (1) practice; (2) the standing orders; (3) rulings irom the chair; and (4) statutes. *Practice* is that part of procedure which developed spontaneously in the course of business and includes what is known as ancient usage. So far as it is expressly formulated, it is to be found in the body of precedents contained in the *Journals.* The formative period of practice was the first half of the 17th century, a period when parliament solved many of the problems confronting a large assembly in a spirit which continued to set a standard for modern procedure. The chief object of the *standing orders* (the second main basis of procedure) is the expedition of public business. They do not themselves form a complete code, being expressed as modifications of earlier practice; and few of them existed before 1832. The standing orders are supplemented by various sessional orders whose duration is in form limited to one session only. Many of these sessional orders, after a period of trial, are made standing orders. The great increase in the prestige of the speakership after the middle of the 19th century involved the chair in the duty of interpreting the rules of procedure whenever the need arises. By means of *rulings from the chair* (the principal source of modern practice) the standing orders are applied to doubtful cases and brought into harmony with the whole body of practice. Procedure relies only in a small degree upon *statute;* for statutory modifications, overriding as they do the orders of either house, tend to fetter the independence of both houses and thus reduce the flexibility of procedure which is one of its most valuable features.

Parliamentary Law and Machinery.— The main disqualifications for membership of the house of commons in force at mid-20th century were: peerage, clergy, alienage, lunacy, minority, bankruptcy, felony, conviction for corrupt practices and the acceptance of certain offices of profit from the crown. The holders of nonpolitical offices, such as judges and civil servants, are disqualified; holders of political offices, such as ministers, are not. A member may not directly resign, but may, by a useful fiction, vacate his seat by acceptance of an office, nominally one of profit from the crown, such as the stewardship of the Chiltern Hundreds.

Officers of the House.—The house is presided over by its own elected officer, the speaker, who represents it in all its external relations. The speaker is chosen by the house by a majority vote if his election is contested. But he is usually re-elected unanimously in each new parliament as long as he wishes to serve. His duties within the house require a degree of impartiality which prevents him from exercising the ordinary rights of a member to speak or vote. In the chair he enforces the rules of debate, maintains order, proposes and puts the necessary questions and announces the decisions of the house. He also exercises a general censorship over notices, questions to ministers, etc., and interprets the rules of the house. In addition, he has certain statutory duties such as the certification of money bills under the Parliament act, 1911. In 1855 powers were given for the chairman of ways and means, and in 1902 for the deputy chairman, to act when occasion arose as deputy speaker. In addition to his duties as deputy speaker, the chairman of ways and means presides over committees of the whole house in much the same way as the speaker does over the house itself; he is assisted by the deputy chairman. There is also a panel of temporary chairmen, set up each session, the members of which may be called on to preside over committees of the whole house; and from this panel the speaker appoints the chairmen of the standing committees. In addition to the above officers chosen irom among members, mention must be made, first, of the clerk of the house, the chief permanent officer, who keeps the records of the house, advises the speaker and members on procedure and is the head of the principal official department which is to a great extent responsible for the efficient working of the parliamentary machine; and second, of the serjeant at arms who attends on the speaker with the mace, executes his orders for the preservation of decorum in the chamber and is responsible for the ancillary services outside.

A New Parliament and the Work of the Session.— The first business of a new parliament is the election of a speaker and the taking by members of the oath of allegiance, after which the session proceeds with the speech from the throne, follo ed in either house by a debate upon the address in answer to this speech, in which the general policy of the government is discussed. Each session is ended by prorogation of parliament by the sovereign on the advice of ministers—an act which terminates all the business before either house. A parliament expires at the end of five years unless it is previously dissolved by the sovereign. Apart from prorogation which affects both houses, either house may adjourn at its own discretion independently of the other.

The average effective length of the session is about 160 days. Apart from about 20 days for the consideration of private members' bills and motions, the government controls the whole time of the house—a power which it often uses to appropriate private members' time or extend the normal length of the sittings. Only a portion of its time can, however, under the rules and conventions which regulate the arrangement of business in the house, be allotted by the government to its program of legislation. On the average, between 1945 and 1955 a little more than one third of the effective days of the session were devoted to government legislation, and the remainder to the financial and routine affairs of the house, private members' business and subjects for criticism initiated by the opposition.

The Sitting and Its Business.— The normal hours of sitting are fixed by standing order irom 2:30 to 10:30 P.M. on Monday. Tuesday, Wednesday and Thursday and from 11 A.M. to 4:30 P.M. on Friday. Certain specified business is, however, exempted from interruption under the provisions of this standing order, such as certain classes of financial business and motions for the confirmation or annulment of the "statutory instruments," by which ministers exercise delegated powers of legislation. Other business, not so specified, may be exempted by an *ad hoc* order of the house. In either case the sitting may be extended for an indefinite period; an *ad hoc* order alternatively may prescribe a limited extension only. A sitting may be terminated prematurely by the absence of a quorum, which in the house of commons consists of 40 members.

At the beginning of the sitting various minor kinds of business are handled which are expected to be unopposed. Not later than 2:45 P.M. on the first four days of the meek begins the period of about one hour reserved for the putting of questions to ministers for oral answer, one of the most effective forms of parliamentary control. Notice of a question for oral answer must be given two full days in advance (or one day by special arrangement) and is printed in the order paper. On his name being called by the speaker the member indicates the number of his question in the printed order paper and the minister reads his reply; a supplementary question may be asked by any member subject to the speaker's discretion. The rules governing questions are many and complicated; they are designed to ensure that the questioner genuinely seeks iniormation or presses for action and that matters of fact or policy, rather than opinion, are dealt with. Questions must be limited to matters for which the government is responsible and must conform to the general rules of decorum in debate. Between questions and the orders of the day, a member may ask leave of the house to move the adjournment in order to raise a matter, which, he must satisfy the speaker, is definite and of urgent public importance. If the speaker is so satisfied, and not fewer than 40 members are willing to support the request, leave is granted and the motion stands over until later in the sitting. At this time, also, complaints of breach of privilege may be raised, provided that a prima facie case is made out to the speaker's satisfaction. When any such miscellaneous business is disposed of, the house proceeds to its main business consisting of the orders of the day (which include all stages of bills and other business set down for consideration by order of the house) and motions of which notice has been given. The order in which these are placed on the paper is, except on days on which private members' business has precedence, a matter for the discretion of the government.

Forms and Rules of Debate.— Motions are classified as substantive or subsidiary. Substantive motions, the usual purpose of which

is to elicit a decision of the house, include adjournment motions which afford an opportunity for an exchange of views rather than for a decision of the house. A bill is debated on a motion; *e.g.,* ior its second or third reading. Debate on any subject must originate in the iorm of a motion. When a motion has been moved (and seconded) the speaker proposes the question (in the same terms as the motion) as the subject of debate, and at the conclusion of the debate puts the question to elicit the decision of the house. On a motion being agreed to, it becomes a resolution or order of the house. This simple form of debate is, however, capable of becoming involved by the introduction, aiter the question has been proposed, oi a subsidiary motion. Subsidiary motions include what are known as dilatory motions; *i.e.,* motions moved in the course of a debate "that the house do now adjourn" (which must be distinguished from the substantive motion of the same form) or "that the debate be now adjourned" or "that the question be not now put" (the "previous question"). These motions are oi a dilatory character because they are designed to evade a decision on the question already proposed. The previous question is rarely moved. Subsidiary motions also include amendments, moved for the purpose oi altering the terms of a substantive motion, which may themselves be the subject oi further subsidiary motions known as amendments to amendments. Subsidiary motions must be disposed of beiore debate on the main question is resumed. No question or hill may be offered in either house that is substantially the same as one on which judgment has already been expressed in the current session. This rule is, however, held not to apply between the various stages of a bill, but it is strictly observed during the same stage; *e.g.,* when a bill is beiore a committee. Dependent on the same principle is the rule of anticipation by which the previous discussion of a matter of which notice has already been given for a future day is forbidden.

Voting.—At the conclusion oi debate the speaker (or chairman) puts the question and "collects the voices" by directing those in favour and those against the proposition contained in the question to call aye and no, respectively. According to his estimate, he declares "the ayes (or the noes) have it." If his opinion is challenged, he directs the ayes into the lobby on his right and the noes into the lobby on his left, where votes are counted and the names of members voting recorded with a view to the publication of the division lists next day. The process of voting is the same in the'house and in committee of the whole house. It takes 10 to 1 j minutes and the chair has power to dispense with it if in his opinion a division is unnecessarily claimed. In standing committees voting is by roll call. The speaker in the house and the chairman in committee vote only when the numbers are equal, and give the casting vote in such a way as to avoid taking responsibility for a final decision.

The *Closure.*—The closure is moved in the form "that the question (under discussion) be now put," and is decided without amendment or debate. When an amendment is closured the closure of the main question may be claimed. The closure may be moved not only at the end of a speech but also when a member is speaking; but it can only be moved with the consent oi the chair which need assign no reason ior its reiusal; and, ior the closure to be carried, not less than 100 votes must be cast in its support. The closure may be resorted to in committees of the whole house and also in standing committees, where rules similar in principle apply. It may not be applied in select committees. Another rule for saving time, and also for ensuring that debate is concentrated on the most important amendments in committees and on the report stage of bills, is that by which the chair is empowered to select which amendments it will call and to pass over others. From 1954, the house has also provided by sessional order that debate on a "statutory instrument" (see above) may not be continued beyond 11:30 P.M.

Allocation of *Time* Orders.—In the case of long and controversial bills a time limit may he imposed by order of the house on the various stages of a bill. This expedient, devised for the first time in 1887, is sometimes called the guillotine or closure by compartments—the latter, because in its developed iorm, at the committee and report stages and on consideration oi lords amendments, a bill may be divided up and a decision enforced on groups of clauses at the end of specified sittings. This is done by empowering the chair at a certain hour to put all the questions necessary to dispose of the business allotted to a particular day and for that purpose to disregard all except government amendments. In 1947 this drastic method oi restricting debate was applied ior the first time to the proceedings of standing committees.

Rules and Conventions *of* Debate.—In addressing the house a member must conform to various rules of order and it is the duty of the chair to see that these are adhered to. These rules apply both to the manner of speaking and the matter of speeches. They are designed to secure orderly discussion and to check irrelevancy. Members not speaking are equally bound by rules of conduct. The ultimate authority in matters of order is the house itself, though practice and the standing orders (especially numbers 20 to 24) have entrusted wide powers of discipline to the chair.

Public Bills.—A bill is an instrument of legislation passing through parliament to become a statute. A public bill, as distinguished from a private bill, is a draft law of general application. For the purposes of procedure public bills iall into two main classes: (1) money bills; and (2) other bills. The former category is iurther divided into: (a) bills which are defined as money bills under the Parliament acts, 1911 and 1949; and (b) bills whose main object is to authorize expenditure or to impose taxation (these two classes overlap but do not coincide). In the latter category are to be iound bills which impose a charge as a subordmate part of their proposals only and bills which contain no financial matter at all. To become an act oi parliament a bill requires, except under the provisions of the Parliament acts, 1911 and 1949, the agreement of both houses and the royal assent. It is then printed and issued under the authority of the house of lords.

The form of a public bill is that of a drait statute. It is labelled with a short title for ease of citation and has prefixed to it a long title descriptive of its purpose. It is preceded by an enacting formula in common form and sometimes by a preamble and contains clauses divided into subclauses and paragraphs, together with schedules setting out matters of machinery or detail consequential on the clauses. The principal stages of its consideration in either house are: introduction and first reading; second reading; committee stage; report stage; third reading; and consideration of amendments made by the other house.

Introduction and First Reading.—A bill may be introduced into the house of commons in one of three ways: upon an order of the house (the old procedure which has been largely superseded), or by presentation aiter notice (the standing order method most generally used), or on being brought from the house of lords. The first reading is a purely formal stage. A day is appointed ior the second reading and the bill is ordered to be printed. When first printed, any provision which imposes a tax or a charge upon the revenue is printed in italics as an indication that it is not effectively incorporated in the bill until it has been authorized by a money resolution of the house.

Second Reading.—The second reading is the most important stage in the progress of a bill. Its whole principle is then submitted for acceptance or rejection. Debate bas a wide scope, being permitted to range over cognate matters relevant to the provisions contained in the bill. Opposition to it is not generally expressed by a mere negative vote, but may be effected either by amending the question so that the bill be read "this day six months"—one of the traditional methods of defeating a hill—or by a reasoned amendment setting out the ground on which the second reading should be refused. The carrying of either of these amendments is equivalent to the rejection of the bill. Once the principle has been agreed to and the hill given a second reading it is reierred to a committee ior detailed examination.

Committee Stage.—Under the system of standing committees introduced in 1907 a public bill (other than a bill imposing taxes, a consolidated fund bill or a provisional order bill) stands committed to a standing committee unless the house orders otherwise. Besides the exceptions mentioned, bills oi constitutional importance are by the good will of ministers committed to a committee oi the whole house, as also are, at the other end of the scale, bills of a noncontroversial nature, the consideration of which is oiten treated as a formality. In some rare cases bills may be committed to select committees or joint committees oi both houses. The general function of a committee on a hill is to go through the text of the bill clause by clause and to make such amendments as may seem advisable, provided that such amendments are, in the opinion oi the chair, relevant to the subject matter and not destructive of the bill. Further rules to which amendments must coniorm are: that they should be intelligible, complete and not inconsistent with any previous decision of the committee; and that they should not extend the purpose or alter the incidence of, or increase, any charge or tax beyond that provided in the associated money resolution. In a standing committee the chairman, who is appointed by the speaker from a panel oi members, exercises powers similar to those of the chairman of ways and means in the committee of the whole house, which include the powers of selection of amendments, of checking irrelevance and repetition, of accepting a motion for the closure and oi declining to accept a dilatory motion which he thinks to be an abuse of the rules of the house. On conclusion of the committee stage, a bill is reported to the house with or without amendments and the house then proceeds to take the bill, as amended (or not amended), into consideration. This stage is known as the report stage.

Report Stage.—This stage is required for all bills except those which have been committed to a committee oi the whole house and reported without amendment. It has tended to become a more formal repetition oi the committee stage, in which debate is governed by the rules applicable to proceedings in the house. On report amendment is governed by the rules applicable to the committee stage, with the iurther restriction that no new burden can be laid upon rates nor can any public charge be imposed or increased, even if within the terms of the money resolution.

Recommittal.—A motion for recommitting a bill or part of a bill to a committee of the whole house may be moved before or aiter report or on the third reading. The recommittal of a bill as a whole is now rare. But partial recommittal is frequent for, in view of the restrictions upon the report stage, recommittal map be needed to insert amendments increasing charges or burdens on rates.

Third Reading.—At its third reading a final review of a bill, as amended at previous stages, takes place. The procedure is similar to that on second reading; the same amendments as were in order on the second reading may be moved to the question that the bill be read the third time. The debate is, however, restricted to the contents of the bill, since there can be no further opportunity for extending its scope. Amendments to the bill itself may be moved only if they

are merely verbal. When a bill has been read the third time, it is deemed to have been passed and is immediately sent to the lords. On reaching the upper house it goes through stages similar to those in the commons. Bills, with certain rare exceptions, are committed to committees of the whole house; and amendments of substance are frequently made on the third reading.

Lords Amendments.—If the lords do not amend a bill sent up to them from the commons it remains, aiter passing through all 'its stages, in the custody of the officers of the house of lords, waiting for the royal assent which is normally given within a fortnight. A money bill, however, such as a finance bill, is returned to the custody of the clerk of the house of commons. If the lords make amendments to a commons bill, the bill is sent back to the commons. If they agree, the bill is ready for the royal assent; if they disagree to or amend any of the lords amendments, then in respect of such amendments iurther exchanges take place between the two houses and this process continues until every amendment made by one house is agreed to by the other (when the hill is ready for the royal assent) or until one house insists on its disagreement in which case the bill is lost for the session.

Bills Originating in the Lords.—Bills which originate in the house of lords follow much the same procedure and, upon being passed, are sent down to the house oi commons. As a rule, however! bills of major importance do not originate in the lords and bills whose main object is the creation of a public charge may not do so.

Committees.— Both houses make use oi committees, classified as committees of the whole house, standing committees, select committees, joint committees and private bill committees.

Committees of the Whole House.—Committees of the whole house (which are, in effect, the house itself sitting under less formal rules and presided over by a chairman and not by the speaker) may be classified into committees on public bills and committees on financial business. The functions of the former have been dealt with in an earlier section. Financial business is transacted by the committee of ways and means and the committee of supply—both committees of the whole house—the former of which inaugurates taxation and authorizes issues out of the consolidated fund, while the latter authorizes expenditure on specific public services, presented in the form of estimates. Committees of the whole house are also specially appointed to authorize the financial provisions of bills.

Standing Committees.—Mention has already been made of the committal of bills after their second reading to standing committees. These are generally not more than six in number. Their members are nominated by the committee of selection, a sessional committee of 11 members set up to provide for the constitution of these and various other committees. With one exception, the number oi members may not exceed jo, chosen to reproduce approximately the relative strength of parties in the house. The exception is the Scottish standing committee, to which is reierred all legislation relating exclusively to Scotland; it must include all the 71 members for Scottish constituencies, together with not less than 10 or more than 15 other members. After committal, bills are reierred to one or other of these committees by the speaker. Their procedure is essentially the same as in a committee of the whole house.

The committees sit generally in the mornings on two or three days a week and the consideration of important bills may take many weeks. The guillotine has also been applied to the consideration of bills in standing committees.

Select Committees.—In certain cases a public bill may be committed to a select committee for a preliminary examination after second reading, but this is relatively rare compared with the usual function of a select committee which is to conduct inquiry into a specified matter. Each session the house appoints sessional select committees, either pursuant to a standing order or by a special order of the house regularly repeated, for the purpose of investigation into certain branches oi business. In addition to these committees, there are set up each session a number of ad *hoc* select committees to inquire into and report on matters of public interest. The inquiries of these committees have tended to become increasingly political or procedural, since matters of public interest requiring specialized knowledge have been on the whole more frequently reierred to royal commissions or departmental committees. Select committees normally consist of not more than 1 j members; a notable exception is the select committee on estimates, which consists of 36 members. If necessary, they may be given special powers, as, for example, the power to send for persons, papers and records; to appoint subcommittees or to examine witnesses on oath. Each committee controls the day and hour of its sittings though it cannot, without special leave, sit on a day on which the house does not sit.

A select committee chooses its own chairman, who is allowed only a casting vo ·. A shorthand note of evidence is kept and usually printed and the minutes record any division of opinion. Rules to be observed in the printing and publishing of minutes of evidence and proceedings are laid down by the standing orders. When the hearing of evidence is concluded. it is usually left to the chairman to prepare a draft report. The committee goes through the drait report paragraph by paragraph, making amendments where necessary. When this is concluded, the report, together with the minutes of evidence, is presented to the house. Any documents material to the report may be included as appendixes. The report presented to the house may not be accompanied by a minority report. A drait report, however, which has been submitted to the committee and not entertained by them, is entered in the minutes, as are also amendments moved to the report and not accepted by the committee. When a committee has made its report, its sittings are usually considered closed. A report from a select committee does not automatically come up ior consideration in the house; it is ordered to lie upon the table and the house may take it up or not as it pleases.

Joint *Committees.*—Matters which are of equal concern to both houses, and do not raise political issues, may be referred to joint committees consisting of an equal number of lords and commons. The chair of these committees is generally taken by a peer and the procedure is that of a select committee of the house of lords (which is less strictly defined than in the house oi commons).

Finance.— Parliamentary control is based on a division of functions between the executive and the house of commons. The crown, the executive power, demands money, the commons grant it and the lords assent to the grant. But the commons do not grant money or vote taxes unless in pursuance of a royal demand; nor does the crown spend money or levy taxes outside or beyond the limits imposed by the commons' grant. Parliamentary control is facilitated by the maintenance of a single fund known as the consolidated iund or exchequer, represented in fact by the account kept by the government at the Bank of England, into which all revenue flows and from which all payments are made. All such expenditure (except for certain fixed charges authorized by statute and known as consolidated iund services) is based on estimates prepared annually by the government departments, and given legislative sanction by appropriation acts. The supply thus granted to the government is ior one year only (running from April 1 to March 31), any surplus having to be surrendered at the end of the financial year.

All revenue is paid into the exchequer, though departments may retain certain incidental receipts (known as appropriations in aid, duly authorized in amount) which are deducted from their estimates of expenditure.

Annual Financial Cycle.—The house begins the main financial work of the year by agreeing to a vote on account in general terms in order to provide for the expenses of the civil services until the Appropriation act, passed by early August, finally authorizes the detailed estimates of each department. This vote on account sanctions a part (equal to iour or five months' expenditure) of the total sum demanded in each estimate and must receive the statutory authority of a preliminary Consolidated Fund act (which authorizes issues from the consolidated fund) before the beginning of the financial year. For the navy, army and air force services no vote on account is needed; instead, several of their major estimates are voted beiore the start of the financial year and the money so obtained is allowed to be used until the passing of the Appropriation act to defray the expenses borne on their other estimates. The consideration of the estimates is carried through during the current financial year until the process ends with the passing of the Appropriation act, which both authorizes the further issues irom the consolidated fund required to make good the outstanding expenditure on the estimates and appropriates in detail the total amount voted to the services specified in the estimates. Any new or additional expenditure must be voted in the form of a supplementary estimate. At the end of the financial year the accounts of the departments are audited by the exchequer and audit department to ensure that no money is spent without parliamentary authority. The head of that department, the comptroller and auditor-general, then presents the accounts with his report thereon for the scrutiny of the public accounts committee.

Principles of Financial Procediwe.—The financial procedure of the house depends on three rules. First, since all financial business is initiated by the crown, no member may make a motion or move an amendment which imposes or increases expenditure or taxation; second, a proposal to impose expenditure or taxation may only originate in a committee of the whole house; and third, after being voted in a committee of the whole house, the resolution approving the charge must be agreed to by the house itself, and he finally authorized by incorporation in a bill. The enforcement of the rule that the crown alone initiates charges is secured, in respect of novel or extraordinary expenditure, by the requirement that the recommendation of the crown be signified before the house can go into committee to consider the relevant motion; but in respect of the ordinary annual expenditure and the consequential taxation the recommendation of the crown is taken as implied in the presentation of the estimates and the reference to them in the speech from the throne.

Expenditure.—The consideration of the annual estimates is the duty of the committee of supply. On first going into committee of supply on the civil estimates, the house preserves the tradition of placing grievances before supply by debating the motion "that Mr. Speaker do now leave the chair," to which it is customary for amendments to be moved by unofficial members. The consideration oi the estimates is spread over a number of allotted days (not less than 26 in all), the opposition being given the right by custom to choose the estimates to be considered on each allotted day. On the last two of these days all outstanding votes whether debated or not must he submitted to the decision, respectively, of the committee and of the house. Debate in the committee of supply is restricted to the policy and administration of the department whose vote is under consideration, all

but incidental reference to matters requiring legislation being out of order. Debate takes place on a motion approving the expenditure of a sum of money for the purposes of the estimate under consideration; and opposition is, by custom, expressed in the form of an amendment that a reduced sum be granted, a form which allows amendments of different amounts to be moved successively. Though in form the motion is concerned with finance, debate is almost invariably directed to questions of policy and administration, rather than to strictly financial questions. When the estimates have been agreed to, they are covered by a vote of the committee of ways and means, authorizing the issue of the necessary sum, which forms the basis of the consequential Consolidated Fund bill. Debate on the second and third readings of such a bill may range over any subject included in the estimates for which the bill provides, though reference to legislation is barred.

Other committees of the whole house relating to finance known as money committees deserve mention here. The function of such a committee, which is appointed ad *hoc,* is to consider a resolution authorizing proposals for new expenditure contained in a bill already before the house. The king's recommendation required for such a resolution is signified by a minister of the crown before the house goes into committee. The resolution, when agreed to by the house, defines the scope and limits of the charge which may not be exceeded by the related provisions of the authorizing bill or any amendments proposed thereto. Two select sessional committees relieve the house of the task, impracticable for a large body, of supervising the intricate details of national expenditure. The committee of public accounts examines, with the help of the comptroller and auditor-general, the appropriation accounts in order to make sure that no sums have been expended on purposes other than, or in excess of, those for which they were granted by the house; the reports made by the officer are used by the committee as a basis for their work, which is conducted mainly by the examination of departmental officers responsible for expenditure. The estimates committee examines the estimates of the current financial year in order to make suggestions for economy consistent with the policy implied in such estimates. Both these bodies have provided a spur to departmental efficiency.

Taxation.—The voting of taxes is the function of the committee of ways and means. Most taxes, having been imposed by permanent legislation, or for a limited number of years, are not subject to annual review. The rate of income tax is, however, voted annually. This vote and any changes in taxation are proposed in the committee of ways and means, and upon the resolutions of that committee, when agreed to by the house, the Finance bill is founded. The consideration of these resolutions begins with the presentation by the chancellor of the exchequer of his budget which consists of a review of the national revenue and expenditure during the financial year just concluded, accompanied by an estimate of the income and expenditure of the current year. This review is immediately followed by the voting of the taxing resolutions, and of any others making changes in the fiscal system which require statutory sanction. To protect the revenue it is necessary to give them temporary validity on the same day as they are made public. This object was secured by the Provisional Collection of Taxes act, 1913, which gave resolutions voted by the committee of ways and means provisional force of law until they are finally authorized by the passing of the Finance act. The Finance bill—there may be more than one each year—must contain no provision not authorized by the budget resolutions on which it is based, or not relating to the finance of the year. As in other bills containing financial provisions, no amendment is allowed which increases the amount or alters the incidence of a charge as expressed in the initiating resolution.

Financial Powers of the Lords.—The restrictions on the power of the house of lords in matters of finance depend partly on their tacit acceptance of the privileges claimed by the commons and partly on the Parliament act, 1911. By practice the lords cannot initiate or amend bills or provisions in bills dealing with public expenditure or revenue, or dealing with local rates. They are constitutionally entitled to reject any such bill, although the effect of such rejection is, in the case of bills certified as money bills under the Parliament act, rendered inoperative beyond the imposition of a month's delay from the receipt of the bill. Privilege is regularly waived by the commons in certain specified cases, and may be in other cases at their discretion; and certain parliamentary devices are employed to enable the lords to include financial provisions in a bill without in appearance infringing the privileges of the commons.

Private Legislation.—Legislation for conferring particular powers, benefits or obligations on any person or body of persons (including local authorities and private corporations) is normally conducted by means of private bills, which pass through the same stages in either house as public bills. Briefly, the differences in procedure between public and private bills are that the presentation of a private bill is preceded by a petition from the parties interested in its promotion; that the progress of private bills through parliament is strictly regulated by a series of special standing orders of either house known as private business standing orders; and that proceedings on these bills in committee are of a quasi-judicial character directed to adjudicating between the parties promoting and those opposing a bill. The house normally delegates this duty of considering private bills to committees of four members known as private bill committees. At the second reading the house, as in the case of a public bill, accepts or rejects the general principle or expediency of the bill, but this expediency being founded mainly on allegations of fact, the principle of the bill is agreed to conditionally on such allegations being proved before a committee. The stages of a private bill before the house are, therefore, generally of a formal nature, though, if opposed, they may be debated at the hour reserved for opposed private business. The committee stage is by far the most important. A private bill committee in either house has many affinities with a court of law. If a bill is opposed, the promoters and those opponents who have deposited petitions against the measure are represented by counsel, and evidence from witnesses is heard on oath. The views of government departments on the implications of certain types of bill are also taken into account. The committee may either find the preamble of the bill proved with or without amendment, or not proved; in the former case they proceed to amend the bill where necessary and report it to the house, where it goes through its remaining stages in the ordinary way; in the latter case the bill is lost. Bills which are not opposed are committed to a special unopposed bills committee whose proceedings are summary.

Provisional Order Bills.—Procedure by private bill has been superseded in certain cases by the provisional order system, by which most government departments are empowered to issue provisional orders which in their scope are practically equivalent to private bills. Under this system the department itself is the promoter and, before bringing an order before parliament, it holds a preliminary local inquiry. Parliament is asked to sanction the draft departmental orders by means of a confirming bill presented by the minister concerned. If orders are opposed they go to a private bill committee in the same way as an opposed private bill; the remaining stages are similar to those of private bills.

Special Procedure Orders.—Under the Statutory Orders (Special Procedure) act, 1945, procedure by way of provisional order is replaced by a summary procedure in certain prescribed cases. Briefly, this procedure is by way of statutory order (which requires parliamentary authorization only by resolution) instead of by provisional order (which requires legislative authorization); consideration in committee is dispensed with unless a general objection to the order is urged.

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PARLIAMENTARY LAW: **see** RULES OF ORDER.

PARMA, a town and episcopal see of Emilia-Romagna, It., head of the province of Parma, situated on the Parma, a tributary of the Po, 55 mi. N.W. of Bologna by rail. Pop. (1957 est.) 128,578 (commune). Parma lies in a fertile tract of the Lombard plain, within view of the Alps and sheltered by the Apennines. 170 ft above sea level. From south to north it is traversed by the river, crossed by five bridges; and from east to west runs the line of the Via Aemilia, by which ancient Parma was connected with Ariminum (Rimini) and Placentia (Piacenza).

The cathedral of the Assumption (originally of St. Laurentius; 1058–74) is a Lombardo-Romanesque building. The west front has three rows of arches and a central porch supported by huge red marble lions (sculptured with the rest of the facade by Giovanni Bona da Bissone in 1281). On the south side of the façade is a large Romanesque-Gothic brick campanile 1284–94). The walls and ceiling of the Romanesque interior are covered with frescoes of about 1570; those of the octagonal cupola, representing the Assumption, are by Correggio. To the southwest of the cathedral stands the baptistery, designed by Benedetto Antelami; begun in 1196, it was completed in 1281.

The church of San Giovanni Evangelista, which dates from 1510, has a façade of 1604–07. The frescoes of the dome are by Correggio, and the arabesques on the vault of the nave by Michangelo Anselmi. The Madonna della Steccata (Our Lady of the Palisade), a church in the form of a Greek cross (1521–39), contains the tombs and monuments of many of the dukes of Parma. The Palazzo della Pilotta (16th and 17th centuries) contains the academy of fine arts (1752), the picture gallery, the library and the museum. The Teatro Farnese, a wooden structure erected in 1618 from G. B. Aleotti's designs, was destroyed in World War II. There are other beautiful ceiling frescoes by Correggio in the former Benedictine nunnery of San Paolo. The Cniversity of

Parma was founded in 1601 by Ranuccio I and reconstituted by Philip of Bourbon in 1768. Parma trades in grain. cattle and dairy produce, especially the cheese known as Parmesan.

History.—The ancient town was preceded by a settlement of the Bronze Age. It became a Roman colony in 183 B.C. It fell into the power of Alboin in 569 and became the seat of a Lombard duchy. During the 11th. 12th and 13th centuries Parma had its share of the Guelph and Ghibelline struggles, in which it mainly took the part of the former. and also carried on hostilities with Borgo San Donnino (Fidenza) and Piacenza. In 1307 the city became a lordship for Giberto da Correggio, who conquered Reggio, Brescello and Guastalla and was made commander in chief of the Guelphs by Robert of Apulia. The Correggio family sold it to the Visconti. From the Visconti it passed to the Sforza. Becoming subject to Pope Julius II in 1512. Parma remained (in spite of the French occupation from 1515 to 1521) a papal possession till 1545, when Paul III (Alessandro Farnese) invested his son Pierluigi with the duchies of Parma and Piacenza.

The Farnese male line ended with the eighth duke's death in 1731 (see FARSESE). The next duke, Charles of Bourbon (Elizabeth Farnese's son, eventually Charles III of Spain), renounced the duchies of .Austria in 1736 so as to secure recognition as king of the Two Sicilies; but his brother Philip became duke oi Parma, Piacenza and Guastalla in 1748. The French revolutionary armies overran the duchies in 1796; Philip's son Ferdinand died in 1802, his own son Louis having already been made king oi Etruria in compensation ior the loss of his duchies to France; and in 1808 Parma was finally attached to the Napoleonic empire. The treaty of Paris (1814) assigned Parma, Piacenza and Guastalla to the former empress Marie Louise ior life. On her death (1847), Parma and Piacenza passed to Charles Louis (Charles II), son of Louis of Etruria. His grandson Robert was dispossessed when the duchies were annexed to "the kingdom of Sardinia in 1860 (see ITALY). (M C. C.)

PARMA, a city of Ohio, U S., immediately south of Cleveland (*q.v.*). Pop. (1960) 82.845. It has grown rapidly in the postwar period; for comparative population figures see table in OHIO: *Population.* Although primarily a residential community. Parma also has a large manufacture of automobile and truck components. several tool and die plants and numerous retail establishments.

Originally named Greenbriar, Parma received township status in 1826. Its early residents of New England stock. as well as later immigrants, were content to remain a predominantly agricultural community until 1912. when a small section seceded to form Parma Heights In 1924 the remainder of the township incorporated as the village of Parma The village electorate defeated a proposal of annexation to Cleveland in 1931, choosing instead to become a city on Jan. 1, 1932. (W. G. K.)

PARMENIDES, of Elea (Velia) in Italy, Greek philosopher, whose application of logical analysis to metaphysical problems was a profoundly original contribution to philosophy. is said by Diogenes Laertius to have been "in his prime" between 504 and 500 B.C. and would thus seem to have been born c. 539. Plato indeed (*Parmenides,* 127 B) makes Socrates hear Parmenides when the latter was about 65 years of age, in which case he cannot have been born before 519; but in the absence of further evidence this may be regarded as one of Plato's anachronisms. At all events Parmenides was a contemporary of Heraclitus. Parmenides attached himself for a time to the aristocratic brotherhood which Pythagoras established at Croton; and this is in keeping with the mystical tone of his writing. The theological speculations of Xenophanes. who described God as one and unchanging, may well have suggested Parmenides' doctrine about reality in general.

The Poem.—Parmenides embodied his tenets in a short poem called Nature, of which about 160 lines have been preserved in the writings of Sextus Empiricus. Simplicius and others. It is traditionally divided into three parts—the "Proem," "Truth" (the way of truth) and "Opinion" (the way of belief).

The "Proem."—In the "Proem" the poet describes his journey from darkness to light. Borne in a chariot, attended by the daughters of the sun, he reaches a temple sacred to an unnamed goddess (variously identified by the commentators with Nature, Wisdom, or Themis) by whom the rest of the poem is spoken. He must learn all things, she tells him, both truth, which is certain, and human opinions; for, though in human opinions there can be no "true faith," they must be studied for what they are worth.

"Truth."—There are three ways of research. and three ways only. Of these. one asserts "*It* is not, and there must be not-being." This is utterly forbidden: what is not cannot even be thought of. A second way to that of mortals without wisdom, who say of what is that "it is and is not," "is the same and not the same." In contrast to them the way of truth starts from the proposition "*It* is, and not-being is impossible."

What is is uncreated, for it cannot be derived either from being or from not-being; it is imperishable, for it cannot pass into not-being; it is whole, indivisible, continuous (for nothing exists to break its continuity), homogeneous and unchangeable (for nothing else can exist or come into existence; it is perfect, for there is nothing which it can want; it never was, nor will be, but only is; it is evenly extended in every direction and therefore a sphere, exactly balanced; it is identical with the thought that recognizes it—thought means thinking "It is," and there is nothing apart from what is.

As then what is is one, invariable and immutable, all plurality, variety and mutation belong to what is not. Whence it follows that all things which men suppose to be real, generation and destruction, being and not-being, change of place, alteration of quality are no more than empty words.

"Opinion."—It remains in "Opinion" to describe the plurality of things, not as they are, for they are not; but as they appear. In the phenomenal world there are, it has been thought (and Parmenides accepts the theory, which appears to be of Pythagorean origin), two primary elements—namely, fire, which is gentle, thin, homogeneous, and night, which is dark, thick, heavy. These elements are separate or different from each other, but self-identical and on an equal footing; all things are composed of them. The foundation for a cosmology thus being laid in dualism, the poem describes the generation of "earth and sun, and moon and air that is common to all, and the milky way, and farthest Olympus, and the glowing stars"; but the scanty fragments which have survived only show that Parmenides regarded the universe as a series of concentric bands composed of the two primary elements and of mixtures of them, the whole system being directed by an unnamed goddess established at its centre. Next came a theory of animal development, followed by a psychology, according to which like is known by like. For thought is identical (?) with the constitution of the elements (not "limbs") in a man's body; and if Parmenides is referring here to sensation, whose objects were mere appearances, knowledge of the one reality was probably identical with a plenum of light (fr. 16). "Thus according to opinion," Parmenides concludes, "were the things of our world generated, and are now, and shall hereafter grow and come to an end."

The Meaning **of** the Poem.—The understanding of the whole poem is beset with difficulties. The most important points are: (1) the meaning of the *It* is of the way of truth; (2) the meaning of the identity between thought and its object; and (3) the relation of opinion to truth.

1. The Ionian philosophers who preceded Parmenides had put the question "What is nature, or reality?" in physical terms. They had looked for some single stuff, such as water or air or something indeterminate, which underlay the plurality and change that we observe. This was what really is, rather than comes to be as a mere process. Parmenides answered the same question by considering, as a matter of purely abstract analysis, what it is for anything to "be." He therefore unfolds a chain of implications involved in the assertion "It is." The subject of the proposition is primarily impersonal (as in "It is freezing"), but it mill also be reality itself or "being", just as "reality" means for us ambiguously both "what it is to be real" and "that which is real." The implications appear in the form of properties which must be possessed by reality in the concrete. The method depends on treating anything besides "being" as not "being" and therefore sheer nothing. Thus reality is "complete," for there is nothing else which it could be; and, because complete, it is "unchanging," for change implies coming to possess a property which it does not yet have.

2. By stressing the abstract or logical nature of the method,

it is possible to reach the identity of thought and reality. Logical "being" is that which is found in thought, or (as the copula) in judgments; and this is the only universal kind of being, hence what really is. But while the translation of the relevant passages is doubtful, they all appear to be associated with the denial of not-being. So it may be that Parmenides means only that thought of reality cannot be anything over and above reality: "thinking" means "thought is" or "there is a thought." The psychology of "Opinion" would be an attempt to explain this. Simply to say that Parmenides is a mystic and a kind of pantheist, who believes that nature is conscious, is not to the point. For his position has to be a deduction from the way of truth.

3. The cosmology is said to be deceptive and concerned only with appearances, but at the same time to be "unsurpassable by mortal judgment." Its dogmatic tone makes it quite improbable that Parmenides meant it ironically or was describing a system which was not his own. It is not truth, because it concedes two realities. All qualities are somehow aspects of these: for instance, heat, life and knowledge are fire or light; cold, death and ignorance are night or darkness. But where it differs from Ionian physics is in substituting mixture of the elements for transmutation. For neither element can ever *not* be what it is. So much is conceded to the way of truth. How unity and reality can ever give rise to appearance and plurality is a problem which Parmenides does not finally answer.

Influence. — His departure from the method of the Ionian physical philosophers made Parmenides the father of metaphysics. Before there was a technical name for metaphysics, Aristotle spoke of "the science of truth as it was introduced by the school of Anaxagoras and Parmenides" (Protrepticus, no. jb in R. R. Walzer's ed. of the Fragments). But just because the new analysis of "reality" was so abstract, it could be used by widely differing thinkers. It suggested the properties of the atom to Leucippus and to Democritus. In his *Parmenides* and in his *Sophist* Plato developed it dialectically so as to account for the formal characteristics of his own "Ideas." The denial of "not-being" was used by the sophists to deny the logical possibility both of contradiction and of falsehood (since this is "saying the thing that is not"). The denial of motion led to Zeno's paradoxes and to the theoretical problem of the continuum. (See also ELEATIC SCHOOL.)

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PARMENIO (c. 400–330 B.C.), Macedonian general in the service of Philip II and Alexander the Great. During the reign of Philip Parmenio obtained a great victory over the Illyrians (356); he was one of the Macedonian delegates appointed to conclude peace with Athens (346), and was sent with an army to uphold Macedonian influence in Euboea (342). In 336 he was sent with Amyntas and Attalus to make preparations for the reduction of Asia. Before he left he declared for Alexander in the confusion that followed Philip's murder. In 335 Alexander recalled him, and Parmenio was his second-in-command throughout the conquest of Persia, commanding the left wing at Granicus, Issus and Gaugamela, at which last he was outmaneuvered by Mazaeus, his formation was cut in half and he had to send to Alexander for help. When Alexander went on to Drangiana he left Parmenio behind to guard his communications in Media; on the campaign Philotas, Parmenio's son, was charged with conspiracy, tried by the army and put to death. Whatever Parmenio's loyalty, and there is some evidence that his reputation was falling with Alexander, it was impossible to leave him in charge of Alexander's communications after that. Alexander decided that his death was preferable to the risk of his defection, and sent orders, swiftly enough to outrun the news, for Parmenio to be killed (330).

PARMIGIANINO (PARMIGIANO; GIROLAMO FRANCESCO MARIA MAZZOLA or MAZZUOLI) (1503–1540), Italian painter, who mas one of the first artists to react against Renaissance classicism, was born in Parma on Jan. 11, 1503. He was brought up by his two uncles who made him learn to draw "under the instruction of excellent masters" (G. Vasari). He was probably never a pupil of Correggio, but there is no doubt that Correggio's was the strongest single influence on his early development. This is apparent, for example, in his first important work, the "Mystic Marriage of St. Catherine" (c. 1521, Canonica di Bardi, near Parma), though that work already contains an element of asymmetry in its composition which foreshadows the later development of his personal style. About 1522–23 he executed two series of frescoes: one in the first two side chapels on the left in S. Giovanni Evangelista, Parma, contemporaneously with Correggio's great work on the dome and pendentives of that church; and the other, representing the "Legend of Diana and Actaeon," on the ceiling of a room in the castle of Fontanellato just outside the city. The scheme of the latter decoration, with its children playing among an imitation pergola which is open to the sky and which forms lunettes below, recalls Correggio's work in the Camera di San Paolo in Parma itself.

In 1524 Parmigianino moved to Rome, taking with him three specimens of his work to impress the pope, including the famous portrait which he had painted of himself reflected in a convex mirror on a convex panel (Kunsthistorisches museum, Vienna). His chief painting done in Rome, the large "Vision of St. Jerome" (National gallery, London), shows the influence of Michelangelo, but it was rather, in Vasari's words, "the spirit of Raphael which passed into the body of Francesco" and which remained with him all his life; it was Raphael's ideal beauty of form and feature, rather than Raphaelesque motives or compositions, which he found sympathetic. While at work on the "Vision of St. Jerome" in 1527, he was interrupted by soldiers of the imperial army taking part in the sack of Rome, and he left for Bologna. There he painted one of his masterpieces, the "Madonna With St. Margaret and Other Saints" (Bologna gallery), which shows a new fluency of linear rhythm and a new technical virtuosity of handling. In 1531 he returned to Parma, where he remained for the rest of his life, the principal works of this last period being the "Madonna dal Collo Lungo" (Uffizi gallery, Florence) and the frescoes on the vault preceding the apse of Sta. Maria della Steccata, Parma. The latter were to have been only part of a much larger scheme of decoration in the church, but Parmigianino was extremely dilatory over their execution and he was eventually imprisoned for breaking his contract. He died on Aug. 24, 1540, at Casal Maggiore, Cremona.

The style which he developed was the first and perhaps the most brilliant exposition of one of the two major aspects within the style known as mannerism, that which might loosely be called its "decorative" aspect (the other, the "expressionist," having been developed in Florence chiefly by Jacopo da Pontormo). This involved a reaction against many of the principles of High Renaissance art, especially its dependence on nature and its basis in stability and clarity of design.

Parmigianino's works are distinguished by ambiguity of space composition, by distortion and elongation of the human figure and by the pursuit above all of what Vasari called "grace," that is to say, a rhythmical, sensuous beauty beyond the beauty of nature. This last quality is evident not only in Parmigianino's paintings, but also in his numerous and marvelously sensitive drawings, which range from elaborate studies for compositions to slight sketches of genre subjects.

He was perhaps the first Italian artist to practise etching (*q.v.*), and he was one of the most remarkable portrait painters of the century outside Venice. Some of his best portraits are in the Naples gallery, including the "Gian Galeazzo Sanvitale" (1524) and the so-called "Portrait of the Courtesan, Antea" (c. 1535–37).

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PARMOOR, CHARLES ALFRED CRIPPS, 1ST BARON (1852–1941), English lawyer and statesman, was born on Oct. 3, 1852, and educated at Winchester and New college, Oxford. He was called to the bar in 1877, in 1890 became a Q.C. and in 1893 a bencher. He made his reputation as a great ecclesiastical lawyer. In 1895 he was appointed attorney general to the prince of Wales, being reappointed in 1901 and 1912. He sat in the house of commons as Conservative M.P. for various divisions between 1895 and 1914 He was a strong High-churchman, and was appointed chancellor and vicar general to the province of York in 1900; he was vicar general to the province of Canterbury (1902–24). In 1914 he was specially appointed a judicial member of the privy council and raised to the peerage, and in 1917 he became treasurer of the Middle Temple. Lord Parmoor was a strenuous worker for peace. In the Labour governments of 1924 and 1929 he was lord president of the council, and in 1924 represented Great Britain at the Assembly of the League of Nations. Lord Parmoor died June 30, 1941.

He wrote *Law of Compensation* (1881, 5th ed. 1905); *Law Relating to the Church,* (6th ed. 1886); also *A Retrospect* (1936).

PARNAIBA, a port of the state of Piauí, Brazil, on the tight bank of the Parnaiba river, 250 mi. below Teresina. Pop. (1950) 30,174. It is the commercial entrepôt of the state, and exports cattle. hides, cotton and tobacco, chiefly through the small port of Luis Correia, on the coast 11 mi. to the east.

PARNASSIANS, a name given to a group of French poets writing between 1866 and 1876 led by two poets in their early twenties, Catulle Mendès and Xavier de Ricart, who with the help of the young publisher, Lemerre, launched the *Parnasse Contemporain* on March 2, 1866. The title was a challenge to the old romantics of the generation of Hugo and Lamartine, and an appeal to the Latin and Hellenic tradition represented by J. du Bellay, André Chénier and the living *tétrarchat,* Leconte de Lisle, Banville, Gautier and Baudelaire, whom the young men took as their patrons. The first series ran to 18 weekly numbers and included poems by 37 writers, the majority unknown or little known to the public. Among them were poets so diverse in temperament as Coppée, Sully Prudhomme, Mallarmé and Verlaine. A second series, projected in 1869 but interrupted by the war, appeared in 1871; the third and last in 1876. Impassibility was the movement's catch-word; its object was in general the plastic presentation of themes admitting romantic freedom and colour but excluding romantic sensibility and Byronic egoism; its method, a refined choice and manipulation of phrase, rhythm and stanza.

The spirit of Parnassianism, or the formula "Art for art's sake" and the *mot juste,* had its vogue outside France in the later years of the 19th century, notably in Spain where it found a fine poet in Rubén Dario, and in England where it fitted into the reaction against the ethical preoccupations of the Victorian classics, and produced in J. E. Flecker a belated but highly gifted representative of its central intention, the cultivation of a style at once clear-cut and suggestive. In France the classicizing impulse survived the departure of the symbolists and decadents and is a controlling force in poetry still.

PARNASSUS (mod. LIÁKOURA or LIKERI), a mountain of Greece, 8,059 ft., in the south of Phocis, rising N. of Delphi. Parnassus was one of the most holy mountains in classical Greece, hallowed by the worship of Apollo, of the Muses, and of the Corycian nymphs. Its chief peaks are Tithorea and Lycoreia. Tno projecting cliffs, named the Phaedriadae, frame the gorge in nhich the Castalian spring flows out, and to the W. of this, on a shelf above the ravine of the Pleistus, is the site of the Pythian shrine of Apollo and the Delphic oracle. The Corycian cave is on the plateau between Delphi (*q.v.*) and the summit.

PARNASSUS PLAYS, a series of three scholastic entertainments performed at St John's college, Cambridge, between 1597 and 1603 They are satirical in character and aim at setting forth the wretched state of scholars and the small respect paid to learning by the norld at large, as exemplified in the adventures of two university men, Philomusus and Studioso. The first part, *The Pilgrimage to Parnassus,* describes allegorically their four years' journey to Parnassus; *i.e.,* their progress through the university course. The sequel *The Returne From Parnassus,* which deals with the adventures of the two students after the completion of their studies at the university, shows them discovering by bitter experience of how little pecuniary value their learning is.

A further sequel, *The Second Part of the Returne From Parnassus, or the Scourge of Simony,* is a more ambitious, and from every point of view more interesting, production than the two earlier pieces. In it on pretense of discussing a recently published collection of extracts from contemporary poetry, John Bodenham's *Bel-vedere* (1600), one of the characters sums up a number of writers of the day, among them being Spenser, Henry Constable, Michael Drayton, John Davies, Marlowe, Jonson, Shakespeare and Thomas Nashe.

Their author is unknown, but the plays have generally been regarded as the work of a single writer — possibly John Day or one William Dodd (for a full discussion *see* A. W. Ward, *A History of English Dramatic Literature to the Death of Queen Anne,* ii, p. 640. note 2 [1875]). The three pieces were evidently performed at Christmas of different years, and allusions to contemporary affairs show that the first cannot have been earlier than 1598 nor the last later than 1602.

BIBLIOGRAPHY.—The only part of the trilogy which was in print at an early date was 2 *Return,* called simply *The Returne* From *Parnassus: Or The Scourge of Simony* (1606), two editions bearing the same date. This has been reprinted several times, the best separate edition being that of E. Arber (1880). Manuscript copies of all three plays were found among T. Hearne's papers in the Bodleian library, Oxford, by W D Macray and were printed by him in 1886 (the last from one of the editions of 1606, collated with the manuscript). G. C. Moore Smith, "The Parnassus Plays," *Modern Language Review,* x (1915) gives a number of corrections of Macray's text *See* also *The Three Parnassus Plays, 1598–1601,* ed. by J. B Leishman (1949), and W. Luhr, *Die drei Cambridger Spiele vom Parnass* (1900). (R. B. McK.)

PARNELL, CHARLES STEWART (1846–1891), Irish Nationalist leader, was born at Avondale, Co. Wicklow, on June 27, 1846, the son of John Henry Parnell and Delia Tudor, daughter of Commodore Charles Stewart of the U.S. navy. The Parnell family came from Congleton, Cheshire, and counted various distinguished persons among its members. Thomas Parnell, who migrated to Ireland after the Restoration, had two sons, Thomas Parnell the poet and John Parnell, an Irish judge. From the latter Charles Stewart Parnell was descended. Sir John Parnell, chancellor of the exchequer in Grattan's parliament, and one of O'Connell's lieutenants in the parliament of the United Kingdom, was the grandson of Parnell the judge. The estate of Avondale was bequeathed by him to his youngest son, William, grandfather of Charles Stewart Parnell. His second son was Sir Henry Parnell (Baron Congleton), who held office under Grey and Melbourne, and died by his own hand in 1842. Charles Stewart Parnell was much influenced by his mother, who inherited a hatred of England from her father. He was, however, of English extraction, a landowner and a Protestant. Educated at private schools in England and at Magdalene College, Cambridge, his temperament and demeanour were singularly un-Irish on the surface — reserved, cold, repellent and unemotional. As a schoolboy he was fond of cricket and devoted to mathematics, but had little taste for other studies or other games. He was subject to somnambulism, liable to severe fits of depression, and invincibly superstitious. He was as little at home in an English school or an English university as he was afterwards in the House of Commons. "These English," he said to his brother at school, "despise us because we are Irish, but we must stand up to them. That's the way to treat an Englishman — stand up to him."

Parnell took no interest in politics in his early years, but he was deeply moved by stories related to him by servants and peasants of certain revolting cruelties perpetrated by English landlords in the not distant past. He was passionately stirred by the execution of the "Manchester Martyrs" in 1867, but did not yet think seriously of politics, though his sister Fanny was already writing patriotic verse. In the meanwhile he paid a lengthened visit to the United States. At the general election of 1874 he

desired to stand for the county of Wicklow, of which he was high sheriff at the time. The lord-lieutenant declined to relieve him of his disqualifying office, and his brother John stood in his place, but was unsuccessful at the poll. Shortly afterwards a by-election occurred in Dublin, and Parnell stood as a supporter of Isaac Butt, but was beaten. He was elected for Meath in 1875.

Butt had scrupulously respected the traditions and courtesy of debate, and disapproved of the obstructive tactics invented by certain members of the Conservative party in opposition to the first Gladstone Administration. Parnell entered parliament as a virtual rebel who knew that physical force was of no avail, but believed that political exasperation might attain the desired results. He resolved to make obstruction in parliament do the work of outrage (he hated outrage and cruelty) in the country, to set the church-bell ringing — to borrow Mr. Gladstone's metaphor — and to keep it ringing in season and out of season in the ears of the House of Commons. He would not condemn outrages to gratify English members of parliament. He accepted the alliance of the physical force party. He invented and encouraged "boycotting" as a substitute for outrage. In the course of the negotiations in 1882, which resulted in what was known as the Kilmainham Treaty, he wrote to Captain O'Shea: "If the arrears question be settled upon the lines indicated by us, I have every confidence that the exertions we should be able to make strenuously and unremittingly would be effective in stopping outrages and intimidation of all kinds."

In 1877 Parnell entered on an organized course of obstruction. He and Joseph Biggar were gradually joined by a small band of the more advanced Home Rulers, and occasionally assisted up to a certain point by one or two English members. Butt was deposed. William Shaw, a "transient and embarrassed phantom," was elected in his place, but Parnell became the real leader of a Nationalist party. After the general election of 1880 the more moderate section of the Nationalist party ceased to exist. Obstruction in Parnell's hands was a calculated policy, the initial stage of a campaign designed to show the malcontents in Ireland and the Fenian Brotherhood in America that strictly correct parliamentary methods were useless, but that the parliamentary machine could be so handled as to secure Irish legislative independence. The Fenians were hard to convince, but in the autumn of 1877 Parnell persuaded the Home Rule Confederation of Great Britain to depose Butt from its presidency and to elect himself in his place. Parnell's opportunity came with the general election of 1880, which displaced the Conservative government of Lord Beaconsfield and restored Mr. Gladstone to power. Parnell would have no alliance with either English party. He would support each in turn with a sole regard to the balance of political power in parliament and a fixed determination to hold it in his own hands if he could. From the time that he became its leader the Home Rule party sat together in the House of Commons and always on the Opposition side. From the first Parnell imposed on the parliamentary party an iron discipline. It was there to obey orders and to vote straight. Members, if required, were to speak at indefinite length, to carry out feats of endurance at all-night sittings; to paralyse parliament under the directions of Parnell, who had the eye of genius for the proper action in any emergency.

In the autumn of 1879 Parnell, after some hesitation, had given his sanction to the Land League founded by Michael Davitt. He then crossed to the United States. There the "new departure" —the alliance of the open and the secret organizations—was confirmed and consolidated. Parnell obtained the countenance and support of the Clan-na-Gael, a revolutionary organization of the American-Irish, and the Land League began to absorb all the more violent spirits in Ireland, though the Fenian Brotherhood still held officially aloof from it. As soon as the general election of 1880 was announced Parnell returned to Ireland in order to direct the campaign in person. Though he had supported the Liberals at the election, he soon found himself in conflict with the Gladstone government, represented in Ireland by Earl Cowper and W. E. Forster. Parliament was summoned at an early date, and a Coercion Bill for one year, practically suspending the Habeas Corpus Act and allowing the arrest of suspects at the discretion of the government, was introduced, to be followed shortly by Harcourt's Arms Bill. Parnell regarded the measure as a declaration of war. It was doggedly obstructed at every stage, and on one occasion the debate was only brought to a close, after lasting for forty-one hours, by the Speaker's claiming to interpret the general sense of the house and resolving to put the question without further discussion. The rules of procedure were then drastically amended, and as soon as the bill was passed Mr. Gladstone introduced a new Land Bill, which occupied the greater part of the session. Parnell accepted it with many reserves. The Land League at his instigation determined to "test" the act by advising tenants in general to refrain from taking their cases into court until certain cases selected by the Land League had been decided. The government treated this policy as a deliberate attempt to wreck the working of the act. On this and other grounds — notably the attitude of the League and its leaders towards crime and outrage — Parnell was arrested under the Coercion Act and lodged in Kilmainham gaol (Oct. 17, 1881).

Parnell in prison at once became more powerful than he had ever been outside. Moreover imprisonment gave him rest which his nervous temperament badly needed. Several of his leading colleagues followed him into Kilmainham, and the Land League was dissolved, its treasurer, Patrick Egan, escaping to Paris and carrying with him its books and accounts. Before it was formally suppressed the League had issued a manifesto, signed by Parnell and several of his fellow-prisoners, calling upon the tenants to pay no rents until the government had restored the constitutional rights of the people. Discouraged by the priests, the No-Rent manifesto had little effect, but it embittered the struggle and exasperated temper on both sides of the Irish Channel.

A *modus vivendi* was desired on both sides. Negotiations set on foot through the agency of Captain O'Shea—at that time and afterwards a close agent of Parnell — resulted in what was known as the Kilmainham Treaty. Parnell and two of his friends were to be released at once, the understanding being, as Gladstone stated in a letter to Cowper, "that Parnell and his friends are ready to abandon 'No Rent' formally, and to declare against outrage energetically, intimidation included, if and when the government announce a satisfactory plan for dealing with arrears." Parnell and his friends were released, and Cowper and Forster resigned.

The Phoenix Park murders (May 6, 1882) followed. Parnell was prostrated by this catastrophe. In a public manifesto to the Irish people he declared that "no act has ever been perpetrated in our country, during the exciting struggle for social and political rights of the past fifty years, that has so stained the name of hospitable Ireland as this cowardly and unprovoked assassination of a friendly stranger." Privately to his own friends and to Mr. Gladstone he expressed his desire to withdraw from public life. A new Crimes Bill was introduced and made operative for a period of three years, and England was exasperated by a succession of dynamite outrages organized chiefly in America. which Parnell was powerless to prevent. The Phoenix Park murders did more than any other incident of his time and career to frustrate Parnell's policy.

For more than two years after the Phoenix Park murders Parnell's influence in parliament, and even in Ireland, was only intermittently and not very energetically exerted. His health was bad, his absences from the House of Commons were frequent and mysterious, and he had already formed those relations with Mrs. O'Shea which were ultimately to bring him to the divorce court. His nervous and passionate temperament found relaxation in the society of Mrs. O'Shea and in his laboratory where he carried out intricate experiments in assaying. He became a figure more remote and mysterious than ever. The Phoenix Park murderers were arrested and brought to justice early in 1883. Forster seized the opportunity to deliver a scathing indictment of Parnell in the House of Commons. In an almost contemptuous reply Parnell repudiated the charges in general terms, disavowed all sympathy with dynamite outrages, their authors and abettors, declined to plead in detail before an English tribunal, and declared that he sought only the approbation of the Irish people. The Irish people responded by a subscription known as the "Parnell Tribute,"

amounting to £37,000, presented to Parnell, partly for the liquidation of debts he was known to have contracted, but mainly in recognition of his public services. The Irish National League, a successor to the suppressed Land League, was founded in the autumn of 1882 at a meeting over which Parnell presided, but he looked on it at first with little favour.

The Crimes Act, passed in 1882, was to expire in 1885; in May notice was given for its partial renewal and the second reading was fixed for June 10. On June 8 Parnell, with thirty-nine of his followers, voted with the Opposition against the budget, and the government was defeated by 264 votes to 252. Gladstone resigned. Salisbury undertook to form a government, and Carnarvon became viceroy. Carnarvon sought an interview with Parnell, explicitly declared that he was speaking for himself alone, heard Parnell's views, expounded his own, and forthwith reported what had taken place to the prime minister. In the result the new cabinet refused to move in the direction apparently desired by Lord Carnarvon.

Parnell opened the electoral campaign with a speech in Dublin, in which he expressed the hope that "it may be possible for us to have a programme and a platform with only one plank, and that one plank National Independence." Parnell invited Gladstone in a public speech to declare his policy and to sketch the constitution he would give to Ireland subject to the limitations he had insisted on. To this Gladstone replied, "through the same confidential channel," that he could not consider the Irish demand before it had been constitutionally formulated, and that, not being in an official position, he could not usurp the functions of a government. Thereupon Parnell instructed Irish Nationalists in Great Britain to give their votes to the Tories. In these circumstances the general election was fought, and resulted in the return of 335 Liberals, four of whom were classed as "independent," 249 Conservatives and 86 followers of Parnell.

Mr. Gladstone's return to power at the head of an administration conditionally committed to Home Rule marks the culminating point of Parnell's influence on English politics and English parties. And after the defeat of the Home Rule ministry in 1886, Parnell more than once found measures, which had been contemptuously rejected when he had proposed them, ultimately adopted by the government; and the comparative tranquillity which Ireland enjoyed at the close of the 19th century may be ascribed partly to legislation inspired and recommended by himself. In 1886 Parnell introduced a comprehensive Tenants' Relief Bill. The Salisbury government would have none of it, though in the following session they adopted and carried many of its leading provisions. Its rejection was followed by renewed agitation in Ireland, in which Parnell took no part. He was ill—"dangerously ill," he said himself at the time—and some of his more hot-headed followers devised the famous "Plan of Campaign," on which he was never consulted and which never had his approval. Ireland was once more thrown into a turmoil of agitation, turbulence and crime. In the course of the spring of 1887 *The Times* had begun publishing a series of articles entitled "Parnellism and Crime," on lines following Mr. Forster's indictment of Parnell in 1883, though with much greater detail of circumstance and accusation. On April 18 appeared an article accompanied by the facsimile of a letter purporting to be signed but not written by Parnell, in which he apologized for his attitude on the Phoenix Park murders, and specially excused the murder of Mr. Burke. On the same evening, in the House of Commons, Parnell declared the letter to be a forgery. He was not believed, and the second reading of the Crimes Act followed. Later in the session Sir Charles Lewis, an Ulster member and a bitter antagonist of the Nationalists, moved that the charges made by *The Times* constituted a breach of privilege. The government met this proposal by an offer to pay the expenses of a libel action against *The Times* on behalf of the Irish members incriminated. This was refused. Gladstone proposed a select committee of inquiry into the charges, including the letter attributed to Parnell, and to this Parnell assented. But the government rejected the proposal. For the rest, Parnell maintained almost superhuman reticence.

The Parnell Commission.—F. H. O'Donnell, an ex-M.P. and former member of the Irish party, now brought an action against *The Times* for libel. His case was a weak one, and a verdict was obtained by the defendants. But in the course of the proceedings the attorney-general, counsel for *The Times*, affirmed the readiness of his clients to establish all the charges advanced, including the genuineness of the letter which Parnell had declared to be a forgery. Parnell once more invited the House of Commons to refer this particular issue—that of the letter—to a select committee. This was again refused; but after some hesitation the government resolved to appoint by act of parliament a special commission, composed of three judges of the High Court, to inquire into all the charges advanced by *The Times*. This led to what was in substance, though not perhaps in judicial form, the most remarkable state trial of the 19th century. The commission began to sit in September 1888, and issued its report in February 1890. The report of the commission was a voluminous document reporting on the whole of the questions arising out of the relation between parliamentary action and outrage; it was variously interpreted by different parties to the controversy.

The specific charges brought against Parnell personally were thus dealt with by the commissioners:—

(a) That at the time of the Kilmainham negotiations Mr. Parnell knew that Sheridan and Boyton had been organizing outrage, and therefore wished to use them to put down outrage.
We find that this charge has not been proved.

(b) That Mr. Parnell was intimate with the leading Invincibles; that he probably learned from them what they were about when he was released on parole in April 1882; and that he recognized the Phoenix Park murders as their handiwork.
We find that there is no foundation for this charge. We have already stated that the Invincibles were not a branch of the Land League.

(*c*) That Mr. Parnell on 23rd January 1883, by an opportune remittance, enabled F. Byrne to escape from justice to France.
We find that Mr. Parnell did not make any remittance to enable F. Byrne to escape from justice.

Pigott's Forgery.—The argument of Parnell's insincerity based on the facsimile letter alleged to have been written by Parnell condoning the Phoenix Park murders broke down altogether. It had been purchased with other documents from one Richard Pigott, who afterwards tried to blackmail Archbishop Walsh by offering, in a letter which was produced in court, to confess its forgery. Cross-examined by Charles Russell on this letter to the archbishop, Pigott broke down utterly. Before the commission sat again he fled to Madrid, and there blew his brains out. He had confessed the forgery to Labouchere in the presence of G. A. Sala, but did not stay to be cross-examined on his confession. The attorney-general withdrew the letter on behalf of *The Times*, and the commission pronounced it to be a forgery. Shortly after the letter had been withdrawn, Parnell filed an action against *The Times* for libel, claiming damages to the amount of £100,000. The action was compromised out of court by a payment of £5,000.

Practically, the damaging effect of some of the findings of the commission was neutralized by Parnell's triumphant vindication in the matter of the facsimile letter and of the darker charges levelled at him. Towards the close of 1889, before the commission had reported, but some months after the forged letter had been withdrawn, Parnell visited Hawarden to confer with Mr. Gladstone on the measure of Home Rule to be introduced by the latter should he again be restored to power. What occurred at this conference was afterwards disclosed by Parnell, but Mr. Gladstone vehemently denied the accuracy of his statements on the subject.

Divorce Case.—But Parnell's fall was at hand. In December 1889 O'Shea filed a petition for divorce on the ground of his wife's adultery with Parnell. Parnell's intimacy with Mrs. O'Shea had begun in 1881, though at what date it became a guilty one is not in evidence. O'Shea had in that year challenged him to a duel, but was pacified by the explanations of Mrs. O'Shea. It is known that O'Shea had been Parnell's confidential agent in the negotiation of the Kilmainham Treaty, and in 1885 Parnell had strained his personal authority to the utmost to secure O'Shea's return for Galway. It is not known why O'Shea suddenly took action in 1889. No defence being offered, a decree of divorce was pronounced, and in June 1891 Parnell and Mrs. O'Shea were married.

At first the Irish party determined to stand by Parnell. The decree was pronounced on Nov. 17, 1890. On the 20th a great meeting of his political friends and supporters was held in Dublin, and a resolution that in all political matters Parnell possessed the confidence of the Irish nation was carried by acclamation. But the Irish party reckoned without its English allies. At a meeting of the National Liberal Federation held at Sheffield on Nov. 21, John Morley was privately told that the Nonconformists would insist on Parnell's resignation. Parliament was to meet on the 25th. Mr. Gladstone tried to convey to Parnell privately his conviction that unless Parnell retired the cause of Home Rule was lost. But the message never reached Parnell. Gladstone then requested John Morley to see Parnell; but he could not be found. Finally, on the 24th, Gladstone wrote to Morley the famous and fatal letter, in which he declared his conviction "that, notwithstanding the splendid services rendered by Mr. Parnell to his country, his continuance at the present moment in the leadership would be disastrous in the highest degree to the cause of Ireland," and that "the continuance I speak of would not only place many hearty and effective friends of the Irish cause in a position of great embarrassment, but would render my retention of the leadership of the Liberal party, based as it has been mainly upon the prosecution of the Irish cause. almost a nullity." This letter was not published until after the Irish parliamentary party had met in the House of Commons and re-elected Parnell as its chairman without a dissentient voice. A few days later Parnell was requested by a majority of the party to convene a fresh meeting. It took place in Committee Room No. 15, and after several days of angry recrimination and passionate discussion, during which Parnell, who occupied the chair, scornfully refused to put to the vote a resolution for his own deposition, 45 members retired to another room and there declared his leadership at an end. The remainder, 26 in number, stood by him. The party was thus divided into Parnellites and anti-Parnellites, and the schism was not healed until several years after Parnell's death.

This was practically the end of Parnell's political career in England. The scene of operations was transferred to Ireland, and there Parnell fought incessantly a bitter and a losing fight, embittered by the hostility of the Church, which had never approved of a Protestant leader. The campaign ended only with his death. An attempt at reconciliation in the party was made in the spring, at what was known as "the Boulogne negotiations," where William O'Brien endeavoured to arrange an understanding; but it came to nothing. Probably Parnell was never very anxious for its success. The life he led, the agonies he endured, the labours he undertook from the beginning of 1891, travelling weekly to Ireland and intoxicating himself with the atmosphere of passionate nationalism in which he moved, would have broken down a much stronger man. He who had been outwardly the most impassive of men became restless, nervous, almost distracted at times. He visited Ireland for the last time in September, and the last public meeting he attended was on the 27th of that month. The next day he sent for his friend Dr. Kenny, who found him suffering from acute rheumatism and general debility. He left Ireland on the 30th, promising to return on the following Saturday week. He did return on that day, but it was in his coffin. He died at Brighton on Oct. 6. His remains were conveyed to Dublin, and on the following Sunday they were laid to rest in the presence of a vast assemblage of the Irish people in Glasnevin Cemetery, not far from the grave of O'Connell.

The principal materials for a biography of Parnell and the history of the Parnellite movement are to be found in *Hansard's Parliamentary Debates* (1875–91); in the *Annual Register* for the same period; in the *Report of the Special Commission* issued in 1890; in *The Life of Charles Stewart Parnell,* by *R.* Barry O'Brien; in *The Parnellite Movement,* by *T.* P. O'Connor, M.P.; and in a copious biography of Parnell contributed by an anonymous but well-informed writer to the *Dict. of Nat. Biog.,* vol. xliii. *See* also Mrs. C. S. Parnell, *Charles Stewart Parnell; his love story and political life* (2 vols., 1914); **J. H.** Parnell, *Charles Stewart Parnell* (1916); M. M. O'Hara, *Chief and Tribune; Parnell and Davitt* (1919); St. John G. Ervine, *Parnell* (1925, pop. ed. 1928); A. F. Robbins, *Parnell: the last five years* (1926).

(J. R. TH.; X.)

PARNELL, THOMAS (1679–1718), Anglo-Irish poet, born in Dublin, was educated at Trinity college. Dublin, and in 1700 took his M.A. degree, being ordained deacon in the same year. In 1704 he became minor canon of St. Patrick's cathedral and in 1706 archdeacon of Clogher. In 1713 he was one of the contributors to the *Poetical Miscellanies* edited for Tonson by Steele, and published his *Essay on the Different Styles of Poetry.* He was a member of the Scriblerus Club. and he wrote the "Essay on the Life and Writings and Learning of Homer" prefixed to Pope's translations. In 1716 Parnell was presented to the vicarage of Finglass. when he resigned his archdeaconry. In the same year he published *Homer's Battle of the Frogs and Mice. With the remarks of Zoilus. To which is prefixed, the Life of the said Zoilus.* Parnell died at Chester, where he was buried on the 24th of October, 1718. Parnell's best known poem is "The Hermit."

In 1770 *Poems on Several Occasions* was printed with a life of the author by Oliver Goldsmith His *Poetical Works* were printed in Anderson's and other collections of the *British Poets* See *The Poetical Works* (1894) ed by George A. Aitken for the *Aldine Edition of the British Poets.* His correspondence with Pope is published in Pope's *Works* (ed. Elwin and Courthorpe, vii. 451–467).

PARNU, second most important seaport of Estonia and summer resort in 58° 23′ N., 24° 30′ E., on the left bank of the Pärnu river, ½ mi. above its entrance into Pärnu bay, the northern arm of the Gulf of Riga. Est. pop. (1939) 21,500. An ice-breaker working from November to April keeps the harbour open for large ships. The imports are salt, herring, coal, manure and cork wood and the exports flax, timber and woodpulp.

Founded on the right side of the river in 1255 by one of the bishops of Saare Maa, Pärnu was in the 16th century occupied in succession by the Swedes, the Poles and the Teutonic Knights. After 1599 the Poles transferred the town to the left side of the river; and in 1642 the Swedes, who had been in possession since 1617, strengthened it with regular fortifications. In 1710 it was taken by the Russians, and in 1918 it was included in Estonia. The Russians occupied it in 1940 and the Germans in 1941.

PAROCHIAL SCHOOLS. In the United States a parochial school is a private elementary school maintained by a Roman Catholic parish. Elementary schools conducted by the Roman Catholic Church are generally known in the United States by this name to distinguish them from public schools supported by taxation.

Parochial schools in the United States date from the early 17th century, the first schools having been founded at that time in Florida and New Mexico. Prior to 1776, 70 Roman Catholic schools existed within the present confines of the United States. The increased immigration, especially from Germany and Ireland, and the consequent expansion of the church after 1840 were the principal factors making for the development of the Roman Catholic school system. The Third Plenary Council of Baltimore (1885) made it obligatory for every parish to maintain a school. From 1880 to 1920 the attendance at Roman Catholic schools increased from 405,234 to 1,795,673, the percentage of total increase for the 40 year period being 343·12%.

Parochial schools are supported financially by each parish, but form a diocesan system administered by a diocesan superintendent who is subject immediately to the bishop or to the diocesan board of education. Each school has a principal and a supervisor belonging, as a rule, to the religious community. The curriculum of the parish school has practically the same content as that of the public elementary school, to which is added religious education in its many phases. The number of hours and the length of the term are the same as in the public school. The text-books used are those ordered by law, or in use in the public school, or texts especially designed for Roman Catholic schools.

The majority of elementary school teachers in parish schools are men and women members of a religious community or order. These teachers are required to undergo a professional preparation, in the main the same as that required of public school teachers. In order to prepare these teachers, various Roman Catholic universities maintain departments of education. A great number of religious communities have established their own training schools. Teachers' institutes, summer courses and summer school work are offered to teachers in service. Wherever necessary, the teach-

ers obtain State certificates; in other cases they are certified by the Diocesan Board of Education. Over 75% of the teachers in parochial schools are above the age of 25.

The 1926 statistics for Roman Catholic parochial schools are as follows: schools, 7,439; teachers, 55,155 (religious, 50,931; lay, 4,224): attendance. 2,111,560.

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PARODY, in the strict meaning of the word, implies a comic imitation of a serious poem (παρωδία is "a song sung beside"). To ridicule the grandiose is a primary impulse, not confined to any one form of art, or indeed to art at all. It is of this stuff that satire is made; but poetic parody, partly through the accidents of history, has acquired a small literature of its own. The Greek epic, the Greek drama, amongst a people quick-witted and politically-minded, were especially liable to this kind of critical assault. Thus, though the true father of parody may well have been the neighbour of the first man who sang, Aristotle is able to attribute the origin of parody as a definite art to Hegemon of Thasos, whose imitation of *The Battle of the Giants* appears to have consoled the Athenians for the disasters of their expeditionary force in Sicily.

We have, however, other examples of early Greek parody. There is a fragment of several hundred lines still extant, by Matron, in which the dishes of an Athenian banquet are introduced in the epic style of Homer, and the *Batrachomyomachia,* or *Battle of the Frogs and Mice,* a travesty once ascribed to Homer himself, is certainly far older than Hegemon of Thasos, or Hipponax of Ephesus, another claimant to the title of first parodist. Hipponax, a man himself embittered by the rude caricatures of sculptors, wrote a parody of the *Iliad,* of which the four opening lines have been preserved by Athenaeus. But the Greek parodist *par excellence* is Aristophanes, who imitates Aeschylus and, with greater gusto, Euripides. His attack upon the latter poet in *The Acharnians* embraces all that is possible in the realm of parody, being a brilliant burlesque not only on mannerisms but on spirit and modes of thought. There is no exact parody so penetrating and acute, or rather, none that has been preserved, until we come down to comparatively modern times.

It should be remembered, however, that rigid forms of metre and an eagerly sophisticated period of letters are the forcing-ground for the parodist, while burlesque and satire flourish abundantly, especially in light drama, on every kind of soil. Roman literature produces the satires of Persius, which contain interludes of parody, some of which are supposed to have been modelled on the verses of Nero. Mediaeval romance is mocked in Cervantes' *Don Quixote,* but the verbal felicities here are plainly not so important as the great conception of the satire as a whole. Scarron's *Vergile Travesti,* written about the middle of the 17th century, was borrowed from the Italian Lalli's *Aeneid Travestita,* and part of it was translated into English by Charles Cotton. This poem is a coarse burlesque, and not in the true sense parody. In England Shakespeare mimicked Marlowe, and was himself parodied by Marston, who wrote a travesty of *Venus and Adonis.* John Philips, who composed *The Splendid Shilling,* a burlesque of *Paradise Lost,* is described on his monument in Westminster Abbey as a "second Milton." But the epithet, even if humorously intended, is flattering in the extreme.

The English Parodists.—The golden age of English parody may be said to begin with Isaac Hawkins Brown, who wrote very passable imitations of Pope, Thomson and Young. Thenceforward English parody flows in a direct stream, and the popularity of the exercise amongst scholars and wits in this country is in all probability due to the practice of setting compositions after the manner of classical poets as a task for pupils in public schools. It is an easy step from compulsory imitations of the Greek dramatists, of Virgil, Horace and Ovid, to critical Imitations of contemporary verse. The *Rejected Addresses* of Horace and James Smith, written as dedicatory odes on the occasion of the re-opening of Drury Lane theatre in 1812, are models of excellent parody, and are even said to have caused no annoyance to the poets on whose work they were based. This is a severe criterion. The authors of the *Bon Gaultier Ballads* created an imaginary contest for the poet laureateship, an office at that time rendered vacant by the death of Southey, and this fashion was followed with great skill by Sir Owen Seaman (during the interregnum between Lord Tennyson and Sir Alfred Austin), in *The Battle* of *the Bays.* C. S. Calverley and J. K. Stephen, the former aided not a little by the mediocre quality of the muses finding favour with mid-Victorian readers, wrote parodies which can scarcely be surpassed. Since the triumph of the novel as a form of literary self-expression there have been many amusing imitations of prose romance, notably by Bret Harte, Sir Max Beerbohm and Stephen Leacock, the American parodists, however, paying far more attention to matter than to form.

It should be noted that parody, if it is to be worth while, must be criticism. It is not by virtue of its self-imposed limitations absolved from the duty of showing some fair cause for ridicule. But the target aimed at by the parodist is not always the poet whose dress he wears. Satire of current manners, politics, or morals may be conveyed by using parody as a vehicle more powerful and more authoritative than the author's unassisted pen. In such cases of borrowed thunder the original author is obviously receiving the tribute of flattery either to his greatness, or to his popularity, or to both. Where, however, imitation involves also criticism of the model imitated, adoration is less easily combined with mirth, and there are those who find all parodies of well-loved poets painful to read, if not blasphemous.

As an example of parody pressed to its extreme limit as a direct form of literary criticism, the following lines may be quoted:—

Two voices are there: one is of the deep;
It learns the storm-cloud's thunderous melody,
Now roars, now murmurs with the changing sea,
Now bird-like pipes, now closes soft in sleep:
And one is of an old half-witted sheep
Which bleats articulate monotony,
And indicates that two and one are three,
That grass is green, lakes damp and mountains steep;
And, Wordsworth, both are thine: at certain times
Forth from the heart of thy melodious rhymes,
The form and pressure of high thoughts will burst:
At other times—Good Lord! I'd rather be
Quite unacquainted with the A B C
Than write such hopeless rubbish as thy worst.

This mock sonnet by J. K. Stephen will be seen to embody a very general, if rather too sweeping, estimate of the poetry of Wordsworth, whilst copying alike the nobler and the less exalted mannerisms of that poet, turn by turn; yet it preserves throughout these variations the authentic cadence of the sonnet form, serenely undisturbed.

Parody then, if well executed, has this merit, that it pours criticism swiftly into an unforgettable mould. But much that is written in the name of parody is either on the one hand clownish mimicry, or, on the other, of no more value than a school exercise neatly performed by an assiduous student. It may be added that several famous English poets have parodied their own poetry as a *tour de force.* But they have not done it well. (E. V. K.)

PAROS, a Greek island in the Aegean sea, one of the largest of the Cyclades, lying west of Naxos, from which it is separated by a channel about 6 mi. broad. Its greatest length from north-east to southwest is 13 mi., and its greatest breadth 10 mi. It is formed of a single mountain. Profitis Ilias (Mt. Elias or ancient Marpessa), 2,529 ft. high, sloping evenly down on all sides to a maritime plain, which is broadest on the northeast and southwest sides. The island is composed of marble, though gneiss and mica schist are to be found in a few places. The capital. Paros (Paroekia or Parikia. Italian, Parechia), on a bay on the northwest side of the island, occupies the site of the ancient capital.

By the sea is a medieval castle built almost entirely of ancient remains. Similar traces of antiquity are numerous in the town. and on a terrace to the south is a precinct of Asclepius. Outside the town is the church of Ekatontapyliani "Our Lady of the hundred gates," said to have been founded by the empress Helena;

one of the two adjoining churches is of very early form, and there is a baptistry with a cruciform font.

On the north side of the island is the bay of Naousa, a safe roomy harbour; in ancient times closed by a chain or boom. Another good harbour is that of Drios on the southeast. The three villages of Tragoulas, Marmara and Kepidi, in an open plain on the east, rich in remains of antiquity, probably occupy the site of an ancient town.

Parian marble, white and semitransparent, with coarse grain and beautiful texture: was the chief source of wealth to the island. The quarries lie on the northern side of Mt. Marpessa. The marble. exported from the 6th century B.C., and used by Praxiteles and other sculptors, came from subterranean quarries driven horizontally or descending into the rock. Several of these tunnels are still to be seen. At the entrance to one is a bas-relief dedicated to Pan and the Nymphs.

History.—In tradition Paros was colonized with Arcadians by Paros of Parrhasia. From Athens came Ionians later. Parian colonies were sent to Thasos and Parium on the Hellespont. In the former, founded in the 15th or 18th Olympiad, the poet Archilochus, native of Paros, is said to have taken part. As late as 385 B.C. the Parians, in conjunction with Dionysius of Syracuse, founded a colony on the Illyrian island of Pharos. In the 6th century Parians were invited by Miletus to reform its constitution. Shortly before the Persian War Paros seems to have been a dependency of Naxos. In the Persian War Paros joined the Persians and sent a trireme to Marathon. In retaliation, its city was besieged by an Athenian fleet under Miltiades, who demanded a fine of 100 talents. But the town offered a vigorous resistance, and the Athenians were obliged to withdraw. Paros also sided with Xerxes against Greece, but after the battle of Artemisium its contingent remained in Cythnos. For this unpatriotic conduct Themistocles exacted a heavy fine (Herod. viii. 112). In the Delian League Paros paid the highest tribute of all the islands—30 talents. Little is known of the constitution of Paros. In 410 B.C. the Athenian general Theramenes found an oligarchy at Paros and restored the democracy (Diod. Sic. xiii. 47). Paros joined the Athenian confederacy of 378 B.C., but withdrew about 357 B.C. along with Chios. Later, the island lost political importance, passing with other Cycladic islands to the Ptolemies of Egypt, and thence to Roman rule. When the Latins made themselves masters of Constantinople, Paros, like the rest, became subject to Venice. In 1537 it was conquered by the Turks, and after the war of Greek independence was annexed to Greece. In 1941 it was occupied by axis troops. Among the most interesting discoveries made in the island is the Parian Chronicle (*q.v.*).

PARR, CATHERINE: *see* CATHERINE (Catherine Parr).

PARR, THOMAS (*c.* 1483–1635), English centenarian, known as "Old Parr," is reputed to have been born in 1483, at Winnington, Shropshire. When 130 years old he is said to have threshed corn. In 1635 his fame reached Thomas Howard, 2nd earl of Arundel, who had him conveyed to London. Here he was presented to King Charles I., but the change of air and diet soon affected him, and the old man died at Lord Arundel's house in London, on Nov. 14, 1635. He was buried in the south transept of Westminster Abbey where the inscription over his grave reads: "Tho: Parr of ye county of Salopp Born in Ao 1483. He lived in ye reignes of Ten Princes viz. K. Edw. 4, K. Ed. V. K. Rich. 3. K. Hen. 7. K. Hen. 8. K. Edw. 6. Q. Ma. Q. Eliz. K. Ja. and K. Charles, aged 152 yeares and was buried here Nov. 15. 1635."

PARRATT, SIR WALTER (1841–1924), English organist, was born at Huddersfield on Feb. 10, 1841. He was educated privately, and displayed his musical aptitude at a very early age. He is said, indeed, to have played the whole of Bach's 48 preludes and fugues, by heart, at the age of ten. In 1872 he became organist of Magdalen college, Oxford, and in 1882 organist of St. George's chapel, Windsor. From 1908–18 he was professor of music at Oxford, and from 1916–20, dean of the faculty of music in London university. He was knighted in 1892. He died at Windsor on March 27, 1924.

PARRHASIUS (fl. 4th century B.C.), of Ephesus, one of the greatest painters of Greece. He settled in Athens and may be ranked among the Attic artists. He was certainly distinguished as a painter before 399 B.C. He is said to have been interested in the study of proportion. Many of his drawings on wood and parchment were preserved and highly valued by later painters for purposes of study. His picture of Theseus adorned the Capitol in Rome. His other works are chiefly mythological groups. A picture of the Demos, the personified People of Athens, is famous.

PARRINGTON, VERNON LOUIS (1871–1929), U.S. literary historian and teacher, who greatly influenced U.S. historical and literary thought, was born on Aug. 3, 1871, in Aurora, Ill., grew up in Emporia, Kan., and was educated at the College of Emporia and Harvard university. He taught English and modern languages at the College of Emporia (1893–97), at the University of Oklahoma (1897–1908) and at the University of Washington, Seattle (1908–29). Influenced by Morris and Ruskin, by the critical principles of Taine and the political program of the Populists, he reappraised U.S. literary history in *Main Currents in American Thought* (2 vol., 1927), which won the Pulitzer prize for history in 1928. Parrington, a Jeffersonian liberal, objected to aestheticism and pedantry, emphasized economic influences and defined literature as any writing successfully presenting important ideas or experiences. He died on June 16, 1929, at Winchcomb, Glos. A third volume with the subtitle *Critical Realism in America,* incomplete at his death, was published in 1930. His work, notwithstanding objections to his political liberalism, his economic determinism and his summary literary judgments of such writers as Poe and Henry James, remains an important landmark in U.S. literary history. He also wrote *The Connecticut Wits* (1926) and *Sinclair Lewis, Our Own Diogenes* (1927). (E. H. E.)

PARROT, a name applied generally to a large group of gaudy, raucous birds whose more than 300 species are placed in the family Psittacidae. order Psittaciformes. Parrots include the popular small pets, parakeets, lovebirds and budgerigars, as well as the larger macaws, Amazon parrots, lories, cockatoos and others. Known from ancient times, parrots have always been popular as cage birds because they are amusing, often affectionate, easy to keep and astonishingly imitative of many sounds, including human speech. Since the chief interest in them still lies in these traits, parrots as pets will be dealt with later at some length. Numerous flocking species of parrots feeding on fruit and grain can become a serious economic threat to agriculture and fruit raising, as has happened in Australia and New Zealand. On the other hand. they destroy many weed seeds. The export of parrots for cage birds is an important industry.

Description **and** Natural History.—Parrots stand apart as a group and are well known to the ordinary observer by the following outstanding features. They have large heads and powerful bills. hawklike in the overhang of the upper mandible. The nostril is set in a fleshy cere at the base of the upper mandible. where the latter is hinged to the skull. This hinge. or its equivalent, present in all birds to permit the raising of the upper bill, is nowhere so easily seen in operation as when a parrot uses its bill as a third foot in climbing. The sharp angle of attack of the jaw muscles on the bony elements closing the bill combine to produce one of the most powerful crushing mechanisms in nature. A tiny budgie can inflict a painful bite: a macaw can take off a finger. The parrot tongue is fleshy and cylindrical. The first and fourth toes are directed backward. a tree-climbing adaptation that permits these birds to grasp food. as if "by hand." and carry it to the mouth, a somewhat amusing trait not found in other birds.

Most species nest in tree holes; a few in ground holes. They usually mate for life and lay from 1 to 12 usually white eggs. The eggs are incubated by one or both parents from 16 to 19 days in small species—nearly 30 in large species—following which the young emerge, usually blind and naked. The period of nest care is from two to three months. and the young are fed by regurgitation. This long period of parental care may he related to the large brain size. which requires a longer period of development before the young bird acquires motor patterns enabling it to care for itself. This large brain is certainly associated with the parrots' remarkable ability to learn a complex sequence of tricks or an

astonishing vocabulary with the same ease. Many parrots live extraordinarily long lives, often longer than 50 years. (Unauthenticated reports of upwards of 80 years have been made for some species of large parrots.) On the other hand smaller cage birds such as parakeets and budgerigars are "old-timers" at five years (though some may of course live longer).

Most species of parrots are confined to the equatorial belt of the old and new world continents, the greatest variety occurring in the Australian region. This near confinement to the equator poses a problem for some zoogeographers. Those who subscribe to the Wegnerian hypothesis of continental drift have no difficulty, since they believe the present continents were once a single land mass: but those who believe in the permanence of continents and oceans must assume that there was once a warm climate connection across the northern part of the old and new worlds, probably at Bering strait. The finding of fossil parrots and tropical vegetation in Europe and even the Arctic supports this possibility but not more recently than 60,000,000 to 100.000.000 years ago.

On the other hand a few modern species have temperate ranges. The parakeet. Platycercus *erythrotis,* lives in the Macquarie Islands (lat. 55° S.) and the now extinct Carolina parakeet. *Conuropsis carolinensis,* ranged as far north as Ontario (lat. 45° N.).

New World Parrots. — The early explorers of the new world, beginning with Columbus. brought back to Europe astonishing tales of the bird life, particularly of the parrots, and before long living examples followed.

Macaws. — The three-foot-long scarlet macaw (Ara macao) and somewhat smaller red and green macaw (A. chloroptera). crushing with enormous bills the palm nuts man must crack with a hammer, still excite wonder. Together with the blue and yellow macaw (A. *ararauna*) and the green macaw (A. nzilitaris). these huge parrots range from the Isthmus of Panamá to the great interior rain forests of South America. A. nzilitaris and *A. macao* even reach tropical hfexico. The hyacinthine macaw (*Anodorhynchus hyacinthinus*) is confined to swampy forests in interior Brazil. where it lays its two eggs in a hole in a bank. Species now extinct once lived on Cuba. Jamaica, Isle of Pines. Guadeloupe and Martinique. Macaws are popular in zoos, where they are often exhibited outside of cages on stands, to which tame individuals need not be chained. The macaws share with the next group an ear-splitting shriek, which may make them difficult pets.

Amazon Parrots. — The stocky Amazon parrots (*Amazona*) are about the size of a large pigeon, predominantly grass green and yellow, but with added patterns of red, blue and black. These are the best known parrots of the American tropics — the familiar talking birds. Some individuals 'become affectionate pets and ecstatically enjoy having their heads scratched by a trusted human friend. This is the bird frequently caricatured as having acquired from an original sailor owner a vocabulary too salty for polite society. There are about 50 species and subspecies ranging through tropical Central and South America and the Caribbean islands. Familiar species in captivity include the yellow-headed and yellow-naped amazons (*Amazona ochrocephala*), blue-fronted amazons (A. *aestiva*j and green-cheeked amazons (*A. viridigena*).

Conures.—A group of smaller relatives of the Amazons, with about 45 species and subspecies, includes the sharp-tailed conures (*Aratinga*), which combine red, green, yellow and blue in numerous patterns. The Jendaya conure (*A.* jendaya) of Brazil has the head and neck yellow, breast and rump vermilion and back, wings and tail bluish green. It is 12 in. long.

The Carolina parakeet (*Conuropsis carolinensis*), now extinct, was a yellow-headed green conure, which was a real hazard to the fruit crop of early settlers in the forests of eastern United States. Still smaller are the five-inch American parrotlets (*Forpus*) of which there are about 19 greenish forms. These are not to be confused with dwarf parrots of which the orange-chinned, deep green Tovi (Brotogerys *jugularis*) is an example. This six-inch Mexican bird once glutted the American market as a spurious "lovebird" (see True Lovebirds, below).

African and Asian Parrots. — The first parrots known to civilization were apparently Indian parrots brought alive to Aristotle about 328 B.C. by his pupil Alexander the Great. African parrots mere presented to Emperor Nero in A.D. 54 by an expedition sent to find the source of the Nile.

African Gray Parrots. — No doubt the African gray parrot (*Psittacus erithacus*), which surpasses all other parrots in mimetic and tonal quality. was considered an amusing pet by the Romans and was imported in great numbers, the surplus becoming a table delicacy. Both sexes are ash gray with a red tail; there are a number of similar related forms in Africa and Madagascar. They are forest birds. feeding in flocks on fruits and nuts. Their two to four white eggs are laid in tree holes.

Afro-Asian Parakeets. — A great many species of parakeets occur in huge flocks in the African and Malaysian areas. Very striking is the blossom-headed parakeet (*Psittacula cyanocephala*) of India. and Ceylon. with red-violet head and shoulders, a black collar and a blue-and-yellow tail. In the Indo-Malaysian region a peculiar group of very small, mainly green parakeets — the hanging parakeets (*Loriculus*)—sleep suspended like bats and resemble clusters of leaves.

True Lovebirds. — The true lovebirds (*Agapornis*) are confined to Africa and Madagascar. about 14 species and subspecies. They are very small and green with a subterminal black bar on the rounded tail. Their common name derives from the mutual affection that mated pairs display.

Australian Region Parrots. — Taking this region to include New Guinea. Celebes, the Lesser Sundas east of Bali, New Zealand, New Caledonia and the Solomons as well as Australia itself, it is here that the parrots reach their greatest diversity. There are 86 subspecies in New Guinea and 46 in Australia.

Lories and *Lorikeets.*—A large group of species belong to the brush-tongued lories, pointed-tailed nectar feeders in which the tongue is covered with soft papillae or bristles, helpful in lapping up nectar or fruit juice. One of the most extensive in range is the rainbow lory (*Trichoglossus haematodus*) with a purple head, red under parts and green back. Lories are generally a little larger than starlings, but the brush-tongued lorikeets (Vini) are much smaller. One lorikeet, *V. margarethae,* is green above and scarlet below; the members of a flock feeding on tropical red tree blossoms in the Solomons appear as blossoms themselves. There are about 15 genera of lories and lorikeets. New Zealand has two species of large, brush-tongued lories.

Australian Parakeets, *Budgerigars, etc.*—A large group of small Australian parrots with blunt tongues (an aid in extracting the meat from a cracked nut) includes the rosellas (Platycercusj and crested parakeets (*Cyanoramphus*). The former occurs in Australia and New Zealand, the latter in New Zealand and in the mountains of New Caledonia. The cockateel (*Nymphicus hollandicus*) is a long-tailed, small Australian species, ash-gray with a yellow head and crest, often seen in pet shops. The smallest parrot in the world is the pygmy parrot (*Micropsitta*), with six species ranging from the Solomons to New Guinea; it .is smaller than a canary and has a spiny tail like a woodpecker.

The Australian budgerigar (*Melopsittacus undulatus*), also called shell, grass and zebra parakeet and (erroneously) lovebird, is one of the long-tailed grassland parakeets that travel in large flocks and feed on grain. The wild budgie is grass green with a yellow forehead. much barred with black and yellow above, and a blue tail; breeders have been successful in bringing out basic colours of blue and mauve. Budgerigars are popular pets because they are small. inexpensive and companionable, and develop extraordinary vocabularies. They are raised in great numbers by breeders.

A peculiar little ground parrot (*Pezoporus*) of Australia nests on the ground and flushes in coveys like quail.

Owl Parrots, Keas, *etc.*—New Zealand. long separated from all other land. has produced some unusual species. The nearly extinct, large owl parrot or kakapo (*Strigops habroptilus*) is completely flightless and lives in burrows. feeding on roots.

The raven-sized kea (*Nestor notabilis*) is a nectar feeder in summer, but sometimes a sheep killer in winter, when it goes down into the valleys from its summer nesting grounds among the rock crevices in the snow country at 6,000 feet. Taken to feeding on discarded sheep carcasses, some keas alight on and peck open

the backs of living sheep to get at the soft fat about the kidneys. A related species, the kaka (N. *meridionalis*), feeds on fruit, nectar and insects in the lowlands, and is prized as a pet. It travels in flocks except during the nesting season, when its four white eggs are layed in tree holes. The kea is dull green with an orange-red rump and underwing, the kaka olive brown. Species of keas formerly found on Norfolk and Phillip islands are extinct.

Cockatoos.—*The* spectacular parrots of the Australian region are the cockatoos (*Cacatua*). They are large-billed species mainly white, square-tailed, and with long, erectile crests. Leadbeater's cockatoo (C. *leadbeateri)* is pink with a red, yellow and white crest. Other species are the rose-crested, sulfur-crested and bare-eyed cockatoos and the galah, found in various parts of the Australian region.

The cockatoo's nest is usually in a high tree hole in the tropical forest; the two white eggs are laid on wood chips. The young, which hatch naked and blind, are fed by the adults by regurgitation of partially digested food for about three months. Cockatoos often travel in immense flocks numbering many thousands They make good pets and are found in all zoos. The giant black cockatoo *(Calyptorhynchus magnificus)* has naked cheeks that blush red under excitement. It spends its life in the New Guinea rain forests cracking hard candlenuts with its massive bill, then extracting the meat with its wormlike tongue.

Parrots as Pets.—*Talking.*—*The* best talkers are the African grays, but the Amazons are good, though inclined to be too harsh and noisy. Budgies may acquire amazing vocabularies, but their voices are too tiny to carry the quality of the human voice. Teaching a parrot to talk requires perseverance. It is also essential that the parrot accept its owner as a companion; this association is encouraged if parrots are kept apart. Training should begin with one- or two-word phrases; these should be repeated frequently after the parrot has mastered them and passed on to other lessons. Unlike mammals, which learn by association entirely, parrots do not relate reward or punishment to the learning of a new phrase, so it is useless to offer a tidbit for each word learned.

Care and Breeding.—*Karl* Plath, former curator of birds at Brookfield zoo, near Chicago, gives the following advice on parrot care. A stainless steel cage is best. Sand or grit placed on the floor is swallowed by the birds to help in grinding food. Soft wood should be provided for chewing—a spool is ideal. If the cage is too small or the pet is lonely, the bird may pluck out its tail feathers or even its body feathers.

The following seed mixture works well for almost all larger parrots, cockatoos and macaws: one part each of sunflower, hemp and millet seeds; two parts canary seed; one part peanuts. Fruit, nuts, greens and fresh water should be supplied regularly. Brush-tongued lories should be fed Mellin's food (evaporated milk and honey, a teaspoonful of each in a half cup of cold water) and also sweet fruit. Some lories will also take canary seed and sunflower seed. Baby parrots are fed a mixture of pablum, clear sugar sirup and a little mashed banana by a narrow wooden spoon three times daily, even when the parents feed them by regurgitation.

The same diet as given for the larger parrots may be used for the smaller ones and for parakeets and budgerigars, except that peanuts should be replaced with whole oats and more millet seed.

Captive budgies breed readily if provided with a box 6 x 6 in. wide and 8 in. deep; a macaw may nest in a wooden barrel or even a dog kennel.

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(W. J. BE.)

PARROT FISH (PARROT WRASSE), a marine fish of the family Scaridae, closely allied to the wrasses or Labridae. The principal genera are *Scarus, Pseudoscarus, Odan* and *Sparisama.* They have large scales; nine spines and ten rays in the dorsal fin and two spines with eight rays in the anal fin.

The dentition is remarkable. The teeth of the jaws are soldered together, and form a sharp-edged beak similar to that of a parrot; the upper and lower beak are divided into two lateral halves by a median suture. By this sharp and hard beak parrot fishes are enabled to bite off those parts of coral stocks that contain the polyps or to cut off branches of rockweed. The process of triturating the food is performed by the pharyngeal teeth, which likewise are united, and form plates with broad masticatory surfaces. Of these plates there is one pair above, opposed to and fitting into the single one that is coalesced to the lower pharyngeal bone.

Nearly 100 species of parrot fishes are known from the tropical and subtropical parts of the Indo-Pacific and Atlantic oceans; like other coral-feeding fishes, they are scarce on the tropical west coasts of America and Africa. Beautiful colours, subject to great variations in the same species, prevail in this group of wrasses. The majority of parrot fishes are eatable. Many attain to three feet in length.

PARRY, SIR CHARLES HUBERT HASTINGS, 1ST BART. cr. 1902 (1848–1918), English musical composer, second son of Thomas Gambier Parry, of Highnam court, Gloucester, mas born at Bournemouth on Feb. 27, 1848. He was educated at Malvern, Twyford, near Winchester, Eton (from 1861), and Exeter college, Oxford. While still at Eton he wrote music, two anthems being published in 1865. He studied music successively with H. H. Pierson (at Stuttgart), Sterndale Bennett and Macfarren; but the most important part of his artistic development was due to Edward Dannreuther. Among the larger works of this early period may be mentioned an overture, *Guillem de Cabestanh* (Crystal Palace, 1879); a pianoforte concerto in F sharp minor, played by Dannreuther at the Crystal Palace and Richter concerts in 1880; his first choral work, *Scenes From Prometheus Unbound,* produced at the Gloucester festival, 1880; and a symphony in G given at the Birmingham festival in 1882. A setting of Shirley's ode, *The Glories of Our Blood and State,* brought out at Gloucester, in 1883, attracted general attention and laid the foundation of his reputation. After this with a noble eight-part setting of Milton's *Blest Pair of Sirens* (Bach choir, 1887) began a fine series of compositions set to sacred or semi-sacred words. These include *Judith* (Birmingham, 1888), *Ode on St. Cecilia's Day* (Leeds, 1889), *L'Allegro ed il penseroso* (Norwich, 1890), *De Profundis* (Hereford, 1891), *The Lotus Eaters* (Cambridge, 1892), *Job* (Gloucester, 1892), *King Saul* (Birmingham, 1894), *Invocation to Music* (Leeds, 1895), *Magnificat* (Hereford, 1897), *A Song of Darkness and of Light* (Gloucester, 1898), and a *Te Deum* (Hereford, 1900). In his *Symphonic Variations* (1897), he displayed his power as an instrumental composer, while his incidental music to *The Birds* of Aristophanes (Cambridge, 1883) and *The, Frogs* (Oxford, 1892) afforded opportunity for the display of that abounding sense of humour which was such an essential part of his genial and engaging disposition. He also wrote much admirable chamber music and many beautiful songs and part songs including a setting of Blake's "Milton" which under the title "Jerusalem" has become universally known and loved.

Parry's writings include: the popular *Studies of Great Composers, The Evolution of the Art of Music* (1896), a volume (*The Seventeenth Century*) of the *Oxford History of Music, Johann Sebastian Bach* (1909) and *Style in Musical Art* (1911). At the opening of the Royal College of Music in 1883 he was appointed professor of composition and of musical history, and in 1894, on the retirement of Sir George Grove, Parry succeeded him as principal. He was appointed Choragus of Oxford university in 1883, succeeding Stainer in the musical professorship of the university in 1900. Parry retired in 1908 and bied Oct. 7, 1918.

See C. *L.* Graves, *Hubert Parry,* 2 vol. (1926); J. A. Fuller-Maitland, *The Music of Parry and Stanford* (1934).

PARRY, SIR WILLIAM EDWARD (1790–1855), English rear admiral and Arctic explorer who attempted to discover the northwest passage, was born in Bath on Dec. 19, 1790. At the age of 13 he entered the Royal Navy and in 1810 became lieutenant in the "Alexandria" which was employed for three years in protecting the Spitsbergen whale fishery. He made many astronomical observations in northern latitudes and published the results of his studies as *Nautical Astronomy by Night* (1816). From 1813 to 1817 he served on the North American station. In 1818 he commanded the "Alexander" during the arctic expedition under

Captain (afterward Sir) John Ross. This expedition returned without success, but the following year Parry obtained the chief command of a new arctic expedition, consisting of the "Griper" and "Hecla." This expedition returned to England in Nov. 1820 after a successful voyage *(see* ARCTIC, THE), having accomplished more than half the journey from Greenland to Bering strait. Parry's *Journal of a Voyage to Discover a North-west Passage,* appeared in 1821. In May 1821 Parry sailed with the "Fury" and "Hecla" on a second expedition to discover a northwest passage, but was compelled to return in Oct. 1823 without achieving his purpose. Meanwhile he had in Nov. 1821 been promoted to post rank, and shortly after his return he was appointed acting hydrographer to the navy. His *Journal of a Second Voyage, etc.,* appeared in 1824.

With the same ships he undertook a third expedition on the same quest in 1824, but was again unsuccessful, and the "Fury" being wrecked, he returned home in Oct. 1825 with a double ship's company. Of this vovage he published an account in 1826. In 1827 the admiralty sanctioned an attempt on the north pole from the northern shores of Spitzbergen, and Parry reached 82° 45′ N. latitude. His *Narrative of the Attempt to Reach the North Pole, etc.,* appeared in 1827. He was knighted in 1829. He became controller of the new department of steam machinery of the navy, retiring in 1846, when he was appointed captain superintendent of Haslar hospital. He became a rear admiral in 1852, and in 1853 a governor of Greenwich hospital.

Parry died on July 8. 1855.

See *Memoirs of Rear-Admiral Sir W. E. Parry* . . . by Rev. Edward Parry, 3rd ed. (1857). (A. M. Ss.)

PARSEC, the unit in which distances of stars are measured, officially adopted by the International Astronomical union in 1922. A parallax of one second of arc corresponds to a distance of one parsec. It is approximately 19 million million (1.9×10^{13}) miles, or 3.26 light-years. *See* also PARALLAX: *Stellar Parallax.*

PARSEES or PARSIS, the followers in India of Zoroaster (*q.v.; i.e.,* Zarathustra), being the descendants of the ancient Persians who emigrated to India on the conquest of their country by the Arabs in the 8th century. They first landed at Diu in Kathiawar (A.D. 766), and later moved to Sanjan on the coast of Gujarat, where the Hindu ruler received them. To this day their vernacular language is Gujarati. The exact date of their settlement at Bombay, which is the principal centre of the Parsee community in India. is not known.

The men have light olive complexions, a fine aquiline nose, bright black eyes, a well-turned chin, heavy arched eyebrows, and thick lips and usually wear a light curling moustache. The women have small hands and feet, fair complexions, beautiful black eyes, finely arched eyebrows and long black hair, which they ornament with pearls and gems. They appear freely in public.

The head is covered with a turban, or a cap made of stiff material, something like the European hat, without any rim. and has an angle from the top of the forehead backward. It would not be respectful to uncover in presence of an equal, much less of a superior. The colour is chocolate or maroon. The priests wear a uhite turban and are wholly dressed in white. Men and women near the sacred shirt, *sadra,* and the girdle, *kusti.*

Sects.—The Parsees of India are divided into two sects, the Shahanshahis and the Kadmis. They differ as to the correct chronological date for the computation of the era of Yazdegerd, the last king of the Sassanian dynasty, who was dethroned by the caliph Omar about A.D. 640. This led to the variation of a month in the celebration of the festivals.

The Parsees compute time from the fall of Yazdegerd. Their calendar is divided into 12 months of 30 days each; the other 5 days, being added for holy days, are not counted. Each day is named after some particular angel of bliss, under whose special protection it is passed. On feast days a division of five watches is made under the protection of five different divinities. In midwinter a feast of six days is held in commemoration of the six periods of creation. About March 21, the vernal equinox, a festival is held in honour of agriculture, when planting begins. In the middle of April a feast is held to celebrate the creation of trees, shrubs and flowers. On the fourth day of the sixth month a feast is held in honour of Sahrevar, the deity presiding over mountains and mines. On the 16th day of the seventh month a feast is held in honour of Mithra, the deity presiding over and directing the course of the sun, and also a festival to celebrate truth and friendship. On the tenth day of the eighth month a festival is held in honour of Farvardin, the deity who presides over the departed souls of men. This day is especially set apart for the performance of ceremonies for the dead. The people attend on the hills where the "towers of silence" are situated and pray in the *sagris* for the departed souls. The Parsee scriptures require the last ten days of the year to be spent in doing deeds of charity.

On the day of Yazdegerd, or New Year's day, the Parsees rise early and, after having performed their prayers and ablutions, don a new suit of clothes and go to the fire temples to worship the sacred fire, which is perpetually burning on the altar. Unless they duly perform this ceremony, they believe, their souls will not be allowed to pass the bridge Chinvad, leading to heaven. Then they visit their relations and friends, when the ceremony of *hamijur,* or joining hands, is performed, a kind of greeting by which they wish each other a happy new year. Their relatives and friends are invited to dinner, and they spend the rest of the day in feasting and rejoicing.

There are only two distinct classes among the Parsees—the priests (destours, or high priests; mobeds, or the middle order; and herbads, or the lowest order) and the people *(behadin, behdin,* or "followers of the best religion"). The priestly office is hereditary, and no one can become a priest who was not so born.

The secular affairs of the Parsees are managed by an elective committee, or panchayat, composed of 6 destours and 12 mobeds, making a council of 18.

Their religion teaches them benevolence as the first principle, and they practise it with liberality. The sagacity, activity and commercial enterprise of the Parsees are proverbial.

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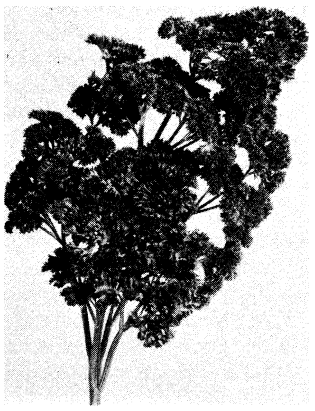
PARSLEY *(Petroselinum crispum)*, a hardy, biennial herb of the family Umbelliferae, native to Mediterranean lands. One form is grown only for its cluster of dark-green, tender, plain, deeply cut or highly frilled leaves that develops the first season of growth. A second form called turnip-rooted, or Hamburg, parsley is grown for its large, white, parsniplike root. Both forms in the second season put up seed stalks two to six feet high, topped by compound umbels of small greenish-yellow flowers. The seeds are similar to those of carrot, but without spines. Parsley leaves were used by the ancient Greeks and Romans as a flavouring and garnish for foods, as they are used in Europe and America in modern times. Turnip-rooted parsley is popular in Europe but little grown in America. Parsley seedlings are small and ueak; they emerge with difficulty from heavy, crusty soils. (V. R. B.)



PARSLEY (PETROSELINUM CRISPUM)

PARSNIP, *Pastinaca sativa,* a member of the Umbelliferae, or parsley family. The plant is a native of Europe, and a wild form with a tough pungent root is found in roadsides and waste places in England and throughout Europe and temperate Asia. It was introduced on the American continent early in the 17th century and has become extensively naturalized in North America, especially in the eastern states and Canada and on the Pacific coast, sometimes becoming a troublesome weed. The parsnip has been cultivated since Roman times for its large, tapering, fleshy

root which has a distinctive flavour. At the end of summer the solids of the root consist largely of starch, but after the roots are exposed to temperature near freezing for a few weeks much of the starch changes to sugar, improving its eating quality. The parsnip seed is sown in the spring. thinly in rows about one and a half feet apart, and the plants thinned to stand two to three inches apart in the row. The root is quite hardy when left in the garden, being undamaged by hard freezing of the soil.

(V. R. B.)

PARSONS, SIR CHARLES ALGERNON (1854–1931), British engineer, best known for the invention of a steam turbine bearing his name, was born in London, June 13, 1854, fourth son of the 3rd earl of Rosse. Educated privately and at St. John's college, Cambridge, he entered the Armstrong works at Elswick in 1877. In 1884, having served for a year on the experimental staff of Messrs. Kitson, of Leeds, he entered into partnership with Messrs. Clarke. Chapman and Co., of Gateshead. On the dissolution of the partnership in 1889, Parsons, whose invention of the Parsons steam turbine was bringing him into considerable prominence, established his own works at Heaton, Newcastle upon Tyne, for the manufacture of steam turbines, dynamos and other electrical apparatus. Besides the chairmanship of C. A. Parsons and Co., he occupied important positions on the directorate of various electrical supply and engineering companies. He was made a fellow of the Royal society in 1898, was awarded the Royal society': Rumford medal in 1902, was president of the Institute of Marine Engineers! 1905–06 and of the British association, 1919–20. He was created knight commander of the Bath in 1911 and given the Order of Merit in 1927.

A collection of his own scientific papers and addresses was published posthumously in 1934. He died Feb. 11, 1931, at Kingston, Jamaica, on board the "Duchess of Richmond."

See R. Appleyard, *Charles Parsons, His Life and Work* (1933).

PARSONS, ELSIE WORTHINGTON CLEWS (pseudonym JOHN MAIN) (1875–1941), U.S. sociologist and anthropologist, best known for her studies of the Indians of the southwest, was born of a socially prominent family in New York city, Nov. 27, 1875. She received a bachelor's degree from Barnard college in 1896 and then studied at Columbia university under Franklin Giddings, receiving her M.A. in sociology in 1897 and her Ph.D. in 1899. She taught sociology from 1899 to 1905 at Barnard. Her early works, such as *The Family* (1906), *The Old Fashioned Woman* (1913), and *Fear and Conventionality* (1914), reflect concern over restrictions imposed upon women in many cuitures and periods. In 1900 she married Herbert Parsons, attorney and U.S. congressman; six children were born of the marriage.

In 1915, as a result of a trip to the southwest where she met the anthropologists Franz Boas and P. E. Goddard, she turned to American Indian research and entered upon 25 years of field study and writing that established her as an authority on the Pueblo tribes. Outstanding among her Pueblo writings were the two-volume work, *Pueblo Indian Religion* (1939), and "The House-Clan Complex of the Pueblos," in *Essays in Anthropology in Honor of A. L. Kroeber* (1936). Her interest in all possible influences upon the Pueblo peoples led her to investigations among the Plains Indians, and in Mexico, Peru, Ecuador and the Caribbean. *Mitla: Town of the Souls* (1936) is one of the best-known products of her extensive Mexican researches. She also published widely in the field of folklore, including Negro folklore.

She served as president of the American Ethnological society (1923–25), and was president of the American Anthropological association at the time of her death on Dec. 19, 1941, in New York city.

See Franz Boas, "Elsie Clews Parsons," in *Science* (Jan. 23, 1942)

(M. E. O.)

PARSONS (or PERSONS), **ROBERT** (1546–1610), English Jesuit and political agitator, son of a blacksmith, was born at Nether Stowey, Somerset, on June 24, 1546. Educated at Balliol college, Oxford, he was fellow, bursar and dean of his college. but in 1574 he resigned or was dismissed from his fellowship and offices, for reasons which have been disputed. He went to London, and thence to Louvain, where he entered the Roman Catholic Church and spent some time in the company of Father William Good, a Jesuit. In July 1575 he entered the Jesuit society at Rome. In 1580 he was selected, along with Edmund Campion, a former associate at Oxford, and others, to undertake a secret religious and political mission to England. The two emissaries engaged in political intrigue in England and on the continent. In 1581 Campion was arrested, but Parsons made his escape to Rouen, whence he returned to Rome, where he continued to direct the English mission. In 1588 he went to Spain. He founded seminaries for the training of English priests at Valladolid, Lucar, Seville, Lisbon and St. Omer. He was made rector of the English college at Rome in 1597, and died there on April 18, 1610.

Parsons was the author of over 30 polemical writings, including *A Conference About the Next Succession of the Crowne of Ingland* (1594); *Treatise of the Three Conversions of England,* 3 parts (1603–04). an answer to Foxe's *Acts and Monuments.*

PARTHENIUS OF NICAEA (XPAMEA) (fl. 1st century B.C.), Greek poet and grammarian, has justly been described as the "last of the Alexandrians." Captured in the third Mithridatic War and carried off to Italy, he became Virgil's teacher in Greek. His collection of 36 love stories made for the poet Cornelius Gallus has survived, and fragments from two funeral poems, one on his wife Arete, have come to light in papyri. He also wrote an encomium of the same lady in three books His poems were favourite reading of the emperors Tiberius and Hadrian.

See S. Gaselee, *Parthenius,* with Eng. trans., "Loeb Series" (1916).

(E. A. B.)

PARTHENOCISSUS, a genus of the Vitaceae family, including the Boston ivy and the Virginia creeper (*q.v.*).

PARTHENOGENESIS. Throughout the animal and plant kingdoms sexual reproduction is common; a ripe egg borne by one organism (called variously female cell, ovum, macro- or megagamete, female gamete) is usually stimulated to develop into a new organism after fertilization (*q.v.*) by a sperm (called also male cell, spermatozoon. microgamete, male gamete) (*see* REPRODUCTION). An alternative to sexual reproduction involves the egg but not the sperm and is termed parthenogenesis or virgin reproduction. It occurs naturally in many animals and plants and may be induced artificially or experimentally by man.

NATURAL PARTHENOGENESIS

Natural parthenogenesis is the exclusive method of reproduction in some plant lice (aphids, *q.v.*), parasitic wasps and thrips in which males are unknown; it is an occasional method in some members of all the major groups of animals except vertebrates and echinoderms (starfish, etc.). In still other groups of plant lice. and in rotifers and water fleas (crustaceans order Cladocera) parthenogenesis alternates with sexual reproduction. In honey bee (and other members of the order Hymenoptera), white fly (order Hemiptera) and some thrips (order Thysanoptera) any egg is capable of developing parthenogenetically or after fertilization, the fertilized eggs are capable of producing females, the unfertilized eggs males.

True parthenogenesis is frequent among certain algae and fungi but is rare among seed plants and has been demonstrated in only a few including dandelion (*Taraxacum*) and cat's foot (*Antennaria*). There occur, however, various types of asexual reproduction which superficially resemble parthenogenesis; these are generally grouped under the term apogamy or apomixis and include the production of adventitious embryos from tissue outside the egg. The process is very much like the production of bulblets externally.

Reproductive Cycles.—In most rotifers, aphids and water fleas the fertilized eggs develop into females whose eggs in turn are parthenogenetic. In the rotifers any successive generation may include both parthenogenetic and sexual females. The parthenogenetic female produces large eggs which remain unfertilized and yield either parthenogenetic or sexual females. The sexual female produces small eggs which may develop without fertilization and yield males, or be fertilized, grow larger and yield females.

In typical aphids several parthenogenetic generations follow the fertilized egg, which hatches in spring; during spring and sum-

mer wingless or winged females or both are produced. As autumn approaches, sexual forms appear — males and egg-laying females — and mating takes place. (When the parthenogenetic females produce sexual forms, sexual females are born mostly of winged mothers, males mostly of wingless mothers.) The fertilized eggs hatch the following spring and the cycle repeats.

The water flea cycle is more flexible. In certain species any female may produce either female or male offspring by parthenogenesis, or eggs which require fertilization and yield females. In all these cycles environment influences the time or frequency of appearance of the sexual forms.

Number of Chromosomes. — Important differences in parthenogenesis are related to the number of chromosomes in the developing egg. In most higher animals, whose body (somatic) cells contain what is known as the diploid or normal number of chromosomes (*e.g.*, in man 46 chromosomes, 23 like pairs) the reproductive cells undergo two maturation divisions in one of which the like or homologous chromosomes (after pairing) separate without division. As a consequence of this reduction division the mature germ cells have half the somatic number of chromosomes. This number is termed haploid (*e.g.*, in man 23 chromosomes, one of each of the like pairs). Some haploid eggs may develop parthenogenetically. More commonly, however, parthenogenetic eggs omit the reducing one of the two maturation divisions, and therefore are diploid. In the bee the fertilized eggs are diploid, as are also the females (queens or workers) which develop from them; but the mature unfertilized eggs are haploid. If they remain unfertilized they develop parthenogenetically to yield males (drones) which are haploid. When the drones produce spermatozoa there is no further reduction of the chromosome number in these germ cells because only one set of chromosomes is present; at what would be the reduction division all the chromosomes pass to one cell, and it is only from such cells that spermatozoa are derived. These male cells, like the eggs, are therefore haploid.

In aphids both parthenogenetic and sexual females are diploid. Eggs of sexual females result from two maturation divisions, and are haploid; but in parthenogenetic females the reducing division is suppressed, and the eggs are diploid. These eggs produce females which are also diploid. The parthenogenetic eggs which develop into males eliminate only one whole chromosome in the maturation division, leaving the males with one less than the diploid number of chromosomes. In maturation of male germ cells there is an unequal division in which one cell receives the full haploid chromosome group, the other cell one less. Only the former cell produces a spermatozoon, so that male germ cells are haploid.

In water fleas, females and males are strictly diploid. Parthenogenetic eggs mature by one division and are diploid; sexual eggs and spermatozoa result from two divisions and are haploid.

Restoration of Diploid Chromosome Number. — In animals, even after a reduction division, the normal or diploid number of chromosomes may be restored in parthenogenesis by duplicating the chromosomes at the end of the reduction division; by fusion of the egg nucleus with the nucleus of the second polar body, the very small one of the two cells produced by the second division; or by fusion of two cleavage cells. In plants other ways of restoring or maintaining diploidy are available because of the long haploid phase of the cycle.

In animals the haploid phase is practically limited to the mature germ cells, but in the lower plants such as fungi, algae, ferns, etc., a conspicuous haploid generation is evident. Even in the flowering plants the embryo sac, which functions in development of the embryo and seed, consists normally of eight haploid cells. Sometimes the embryo sac develops from an unreduced spore, and thus is diploid. The eggs in diploid embryo sacs are ordinarily parthenogenetic. since fertilizing them would increase the chromosome number in the next generation. Diploid embryo sacs may also arise not from spores but from some kind of somatic cell, a process known as apospory. The eggs in such embryo sacs need some way to avoid doubling their already double chromosome number, and omitting fertilization is the remedy. Sometimes the embryo is produced not from the egg but from scme other embryo sac cell. This process, called apogamy, is like parthenogenesis in not involving fertilization, and prevents the doubling of chromosome numbers.

Relation to Hybridization and Evolution. — Often some of the offspring of a species cross reproduce by parthenogenesis. In species hybrids the chromosomes must usually be to some degree unmatched. This inequality interferes with their pairing in maturation, and parthenogenesis is common. While failure of chromosome pairing can hardly be the cause of parthenogenesis, diploid parthenogenesis clearly furnishes a correction of the defect. Species crosses in plants have often been followed by a prompt doubling of the chromosomes, after which pairing can take place because like chromosomes have been provided by the doubling. Many new species have arisen in this way, possessing the number of chromosomes of the two parent species combined. Doubling of chromosomes also occurs independently of species crosses. As a result there are many species which are polyploid, *i.e.*, possessed of a chromosome number higher than the diploid and a multiple of the basic haploid number present in some primitive species. Parthenogenesis occurs so much more frequently in polyploid species that there must be some causal relation between the two phenomena.

In organisms which reproduce by parthenogenesis evolution is restricted because, in the absence of chromosome pairing, recombination of characters does not occur. Ineffectiveness of selection within parthenogenetic lines of descent indicates that changes are rare, though if crossing over (exchange of fragments between homologous chromosomes) ever occurs, recombination of characters is still possible, permitting a slow evolution. In species reproducing alternately by the parthenogenetic and sexual methods, parthenogenesis may be an evolutionary asset. When recombination in the sexual period produces an individual which fits some special niche in the environment, that individual need not stand alone in holding its place. By parthenogenesis it may produce hundreds of individuals having the same genetic constitution, some of which, even after high accidental losses, may well survive.

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ARTIFICIAL PARTHENOGENESIS

Unfertilized eggs, under ordinary conditions. die within a relatively short time (one to several days, depending on the species) after having been shed from the ovary. However, it has been found that in a great many species of animals unfertilized eggs may be incited to develop by means of treatment with certain simple chemical or physical agents. This was initially discovered in 1886 by A. Tichomiroff, working with eggs of the silkworm moth. His results, however, attracted very little attention, presumably because the occurrence of natural parthenogenesis in the same species obscured the special significance of his work. In 1896–1900 T. H. Morgan and A. D. Mead showed that development could be initiated in unfertilized eggs of marine animals (sea urchins and worms) by treatment with certain salt solutions or hypertonic (concentrated) sea water. and Jacques Loeb in 1900 first demonstrated that normal larvae could be obtained by such means. Later, extensive investigations by many workers showed that in practically all the main groups of animals normal development can be obtained by artificial activation of the unfertilized eggs, although methods of treatment may vary considerably from one species to another. From this it may be concluded that the eggs of all species of animals are capable of development by artificial parthenogenesis.

Among plants artificial parthenogenesis has not received the same attention as it has among animals. However, eggs of the marine rockweed (Fucus) have been induced to develop into new plants by subjecting them to treatment with certain organic acids. Parthenocarpy or the "setting" of fruit without the usual development of seed, *i.e.*, aithout fertilization, should not be confused with parthenogenesis, for in the former only the seedless fruit results and not an embryo or a new organism (see FRUIT; PLANTS AND PLANT SCIENCE: Plant Physiology: Growth).

Methods of Artificial Activation. — Marine invertebrate animals (particularly echinoderms, mollusks and worms) (1) have been most extensively used in experiments on artificial parthenogenesis because they generally produce large quantities of eggs that are shed directly into the sea water or that are readily removable from the animal; and (2) because the eggs are easily handled and cultured during their early development simply in sea water. However, many experiments have also been performed on eggs of insects, fish, frogs and mammals. One of the most interesting features of the experiments is the great variety of methods of treatment that have been found to be effective. Even in a single species the eggs may be activated by any one of a number of diverse agents. Thus, in the sea urchin Arbacia activation has been obtained by exposure of the eggs to increased acidity, increased alkalinity, neutral salt solutions (certain constituents of sea water), hypertonic (concentrated) or hypotonic (dilute) sea water, certain alkaloids, fat solvents, puncture with a fine needle, heat, cold, ultraviolet radiation and radium emanations. While not all of these agents have been found to be equally effective, several of them have given practically similar results, and differences may reflect in part the failure of the investigator to find the best exposure to employ with a particular agent. The eggs of different species of animals generally differ in the kinds of agents to which they will best respond. Certain agents, such as heat and weak acids, have been found to be effective in a number of different species of animals, although with different optimum times of exposure.

Loeb's original method of treatment of sea urchin eggs consisted in exposure to a hypertonic solution. He later discovered a double treatment that proved very effective in giving a high percentage of normal development. This consisted in exposure for 1–3 min. to a mixture of 25 vol. of sea water plus 1 vol. of .1 N butyric acid, followed after 15 min. by a mixture of 25 vol. of sea water plus 4 vol. of 2.5 N sodium chloride for about ½ hr. E. E. Just subsequently showed that a single treatment with a somewhat stronger hypertonic solution (1 vol. or more of 2.5 N sodium chloride plus 4 vol. or less of sea water) for 10 min. or less gives equally good results. Details of methods used with eggs of various species of animals may be found in the references listed in the bibliography.

Production of Normal Embryos and Adult Animals. — With appropriate artificial treatment the percentage of eggs that develop normally may be quite as high as is obtained by fertilization. This high degree of effectiveness has been obtained with eggs of several species of animals particularly among the echinoderms and annelid worms which have been extensively studied. Generally, the eggs have been reared only to the larval stage; however, several parthenogenetic sea urchins and starfish have been reared to the adult condition. It is clear that when perfectly normal larvae are produced, the problem of obtaining the adults is principally a matter of finding proper culture methods.

In several species of higher animals, adults have been obtained by artificial parthenogenesis. Sexually mature adult moths as well as caterpillars have been obtained in large numbers from eggs of the silkworm moth after activation by heat and by acid. Young carp are reportedly obtained by activation of the eggs with male human saliva. Another report cites the rearing of shad to a practically full-grown condition after activation of the eggs, on an industrial scale, by means of a weak electric current. In frogs several dozen adults have been obtained by various investigators using the method of puncturing the egg with a fine (about 0.005-millimetre diameter) glass or platinum needle. In mammals, Gregory Pincus (1939–40) reported the production of seven parthenogenetic rabbits. Six of these were obtained by exposure of the eggs to heat or hypertonicity after they were taken from the mother's body and then implanting them in the uterus of another prepared female rabbit. One was obtained by cold treatment of the eggs while they remained in the oviducts in the animal. This was accomplished by surgically exposing and cooling the oviduct, and its contained recently ovulated eggs, by means of cold water.

Number of Chromosomes. — The egg nucleus after the reduction divisions contains a haploid (single) set of chromosomes, as does also the nucleus of the spermatozoon. Union of the egg nucleus with the sperm nucleus in normal fertilization restores the diploid (double) chromosome number characteristic of all cells of the animal except the germ cells. (See CYTOLOGY; FERTILIZATION.) In artificial parthenogenesis. since the haploid set of chromosomes ordinarily contributed by the spermatozoon is absent, one would expect only haploid individuals to develop. However. cytological investigations have shown that, besides haploids, diploid embryos also occur. In fact, the only individuals that have been reared to or near the adult condition have turned out to be diploid. The haploid individuals generally die in an embryonic stage.

Several investigators have examined the fascinating problem of the manner in which artificially activated eggs spontaneously restore the chromosome number to diploid. This has been studied principally in eggs of the frog, the silkworm and the gephyrean worm, Urechis, and a number of methods of regulation have been revealed. Much is found to depend upon the stage of meiosis (reduction divisions) attained by the egg at the time it is ready for activation. In some animals, such as the sea urchins, the eggs are not ready for activation (either fertilization or artificial parthenogenesis) until they have extruded both polar bodies, thus completing the meiotic divisions. In fact they are not shed from the ovaries until they have attained that stage Eggs of other animals, such as Urechis, are ready for activation at a stage considerably earlier than the first polar division. In Urechis, after activation by brief treatment with hypotonic sea water or with dilute ammonia, many of the eggs fail to extrude the polar bodies and the presumptive first polar spindle becomes the first cleavage spindle. The two cells resulting from this first division each have the diploid chromosome number. Successive divisions occur mitotically, thus retaining the diploid number in all of the cells of the embryo.

Another type of behaviour is exhibited by eggs of Urechis that have been given a somewhat prolonged treatment with dilute ammonia. In these, the first or both the first and second meiotic divisions occur submerged within the egg, and the corresponding polar bodies fail to be extruded. The egg nucleus then unites with one, two or three polar-body nuclei, depending upon how many have been left within the egg. Fusion with one polar-body nucleus provides a diploid nucleus for the first cleavage which divides the egg into two cells, and the succeeding ordinary mitotic divisions would maintain the diploid condition.

Another type of regulation to diploidy has been discovered in the frog. In this species the eggs have completed only the first meiotic division when they are ready for fertilization or artificial activation. Upon artificial activation by means of the puncture method, the great majority of the eggs complete their second meiotic division normally, and about 1% of them undergo cleavage and early development. Most of these cleave at the regular time and develop as haploids. but some exhibit a delay in cleavage and develop as diploids. The delay generally occurs at the first cleavage, and during this time an extra division of the chromosomes (without cytoplasmic division) occurs, thus providing the diploid number of chromosomes for the cells of the embryo and adult.

A few diploids have also been obtained from eggs that exhibited no delay in cleavage but have evidently been regulated by means of one of the mechanisms described above for *Urechis*. In the silkworm moth it has been found that regulation to diploidy can occur by doubling of the chromosomes at the first cleavage or at a later division stage, or by elimination of the reduction division, depending upon the method of artificial activation employed.

Sex. — The sex of individuals obtained by artificial activation will depend upon the behaviour of the chromosomes, since they are known to carry the primary sex-determining factors. Maleness or femaleness is determined by the ratio of the number of sex chromosomes to the number of sets of autosomes (see HEREDITY). Most species of animals, including man, belong to the so-called male-digametic type in which the somatic cells of the males of the species have a single sex chromosome (X) and a diploid set of autosomes (2A) and the females have 2X + 2A. Birds. butterflies and moths and some fish belong to the female-digametic type in which the somatic cells of the females have a single sex chromosome (termed Z in this type), the chromosome constitution being

Z + 2A for the female and 2Z + 2A for the male.

Animals of the male-digametic type produce only one kind of egg and these have the haploid chromosome constitution X + A. Cpon artificial activation and regulation to diploidy the constitution would be 2X + 2A, which is that of the female. In animals of this type, then, it is to be expected that only females would be obtained from eggs that have been activated artificially. In accord with this, all the rabbits and most of the frogs raised to the stage at which their sex could be identified have been found to be female. The few male frogs were obtained presumably as a result of overripeness of the eggs or sex-chromosome elimination.

Animals of the female-digametic type produce two kinds of eggs, one with and one without the Z chromosome. The former, upon regulation to diploidy by doubling of the chromosome number, would give a male (22 + 2X) and the latter would give a "hyper-female" (0 + 2A) which is a type that does not ordinarily develop very far. If the regulation to diploidy is accomplished by fusion of the egg nucleus with a polar-body nucleus, females as well as males would be expected. depending upon the constitution of the nuclei involved. Extensive investigations have been made with eggs of the silkworm moth (which belongs to the female-digametic type) and these have shown the occurrence of both males and females, the, results depending upon the method of activation employed and consequent method of regulation to diploidy.

Thus, it may be seen that, in most species of animals, artificial parthenogenesis would produce only females while in a relatively few species both sexes would be obtained.

General Significance. — The experiments on artificial parthenogenesis have removed one mystical element from the problem of the initiation of development of the egg by showing that, in many cases? relatively simple chemical or physical agents can be employed in place of the complex living spermatozoon. Stimulation of the egg cell is thus analogous to the stimulation of nerve, muscle or gland cells which are known to respond to a variety of nonspecific agents. Various theories have been advanced to explain cell stimulation in general as well as artificial activation of eggs, but up to the 1960s there had been no satisfactory solution. One theory, proposed independently by investigators at Brussels and at Philadelphia. emphasized the role of calcium ions. the presence of which is shown to be important to obtain activation by various agents.

Special interest centres around the origin of the spindle and amphiaster ahich comprise the essential mechanism for cell division *(see* CYTOLOGY). In fertilization the amphiaster for the first cleavage arises from the sperm aster which forms around the central body (centriole or centrosome) brought in by the middle piece of the spermatozoon. In artificial parthenogenesis it has been found that the original central body of the egg takes over this function in some species of animals, while in other species new central bodies (and asters) are brought into existence as a result of the treatment. The latter has been shown especially in experiments on parthenogenetic merogony. Since the central bodies are known to be of the same nature as chromosomal material, these experiments have indicated the possibility of a de *novo* formation of self-producing bodies, perhaps genes, from cytoplasmic materials in the absence of a nucleus.

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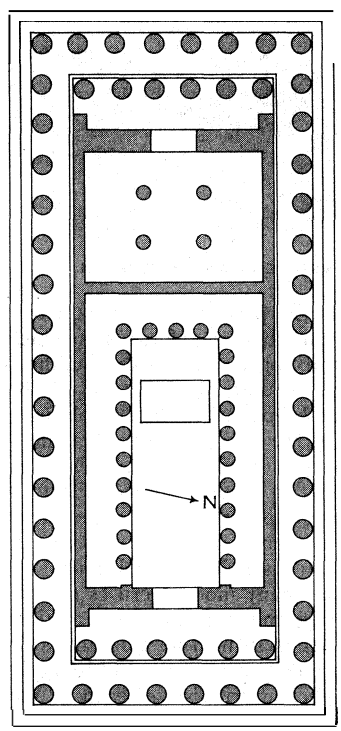
PARTHENON, the name generally given, since the 4th century B.C., to the chief temple of Xthena on the Acropolis at Athens. The name is applied in the official inventories of the jth and early 4th centuries to one compartment of the temple, and this was probably its original meaning. It is certainly to be associated with the cult of Athena Parthenos. "the Virgin."

History. — The most convenient position for a temple upon the rock platform of the Acropolis was occupied by the early temple of Athena. When, after Marathon. it was decided to supersede this by a more magnificent temple. it was necessary to provide a new site by means of a great substructure, nhich on its south side reaches down 40 ft. to the rock. The extant example is the chief among the buildings with which Pericles adorned the Acropolis. Ictinus and Callicrates were architects under the general supervision of the sculptor. Phidias. Work began in 447 B.C., though the decision to build was made ten years earlier. Structurally completed by 438 B.C., when the gold and ivory statue of Athena was dedicated, the work on the carvings and decoration continued to 432 B.C.

Save for repairs to the roof and interior after a fire in the 2nd century AD.. the Parthenon remained essentially intact until the 5th century. when the colossal statue was removed and the temple transformed into a church dedicated to Sta. Sophia (the Holy Wisdom).

In AD 662 it was dedicated to the Virgin Mother of God. The adaptation of the building, as a church involved the alteration of the inner columns and the roof. the construction of an apse at the east end. the opening of doors between the cella and the chamber to the west and the cutting of windows in the upper part of the cella wall. The Turks, after the capture of Athens in 1458, transformed the Parthenon into a mosque without material change save for carrying up a campanile, built in the southwest angle to form a minaret. In this state it was described by Spon and Wheler in 1676 and the sculpture drawn by the artist Carrey. for the marquis de Nointel, in 1674. In the same year the building was visited by Francis Vernon, who left valuable, unpublished notes. A powder magazine located in the building blew up in the bombardment of the Acropolis (1687) by the Venetian general, Morosini, and the middle of the temple was ruined. Further damage was done to the sculptures by Morosini's attempt to remove the horses of Athena from the west pediment.

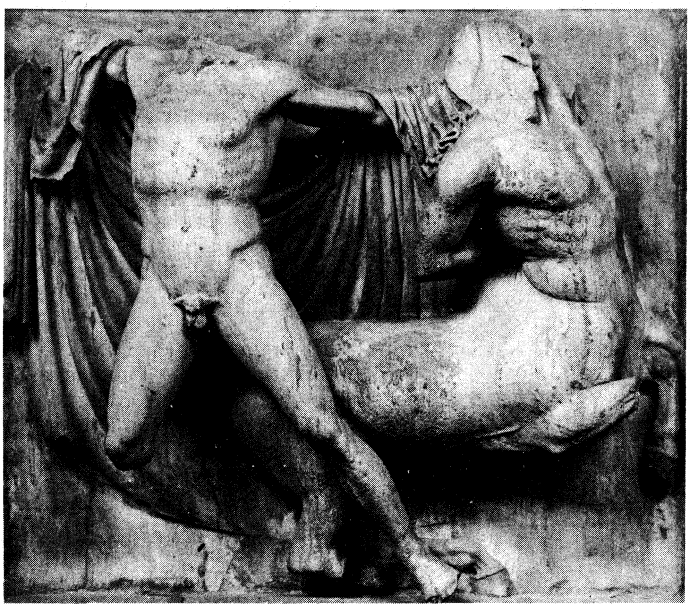


FROM W B DINSMOOR S THE ARCHITECTURE OF ANCIENT GREECE (1950)

PLAN OF THE PARTHENON

A small mosque was built in the ruins, but nothing further of interest is recorded until the visit of James Stuart (1751–53) and Nicholas Revett (1751–54, 1765–66), to whom we ome the best drawings of the sculptures that remained They were removed in 1801–03 by Lord Elgin, on the authority of a firman, and subsequently sold in 1816 to the British museum Certain other sculptures from the Parthenon are in the Louvre, in Copenhagen and elsewhere; many are still in Athens.

Description. — The temple designed by Ictinus measured 101.34 by 228 14 ft. on the stylobate (thus about 1 j ft shorter and about 6 ft. wider than its incompleted predecessor), and had a peripteron of 8 by 17 columns. The cella, known as the hecatompedon naos, a name inherited from the archaic Hecatompedon, was divided into three aisles by two-story Doric colonnades, returned at the west end just behind the great cult statue. The only light came through the east doorway, and possibly filtered through marble tiles in the roof and ceiling. Behind the cella, but not connected with it, was a square chamber. officially called the Parthenon, entered from the west. The prodomos (*i.e* , the space before the entrance of the cella) and opisthodomos (*i.e.*, the room at the rear of the cella), each faced by a portico of six columns, were enclosed by bronze gratings fixed between the columns. and were thus adapted to contain valuable offerings and other treasures. There are inventories on marble of the contents of these four compartments of the temple The opisthodomos, especially, would seem to have served as a treasury.



BY COURTESY OF THE BRITISH MUSEUM

LAPITH AND CENTAUR FROM A METOPE OF THE PARTHENON

The Parthenon, which represents the peak of the Greek Doric order, embodies an extraordinary number of refinements which combine to give a plastic, sculptural appearance to the building. Among these may be mentioned: the upward curvature of the stylobate along the ends and sides and repeated in the entablature; the inward inclination of the axes of the columns, with their delicate, curving entasis as they diminish in diameter toward the top; the thickening of the angle columns to counteract the effect of being seen at certain angles against the sky; and the fact that scarcely a surface of the building is truly vertical, but sets in or out to give definition under simultaneous lighting conditions.

The perfection and detail have led many modern critics to propose various and often fantastic geometrical or mathematical systems of related sizes that could thus furnish an infallible rule of beauty. That so many different ones have been found to apply within relatively narrow limits is sufficient criticism of each. *(See* also ERECHTHEUM; GREEK ARCHITECTURE; ORDER; TEMPLE.)

Sculpture.——Over the outer colonnade the metopes, carved in high relief, represented: on the east. the battle of gods and giants; on the south. Greeks and centaurs; on the west, probably Greeks and Amazons. Those on the north are almost lost. The continuous frieze around the top of the cella wall and above the hexastyle porticoes is one of several features that show the popularity of Ionic motifs in 5th-century Athens. It represents. in low relief, the Panathenaic procession, culminating on the east side. where two groups of seated gods flank a central panel in which appear the priest and priestess of Athena with three young attendants, to one of whom the priest confides a folded peplos. In the procession are! successively, the horsemen, chariot groups, citizens and offering bearers, the sacrificial sheep and cows and, lastly, the maidens of Athens, who appear in either flank of the eastern part of the frieze. The pediment groups, carved in the round. show. on the east, the birth of Athena, and on the west, her contest with Poseidon for the land of Attica. The entire work is a marvel of composition and clarity, which was further enhanced by colour and bronze accessories. Traces of colour are recorded in the frieze, and many details were added in bronze. The gold and ivory Athena, in the interior of the cella, was a masterpiece of Phidias. The goddess stood fully armed, with a Victory held in her right hand. Pausanias, a Roman traveler of the 2nd century A.D., has left us a very full description, and the general aspect of the statue is known through several small-scale. inferior Roman copies. On the pedestal of the image was a representation of the birth of Pandora.

The original was removed, possibly to Constantinople, in the jth century A.D., when the Parthenon was made into a church. *See* also GREEK ART. (R. SL.)

FEDERICO ARBORIO MELLA

PARTHENON (447–432 B.C.) AS SEEN FROM THE NORTHWEST. DESIGNED BY THE ARCHITECTS ICTINUS AND CALLICRATES. IT REPRESENTS THE PEAK OF THE DORIC ORDER IN GREEK ARCHITECTURE

PARTHIA, the mountainous country south-east of the Caspian sea, which extends from the Elburz chain eastwards towards Herat, and is bounded on the north by the fertile plain of Hyrcania (about Astrabad) at the foot of the mountains in the corner of the Caspian and by the Turanian desert; on the south by the great salt desert of central Iran. It corresponds to the modern Rhorasan. It was inhabited by an Iranian tribe, the Parthava of the inscriptions of Darius; the correct Greek form is Παρθναῖοι. Parthia became a province of the Achaemenian and then of the Macedonian empire. Seleucus I. and Antiochus I. founded Greek towns: Soteira, Charis, Achaea, Calliope (Appian, Syr. 57; Plin. vi. 15; cf. Strabo xi. 516); the capital of Parthia, the ruins of which are around the present town Damghan, is known only by its Greek name Hecatompylos ("The Hundred-gated"), from the many roads which met there (Polyb. x. 28), and was, according to Appian, founded by Seleucus I. (cf. Curtius vii. 2). In 208 many Greek inhabitants are found in the towns of Parthia and Hyrcania (Polyb. x. 31, 11).

When about 255 B.C. Diodotus had made himself king of Bactria (*q.v.*), and tried to expand his dominions, the chieftain of a tribe of Iranian nomads (Dahan Scyths) east of the Caspian, the Parni or Aparni, who bore the Persian name Arsaces, fled before him into Parthia.[1] Here the satrap Andragoras appears to have shaken off the Seleucid supremacy, as he struck gold and silver coins in his own name, on which he wears the diadem, although not the royal title (Gardner, *Numism. Chronicle,* 1879–81). He was slain by Arsaces (Justin xli. 4), who occupied Parthia and became the founder of the Parthian kingdom (248 B.C.). The origin and early history of the Parthian kingdom, of which we possess only very scanty information, is surrounded by fabulous legends, narrated by Arrian in his Parthica (preserved in Photius, cod. 58, and Syncellus, p. j39 seq.). Arsaces ruled for many years. The troubles of the Seleucid empire, and the war of Seleucus II. against Ptolemy III. and his own brother Antiochus Hierax, enabled him not only to maintain himself in Parthia, but also to conquer Hyrcania; but he was constantly threatened by Diodotus of Bactria (Justin xli. 4). When, about 238 B.C., Seleucus II. was able to march into the east, Arsaces fled to the nomadic tribe of the Apasiacae (Strabo xi. 513; cf. Polyb. x. 48). But Seleucus was soon recalled by a rebellion in Syria, and when Diodotus died, Arsaces returned victorious to Parthia; "the day of this victory is celebrated by the Parthians as the beginning of their independence" (Justin xli. 4). Arsaces was proclaimed king at Asaak in the district of Astauene, now Kuchan,

[1] Strabo xi. 515; *cf.* Justin xli. 4; the Parni are said by Strabo (ibid.) to have immigrated from southern Russia, a tradition wrongly transferred to the Parthians themselves by Justin xli. 1, and Arrian *ap.* Phot. cod. 58.

in the upper Atrek (Attruck) valley (Isidor. Charac.), and built his residence Dara on a rock in a fertile valley in Apavarktikene (Justin xli, 5; Plin. vi, 46), now Kelat still farther eastward; the centre of his power evidently lay on the borders of eastern Khorasan and the Turanian desert. The principal institutions of the Parthian kingdom were created by him (*cf.* Justin xli, 2). The Scythian nomads became the ruling race; they were invested with large landed property, and formed the council of the king, who appointed the successor. They were archers fighting on horseback, and in their cavalry consisted the strength of the Parthian army; the infantry were mostly slaves, bought and trained ior military service, like the janissaries and mamelukes. But these Scythians soon amalgamated with the Parthian peasants. They adopted the Iranian religion of Zoroaster, and "their language was a mixture of Scythian and Median" (*i.e.*, Iranian). Therefore their language and writing are called by the later Persians ("Pehlevi"), *i.e.*, Parthian (Pehlevi is the modern iorm of Parthawa) and the magnates themselves Pehlevans; *i.e.*, "Parthian~," a term transferred by Firdousi to the heroes of the old Iranian legend. But the Arsacid kingdom never was a truly national State; with the Scythian and Parthian elements were united some elements of Greek civilization.

To Arsaces I probably belong the earliest Parthian coins; the oldest simply bear the name Arsaces; others. evidently struck after the coronation in Asaak, have the royal title (βασιλέως Ἀρσάκου). The reverse shows the seated archer, or occasionally an elephant; the head of the king is beardless and wears a helmet and a diadem; only from the third or fourth king do they begin to wear a beard after the Iranian fashion.

Of the successors of Arsaces I very little is known. His son, Arsaces II, was attacked by Antiochus III, the Great, in 209, who conquered the Parthian and Hyrcanian towns but at last granted a peace. The next king, whom Justin calls Priapatius, ruled 15 years (about 190–175); his successor, Phraates I, subjected the mountainous tribe of the Mardi (in the Elburz). He died early, and was succeeded not by one of his sons but by his brother, Mithridates I, who became the founder of the Parthian empire. Mithridates I (c. 170–138) had to fight hard with the Greeks of Bactria, especially with Eucratides (*q.v.*); at last he was able to conquer a great part of eastern Iran. Soon after the death of Antiochus IV Epiphanes (163) he conquered Media, where he refounded the town of Rhagae (Rai near Teheran) under the name of Arsacia; and about 141 he invaded Babylonia. He and his son Phraates II defeated the attempts of Demetrius II (139) and Antiochus VII (129) to regain the eastern provinces, and extended the Arsacid dominion to the Euphrates.

For the later history of the Parthian empire reference should be made to PERSIA: History, and biographical articles on the kings. The following is a list of the kings, as far as it is possible to establish their succession. The names of pretenders not generally acknowledged are put in brackets: —

Arsaces I . . . . 248–*c.* 211 (perhaps Tiridates I.)	(Tiridates III . . . 36)
Arsaces II . . . c. 211–190	(Cinnamus . . . . 38)
Priapatius . . . c. 190–175	(Vardanes I . . . . 40–45)
Phraates I . . . c. 175–170	Gotarzes 40–51
Mithridates I . . . *c.* 170–138	Vonones 11 51
Phraates II . . . c. 138–127	Vologaeses I 51–77
Artabanus I . . . c. 127–124	(Vardanes II . . . . 55)
Mithridates II the Great . . . . c. 124–88*	Vologaeses II 77–79; 111–147
Sanatruces I 76–70	Pacorus 78–*c.* 105
Phraates III 70–57	(Artabanus III . . . 80–81)
Orodes I 57–37	Osroes 106–120
(Mithridates III .. . . 57–54)	(Mithridates IV and his son Sanatruces II, 115; Parthamaspates. 116–117; and other pretenders.)
Phraates IV 37–2	Mithridates V . . c. 129–147
(Tiridates II . . 32–31 and 26)	Vologaeses III . . 147–191
Phraates V (Phraataces) . . . 2 B.C.–A.D. 5	Vologaeses IV . . 191–209
Orodes II . . . . A.D. 5–7	(Vologaeses V . . 209–*c.* 222)
Vonones I 8–11	Artabanus IV . . . 209–227
Artabanus II . . . c. 10–40	

*The names of the following kings are not known; that one of them was called Artabanus II is quite conjectural.

BIBLIOGRAPHY.—Persian tradition knows very little about the Arsacids, who by it are called Ashkanians (from Ashak, the modern form of Arsaces). Of modern works on the history of the Parthians (besides the numismatic literature), the most important are: G. Rawlinson, *The Sixth Oriental Monarchy* (1873), and A. von Gutschmid, *Geschichte Irans und seine Nachbarländer von Alexander d. Gr. bis zum Untergang der Arsaciden* (1888). The principal works on the Arsacid coinage are (after the earlier pub. of Longpérier Prokesch-Ostan, etc.): Percy Gardner, *The Parthian Coinage* (1877), and esp. W. Wroth, *Catalogue of the Coins of Parthia* in British Museum (1903), who revised the statcmcnts of his predecessors. *Cf.* also Petrowicz *Arsacidenmünzen* (Vienna, 1904), and Allotte de la Fuye, "Classement des monnaies arsacides," in *Revue numismatique,* 4 *série,* vol. viii, 1904. (ED. M.)

PARTICLES, ELEMENTARY. Elementary particles are the fundamental constituents of matter and energy. As might be expected from this definition, there has been a considerable change in the notion of an elementary particle as knowledge has grown. Before the discoveries of the late 19th and early 20th centuries, atoms could be and sometimes were regarded as elementary particles. The discovery of the electron and the structure of atoms led to a complete transformation of this view. In the half century following Ernest Rutherford's discovery (1911) of the existence of atomic nuclei, ideas about elementary particles changed even more radically. Good evidence was found for the existence of more than 20 distinct elementary particles, and the quantum theory suggested new ways of describing them quantitatively. The significance of current ideas on the subject is best appreciated in the light of the historical development which this article reviews. See the articles ATOM; ELECTRON; NUCLEUS; QUANTUM MECHANICS; and SPECTROSCOPY for detailed accounts of the structure of atoms and nuclei, matters which will only be mentioned here.

Negative Electrons, Photons and Protons. — By the early 1920s the following account of the structure of matter was current: matter is made of atoms. An atom consists of a positively charged nucleus with a cloud of negative electrons around it. The electron cloud is capable of existing in various states, and transitions between these states are accompanied by the emission or absorption of photons (γ), the elementary quanta of electromagnetic radiation. The nucleus consists of electrons (e) and protons (p) held together by unknown forces. This physical picture was not supported by a systematic quantitative theory, but the behaviour of the electron clouds could be semiquantitatively described by a combination of the classical theory of electricity and magnetism with the quantization rules of Albert Einstein and Niels Bohr.

A far-reaching improvement in the theoretical situation resulted from discovery of the true quantum mechanics in 1926. Once the quantum mechanics of the electromagnetic field had been worked out (Paul Dirac, 1927) a quantitative theory of photon emission and absorption could be given, and it agreed very well with experiment. The first application of quantum mechanics to the atomic nucleus, the theory of α radioactivity (G. Gamow, R. Gurney and E. Condon, 1928), was also quite successful (see RADIOACTIVITY, NATCRAL). These results were not inconsistent with the idea that electrons and protons could not be created or destroyed but could be bound together by electrical forces. as in atoms, or by some other forces, as in the nucleus. However. there were at least three indications that such a picture is incomplete, and each of these led to a decisive advance in understanding.

First of all, there was the problem of N^{14}, the nitrogen isotope of mass number 14. According to the ideas of nuclear structure already described, this nucleus should contain 14 protons and 7 electrons, an odd number of particles. R. Kronig (1928) predicted from this a set of states for the nitrogen molecule which turned out to be in disagreement with experiment: an even number of particles in the nucleus seemed to be required. Second. there was a puzzling phenomenon in β radioactivity. Experiments showed that when an α particle is emitted from a radioactive nucleus, it has an energy which is the difference between the energies of the final and initial states of the nucleus. On the other hand, when β particles are emitted, they may have any energy less than the energy difference between the initial and final states of the nucleus. Apparently, energy is not conserved. The third indication was a theoretical paradox. The first quantum-mechanical theory of the electron was nonrelativistic and did not take into account effects of the finite propagation velocity of light. In 1928 Dirac introduced a relativistic theory of the electron which was

successful in accounting for the spin of the electron and for the fine structure of the energy levels of hydrogen. Unfortunately, this theory also predicted the existence of states whose properties did not make sense, the so-called negative energy states. All attempts to amputate these negative energy states from the theory proved unsatisfactory.

Neutrons, Neutrinos and Positrons. — The difficulty concerning N^{14} vanished with J. Chadwick's discovery (1932) of the neutron (n). A new picture of nuclear structure developed in which a nucleus of mass number A is conceived of as a system of A nucleons, nucleon being a generic term used to describe neutrons and protons. In particular, N^{14} contains seven neutrons and seven protons, in agreement with the analysis of the light emitted by N^{14} molecules. (See MOLECULAR SPECTRA; NEUTRON.)

To explain the apparent disappearance of energy in the β decay of nuclei, W. Pauli proposed (1931) the hypothesis that a neutral particle of small mass (usually taken to be zero) is emitted which carries off the missing energy. This particle, later named the neutrino (ν), is quite difficult to detect because its interaction with matter is so weak. For a long time the main evidence for the existence of the neutrino was indirect. (Enrico Fermi's successful theory of β radioactivity [1934] is a quantitative formulation of the neutrino hypothesis. In it, a neutron can transform into a proton while emitting an electron and a neutrino.) Experiments showed that the missing energy E was accompanied by a missing momentum p. To within experimental error these quantities satisfied the equation $E = cp$, where c is the velocity of light. This is the relation expected according to the theory of relativity for a particle of rest mass zero. The first experiment in which a neutrino beam produced an observable effect was reported by F. Reines and C. Cowan in 1956.

The third difficulty, that of the superfluous negative energy states in the Dirac theory, had a more involved history. In 1930 Dirac made a bold proposal to put the negative energy states to good use to explain the existence of the proton. He noted that the Pauli exclusion principle (see QUANTUM MECHANICS: Electron Spin) forbids two electrons from occupying the same state. He then made the hypothesis that in *vacuo* all the negative energy states predicted by his theory are occupied by electrons but that the resulting charge distribution is unobservable. Thus a positive-energy electron (e^-) moving in the vacuum cannot jump into a negative energy state with the emission of a photon because there is no negative energy state which is not occupied. Furthermore, the removal of an electron from a negative energy state would result in an observable "hole" Dirac showed that a hole would behave like a normal positive-energy particle of opposite charge (e^+). However, his initial proposal to interpret the proton as this hole turned out to be unsatisfactory for two reasons. First, it was found that a hole in the sea of negative-energy electrons would have to have the same mass as an ordinary electron, in disagreement with the observation that protons are 1.836 times heavier than electrons. Second, the hydrogen atom formed of an electron and a hole would annihilate itself in a small fraction of a second, leaving nothing but photons. In 1931 Dirac concluded that if holes existed, they would describe a new positive particle.

About a year later the positive electron was discovered by C. D. Anderson and was named the positron. (A later proposal of using the word "electron" as a generic term for positive and negative electrons and "negaton" and "positon" for the individual particles has not gained wide acceptance among physicists; therefore, the standard ambiguous usage in which electron is sometimes the generic term and sometimes means the negative electron is followed in this article.) Dirac's prediction was certainly one of the most spectacular achievements of theoretical physics, being comparable with Hideki Yukawa's prediction of the existence of the meson, which is described later.

Quantum Field Theory. — It was later shown that Dirac's hole theory is essentially equivalent to a theory in which electrons and positrons appear symmetrically with positive energies only. so that there is no unobservable sea of negative-energy electron states. The natural language for such a description was that of the quantum theory of fields. Indeed, the same remark applies to Fermi's theory of β disintegration, which described the interaction of nucleons, electrons and neutrinos also in terms of fields.

The notion of particle has such a different status in the relativistic quantum theory of fields and in the nonrelativistic theory of particles that it deserves an explicit discussion, even though it must be somewhat oversimplified. The main idea of field theory is that all particles of the theory appear as the quanta of some field. For example, photons are the particles associated with the electromagnetic field, while electrons and positrons are the quanta of a Dirac field. This appears to be a perfectly innocent requirement devoid of physical consequences, and indeed it is, until the additional requirement that the theory be relativistically invariant according to the special theory of relativity is introduced. Then the remarkable result is found that if the particles are to interact at all it must also be possible for them to be created and annihilated. Thus, if electrons and photons are to be described by a relativistic field theory and interact at all, electron pair creation and annihilation must be possible. The fact that particle creation and annihilation necessarily takes place in such a theory makes the definition of an elementary particle essentially more difficult. Even if in a given physical situation no actual particle creation is possible without violation of the laws of conservation of energy and momentum, nevertheless the interaction responsible for pair creation and annihilation has indirect effects, the so-called "virtual" creation and annihilation processes. For example, in such a theory a single electron moving through the vacuum polarizes it, and thus the electron may be thought of as surrounded by a cloud of virtual photons and pairs. Under such circumstances there are at least two possible ways (and actually many more) to define an electron: with its cloud (the dressed electron) or without (the bare electron). The situation is even more complicated in Fermi's theory of β decay, where a proton has to be considered as sometimes existing as a neutron plus a positron plus a neutrino.

Antineutrinos.—There is one additional feature of Fermi's theory which deserves mention, viz., the antineutrino ($\bar{\nu}$). Fermi developed his theory in strict analogy with electrodynamics so that he had as particles, neutrinos, and as antiparticles, antineutrinos, just as in electrodynamics there are as particles, electrons, and as antiparticles, positrons. E. Majorana in 1937 showed that this was not necessary and that a theory of β decay could be made in which the neutrino was identical with its own antiparticle, as is the photon in electrodynamics. Although at first sight it might seem difficult to distinguish between these two theories, a distinction is (in principle) possible as follows: In the theory involving antineutrinos the existence of the decay $n + p + e^- + \nu$ implies that $\bar{\nu} + n \rightarrow p + e^-$ is possible, but not necessarily that $\nu + n \rightarrow p + e^-$ is possible, while in the Majorana theory the first decay implies the second and third since ν is the same as $\bar{\nu}$ in the Majorana theory.

Experimental and theoretical developments in the late 1950s led to great progress in understanding the neutrino and the antineutrino. (There were certain changes in notation as well. It had become standard practice to call the particle emitted in neutron decay an antineutrino: $n \rightarrow p + e^- + \bar{\nu}$. This is a matter of convention.) R. Davis showed that the antineutrinos produced in nuclear reactors do not cause radioactivity in Cl^{37}. This was interpreted to mean that there is indeed a neutrino as well as an antineutrino. Furthermore, it turned out that antineutrinos always have their spins directed along their direction of motion, whereas the neutrino's spin is always opposite to its direction of motion (M. Goldhaber and co-workers and others). To describe this latter fact, a new theory, the so-called two-component theory, was devised (T. D. Lee and C. N. Yang, A. Salam and L. Landau).

Breakdown of Electrodynamics; Mesons. — In the preceding account of the properties of the quantum theory of fields, an important fact was ignored which had a strong influence on later developments, viz., the divergences. This refers to the infinite or ambiguous answers to some simple physical questions which can be obtained from the equations of the theory. In quantum electrodynamics, these difficulties were almost universally attributed to the physical assumption underlying the theory, viz., that

the electrons are point particles. It was well known that in the classical theory of electrons difficulties of a similar type occur and are overcome by attributing a spatial extension to the electron. In the classical theory, this spatial extension leads to modifications not only of the divergent quantities of the theory but also of the quantities for which the point-electron theory predicts finite answers. Similar effects were expected in the quantum theory. Thus, for example, a breakdown in the theory was expected in the description of the process in which an electron loses energy by the emission of photons in a collision with a nucleus. When, in the period between 1933 and 1936, preliminary evidence appeared of particles in cosmic rays, with anomalously high penetrating power, it was tempting to explain them as electrons whose energy was sufficiently high that the predictions of quantum electrodynamics break down. This explanation was short-lived because more detailed experiments showed that there were two groups of particles, one of which lost energy by radiation (as they should, according to the predictions of the quantum electrodynamics worked out by H. Bethe and W. Heitler in 1934), while particles in the other group were far more penetrating. By 1937, the conclusion was inescapable. S. Pieddermeyer, Anderson, J. Street and E. Stevenson announced the discovery of a new particle, first called a mesotron but later known as the meson, of mass several hundred times that of the electron. The laws of electrodynamics had not broken down in the anticipated way at all but rather in a different way: they did not predict the existence and production of mesons.

Unanticipated in electrodynamics, the discovery of the meson appeared to be a remarkable verification of ideas which Yukawa had put forward nearly three years before in an attempt to understand the origin of nuclear forces. (The term "nuclear forces" refers to those forces other than electrical forces which act between two nucleons [see NUCLEUS: *Nuclear* Structure and *Nuclear* Forces].) Yukawa's ideas were based on an instructive analogy with the theory of electrical forces which will now be explained. Coulomb's law of electrostatics states that the force which two charges e_1 and e_2 exert on one another when they are separated by a distance r_{12} is given by e_1e_2/r_{12}^2. There is an equally accurate, if somewhat less familiar, description of this force which attributes it to the exchange of photons between the two charges. The factor e_1e_2 in Coulomb's law then comes about because the ability of the first charge to emit and absorb photons is proportional to e_1 and that of the second charge is proportional to e_2. The factor $1/r_{12}^2$ proves to be a simple geometrical factor. Yukawa pointed out that if two particles, instead of emitting and absorbing massless photons, emitted and absorbed mesons of mass $m \neq 0$, then the only essential change in the results is the replacement of e_1, e, by g_1, g„ two numbers which are measures of the ability of the particles to emit and absorb mesons! and the appearance of a factor $\exp -r_{12}/(h/mc)$ in the force law, where $h = 1.06 \times 10^{-27}$ erg sec. is Planck's constant divided by 2π, and $c = 3.0 \times 10^{10}$ cm./sec. is the velocity of light. This latter factor is important because it makes the force fall off much faster with increasing r„. Stated briefly, the forces which would arise from the exchange of mesons of mass m have a range which is approximately h/mc, a length which is called the Compton wave length of the meson. For m of the order of magnitude of a few hundred electron masses, h/mc is of the order of magnitude of 10^{-13} cm., which is that observed for nuclear forces. Although it was difficult to build Yukawa's ideas into a quantitative theory of nuclear forces, the ideas were accepted almost universally as giving a qualitative account of these forces.

Yukawa also remarked that nuclear β radioactivity could be accounted for if the meson were unstable against decay into an electron and a neutrino. The β decay of the neutron is then a two-step process. The neutron first emits a negative meson and becomes a proton. Then, the negative meson decays into an electron and a neutrino. It was therefore a second success of the theory when in the late 1930s it was shown that mesons reaching sea level were less intense when they arrived at large angles with the vertical, even if the stopping effect of the atmosphere was taken into account. The phenomenon was interpreted as being a result of meson decay in flight from the region 50,000–100,000 ft. above sea level, where the mesons were presumably produced. The value of the half life of a meson derived from this experiment was a few millionths of a second.

The mesons introduced by Yukawa were positively or negatively charged and of spin zero. (According to quantum mechanics, an elementary particle can have an intrinsic angular momentum or spin which is in magnitude some integer or half-odd integer measured in units of h. Reference has been made to the spin of the electron, which is $\frac{1}{2}$. Neutrons and protons also have spin $\frac{1}{2}$, while photons have spin 1.) A theory which described the interaction of spin-zero particles with the electromagnetic field had already been published by Pauli and V. F. Weisskopf in 1934. The years between 1935 and World War II saw a turbulent development of meson theory for charged and neutral mesons of spin 1 and spin 0. Probably one of the most significant developments of the period was the development by N. Kemmer of the charge symmetrical theory. In this theory, the interaction of nucleons with charged mesons is so related to their interaction with neutral mesons that the resulting nuclear forces are the same between proton and proton, proton and neutron, and neutron and neutron. Such nuclear forces are referred to as charge independent, and subsequent developments confirmed the idea that charge independence is a basic symmetry property in nature.

The basic divergence difficulties referred to previously in connection with electrodynamics turned out to be even more acute in meson theory because the dimensionless number g^2/hc, which measures the strength of the meson-nucleon interaction, is much larger than the corresponding one in electrodynamics, e^2/hc, which is approximately $\frac{1}{137}$. (The constant g is called the coupling constant; it has the dimensions of electric charge and plays an important role in meson physics.) The simple approximation methods based on the smallness of e^2/hc could scarcely be expected to work in meson dynamics. Practically none of the quantitative calculations in meson theory undertaken during this period are of more than historical interest, since they were carried out in strict analogy to calculations in electrodynamics. On the other hand, the success of the electrodynamical calculations of the period deepened confidence in the essential validity of the theory. For example. J. Carlson and J. R. Oppenheimer and H. Bhabha and Heitler (1934) independently demonstrated how the cascade phenomenon of photons and electrons in cosmic rays could be interpreted as a chain of events in which high-energy photons make pairs and the electrons of the pairs make photons in colliding with nuclei.

The developments of this period illustrate a point which has not been emphasized in this summary account—the immensely fruitful connection between the theory of elementary particles and the study of cosmic-ray phenomena. In the mid-1950s there were only eight elementary particles known which had not been identified first in cosmic radiation (see COSMIC RAYS: *Particles Discovered in Secondary Rays*). However, it also became clear about that time that the giant particle accelerator would eventually replace the cosmic-ray beam except for studies of very high-energy events. Of course, the cosmic rays retain their astrophysical and cosmological interest.

Postwar **Developments; π and μ Mesons.**—At the end of World War II physicists returned with renewed vigour to the problems which had been left unsolved before the war. One of the first significant developments (an apparently stunning blow to the Yukawa theory of mesons) was the experiment of M. Conversi, E. Pancini and O. Piccioni on meson absorption (1947). According to Yukawa's theory, negative mesons stopped in ordinary solid materials would be absorbed very rapidly by nuclei long before they could decay. The Conversi–Pancini–Piccioni experiment showed that for a nucleus with about ten protons, decay and absorption were equally probable, a result disagreeing with the absorption rate calculated from Yukawa's theory by a factor of 10^{12}. Piumerous suggestions of varying plausibility were made to save the theory. The one which proved to be correct was the t o-meson hypothesis of R. E. Marshak (1947): the mesons observed at sea level were not Yukawa mesons but were weakly interacting

decay products of the true Yukawa particle, which is produced copiously in nucleon-nucleon collisions high in the atmosphere. Shortly thereafter C. Lattes and co-workers turned a plausible explanation into an important discovery by publishing pictures of positive particles (π^+ mesons) which decayed into one positive particle (μ^+ meson) and one neutral particle (v) according to the scheme $\pi^+ \rightarrow \mu^+ + \nu$. Later cloud-chamber experiments by a number of workers (see CLOUD CHAMBERS) showed that the μ^+ decays into an e^+ and two light neutral particles: $\mu^+ \rightarrow e^+ + \nu + \bar{\nu}$.

The discovery of the π^+ meson was made using a specially prepared photographic emulsion sensitive to the passage of charged particles. These so-called nuclear emulsions have proved to be one of the most powerful tools in the search for elementary particles. Their use has become a highly refined art (see COSMIC RAYS: Methods of Detection). Two important later innovations were electron-sensitive emulsions and stripped emulsions. Electron-sensitive emulsions are so sensitive that they record the tracks of all charged particles, even those of minimum ionization. The phrase "stripped emulsions" refers to a technique for exposing emulsion in a more or less solid block and then putting it in layers on glass backing for processing and study. The discovery of the π^+ and the μ^+ mesons was followed shortly by systematic studies of their negative counterparts. π^- and μ^-, by means of the nuclear disruptions or "stars" which they cause when absorbed in photographic emulsions.

In the decays of **a** and μ mesons (often called pions and muons), neutrinos have been indicated as the neutral reaction products. All that actually has been proved experimentally is that they are of small (but not necessarily zero) mass, zero charge and half-odd integer spin. It is mainly on the grounds of simplicity that they are regarded as neutrinos (or antineutrinos).

The decay of the μ meson into three particles naturally suggests a comparison with the neutron decay. A number of physicists explored the possibility that a theory analogbus to Fermi's theory of β decay could describe p-meson decay quantitively. They obtained the remarkable result that the basic rate constant (Fermi constant) is of the same order of magnitude as in nuclear β decay. The discussion of the reaction $\mu^- + p \rightarrow n + \nu$, which accounts for the absorption of μ^- mesons by nuclei, led to a similar conclusion. The equality of these three Fermi constants led to speculations about the possibility of a universal Fermi interaction between spin-$\frac{1}{2}$ particles. Ten years later (1956–58), after a series of spectacular experiments on p-meson decay and β decay, it became possible to single out a specific type of universal Fermi interaction which has thus far passed every experimental test (R. Marshak and E. C. G. Sudarshan, R. Feynman and M. Gell-Mann).

The successful operation of the synchro-cyclotron at Berkeley, Calif., in 1948 and of a number of other particle accelerators at other places in subsequent years made possible a variety of experiments with momentum-analyzed high-intensity beams of **a** mesons, of which only a few will be mentioned.

An analysis of the γ radiation from a cyclotron target led K. Björklund and collaborators in 1950 to the discovery of the π^0 meson. The γ radiation was interpreted as resulting from the decay $\pi^0 \rightarrow \gamma + \gamma$. The existence of such a process had been strongly indicated previously by cloud-chamber studies of cosmic rays.

Experiments on the absorption of π^- mesons in hydrogen led to a great deal of information about π^- and π^0 mesons. W. Panofsky and collaborators (1951) observed the reactions:

$$\begin{aligned} \pi^- + p &\rightarrow n + \gamma \\ \pi^- + p &\rightarrow n + \pi^0 \\ \pi^- + d &\rightarrow 2n \\ \pi^- + d &\rightarrow 2n + \gamma \end{aligned}$$

The second reaction gave a value of 10 electron masses for the π^-, π^0 mass difference. The third reaction showed that if the π^- meson has spin zero it is pseudoscalar. (In explanation of this last term: there are two kinds of spin-zero mesons, which differ in their transformation properties under inversion of all space co-ordinates. For one kind, the scalar, the third reaction is impossible for π^- mesons in the lowest orbit around a deuteron [d]. For the other kind, the pseudoscalar, the third reaction is possible.)

The spin of the π^+ meson was measured as zero by observing the rates of the inverse reactions $\pi^+ d \rightleftarrows p + p$ in experiments by D. Clark and co-workers and by R. Durbin and collaborators (1951).

Systematic measurements on the scattering of **a** mesons by nucleons were initiated by Fermi and associates, whose study of the angular distributions and total cross sections of the reactions

$$\begin{aligned} \pi^+ + p &\rightarrow \pi^+ + p \text{ (scattering)} \\ \pi^- + p &\rightarrow \pi^- + p \text{ (scattering)} \\ \pi^- + p &\rightarrow \pi^0 + n \text{ (charge-exchange scattering)} \end{aligned}$$

showed that there was a remarkable resonance in the positive-meson scattering and a lesser one in the negative-meson scattering.

The availability of data of this kind together with similar information on the reactions $\gamma + p \rightarrow n + \pi^+$ and $\gamma + p \rightarrow p + \pi^0$ furnished by workers at the California and Massachusetts institutes of technology, the University of Illinois and Cornell university led to a new era in meson theory. Heroic efforts were made to extract well-defined and physically sensible answers either from the relativistic theory or from models which embodied some essential features of the relativistic theory. The result was progress but not spectacular success. Part of the trouble could certainly be blamed on lack of progress in understanding the structure of the quantum field theory as later described. Possibly the most important result of the analysis was the support which it gave for the charge symmetrical theory already mentioned in connection with the charge independence of nuclear forces.

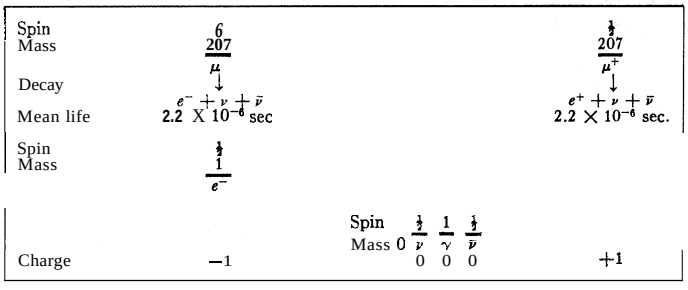


CHART 1.—MASS AND CHARGE SPECTRUM OF LIGHT PARTICLES
Masses are in units of the electron mass: m = 9.11 X 10^{-28} grams. Charges are in units of the electron charge: e = 1.60 X 10^{-20} electromagnetic units. Spins are in units of Planck's constant divided by 2π: h = 1.06 X 10^{-27} erg sec. Masses and mean lives have been rounded off. The light particles of spin ½, *i.e.*, all light particles except the photon, are called "leptons."

K Mesons, Hyperons **and** Antiprotons.— Even before the discovery of the **a** meson, isolated cloud-chamber photographs had been made which were best interpreted as showing particles distinct from those discussed so far. Two extremely clear events of this kind were found by G. Rochester and C. Butler in 1947. The pictured events were interpreted as the decays of two new particles, one neutral and one charged, which came to be known as V particles because of the characteristic appearance of their decays in a cloud chamber. Over a period of years further detailed studies. using both cloud chambers and photographic emulsions as particle detectors, showed that a number of different decay modes were involved. In some cases these modes were naturally ascribed to a single particle, in others they were not.

The new particles were divisible into two classes: the K mesons, whose mass is between that of the **a** meson and the proton; and the hyperons, whose mass is larger than that of the proton. In the first category are particles that undergo the following decays:

$$\begin{aligned} K^0 \text{ (or } \overline{K^0}) &\rightarrow \pi^+ + \pi^- \\ &\rightarrow \pi^0 + \pi^0 \\ &\rightarrow \pi^+ + \pi^- + \pi^0 \\ &\rightarrow \pi^0 + \pi^0 + \pi^0 \\ &\rightarrow e^\pm + \nu + \pi^\mp \\ &\rightarrow \mu^\pm + \nu + \pi^\mp \end{aligned} \qquad \begin{aligned} K^\pm &\rightarrow \pi^\pm + \pi^0 + \pi^0 \\ &\rightarrow \pi^\pm + \pi^+ + \pi^- \\ &\rightarrow \pi^\pm + \pi^0 \\ &\rightarrow \mu^\pm + \nu \\ &\rightarrow \mu^\pm + \pi^0 + \nu \\ &\rightarrow e^\pm + \pi^0 + \nu \end{aligned}$$

In the second category are the Λ^0, the $\Sigma^{\pm}$ and Σ^0, and the Ξ^- (the so-called "cascade" particle) and Ξ^0 hyperons, which decay as follows:

$$\Lambda^0 \rightarrow p + \pi^- \qquad \Sigma^- \rightarrow n + \pi^-$$
$$\Lambda^0 \rightarrow n + \pi^0 \qquad \Sigma^0 \rightarrow \Lambda^0 + \gamma$$
$$\Sigma^+ \rightarrow p + \pi^0 \qquad \Xi^- \rightarrow \Lambda^0 + \pi^-$$
$$\Sigma^+ \rightarrow n + \pi^+ \qquad \Xi^0 \rightarrow \Lambda^0 + \pi^0$$

An interesting and informative phenomenon connected with hyperons was discovered by M. Danysz and J. Pniewski (1953)—the hyperfragments. These objects are nuclei formed of nucleons together with a Λ^0 hyperon. The study of hyperfragments gives information not only on the spin of the Λ^0 hyperon and its interaction aith nucleons but also on the structure of nuclei.

The mean lives of the K mesons and hyperons described above range from about 10^{-8} sec. to 10^{-11} sec. Although these are very short times by the standards of everyday life they are exceedingly long by nuclear standards; for example, the compound system $\pi^+ + p$ which gives the resonance in the scattering of π^+ mesons by protons lasts about 10^{-23} sec. This relative stability of the K mesons and of the hyperons is one of the basic facts which any theory of elementary particles has to explain.

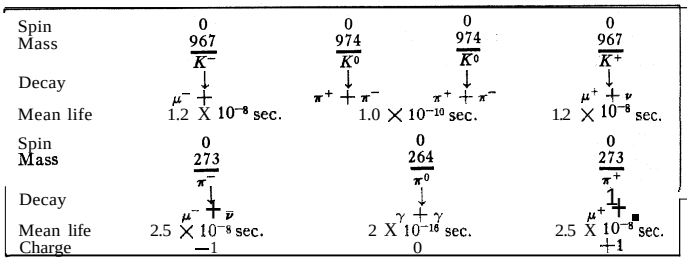


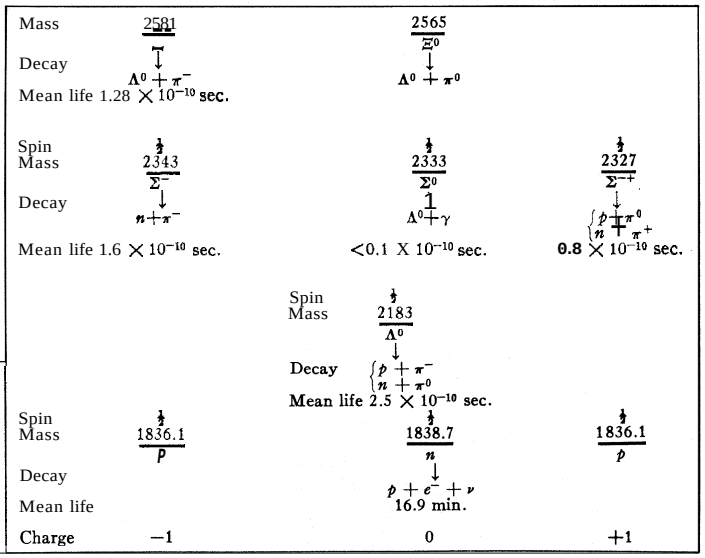
CHART 2.—MASS AND CHARGE SPECTRUM OF MESONS
Masses are in units of the electron mass Charges are in units of the electron charge. Masses and mean lives have been rounded off. The particles possess other modes of decay not listed.

The question of how many different K particles there are remained unanswered for a number of years. An analysis by R. Dalitz of the energy distribution of the π mesons appearing in the reaction $K^{\pm} \rightarrow \pi^{\pm} + \pi^+ + \pi^-$ indicated that a spin-zero pseudoscalar K gave the best fit. Experiments on neutral K decay showed that the reaction $K^{\pm} \rightarrow \pi^{\pm} + \pi^0$ occurs, which indicates that $K^{\pm}$ is not pseudoscalar. Nevertheless. the masses of the particles undergoing the decays seemed very close to the same. (This was referred to as the τ-θ puzzle, the three-pion mode of decay being denoted by τ and the two-pion mode being denoted by θ.) The solution to the difficulty mas suggested by Lee and Yang (1956). It had been assumed in the analysis of the decays that all the usual conservation laws of physics hold. Lee and Yang proposed that parity, the quantum number arising from the symmetry of the laws of nature under reflections. is not conserved in the reactions. They iurther suggested that similar failures in the law of parity conservation might take place in other weak interactions. such as nuclear β decay. Their proposal for a test of this idea in nuclear β decay was triumphantly verified by C. S. Wu and co-workers (1957). Other experiments (R. Garwin and coworkers, and J. Friedman and V. Telegdi) showed that parity is not conserved in μ-meson decay, and that the failure of the law of parity conservation is an essential feature of the weak interactions *(see* Table II). *(See* PARITY. LAW OF CONSERVATION OF.)

The study of K mesons and hyperons mas greatly aided by two research tools: accelerators capable of producing protons of energies in the range of billions of electron volts; and the bubble chamber *(see* ACCELERATORS, PARTICLE; BUBBLE CHAMBER).

Accelerators made available intense beams of the particles to be studied. In addition. the 6-Bev bevatron at the University of California at Berkeley made possible the discovery of the antiproton *(see* PROTON). In 1955 Emilio Segrè, Owen Chamberlain and co-workers published convincing evidence of the existence of that long-awaited elementary particle. The existence of the antiproton requires the existence of the antineutron and a whole tribe of antihyperons. It opened an entire new field for experiment.

The bubble chamber was invented by D. Glaser in 1952. It is a liquid-filled vessel which can be expanded periodically to the point where the liquid starts to boil. If a charged particle happens to pass through the liquid just as the boiling is about to begin. the bubbles form along the track of the particle. An advantage of the bubble chamber compared to the cloud chamber is that it contains much more matter for the same volume, therefore giving a much larger number of nuclear events per photograph.



CIIART 3.—MASS AND CHARGE SPECTRUM OF HEAVY PARTICLES (BARYONS)
Masses are in units of the electron mass. Charges are in units of the electron charge. Spins are in units of *h*. Masses and mean lives have been rounded off.
The principle of symmetry in particle and antiparticle, verified in the case of proton and antiproton, requires that each particle in the diagram have a corresponding antiparticle; *i.e.*, in addition to those particles shown the antineutron % the antilambda $\bar{\Lambda}^0$, the antisigmas $\bar{\Sigma}^+$, $\bar{\Sigma}^0$, $\bar{\Sigma}^-$ and the antixis $\bar{\Xi}^-$, $\bar{\Xi}^0$ must exist. All but the last had been produced in the laboratory by 1962.

Renormalization; Strangeness Quantum Number.—As mentioned in connection with the discovery of mesons, divergences can appear in the answers given by electrodynamics to very simple physical questions. In the late 1940s great progress in overcoming these difficulties was made by S. Tomonaga, J. Schwinger, R. Feynman. F. Dyson and others. Their contribution was twofold. First, they reworked the formalism of electrodynamics. using methods which made calculation and insight much easier. Second. they showed that the divergences appearing in physical quantities were all direct or indirect consequences of two fundamental divergences. those in the corrections to the mass and charge of the electron arising from its interaction with photons. If the corrected mass and charge were set equal to the observed mass and charge of the electron (a process called mass and charge renormalization), all answers to physical questions become finite.

Actually, much of this advance in theory was stimulated by two fundamental experimental discoveries: the anomalous gyromagnetic ratio of the electron and the Lamb shift. In experiments carried out in 1937. P. Kusch and H. Foley showed that the value of the electron's spin magnetic moment was not $eh/2mc$ (e is the charge on the electron, m is its mass: c is the velocity of light and h is Planck's constant divided by 2π) as was predicted by Dirac's 1928 theory of the electron but $eh/2mc$ $(1 + \epsilon)$, where ϵ is a very small but nonzero quantity. (The quantity $2[1 + \epsilon]$ is called the gyromagnetic ratio.) Later measurements gave $\epsilon = 0.001168 \pm 0.000005$. At about the same time, W. E. Lamb. Jr.. measured the position of the energy levels of hydrogen and found a shift from those predicted by Dirac's 1928 theory. It had been known from the 1930s that the hole theory predicted corrections to Dirac's original values for both these quantities, but, unfortunately, divergent ones. The existence of these experiments was an enormous incentive to make some sense out of the predictions of the theory. After this had been done in a more or less *ad hoc* way for these particular experiments, it was extended to the general theory described above. The detailed comparison

with experiment gave excellent agreement. For example

$$\epsilon = \frac{\alpha}{2\pi} - \frac{0.328\alpha^2}{\pi^2} = 0.0011596 \text{ where } \alpha = e^2/hc$$

(Schwinger, 1947; R. Karplus and N. Kroll, 1950; C. Sommerfield and A. Petermann, 1957).

The renormalization process was successfully extended from electrodynamics to meson theory by J. Ward, A. Salam and others (1951). They showed that renormalization of nucleon mass, meson mass, coupling constant (g) between nucleons and mesons, and a meson scattering constant would be sufficient to yield finite answers for all physical quantities. Unfortunately, it turned out that these results were of little practical value because the entire method was based on expansions of the quantities involved as a sum of terms proportional to the powers of g^2/hc; for the large value of g^2/hc necessary to describe π mesons it is doubtful whether the sum has a finite value. The situation is different in electrodynamics, where e^2/hc is small, and the first few terms are a good approximation.

The remarks of the preceding paragraph are indications of a general difficulty. The success of renormalization represented great progress in quantum field theory but it did not go far enough. It did not permit elimination of the manipulation of infinite quantities completely from physical calculations. In fact, it left open the question as to whether a quantum field theory could be formulated without any divergences at all. This lack of insight into the structure of quantum field theory is a serious block to all systematic progress in elementary-particle theory.

The nonexistence of a consistent relativistic language in which to express ideas about the interaction of elementary particles made attractive a phenomenological approach to elementary-particle theory. A striking success along this line was the introduction of a new quantum number, the strangeness, to explain the relative stability of hyperons and K mesons and related regularities. M. Gell-Mann. K. Nishijima and A. Pais were associated with these developments. The strangeness number is an integer — positive, negative or zero — associated with certain elementary particles according to Table I. The scheme assumes that neutral K mesons are associated in pairs with the $\overline{K^0}$ meson of strangeness -1 being the antiparticle of K^0, which is of strangeness $+1$.

TABLE I.—*Strangeness Quantum Numbers*

The assumption that strangeness is conserved implies that in a collision of two nucleons or a nucleon and a meson the strangeness of the K^+ and K^0 particles produced must balance with that of the particles of negative strangeness. For example, $\pi^- + p \rightarrow \Lambda^0 + K^0$ is possible but, $p + p \rightarrow \Sigma^+ + p$ is forbidden. Thus, only "associated" production of hyperons and K mesons is possible.

The strangeness-conservation law is not exact because K mesons and hyperons decay into particles of zero strangeness, but they do so at a rate characteristic of weak interactions. The classification of the interactions which so far have been found among the elementary particles is contained in Table II. (Isotopic-spin conservation is a formal expression of the hypothesis of charge independence already described.) No rational basis for this classification is known.

What **Is** an Elementary Particle? — The phenomena described in the preceding paragraphs are complex and full of interesting regularities but as of the early 1960s there was no satisfactory quantitative theory which made any pretense of connecting them in a fundamental way. The orthodox approach of introducing a field for each particle and coupling the fields together was unsatisfactory for two reasons. First, there were too many different particles and second, the divergences made it difficult to extract answers from such a theory. The first objection could be removed by attempting to derive all the different particles from one underlying field (Urmaterie) but the second objection prevented effective pursuit of such an idea. There were physicists who advocated abandoning the formalism of the quantum field theory altogether or at least altering it to enable incorporation of the notion of a fundamental length below which some essential restrictions on measurement held. Such speculations have not yet led to anything particularly significant.

TABLE 11.—*Validity of Conseraation Laws Under Various Types of Interaction*

Conservation Law	Interaction		
	Strong*	Electromagnetic	Weak†
Linear momentum, Angular momentum, Energy	Holds	Holds	Holds
Parity	Holds	Holds	Fails
Charge	Holds	Holds	Holds
Heavy particle number‡	Holds	Holds	Holds
Isotopic spin	Holds	Fails	Fails
Strangeness	Holds	Holds	Fails

*For example, pion-nucleon or nucleon-nucleon
†For example, K meson decay, hyperon decay and neutron β decay
‡(Number of nucleons + hyperons) — (number of antinucleons + antihyperons)

Another line of speculation about elementary particles started with general relativity and the theory of gravitation, subjects which have not been touched on here because no one has succeeded in connecting them with elementary particles.

What is an elementary particle? A provisional phenomenological answer is given by Charts 1. 2 and *3.* A more satisfactory and fundamental answer would be provided by a quantitative theory, which as yet does not exist.

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(A. S. WN.)

PARTNERSHIP, in general, the voluntary association of two or more persons for the purpose of gain, or sharing in the work and profits of any enterprise.

Though the English law of partnership is based upon Roman law, there are several matters in which the two systems differ: (1) There was no limit to the number of partners in Roman law. (2) In societas one partner could generally bind another only by express *mandatum;* one partner was not regarded as the implied agent of the others. *(3)* The debts of a *societas* were apparently joint, and not joint and several. (4) The heres of a deceased partner could not succeed to the rights of the deceased, even by express stipulation. There is no such disability in England. (5) In actions between partners in Roman law, the *beneficium competentiae* applied — that is, the privilege of being condemned only in such an amount as the partner could pay without being reduced to destitution. (6) A Roman partner could not retire in order to enjoy alone a gain which he knew was awaiting him.

Previous to the Partnership act of 1890 the English law of partnership was to be found only in legal decisions and in textbooks; the act came into operation on Jan. 1, 1891. With one important exception (s. 23), it applies to the whole Cnited Kingdom. It is not a complete code of partnership law; it contains no provisions regulating the administration of partnership assets in the event of death or bankruptcy, and is silent on the subject of goodwill. The existing rules of equity and common law continue in force, except so far as they are inconsistent with the express provisions of the act.

Nature **of** Partnership. — Partnership is defined to be the "relation which subsists between persons carrying on a business in common with a view of profit." Co-ownership of property does not of itself create a partnership, nor does the sharing of gross returns. The sharing of profits, though not of itself sufficient to create a partnership, is prima-facie evidence of one. Partners are called collectively a firm. Under English law the firm is not a corporation, nor is it recognized as distinct from the members composing it; any change among them destroys the identity of the

firm. In Scotland a firm is a legal person distinct from its members, but each partner can be compelled to pay its debt.

At common law there is no limit to the number of partners. but by the Companies act, 1862 (25 and 26 Vict.. c. 89, s. 4), not more than 10 persons can carry on the business of bankers, and not more than 20 any other business, unless (with some exceptions) they conform to the provisions of the act. *(See* COMPANY; CORPORATION; and also *Limited Partnerships* below.)

Relations of Partners to Persons Dealing With Them. — Every partner is an agent of the film and of his copartners for the purpose of the partnership business. The partners may, however, by agreement between themselves restrict the power of any of their number to bind the firm. If there be such an agreement, no act done in contravention of it is binding on the firm with respect to persons who have notice of the agreement.

A firm is liable for loss or injury caused to any person not a partner, or for any penalty incurred by any wrongful act or omission of a partner acting in the ordinary course of the partnership business, or with the authority of his copartners; the extent of the firm's liability is the same as that of the individual partner. The firm is also liable to make good the loss (1) where one partner, acting within his apparent authority, receives money or property of a third person and misapplies it; and (2) where a firm in the course of its business receives money or property of a third person, and such money or property while in the custody of the firm is misapplied by a partner.

The liability of partners for the debts and obligations of their firms arising *ex contractu* is joint, and in Scotland several also; the estate of a deceased partner is also severally liable in a due course of administration, but subject, in England or Ireland, to the prior payment of his separate debts. The liability of partners for the obligations of their firm arising *ex delicto* is joint and several. A partner who retires from a firm does not thereby cease to be liable for debts or obligations incurred before his retirement.

Relations of Partners to One Another. — The mutual rights and duties of partners depend upon the agreement between them. Many of these rights and duties are stated in the Partnership act but may be varied by the consent of all the partners. Subject to agreement. partners share equally in the capital and profits of their business, and must contribute equally to losses; they are entitled to be indemnified by their firm against liabilities incurred in the conduct of the business, and for anything done for its preservation; they are entitled to interest at 5% on their advances to the firm, but not on their capital. Every partner may take part in the management of the business, but without remuneration. The majority can bind the minority in ordinary matters connected with the partnership business, but cannot change its nature nor expel a partner, unless expressly authorized so to do. No partner may be introduced into the firm without the consent of all the partners. The partnership books must be kept at the principal place of business, open to every partner. Partners must render to each other true accounts and full information of all things affecting the partnership. A partner may not make private use of anything belonging to his firm nor may he compete with it.

Partners may agree what shall be partnership property, and can by agreement convert partnership property into the separate property of the individual partners, and vice versa. Subject to any such agreement, all property originally brought into the partnership stock, or acquired on account of the firm or for the purposes and in the course of its business, is declared by the act to be partnership property. Partnership property must be applied exclusively for partnership purposes. The legal estate in partnership land devolves according to the general law, but in trust for the persons interested therein.

When no fixed term has been agreed upon for the duration of the partnership, it is at will, and may be determined by notice at any time by any partner. If a partnership for a fixed term is continued after the term has expired without any express new agreement, the rights and duties of the partners remain as before, so far as they are consistent with a partnership at will.

A partner may assign his share in the partnership either absolutely or by way of mortgage. The assignee does not become a partner, but during the continuance of the partnership he has the right to receive the assignor's share of profits.

Since the act came into operation no writ of execution may issue in England or Ireland against any partnership property except on a judgment against the firm. If a judgment creditor of a partner wishes to enforce his judgment against that partner's share he must obtain an order of court. The court may appoint a receiver of the partner's share and may order it sold.

Dissolution of Partnership. — A partnership for a fixed term, or for a single adventure, is dissolved by the expiration of the term or the termination of the adventure. A partnership for an undefined time is dissolved by notice of dissolution at any time by any partner. The death or bankruptcy of any partner dissolves the partnership. If a partner suffers his share to be charged under the act for his separate debts, his partners may dissolve the partnership. A partnership is in every case dissolved by any event which makes the partnership or its business unlawful. The court may order a dissolution in cases when a partner is incapable of performing his duties as a partner or so conducts himself that it is not practicable for his partners to carry on business with him; when the partnership can only be carried on at a loss; and when a dissolution appears to be just and equitable. A dissolution usually is not complete as against persons who are not partners, until notice of it has been given. Notice is not necessary to protect the estate of a dead or bankrupt partner from partnership debts contracted after his death or bankruptcy; nor is notice necessary when a person not known to be a partner leaves a firm.

The act makes no mention of good will, but in the absence of special agreement, a seller may set up business in competition with the purchaser but may not represent himself as carrying on his former business. nor canvass his former customers. The purchaser may advertise himself as carrying on the former business, canvass its customers and trade under the old name. unless that name is or contains the name of the vendor, and the purchaser by using it without qualification would expose the vendor to the liability of being sued as a partner. If, on a dissolution or change in the constitution of a firm, the good will belongs exclusively to one or more of the partners, the partner so entitled has the rights of a seller.

If a partner ceases to be a member of a firm, and his former partners continue to carry on business with the partnership assets without any final settlement of accounts, he or his estate is, in the absence of agreement. entitled to such part of the subsequent profits as can be attributed to the use of his share or to interest at 5% on the amount of his share. If his former partners have an option to purchase his share, and exercise the option, he is not entitled to any further or other share in profits.

Limited Partnerships. — The Limited Partnership act, 1907, introduced the power to form limited partnerships; *i.e.*, a partnership consisting not only of general partners, but of others whose liability is limited to the amount contributed to the concern. Such a limited partnership must not consist, in the case of a partnership carrying on the business of banking, of more than 10 persons, and in the case of any other partnership of more than 20 persons. There must be one or more persons called general partners who are liable for all the debts and obligations of the firm, and limited partners, who on entering into partnership contribute a certain sum or property valued at a stated amount, beyond which they are not liable. Limited partners cannot withdraw or receive back any of their contributions; any withdrawal brings liability for the debts and obligations of the firm up to the amount withdrawn. A body corporate may be a limited partner. No limited partner can take part in the management of a partnership business; if he does so he becomes liable in the same way as a general partner. The law of private partnership applies to limited partners except where it is inconsistent with the express provisions of the Limited Partnership act.

Scots Law. — The law of Scotland as to partnership agrees in the main with the law of England, and the act of 1890 applies. The principal difference is that Scots law recognizes the firm as distinct from the individuals composing it. The name of the company may be either personal or descriptive. A firm with a

personal name may sue or be sued under that name, but a firm with a descriptive name may sue and be sued only with the addition of the names of three at least (if there are so many) of the partners. Heritable property cannot be held in the name of a firm; it can only stand in the name of individual partners. The law of Scotland draws a distinction between joint adventure and partnership. Joint adventure or joint trade is a partnership confined to a particular adventure or speculation, in which the partners, whether latent or unknown, use no firm or social name, and incur no responsibility beyond the limits of the adventure. In the rules applicable to cases of insolvency and bankruptcy of a company and partners a company can be made bankrupt without the partners being made so as individuals. And, when both company and partners are bankrupt, the company creditors are entitled to rank on the separate estates of the partners for the balance of their debts equally with the separate creditors. But in sequestration, by the Bankruptcy Scotland act, 1913, s. 62, the creditor of a company. in claiming upon the sequestrated estate of a partner, must deduct from the amount of his claim the value of his right to draw payment from the company's funds. (X.)

United States.—In the United States two divergent legal theories as to the nature of the partnership had been developed by the courts, one adhering to the old common law conception that the partnership was simply an aggregate of individuals, and the other building up the ne er conception that the partnership existed as an entity distinct from the partners. The Uniform Partnership act, with some exceptions, is an attempt to codify the existing common law on the subject of partnership. In its major provisions it conforms with the law as found in the English Partnership act. Like the English act its provisions must be read in the light of the earlier common law decisions. The tests for establishing the existence of a partnership are essentially similar to those in the English act, though greater emphasis is laid upon the fact of the sharing of the profits of a business as being an indication that such person is a partner in the business. The act lays down no limit as to the number of persons that may comprise a partnership nor the types of business in which a partnership may engage. Such limitations may, however, be commonly found in other legislation. Partners are the agents of the partnership to carry on the partnership business, but specific authority from all the partners must be had in order that a partner may bind the partnership in a limited class of transactions. Partnership liability in contract is made joint, but in tort is joint and several. Partners may be created by estoppel, as where a person gives credit to a partnership upon the representation by one who is not a partner but represents himself or consents to others representing that he is a partner. A person admitted to the partnership is liable to the extent of the partnership property for liabilities incurred before he became a member.

The relations of the partners to one another are substantially those prevailing in England. The extent of partnership property and its devolution upon the death of a partner are regulated in detail. Assignment of a partner's interest does not operate to dissolve the partnership. In the dissolution and winding up of a partnership, the act even more closely follows its English model. The causes for dissolution are identical, notification of dissolution to third parties is essential in order that the limited authority of any partner to bind the partnership shall be effectual. Special provision is made for the continuation of the partnership business with the aid of the partnership assets in cases where the dissolution is caused in contravention of the partnership agreement, those partners who have not wrongfully caused the dissolution being permitted to carry on the business.

Limited partnerships are wholly a creation of statute law, originating from the need of new commercial ventures for increased capital. The desire of the legislatures, however, to safeguard the interests of persons dealing with an association and relying upon the individual liabilities of the associates as well as the joint assets, led them to subject the limited partner to an unlimited liability for the slightest infraction of the statutory rules. By the Uniform Limited Partnership act drafted in 1916 the limited partner was given a greater protection. To give publicity to the limitation of liability, a device of registering that fact is employed together with complete details as to the organization of the partnership. The limited partner is given the character of an investor rather than a general partner and does not participate in the management of the business. No limitations exist as to the character of the business that can be conducted by a limited partnership. except as other legislation excludes this form of enterprise from particular enterprises. (J. M. LA.)

PARTONOPEUS DE BLOIS, hero of romance. The French romance dates from the 13th century, and is in fact a variation of *Cupid and Psyche*. Partonopeus is represented as having lived in the days of Clovis. He was seized while hunting, and carried off to a castle, the inhabitants of which were invisible. Melior, empress of Constantinople, came to him at night, stipulating that he must not attempt to see her for two years and a half. After successful fighting against Sornegur of Denmark, he returned to the castle, armed with an enchanted lantern which broke the spell. The tale ends happily. It had a continuation giving the adventures of Fursin or Anselet, nephew of Sornegur.

BIBLIOGRAPHY.—The French romance was edited by G. A. Crapelet, with an introduction by A. C. M. Robert, as Partonopeus de Blois (2 vol., 1834); an English *Partonope of Blois,* by W. E. Buckley for the Roxburghe club (1862), and another fragment for the same society in 1873; the German *Partonopier und Melior* of Konrad von Würzburg by Bartsch (1871); the Icelandic *Partaldpa saga* by Klockhoff in *Upsala Universitets Arsskrift* for 1887. *See* also H. L. Ward, *Catalogue of Romances,* vol. i, pp. 689 ff. (1883 *et seq.*); E. Kolbing, *Die verschiedenen Gestaltungen der Partonopeus-Sage,* in *Germ. Stud.,* vol. ii (1875), in which the Icelandic version is compared with the Danish poem *Persenober* and the Spanish prose *Historia del conde Partinobles;* E. Pfeiffer, "Über die MSS. des Part. de Blois" in Stengel's *Ausg. in Abh. phil.,* no. 25 (1885).

PARTRIDGE, SIR BERNARD (1861–1945), British artist, born in London on Oct. 11, 1861, was educated at Stonyhurst, and after matriculating at London university entered the office of Dunn & Hansom, architects. He then joined for a couple of years a firm of stained glass designers (Lavers, Barraud & Westlake), learning drapery and ornament, and then studied and executed church ornament under Philip Westlake, 1880–84. He began illustration for the press and practised water-colour painting, but his chief success was derived from book illustration. In 1891 he joined the staff of *Punch* and became its chief cartoonist. He developed a reputation as a political cartoonist and he lampooned world celebrities from Queen Victoria to Franklin D. Roosevelt, Churchill, Stalin, Hitler and Mussolini. His black-and-white delineations were conservative and minutely detailed and preserved their strong Victorian character throughout. Partridge was knighted in 1925 and died in London on Aug. 9, 1945.

PARTRIDGE, any one of certain game birds. The name was originally applied to the grey partridge *(Perdix cinerea),* the only species indigenous to Britain.

The grey partridge has largely increased in numbers in Great Britain in the last century. During incubation the normal scent of the hen is suppressed. Allied species occur in eastern Siberia and in Tibet.

The common red-legged partridge of Europe, generally called the French partridge, *Caccabis rufa,* is considered the type of a separate group. This bird was introduced into England in the last quarter of the 18th century. It prefers heavy clay soils or the most infertile heaths.

In Africa north of the Atlas is the Barbary partridge, *C. petrosa;* in southern Europe another, C. *saxatilis,* which extends eastward till it is replaced by *C. chukar,* which reaches India. Two desert forms are *Ammoperdix heyi* of north Africa and Palestine and *A. bonhami* of Iran. The francolins and snow-partridges are generally furnished with strong but blunt spurs. Of the former, *Francolinus francolinus* used to be found in many parts of the south of Europe; it extends to India, where it is known as the black partridge. The snow-partridges (*Tetraogallus*) are the giants of their kin, and nearly every considerable range of mountains in Asia seems to possess its specific form.

The name "partridge" has been loosely applied in North America to the ruffed grouse *(Bonasa urnbellus),* the Virginia quail *(Ortyx virginianus)* and other species. In South America

the name is given to various tinamous (*q.v.*).

PARTRIDGEBERRY (**Mitchella** *repens*), a North American plant of the madder family (Rubiaceae), growing in dry woods from Nova Scotia to Minnesota and southward to Florida and Texas. It is evergreen, with a round, often whitish, trailing stem and white flowers, often borne in pairs, which are replaced by scarlet, edible berries. The flowers are dimorphic, long-styled and short-styled forms occurring, as in the primrose. The plant is also called checkerberry, squaw vine and twinflower.

PARTS OF SPEECH: *see* GRAMMAR.

PARTURITION: *see* CHILDBIRTH.

PARTY, POLITICAL, a group that attempts to bring about the election of its candidates to public office and, by this means, to control or influence the actions of the government. A political party is only one of several types of groups which, under various political systems, seek to control the personnel and policy of government. Political parties, as defined here, are instruments of democratic or republican regimes in which the chief governmental officials are chosen by election. A clique of military officers that gains control of a government by its command of the armed forces of a country is hardly a political party although it may masquerade as such. A landed aristocracy that exerts a continuing influence on affairs of state under an absolute monarchy may play an important role in the governance of the realm, but it does not constitute a political party in the modern usage of the term. Under dictatorships one-party systems have been established to bolster the power of the dictator. Such parties may be effective props for the regime but they are in reality extensions of the governmental apparatus rather than political parties. The essential condition for the existence of political parties is'freedom to form organizations that strive for power by electoral methods. Under other circumstances groups of citizens may influence the government, or they may form part of the coalition of interests supporting it; but without freedom of competition for power by electoral methods, political parties, in the strict sense of the term cannot exist Hence, the Communist party of Russia, the Nazi party of Hitler's Germany and the Fascist party of Italy could not be considered political parties as that term has been generally understood. The Communist party was, in fact, outlawed in the United States in 1954, and in many other countries as well, on the ground that it was not a true political party but a subversive influence and a tool of the Soviet government. In other countries, such as France, Italy and India, the Communist party gained acceptance as a bona *fide* political organization and wielded immense influence. *See* COMMUNIST PARTIES; FASCISM; NATIONAL SOCIALISM; SOCIALISM.

Differentiation from Other Groups. — Political parties are to be differentiated from pressure groups or interest groups which seek to influence government by such means as propaganda and persuasion rather than by putting forward candidates for office. These are groups of individuals or federations of associations founded on some common interest; exertion of influence on the government is generally only one of the purposes of association. Professional societies, for example, make themselves heard by public authorities when matters of concern to them are under consideration, but influencing public policy is not the sole objective of such societies.

Interest groups sometimes become constituent parts of a political party. The British Labour party, for example, originated as a federation of trade unions, trades councils and socialist societies. The American Federation of Labor (A.F.L.) originally had a different relationship to political parties. Under its nonpartisan policy it called to the attention of unionists the records of candidates of all parties on issues of interest to labour, while some of its leaders might favour one presidential candidate and others, another. The Congress of Industrial Organizations (C.I.O.) adopted a more definitely partisan policy and supported Democratic candidates by substantial campaign contributions and by other means through its political action committee. After the two organizations merged in 1955 to form the A.F.L.-C.I.O., they formed a committee on political education to work for specific political goals.

The line between political parties and pressure groups is sometimes blurred; but a distinction may be drawn from the fact that pressure groups, unlike political parties, do not nominate candidates for public office or desire to accept the responsibility for management of the government. It should also be noted that an interest group which under certain circumstances promotes its cause through pressure tactics may under different conditions act as a political party. In the United States, agriculturalists lobby for their objectives through such organizations as the American Farm Bureau federation, while in European democracies farmers' and peasants' parties have been common.

Revolutionary mass movements in recent years have taken on some. but not all, of the characteristics of political parties, including the name party. The Congress party in India. for example. and the Moslem league in Pakistan helped spearhead the drive for national independence. Once that goal was won, both organizations encountered difficulties in fitting into the new scheme of things and assuming the normal functions of a political party. The general tendency was for these parties to lose some of their influence and to split into factions once independence was gained.

Party Functions. — In the 18th century, on both sides of the Atlantic, the term party, like faction, suggested something politically unwholesome if not actually subversive. George Washington in his "Farewell Address" warned "against the baneful effects of the party spirit generally." Even at mid-20th century it was not uncommon to hear parties spoken of disparagingly. In West Germany, for example, political parties did not have the same historical roots and emotional attachments that they had in the United States or Great Britain. Many German voters held parties in contempt and preferred to think of themselves as "above party." Much the same was true of Japan where there was a great deal of uncertainty in the mind of the average citizen in the 1950s as to his affiliation with a political party. Powerful voices in India expressed the view that parties were unnecessary and undesirable. In Indonesia. President Sukarno declared in an address to the constituent assembly in 1956 that the freedom to set up political parties did not constitute the only means "to keep the democratic system going." But in most countries, particularly in those with long traditions of successful party government, political parties were regarded as being essential to popular government. Defenders of parties argued that formal institutions of government are not enough to make democracy work. They point out that the abolition of political parties (or the outlawing of all parties but one) is usually a first step toward the establishment of a dictatorial regime.

The political party provides a method by which people of similar views can organize to contend for control of the government. Party competition for power is in a sense a sublimation of civil warfare, and parties are in a way political armies consisting of segments of the population with certain common or compatible aspirations. Men bind themselves together in parties for much the same reasons that they join together in warring factions. A tie which often brings men together in a political party is a common economic interest susceptible of promotion or defense by political methods. Labour and peasant parties are examples which are paralleled by parties dominated by industrial interests. In some countries racial or nationalistic minorities form political parties. On the continent of Europe common religion has furnished the cohesive element for some parties. *See* ANTIMASONIC PARTY; CHRISTIAN DEMOCRATIC PARTIES; CONSERVATIVE PARTY (BRITISH); DEMOCRATIC PARTY (U.S.); LABOUR PARTY, THE (BRITISH); REPUBLICAN PARTY (U.S.).

M'hatever the factors may be that draw men together in parties, these organizations perform functions indispensable to popular government. They select candidates for public office and present them to the entire electorate. which then may choose from among the contenders. The process of nomination of candidates is in most countries highly informal; caucuses or inner cliques of the leaders of a party determine its candidates. In the Cnited States, however, because of abuses within the party organizations in the making of nominations, the process of nomination is regulated by law. The more general method of nomination for state and

local office and for representatives and senators in the national congress is by the direct primary, which is conducted as an election in which the members of the party are entitled to participate. (*See* PRIMARIES.) The nomination of presidential candidates, however, is accomplished by conventions which operate in accordance with party rule rather than statute. *See* NATIONAL CONVENTION.

In addition to nominating candidates, parties define the issues before the electorate in campaigns and elections. They present to the electorate not only a choice among candidates but a choice among governmental programs. At times, particularly in countries with the dual party system, the differences between party programs are by no means sharp. In the United States the issues between the Republican and Democratic parties are more notable for their similarities than their differences. Nevertheless, the general direction and emphasis of one party program may more nearly approximate the beliefs of a voter than the other. In multiparty countries such as France the voter may be able to cast his ballot for the candidate of a party which reflects his viewpoint with relative exactness. The multiparty system permits the formation of separate parties, with programs tailored to fit the views of comparatively small segments of the population. Parties also carry a large part of the burden of education and debate incidental to the choice of governments by the electorate. Especially after the development of universal suffrage the conduct of campaigns and of other work incident to the electoral process became extremely burdensome and costly.

Party Organization. — As with all but the most rudimentary associations, a political party possesses organizational machinery through which it acts. Such organization is, in effect, the government of the party. It is the machinery by which party decisions are made and by which factional disputes within the party are settled. It tends, in fact, to be the party. Parties pose as mass organizations and adopt all the paraphernalia of representative government for control of their affairs, but everywhere their management tends to be oligarchical. It is productive of clearer thinking if the concept of parties as associations with vast memberships is regarded as fictitious. In practice, membership in a political party is an affiliation with no heavy obligation for participation in party management; membership is ordinarily nothing more than a voting affiliation of varying degrees of durability. The members leave the operation of the party machinery to the inner core of professional and semiprofessional party workers. When there is competition among parties, this state of affairs is not necessarily undesirable since the party oligarchy that ignores the interests of its partisans will find that its following disappears.

Commonly the supreme authority within the party is an assembly, in form directly or indirectly representative of the membership, which convenes annually or at less frequent intervals. The national conventions of the Democratic and Republican parties in the United States meet at four-year intervals. Each consists of more than 1,000 delegates selected by state party conventions or by party members in the states through direct primaries. The conventions nominate presidential candidates, adopt platforms and designate party officials.

British Conservative, Liberal and Labour parties hold annual conferences to which local party associations send delegates. These conferences, like U.S. conventions, are largely managed by the inner circle of party leaders and serve more to ratify the recommendations of the party leaders than as forums for deliberation on party affairs. Unlike the British party assemblies, the national conventions of the Canadian Liberal and Progressive Conservative parties have taken from the party groups in parliament the power to designate the party leader (who becomes premier if the party is victorious). Such conventions are held only when it becomes necessary to choose new party leaders.

Ordinarily the national party organization includes an executive. The British Conservative party, for example, has a national council, a president and a treasurer. It maintains a central office, with a paid staff to distribute literature, aid local party associations, raise money and generally keep the party machinery in tune. The Republican and Democratic parties in the United States have national committees, the chairmen being designated by the presidential nominees. The Labour party has a national executive committee in which government of the party is vested between annual party conferences. As the national committees are large and unwieldy, executive leadership is commonly handled by the chairman with the assistance of a small executive committee. The parties maintain national headquarters staffed to carry on research and propaganda activities. The typical continental party also maintains a central bureau or secretariat which operates under the direction of the national executive of the party. The party national staff varies widely in size and importance. In the United States, with elections at fixed intervals, the activities of national headquarters increase in scope and importance as an election approaches. In countries in which parties must maintain a more constant state of readiness for an election and in which the parties carry on more extensive educational, organizational and publishing activities a larger and more stable national staff is likely to exist.

The central or national organization of the party is usually superimposed over a system of local party organizations or associations which vary in their form from country to country with the nature of the governmental system. Local associations usually developed first and the national party machinery evolved later to lead and unify the work of these associations in national politics. In England, for example, the National Union of Conservative and Constitutional associations (or the Conservative party) was formed shortly after the adoption of the Reform act of 1867 and gradually affiliated with itself local Conservative and Constitutional associations which were already in existence in parliamentary constituencies or parts of such constituencies. In the United States local party organization conforms to the structure of local government. City and county party organs are tied into state party organizations which in turn occupy a position in the national structure of the party. Although provision is often made for party committees and conventions based on congressional districts, the city or county party machinery is more generally the centre of power in the party locally.

The nature of a nation's politics is profoundly influenced by the degree of centralization of power nationally over local party actions. The central offices of British parties, for example, are able to exert great influence over the choice of candidates by local party associations. This relation within the party organization is reflected in the fairly high degree of discipline prevailing within the party groups in parliament. Unity within the majority party lays the basis for, but does not assure, a stable and firm governmental policy. Radically different relations have prevailed between national and local party organizations within the United States. The national party organizations are only loose federations of state and local party machines. Relatively slight control of local party actions may be exercised by the national leadership of the party. Local party organizations rebuffed attempts even by such strong party leaders as Woodrow Wilson and Franklin D. Roosevelt to influence the selection of candidates for the house and senate. Local party autonomy is accompanied by weak cohesion within party groups in the congress, and by consequent difficulty in the enactment of a party program into legislation. In practice, most legislation is enacted by combinations across party lines. In the French fourth republic national leadership within the party organizations was characteristically weak and this contributed to the fluidity of party alignments in the chamber of deputies and to governmental instability.

Parliamentary and Extraparliamentary Organization. — A distinction must be made between the parliamentary party and the party organization outside the government. The party group in the parliament usually has its own organizational apparatus consisting of a chairman, president or leader, a secretary and other functionaries, differing in detail from country to country. In some instances the parliamentary group even has a different name from the external party.

The parliamentary group may enjoy considerable freedom from control by the extraparliamentary party organs. Such autonomy was established most clearly in Great Britain where the party organs of the Liberal and of the Conservative parties once adopted

resolutions for the guidance of the members of parliament elected under their respective banners. Control of members of parliament (who refused to be controlled) by an external authority was soon seen to be incompatible with the sovereignty of parliament; the extraparliamentary organizations came to limit themselves principally to the tending of the party machine. Although elsewhere the issue of principle is not always so sharply settled in favour of autonomy for the parliamentary group, generally party functionaries concentrate their efforts primarily on the winning of elections — the canvassing of the electorate, the dissemination of propaganda, the maintenance of the party machinery — rather than on the formulation of policy for the guidance of the party's candidates and officials.

Party Finance. — The financing of party activity is one of the vexing problems of popular government. Party operations cost tremendous sums. The total expenditure by national, state and local party organs of the Democratic and Republican parties during the 1956 presidential campaign in the United States was estimated by a senate committee at $133,000,000. In Great Britain somewhat less is probably spent, on a per capita basis, in a general election. To get funds to meet its needs a party is tempted to yield to plutocratic influences. An ambition of managers of parties with pretensions to a broad popular base has been to organize party finance so as to obtain a great number of small contributions from the party membership.

In the United States both national and state governments attempt to limit the amounts of campaign expenditures, to prohibit contributions from such sources as corporations, to limit the size of contributions and to enforce publicity of the financial affairs of parties. The defects of legislation with these objectives, both in form and in enforcement, are serious. The difficulty of regulation of party finance has led to the suggestion that the government finance the expenses of the major parties. (See CORRUPT PRACTICES; ELECTORAL SYSTEMS.)

Biparty and Multiparty Systems. — A puzzling feature of party systems is that in some countries the electorate divides itself into two major parties while in others a multiplicity of parties develops. The United States is the classic example of a nation with a two-party system. Control of the national government has alternated between the Republican and Democratic parties and their predecessors. In most other English-speaking countries the two-party system does not exist in its pure form, although its essence is approached in that usually a single party has adequate strength to form a government. In Great Britain the historical cleavage was between the Conservative and Liberal parties, but after World War I the Labour party gained strength and in 1945 won control of the government. The Liberal party became a weak third party that usually elected only about five or ten members of parliament compared to approximately 300 for each of the other parties. With occasional exceptions, Canada, Australia and New Zealand also followed the two-party pattern.

In contrast, the multiparty system has been the rule in European democracies, notably France and pre-Hitler Germany. A multiparty nation may have a dozen or more parties ranging from the most radical on the left through the political spectrum to the most conservative on the right. The right-left classification arises from the custom of seating the party groups in this order in relation to the presiding officer in semicircular legislative chambers. (Data on the current strengths and programs of parties of all countries are available in such annual publications as The *Statesman's* Year-Book and The Political Handbook of the World.)

The two-party system is said to promote governmental stability because a single party can win a majority in the parliament and govern. In a multiparty country, on the other hand, the formation of a government depends on the maintenance of a coalition of parties with enough total strength to form a parliamentary majority. The weakness of the ties that bind the coalition may threaten the continuance of a cabinet in power. The governments of Great Britain, Canada and the United States may be contrasted with those of France and Germany in the years between World Wars I and II. In the decade that followed her liberation in 1945, France had one cabinet crisis after another; the average life span of a French cabinet during these years was less than six months. But it must be borne in mind that the weakness of the government under the fourth republic, as under the third, was not caused entirely by its party system. Constitutional factors such as the lack of power in the French cabinet to dissolve the chamber of deputies were also involved. The constitution of the fifth republic, adopted in 1958, was aimed at strengthening the position of the executive, not reducing the number of parties. The stability shown by the government of the United States was not entirely due to its party system but was promoted also by the fixed tenure and strong constitutional position of the president.

The two-party system moderates the animosities of political strife. To appeal for support of a majority of voters a party must present a program sympathetic to the desires of most of the politically active elements of the population. In the formulation of such a program an effort must be made to reconcile the conflicting interests of different sectors of the population. This enables the party, if expedient, to resist demands that it commit itself without reservation to the policies urged by any particular extremist element. In effect, the party is a coalition for the purpose of campaigning for office. In the formation of the coalition compromises have to be made, and coalition occurs outside the government prior to election rather than within the parliament after election as under the multiparty system. The necessity that each party appeal to practically all social classes for support ensures a marked resemblance in party programs and composition. Similarities between Republican and Democratic platforms in the United States are more striking than their differences. Both parties also draw electoral support from all social classes. In Great Britain and Canada differences in program and in composition between the two major parties have been perhaps greater than in the United States. Nevertheless, in these countries a broad area of agreement exists among the leading parties. With two major parties of similar views and of approximately equal strength competing for control of a government it is possible for governmental control to alternate between the parties without shifts in policy so radical as to incite minorities to resistance.

Contrasts between two-party and multiparty systems are often exaggerated. The existence of two major parties in the United States obscures the fact that within each party are many factions struggling for power. Within the Democratic party the southern planters and the workers of the great urban centres came to live in uneasy union. In the Republican party the midwestern farmer and the eastern manufacturer formed a similar alliance. Presence of divergent interests under a single party canopy masks a process of struggle and compromise which under a multiparty system is out in the open. Nevertheless, party leadership under a two-party system must concentrate on building a coalition of voters; it gains strength by seeking areas of agreement and suppressing conflict rather than by exploiting points of difference. Apologists for the two-party system, however, sometimes ignore the fact that frequently under that system a single party dominates local administration over considerable areas. That is the case in the solidly Republican and Democratic areas in the United States where the only channel for expression of political differences is by factional strife within the dominant party. Party factions may be as numerous as parties under a multiparty system and yet lack the redeeming feature of clarity that comes from being labeled as parties.

Bases **of** Biparty Systems. — Major influences favourable to the two-party system are the use of single-member districts for the election of representatives, the presidential system and the absence of proportional representation. In Great Britain and the United States most members of the national representative assemblies are chosen from single-member districts and the candidate polling the largest number of votes is the winner. Such an electoral system compels a party to strive for a majority of the votes in a district or other electoral area. No more than two fairly evenly matched parties may successfully compete for office in a single-member district; a third party is doomed to recurring defeat unless it can swallow up one of the other parties. Parties do not thrive under the certainty of defeat.

A third party may have a substantial popular following and yet capture few seats in the representative body. With, say, 20% of the popular vote spread evenly over an entire country such a party would not win a single seat. The rise of the Labour party in Great Britain, for example, virtually deprived the Liberal party of parliamentary seats even when it had a substantial popular following. The corollary is that the strength of the majority party in the representative body is proportionately greater than it is in the popular vote.

In addition to the single-member-district system, in the United States the presidential system induces parties to seek majority support. No fractional party can elect its presidential candidate and third parties in national politics are protest movements rather than serious electoral enterprises. When minor parties exist for long in two-party countries, their strength is likely to be concentrated geographically which enables them to win seats in the parliament. In such areas of concentration, the two major parties nationally may be forced toward coalition locally which illustrates the influence of the electoral system in the formation of dual-party systems.

Systems of proportional representation, in contrast with the single-member-district system, are designed to permit party representation in the representative body more or less precisely in the same proportion as the party strength in the popular vote over the entire country. The number of seats won depends on the number of popular votes received rather than success in polling a plurality in each individual constituency. I'arty splintering may be encouraged by the electoral system. but there must be groups susceptible to narrow political appeals before proportional representation can facilitate party fission.

A significant factor in differences in party organization is the presence of certain influences in multiparty countries that are absent in two-party countries. The lack of consensus on constitutional issues in some European countries led to the formation of parties irreconciled to the regime. A few royalist parties persisted long after the abolition of monarchies. Parties formed to espouse the cause of the church were generated by issues not important in most Anglo-American countries. The socialist movement spawned numerous continental parties, most generally designated as Social Democratic, and the British Labour party had a socialist origin. Proletarian movements looking toward the ultimate socialist transformation of the state gained a stronger foothold in Europe than in most two-party countries. The existence of considerable bodies of people deeply attached to doctrines which cannot be readily compromised is in contrast with a state in which a broader area of consensus on fundamental issues prevails. Diversity of political beliefs on fundamental issues coupled with suitable electoral systems leads to a multiplicity of political parties.

Newly Independent States.—India, Pakistan and Indonesia may be cited as examples of the differing responses to the challenge of party government in states of the far east that won their independence during the 1940s. In India, the largest and most stable of the new states of the post-World War II era, Nehru's Congress party, which had led the fight for independence, dominated the political scene during the first decade of self-government. There was no second party of comparable strength to stand in opposition on a national scale, though fourteen national parties took part in the 1952 election and opposition to the Congress party was strong in many regions and states. Appealing to the largest free electorate in the world, the Congress party won 362 of 489 contested seats in the parliament elected in Jan. 1952, India's first election as a free nation. In the 1957 elections the Congress party continued its dominance.

Meanwhile, many observers, both in and out of India, regarded this situation as politically unhealthy and predicted change, either in the direction of a two-party system or the complete abolition of all parties.

The efforts of Pakistan to solve its political party prohlems took a different turn. The Moslem league, spearhead of the independence movement in Pakistan, held power at all levels of government from 1947 to 1954. Thereafter other groups gained influence with the result that no party was strong enough to win a working majority at the national level; coalition cabinets held office from 1955 to 1958.

Elections under a new constitution were scheduled for 1958; however, in October of that year the president of Pakistan abolished the constitution, dissolved all political parties, and declared martial law. The new nation's first efforts to govern itself in normal democratic fashion through political parties thus ended in failure, at least temporarily.

The Republic of Indonesia exhibited still a different response to the problems of party government. Indonesian parties (except the Communist party) were loosely organized groups formed about locally influential individuals and were far different from parties in the western democracies. When Indonesia held its first general election as a free nation in Sept. 1955 two parties—the Nationalist party (P.N.I.) and the Moslem council (Masjumi)—captured the same number of seats in the legislature. They chose a compromise candidate for the office of premier. The two strongest parties were closely followed by the Moslem Schoolmen league and the rapidly growing Communist party. The coalition cabinet did not last long, resigning in 1957 when the Moslem council and three minor parties withdrew their support. President Sukarno, who had earlier remarked that political parties should be "buried" in the interest of national unity, then appointed a new cabinet himself without reference to party alignments.

Early in 1960 Sukarno dissolved the legislature and ruled by decree.

The experience of these states emerging from colonial rule illustrates the obvious point that lack of agreement on constitutional fundamentals spells difficulty for any political party system. as does lack of a long tradition of governing through political parties. Mass organizations created to promote revolutionary nationalist movements proved to be poorly suited to function as political parties once their main goal had been won. To keep the situation in proper perspective, however, the shortcomings of the new regimes must be considered in relation to the fact that all the newly independent states had to face difficult tasks in establishing new political procedures, developing public support, dealing with largely illiterate electorates, countering communist pressures, and carrying through a host of social and economic reforms. Their experience suggests that new forms and procedures are being developed anti that the political parties typical of western parliamentary democracy are not being blindly transplanted to alien soil. *See* also Index references under "Party, Political" in the Index volume. (V. O. K.; X.)

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PASADENA, a city of Los Angeles county, Calif., U.S., lies 11 mi. E. of Los Angeles (*q.v.*) at the western end of the San Gabriel valley along the foot of the Sierra Madre range. *Pa-sa-de-na* is a Chippewa phrase meaning "crown of the valley."

Pasadena's site was carefully chosen by agents of Thomas B. Elliott. head of the California colony of Indiana. Though delayed by the panic of 1873, Elliott (still in Indiana j persevered in organizing the San Gabriel Orange Grove association, the founding corporation. In 1874 for the sum of $25.000 the association obtained 4,000 ac., formerly part of the Mexican Rancho San Pasqual, on

the western side of the present city. Population and land values grew slowly. By 1880 Pasadena had 400 inhabitants, and good land had risen to $100 an acre.

Pasadena's great boom began in 1885 and the city was incorporated the next year. The land boom, experienced throughout southern California, was intensified locally by the advent of the Santa Fe railroad. The winter resort trade, mainly health seekers at first, reached unbelievable proportions. Speculation in real estate was rife and land was bringing as much as $1,000 per acre. The population jumped to 6,000. Although the inevitable collapse hit Pasadena hard, conditions were normal by 1890. Its permanent population had increased 15-fold during the 1880s, and with urbanization its citrus groves began to disappear.

For the next 40 years Pasadena continued to attract large numbers of middle westerners, many of the professional or retired class. In the early 1960s the city, surrounded by suburbs, was mostly a community of homeowners. The commuter replaced the midwestern immigrant, as the Los Angeles freeway system brought Pasadena to within 30 min. of the metropolis. As marketing supplanted agriculture, Pasadena became the wholesale and retail centre for much of the San Gabriel valley. After World War II the city, with a view to spreading the tax base, encouraged light industries such as ceramics, machine shop products, scientific instruments, electronics, plastics and pharmaceuticals.

California Institute of Technology, a privately endowed college, graduate school and research institute for men, established as Throop Polytechnic institute in 1891, is located there. It includes divisions of biology; chemistry and chemical engineering: civil, electrical and mechanical engineering and aeronautics; geological sciences; humanities; and physics, mathematics and astronomy. Institute facilities in Pasadena include, in addition to the main campus, the jet propulsion laboratory, operated in conjunction with the National Aeronautics and Space administration. Other institute facilities include the marine biological laboratory at Corona del Mar; an observatory on Palomar mountain in San Diego county; and a centre at Bishop for the study of radio astronomy. The institute is also associated with Mount Wilson observatory (established 1904). The Henry E. Huntington library and art gallery is located in nearby San Marino. The Pasadena college was established as Kazarene university in 1902 and is affiliated with the Church of the Nazarene. The city supports a full-fledged school system through the junior college level, with an excellent adult education program; there is also a public library and an art museum. The Pasadena Community playhouse, organized in 1916, is a nationally known little theatre with a school of drama and a laboratory theatre workshop. Pasadena adopted the commission-manager form of municipal government in 1921.

The community unites each New Year's day in supporting the Tournament of Roses, first introduced in 1890, originally inspired by the "battle of flowers" at Nice, France. After 1916 the festivities were culminated by the Rose Bowl football classic between the champion teams of eastern and western U.S. universities. Pop. (1960) 116,407. For comparative population figures *see* table in CALIFORNIA: Population. (J. E. P.)

PASADENA, a city of southeastern Texas in Harris county, U.S., in the Houston (*q.v.*) metropolitan area. It was founded in 1895 by J. H. Burnett and incorporated in 1929. Pasadena owes its rapid post-World War II growth to the stimulation of adjacent industry, chiefly petrochemical plants and oil refineries, on the Houston ship channel, to the north. The city's area of 100.21 sq.mi. is circumscribed by the boundaries of Houston and Deer Park. It is a residential community and many of its citizens are members of organized labour. Immigrants from the Calvinistic region of east Texas form the main population element. Sorthe-east of Pasadena is the site of the capture, in 1836, of Antonio Lopez de Santa Anna, the Mexican president-general, after the battle of San Jacinto.

The population was 58,737 in 1960. For comparative population figures see table in TEXAS: *Population.* (G. M. F.)

PASARGADAE, a city of ancient Persia. situated in the modern plain of Murghab. about 30 mi. N.E. of the later Persepolis. The name originally belonged to one of the tribes of the Persians, which included the clan of the Achaemenidae, from which sprang the royal family of Cyrus and Darius. According to the account of Ctesias, the last battle of Cyrus against Astyages, king of the Medes, in which the Persians were incited to a desperate struggle by their women, was fought there.

After the victory Cyrus built a town, with his palace and tomb, which was named Pasargadae after the tribe. Every Persian king was, at his accession, invested there, in the sanctuary of a warlike goddess (Anaitis?), with the garb of Cyrus, and received a meal of figs and terebinths with a cup of sour milk; and whenever he entered his native country he gave a gold piece to every woman of Pasargadae in remembrance of their ancestors' intervention in the battle.

According to a fragment of the same tradition, preserved by Strabo, Pasargadae lay "in the hollow Persis (Coele Persis) on the bank of the river Cyrus, after which the king changed his name, which was formerly Atradates." The Cyrus river is the Kur of the Persians, later generally named Bandamir; the historians of Alexander call it Araxes, and give to its tributary, the modern Pulwar, the name Medos.

The capital of Cyrus was soon supplanted by Persepolis, founded by Darius; but in Pasargadae remained a great treasury, which was surrendered to Alexander in 336 after his conquest of Persis. After his return from India, he visited Pasargadae on the march from Carmania to Persepolis, found the tomb of Cyrus plundered, punished the malefactors and ordered Aristobulus to restore it. Aristobulus' description agrees exactly with the ruins of Murghab on the Bandamir, about 30 mi. upward from Persepolis. The identity of the ruins of Murghab with Pasargadae was established in modern times by the discovery of the sculpture of Cyrus, bearing the trilingual inscription "Cyrus, the great King, the Achaemenian."

The principal ruins of the town of Pasargadae at Murghab are a great terrace like that of Persepolis, and the remainders of three buildings, on which the building inscription of Cyrus occurs five times in Persian, Susian and Babylonian. They were built of bricks with a foundation of stones and stone doorcases, like the palaces at Persepolis; and on these fragments of a procession of tribute bearers and the figure of a winged demon were preserved. Outside the town was found the tomb of Cyrus himself.

PASCAL, BLAISE (1623–1662), French scientist and writer on religious subjects, a man whose genius gives him a unique eminence among modern thinkers, was born on June 19, 1623, at Clermont-Ferrand, where his father, Btienne Pascal. was president of the *cour* des aides. His mother, née Antoinette Bégon, died in 1626; and in 1631 Btienne Pascal moved to Paris. Btienne, who was himself highly respected as a mathematician, devoted himself henceforth to the education of his children. While his sister Jacqueline (born in 1625) figured as an infant prodigy in literary circles, Blaise proved himself no less precocious in mathematics. His *Essai pour les coniques* (1640), based on his study of Gerard Desargues, aroused Descartes' envy by its success in the mathematical world; and, between 1642 and 1644, he conceived and constructed an arithmetical machine to help his father in his calculations (Étienne having been appointed intendant at Rouen in 1639). This machine: indeed, was regarded by his contemporaries as his main claim to fame, so that the youthful pride which appears in his dedication to the chancellor, Pierre Séguier, in 1644 is easily understandable.

Up to 1646 the Pascal family had held strictly Catholic principles, even if, as a consequence of dividing life into separate compartments, they had often substituted *l'honnêteté* (conventional integrity, polite respectability, decent social behaviour) for inward religion. An illness of his father's, however, brought Blaise into contact with two disciples of the abbé de St. Cyran, who had been director of Port Royal until his death a short time before; and Blaise, himself the first to feel the necessity of entirely turning away from the world to God, won his family over to his point of view (1646). His letters indicate that he was for several years his family's spiritual adviser, but the conflict within himself was not yet resolved. Absorbed again in his scientific interests, he tested Galileo's and Torricelli's theories in Paris and on the Puy de Dôme

(1646); and his publications on the problem of the vacuum (1647–48) added to his reputation. These latter works, however, gave rise to controversies in which it became clear that self-love was still his ruling passion. When he fell ill from overwork—he was of a weak constitution—his doctors advised him to seek distractions; but what has been described as Pascal's "worldly period" (1651–54) was in fact primarily a period of intense scientific work, during which he composed his *Traitk de l'équilibre des liqueurs*, his *Traitk de la pesanteur de la masse de l'air* and also his *Traitk du triangle arithmétique* (this last a fragment of the *De alea geometriae*, in which he laid the foundations of the calculus of probabilities). By the end of 1653, however, he had begun to feel religious scruples; and the "night of fire" which he experienced on Nov. 23, 1654, he believed to be the beginning of a new life. Though he never became one of the solitaries of Port Royal, it was henceforth only at their request that he was ever to take up his pen.

Les **Provinciales.**—Though the epistolary form and the pervading spirit of Port Royal serve to give unity to the collection, the 18 *Lettres écrites par Louis de Montalte à un provincial* (Jan. 23, 1656—March 24, 1657), better known as *Les Provinciales*, exhibit wide differences of style and enable us to trace a far-reaching development in the author as his spiritual and his theological potentialities are progressively revealed. Written in defense of Antoine Arnauld (*q.v.*), who was on trial before the faculty of theology in Paris, letters i–iii state the case with comic dramatization. Letter iv deals more profoundly with the question of divine grace, though the character of the Jesuit in it is extraordinarily lifelike. Letters v–ix transfer the argument to the subject of moral theology, which was the weak point of the adversaries of Port Royal; and Pascal quotes freely in their own words the casuists (especially Antonio Escobar), sometimes in a spirit of derision, sometimes with indignation. Indignation is the keynote of letter x (on the love of God), of letters xi–xiv, in which Pascal varies attack and defense, and of letters xv and xvi, in which the persecution of Port Royal is interpreted as the consequence of the Jesuits' policy. In the two last letters, xvii and xviii, dealing with the question of grace, Pascal proposes a conciliatory position that was later to make it possible for Port Royal to subscribe to the "Five Articles" (1663) and to the "Peace of the Church" (1668).

The *Provinciales* were an immediate success, and their popularity has remained undiminished. This they owe primarily to their form, in which for the first time bombast and tedious rhetoric as exemplified by J. L. Guez de Balzac and by Antoine Lemaistre are replaced by variety, brevity, tautness and precision of style; as Boileau recognized, they mark the beginning of modern French prose. Something of their popularity, moreover, in fashionable, Protestant or sceptical circles, must be attributed to the violence of their attack on the Jesuits. In England they have been most widely read when "popery" has seemed a danger (for example, after the Restoration of the Stuarts and at the time of the Oxford movement). Yet they have also helped Catholicism to rid itself of laxism; and, in 1678, Pope Innocent XI condemned half of the propositions that Pascal had already denounced. Thus the *Provinciales* played a decisive part in promoting a return to inner religion and helped to secure the eventual triumph of the ideas set forth in Antoine Arnauld's treatise *De la fréquente communion* (1643), which thereafter remained almost unchallengeable until the French church felt the repercussion of the revocation of the Edict of Nantes (1685). Whereas the Jesuits seemed to represent a Counter-Reformation predominantly concerned with orthodoxy and obedience to ecclesiastical authority, the *Provinciales* advocated a more spiritual approach, emphasizing the soul's union with the Mystical Body of Christ through charity.

Further, by rejecting any "double standard" of morality and the distinction between counsel and precept, Pascal aligns himself with those who believe the ideal of evangelical perfection to be inseparable from the Christian life. While there was nothing original in these opinions, Pascal nevertheless stamped them with the passionate conviction of a man in love with the absolute, of a man who saw no salvation apart from a heartfelt desire for the truth together with a love of God that works continually toward destroying all self-love. For Pascal, morality cannot be separated from spirituality. Moreover, his own spiritual development can be traced in the *Provinciales*. The religious sense in them becomes progressively refined after the first letters, in which the tone of ridicule is smart rather than charitable. Contemporary with the *Provinciales*, Pascal's letters to the duc de Roannez and his sister give invaluable evidence of the depth and sensitivity of his religious perception.

Last Years.—"The miracle of the Holy Thorn," of which Pascal's niece was the beneficiary, took place at Port Royal on March 24, 1656; and it was as a consequence of his meditations on miracles and on other proofs of Christianity that Pascal finally decided to write his work of Christian apologetics (*see* below), though his efforts to convert his fashionable friends had prepared his mind for the decision. Between the summer of 1657 and the summer of 1658 he put together most of the notes and fragments that editors have published under the inappropriate title *Pensées;* and in 1658 he outlined his plan to his friends of Port Royal. He was next involved, however, in scientific work again. First, "Messieurs de Port-Royal" themselves asked for his help in composing the *Élements de gkomktrie;* and secondly the duc de Roannez suggested that he should publish what he had discovered about cycloid curves (on which the greatest mathematicians of the time had been already working). Once more fame aroused in him feelings of self-esteem; but from Feb. 1659 illness brought him back to his former frame of mind, and he composed the "prayer for conversion" that the Wesleys were later to regard so highly. Henceforth, scarcely capable of regular work, he gave himself over to helping the poor and to the ascetic and devotional life. He took part intermittently, however, in the disputes to which the "Formulary" gave rise, until a difference of opinion with the theologians of Port Royal led him to withdraw from controversy (though he did not sever his relations with them).

After terrible pain, probably from carcinomatous meningitis following a malignant ulcer of the stomach (Lucien Jerphagnon), he died on Xug. 19, 1662, assisted by a non-Jansenist parish priest who found him to be "most submissive to the Sovereign Pontiff and to the Church."

Apologie **de** la **Religion Chrétienne.**—The fragments of Pascal's great work are preserved in the manuscript known as the *Recueil original.* No edition of them, however, was even approximately correct until that of A. P. Faugère (1844); and for a further century the true plan of the work remained unknown, with the result that editors and readers could feel themselves free to interpret in accordance with modern philosophical preoccupations ideas which to the author had had an exclusively religious meaning. Eventually, thanks to the researches of Z. Tourneur, L. Lafuma, J. Mesnard and Mrs. **A.** Barnes, it was proved that the two "copies" in the Bibliothbque Nationale give the text of a provisional grouping made by Pascal himself in 1658. This doubtless is only a program of work and would have been replaced, in the completed book, by a complex structure developing the thought on several planes as in a musical composition (this can be seen from the way in which major themes recur again and again in the text). The division of the manuscript into 27 files reveals, however, a highly dramatic approach toward a climax and settles decisively a number of points on which previous editors were in doubt with regard to the progress of the argument and the significance of certain details. The first part of the *Apologie,* then. would have drawn a portrait of man without divine grace. Pascal shows him as an incomprehensible mixture of greatness and abjectness, since he is incapable of truth or of reaching the supreme good to which his nature nevertheless aspires. A religion that accounts for these contradictions—which philosophy and worldliness fail to do—is for that very reason "to be venerated and loved." The next chapters are transitional, dealing in an extremely complex way with the psychology of the *libertin* or emancipated freethinker and with the method of approach to be adopted before presenting him with revealed truth. The indifference of the sceptic is to be overcome by means of the "wager" *(le pari)*; the true function of reason is demonstrated; and Pascal insists that we must bring men to God through Jesus Christ alone, since a creature could never know the Infinite if Jesus had not descended to assume the proportions of

our fallen state. This exposes the error of other religions and even of those worldly Christians who do not sincerely seek the truth. Light and darkness are so closely interwoven that only the pure vision of one who has triumphed over self-love can know the validity of the Christian position, even though history itself is full of rigorous proofs of it The second part of the Apologie, complementary to the first part, begins by applying the Augustinian theory of allegorical interpretation to the biblical types (*figuratifs*); it then reviews the rabbinical texts, the persistence of true religion, the work of Moses and the proofs of Jesus Christ; and finally it gives a picture of the primitive church. the fulfilment of the prophecies. The grouping as shown in the "copies" concludes with reflections on the Mystical Body, which demands the renunciation of self-love; and on the faith of the humble, nhich does not ask for proofs. The Apologie, then, is a treatise of spirituality. Pascal is not interested in making converts if they are not going to be saints.

Pascal's apologetic has stood the test of time, but it is primarily addressed to individuals of his own acquaintance. To convert his libertin friends, he looks for arguments in their favourite authors: in Montaigne, in Charron. in the more or less heterodox followers of Nicolaus Cusanus and perhaps also in Gassendi and in Hobbes. For him, however, scepticism is but a stage. Man would not be wretched if nostalgia for his original state did not make him conscious of his wretchedness. Likewise, the fall of man is stressed to counterbalance Neoplatonic tendencies, in such a way as to enable Pascal to found an immanentist apologetic on the impossibility of the "state of pure nature" (status *purae* naturae) without having to protect himself against an idealist interpretation. Modernist theologians in particular have tried to make use of his main contention, that "man is infinitely more than man," in isolation from his other contention, that man's present wretchedness is explicable only as the effect of a fall, about which moreover we can learn what we need to know from history. This, however. is to sacrifice the second part of the Apologie to the first, to keep the philosophy while losing the exegesis; and it also counteracts Pascal's whole purpose by establishing deism instead of the actual coming of a Redeemer. For Pascal as for St. Paul, Jesus Christ is the second Adam, inconceivable without the first.

Finally, too, Pascal expressly admits that his psychological analyses are not by themselves sufficient to exclude a "philosophy of the absurd"; to do so, we must have recourse to the convergence of these analyses with the "lines of fact" concerning Revelation, this convergence being too extraordinary not to appear as the work of Providence to an anguished seeker after truth (qui cherche en *gémissant*).

At once a physicist, a mathematician, an eloquent publicist in the Provinciales and an inspired artist in the Apologie and in his private notes, Pascal was embarrassed by the very abundance of his talents. A. Koyré suggests that it was his too concrete turn of mind that prevented his discovering the infinitesimal calculus; and in some of the Provinciales the mysterious relations of the person with God are treated as if they were a geometrical problem. But these considerations are far outweighed by the profit that he drew from the multiplicity of his gifts; his religious writings are rigorous because of his scientific training; and his love of the concrete emerges no less from the stream of quotations in the Provinciales than from his determination to reject the method of the Summa contra gentes in his Apologie. Finally, it is as a unique experience that the moment when he believed himself to have been raised above the faculties with which nature had endowed him should be viewed; the *Mémorial* was constantly to remind him of this.

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PASCHAL (PASCHALIS), the name of two popes and one antipope.

ST. PASCHAL I (d. 824), pope from 817 to 824. was a Roman. Elevated immediately after the death of Stephen V (IV), in Jan. 817, he informed the emperor Louis the Pious, who confirmed the independence of the Holy See and the Romans' right to freedom of election. In 823 Paschal crowned Louis's son Lothar I as co-emperor. Some of Paschal's servants executed two papal functionaries who were thought to favour imperial control of Rome; the pope swore to his innocence of the crime. He intervened without success against the revival of iconoclasm in the east. Paschal I died in May 824. (A. G. BI.)

PASCHAL II (Ranierus, of Bieda, Ravenna) (d. 1118). pope from 1099 to 1118. was born at Bieda di Galeata. near Ravenna. He entered a Cluniac monastery as a boy, was made a cardinal by Gregory VII about 1080. and was elected pope Aug. 13, 1099, succeeding Urban II. Paschal followed Gregory VII's policies (see GREGORY), as had his predecessor but with less success. The long conflict of popes and rulers over which authority was supreme in the church nou centred on the right of investiture (*q.v.*) for major church offices. This problem dominates Paschal's reign, although he also fostered the crusade cause. Settiements were made between St. Anselm and Henry I for England and with Philip I for France in 1107; but Paschal continued the conflict in Germany nith Henry IV and Henry V (*qq.v.*). One agreement preliminary to Henry's coronation was vehemently rejected by the German prince-bishops, and Paschal's consent (after two months' harsh captivity) to the full demands of the king irked the Gregorian party. Paschal revoked this extorted act and renewed his earlier condemnations of regal investiture, but the problem remained unsolved until 1122, when Calixtus II concluded the Concordat of Worms. Paschal II died Jan. 21, 1118.

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PASCHAL III (Guido of Crema) (d. 1168), antipope from 1164 to 1168 was one of the original supporters of the antipope Victor IV against Alexander III. Guido succeeded Victor on April 22, 1164. through the influence of Reinald of Dassel, Frederick I's chancellor and vicar in Italy, but he won only limited allegiance even in the empire. Enthroned when Frederick took Rome, Paschal crowned him emperor (Xug. 1167), but had to accompany his retreating army. His successor, antipope Calixtus III, was a less significant figure. Paschal died Sept. 20, 1168.

See H. K. Mann, *Lives of the Popes in the Middle Ages,* 2nd ed, vol. x (1925). (J. J. Rx.)

PASCHAL CHRONICLE (*Chronicum* Alexandrinum or *Constantinopolitanum*) was originally an outline from Adam to A.D. 628 (only extant to 627) with historical and theological notes and an introduction on Christian chronology and the Easter cycle (hence the name "Paschal" Chronicle). It was written under the emperor Heraclius (610–642) by a Byzantine cleric in the circle of the patriarch Sergius. It uses the so-called Byzantine era that calculated the creation from March 21, 5507 B.C. (which with slight modifications continued in general use in the Greek Church until its liberation from Ottoman rule in the 19th century). It was a popular work; the part covering the 7th century is of independent historical value.

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PASCHEN-BACK EFFECT: see ZEEMAN EFFECT.

PASCHER, ADOLF (1881–1945), distinguished botanist known for his reclassification of flagellates and algae (*q.v.*) emphasizing probable evolutionary relationships. He was born May 13, 1881, at Tusset, in Bohmer Wald, Krumau, now in Czechoslovakia, and died in 1945 at Prague. A student at the German university and, after 1933, ordinarius and director of the Botanical institute and Botanical garden at Prague, Pascher published over 150 scien-

tific articles; some were on the structure and classification of higher plants. He was the first to hybridize two species of algae (*Chlamydomonas*) (1916). (H. C. Bd.)

PASCIN, JULES (Julius Pincas) (1885–1930), an outstanding painter of the school of Paris and a typical internationalist of the early 20th century, was born in Bulgaria of Italian-Serbian and Spanish-Jewish parents. He spent a number of years in Austria and Germany working for such satirical journals as the Lustige Blatter and *Simplicissimus*. In 1905 he moved to Paris, where he continued to produce tragically satirical drawings of the underworld. The outbreak of World War I caught him away from France. He traveled for awhile in the United States where he became a citizen, and Cuba, returning to Paris in 1920. There he began painting a series of large-scale, representational and very sensitively drawn biblical and mythological themes, as well as portraits. Later he turned to the material for which he is generally known, the delicately toned, thinly painted but poetically bitter and ironic studies of decadent female types, generally prostitutes. These suggest an analogy to Henri de Toulouse-Lautrec, but Pascin's characters have an individual grace and perverse tenderness that bespeak a personal identification with these creatures of sorrow. On the eve of an important one-man show of his work in 1930, Pascin committed suicide.

See Horace Brodzky, *Pascin* (1946) and Paul Morand, *Pascin* (1931). (B. S. Ms.)

PASCO, a department in the highlands of central Peru, bounded north by Huánuco, east by Loreto, southeast by Cuzco, south by Junin and west by Lima. Area 8,438 sq.mi. The department was created in 1944 out of the northern part of Junin. Pop. (1958 est.) 160.309. The western part of the area is very high and rugged. Cerro de Pasco (*q.v.*), pop. (1958 est.) 26,000, the capital of the department and major mining centre, is located on a gently rolling high-level surface at an elevation of 13.973 ft. Above this surface there are discontinuous ranges and clusters of peaks which reach elevations of over 18.000 ft. above sea level. The western part of Pasco is drained by the headwaters of the Rio Huallaga. The eastern part of the department, on the other hand, is on the steep, rain-drenched slopes of the Andes and the forested plains beyond. This area is drained by the Río Pachitea, a river that descends through a narrow canyon to the eastern plains and then meanders through the lowland forests to join the Rio Ucayali, one of the Amazon headwaters.

The western part of Pasco is one of the world's greatest mining regions. Silver ores at Cerro de Pasco were discovered in 1630, and during the colonial period silver was Peru's distinctive product. In the modern period, copper is more important than silver; but in addition to copper, there are also gold, lead, zinc, bismuth and vanadium. Bismuth is extracted from the dust in flues of the copper smelters. Vanadium comes from mines at Mina Ragra, more than 16,500 ft. above sea level. Coal of good quality is mined at Goyllarisquizca and Quishuarcancha.

At the higher altitudes of western Pasco cattle and sheep are pastured. The highest crop is the potato and below that the Indians grow wheat and barley. On the lower eastern slopes colonies of pioneer farmers raise coffee, cacao, sugar cane, coca! rice and maize. The high cost of transportation, however, permits only the sale of high-value products such as aguardiente (sugar brandy). (P. E. J.)

PASCOAIS, TEIXEIRA DE (real name Joaquim Pereira Teixeira de Vasconcelos) (1878–1952), founder of the *saudosista* movement in Portuguese poetry was the most notable and inspired poet-philosopher in Portugal in the first half of the 20th century. He was born Nov. 2, 1878, at São Gonçalo de Amarante in the Douro region. He studied at the University of Coimbra, taking his degree in law. For a time he practised law in Oporto but soon went to live on his estate at Pascoais (from which he took his pseudonym) in the Marão mountains. His first volume, *Embriões,* appeared in 1895, when he was 17. But it was in 1898 that he made a name with the publication of the collection of verse entitled *Sempre,* the first revelation of his saudosista outlook. This developed in succeeding volumes—Terra Proibida (1899), *Jesus* e Pan (1903), Para a *Luz* (1904)—and gave rise to the movement known as *Renascença* Portuguesa, founded by Pascoais at Oporto in 1912, with its review *Águia. Maranos* (1911) and Regresso ao Paraiso (1912) are the two volumes most deeply inspired by *saudosismo,* a mingling of intuitive thought and mystical lyricism. Fernando Pessoa called the essence of Pascoais' lyricism "pantheistic transcendentalism," and it was this that Pascoais wanted to turn into a kind of religion for the Portuguese people. In *Águia* and in some of his books of this period—0 *Saudosismo* (1913), *O Génio Português* (1913), *A* Arte de ser *Português* (1915) and *Poetas* Lusiadas (1918)—he expounded rather nebulously his saudosisfa thought. An intuitive and inspired visionary, Pascoais, though unsuccessful in his attempt to create a species of nationalistic mystique based on *saudade* (an untranslatable and typically Portuguese feeling: a fusion of hope with nostalgia), produced some of the most original work in Portuguese poetry. Later he devoted himself to writing long biographies in prose—a prose interwoven with poetic passages—of which *São* Paulo (1934) is the most notable. Some were translated into German and were highly esteemed in German-speaking lands. He was much discussed and denounced as a "thinker" because his thought is more poetry than philosophy, properly speaking.

At the time of his death, Pascoais was recognized as the greatest poet in Portuguese. He died in Pascoais, São João de Gatões, Dec. 14, 1952.

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PASCOLI, GIOVANNI (1855–1912), Italian poet and scholar, author of graceful, melancholy lyrics, was born at San Mauro, Romagna, on Dec. 31, 1855. An orphan from childhood (his father was murdered), he knew poverty and when a student was imprisoned for socialist activity. In 1882 he became a secondary school teacher. He later held professorial appointments at a number of Italian universities and in 1905 succeeded to the chair of Italian literature at Bologna, where he died on April 6, 1912.

Pascoli's first poems, Myricae, which won him popularity in 1891, are short, delicate, musical lyrics inspired by nature and a rather feminine choice of themes (the family, the home, the garden. children and birds). His *Canti* di Castelvecchio (1903) contains moving evocations of the poet's sad childhood and meditations on his lonely life. His Latin poems (Carmina; 1914) and the Poemi Conviviali (1904) show his erudition and refinement as a classical scholar.

Pascoli's *Opere* were edited by A. Mondadori and published in 1952.

Bibliography.—B. Croce, *G. Pascoli* (1920); *E.* Turolla, *G. Pascoli* (1926); bibliography in *Studi pascoliani* (1927–33). (F. Di.)

PAS-DE-CALAIS, a maritime *département* of northern France, formed in 1790 of nearly the whole of Artois and the northern maritime portion of Picardy including Boulonnais, Calaisis, Ardrésis and the districts of Langle and Bredenarde, bounded north by the Straits of Dover ("Pas de Calais"), east by the department of Nord, south by that of Somme and west by the English channel. Pop. (1954) 1,276,833; area 2,607 sq.mi. Except in the neighbourhood of Boulogne-sur-Mer with its *côtes* de fer or "iron coasts," the seaboard of the department, which measures 65 mi., consists of dunes. From the mouth of the Aa (the limit toward Nord) it trends west-south est to Gris Nez, the point of France nearest to England; in this section lie the port of Calais, Cape Blanc Nez, rising 440 ft. above the sandy shores, and the port of Wissant (Wishant). The seaside resorts include Boulogne, Berck-sur-Mer, Paris-Plage, Wimereux, etc. Beyond Gris Nez the direction is due south; in this section are the small port of Ambleteuse, Boulogne, at the mouth of the Liane, and the two bays formed by the estuaries of the Canche and the Authie (the limit toward Somme).

The dominant feature of the department is the Cretaceous scarp extending northwestward toward the sea and revealing, between Boulogne and Calais, Lower Cretaceous? Jurassic and a little Paleozoic rock in what is really the eastern end of the Wealden dome

of southeast England. The greatest height reached by the scarp in the department is about 710 ft. in the northwest. The scarp overlooks the plains of Flanders on the north and is the source of the Aa, Lys, Scarpe. Sensée and Escant. To the north of the hills running between St Omer and Boulogne, to the south of Gravelines and the southeast of Calais, lies the district of the Wattergands, fens drained by means of canals and dikes and turned into productive land. Cereals are largely grown and also potatoes, sugar beets, forage, oil plants and tobacco. Market gardening flourishes in the Wattergands. Livestock and poultry are reared, and the horses of the Boulonnais are famous.

The department is the chief in France for the production of coal, its principal coal basin, a continuation of that of Valenciennes, centring round Béthune. The manufacture of beetroot sugar, oil and alcohol distilling, ironworking, dyeing, brewing, papermaking and various branches of the textile manufacture are the chief industries. Boulogne, Calais and fitaples equip vessels for the cod, herring and mackerel fisheries. Calais and Boulogne are important ports of passenger transit for England, and Boulogne also carries on a large export trade in the products of the department. The canal system comprises part of the Aa, the Lys, the Scarpe, the Deûle (a tributary of the Lys passing by Lille), the Lawe (a tributary of the Lys passing by Béthune) and the Sensée (an affluent of the Scheldt), as well as the canals of Aire to Bauvin, Neuffossé, Calais, Calais to Ardres, etc. The *département* is served by the Northern railway. There are five *arrondissements* (Arras, Béthune, Boulogne, Montreuil and St. Omer) with 46 cantons and 908 communes. The chief towns are Arras, the capital, Boulogne, Calais, St. Omer, Béthune, Lens, Montreuil, Bruay, Berck, fitaples and Aire-sur-la-Lys. Liévin (1954; 18,005) and Hénin-Liétard (23,399), in the neighbourhood of Lens, are large centres of population. Lillers (pop. 5,456) carries on bootmaking and has a 12th-century Romanesque church; Hesdin owes its regular plan to Charles V, by whom it was built; and St. Pol has the remains of medieval fortifications and castles and gave its name to the counts of St. Pol.

PASHA, a Turkish title, superior to that of bey (*q.v.*), borne by persons of high rank and placed after the name. The title appears, originally, to have been bestowed exclusively upon military commanders, but was subsequently given to any high official and also to unofficial persons whom it was desired to honour. A pashalik was a province governed by or under the jurisdiction of a pasha. The word is variously derived from the Persian *padshah,* Turkish padishah, equivalent to king or emperor, and from the Turkish bash, in some dialects *pash,* a head. chief, etc. In old Turkish there was no fixed distinction between b and *p*. As first used in western Europe the title was written with the initial b. The English forms *bashaw, bassaw,* bacha, etc., of the 16th and 17th centuries, were derived through the medieval Latin and Italian bassa.

PASIC, NIMOLA (1845–1926), Serbian statesman, was the son of a merchant at Zajecar. He studied engineering at Belgrade and then, with the help of a state bursary, at the University of Zurich, where he and other young Serbs came under the influence of Mikhail Bakunin. Pasic was one of a small group who surrounded Svetozar Markovic, and on the latter's death in 1875 became one of the chief exponents of his views. He volunteered to help the insurgents in Hercegovina in 1875 and there met Peter Karageorgevic, later king of Serbia. He became a deputy in 1878 and was in 1881 one of the founders of the Radical party.

A popular rising which broke out at Zajecar in 1883 led to the arrest of most of the Radical leaders and fresh repressive measures. Pasic fled across the Danube and was condemned to death in absentia, remaining in exile until after King Milan's abdication in 1889. While in exile he made friendships in Russia, Bulgaria and Rumania invaluable to him later on. He became an ardent Russophile and supporter of the Karageorgevic dynasty. On his return he became president of the national assembly (*skupstina*) and on two occasions mayor of Belgrade. He was premier for the first time from Feb. 1891 to Aug. 1892, and as foreign minister accompanied the young King Alexander on his first visit to the tsar. He was made Serbian minister in St. Petersburg, but resigned as a mark of protest against the illegal return of King Milan to Serbia in 1894. The Radicals were now in keen opposition, and when an attempt was made on the former king's life in 1899 the government rid itself of their leaders by trumped-up charges of engineering the crime. Pasic, as a result of Russian remonstrances, was soon amnestied on condition of leaving the country. He returned only after Milan's final withdrawal. After the fall of the Obrenovic dynasty in 1903 the Radical party became dominant, and Pasic was foreign minister in 1904 and premier in 1905 and again from 1908 to 1910. He shared in Milovan Milovanovic's negotiations for a Balkan league and on Milovanovic's death in 1912 resumed the premiership. He remained in office throughout the two Balkan Wars, and contributed materially toward the alliance with Greece and the rapprochement with Rumania.

Pasic remained prime minister throughout World War I. He was interested in the union with Serbia of provinces inhabited predominantly by Serbs, but not in the formation of a federal Yugoslavia in which the Serbs, Croats and Slovenes would be autonomous and equal.

The revolution of March 1917 and the fall of tsardom weakened Pasic's position both at home and abroad, forcing him to recede from his plans for a greater Serbia and to negotiate, upon equal terms with the Yugoslav committee under Ante Trumbic, the so-called declaration of Corfu (July 1917), which laid down the broad lines of the future unified Yugoslav state. But his relations with the committee became increasingly strained, and he stubbornly denied to the members any status in the Allied camp and refused to admit them to a coalition cabinet. Austria-Hungary collapsed before any agreement was reached among the Allies on the Yugoslav problem and Italy, abandoning the compromise reached at the Roman Congress of Oppressed Nationalities in the previous April, reasserted its full territorial claims under the secret treaty of London. Despite this dangerous situation Pasic maintained his obstructive tactics not merely toward the Yugoslav committee but also toward the new provisional government which had been formed in Zagreb. Finally, a compromise was reached, and while Stojan Protic became the first premier of Yugoslavia, Pasic was made first delegate to the peace conference, with Trumbic and Milenko Vesnic as his colleagues.

In Jan. 1921 Pasic again became premier and, thanks mostly to the abstention of the Croat Peasant party, was able to maneuvre the new centralist constitution through parliament (June 28, 1921). In the following winter he maneuvred his Democratic allies out of the government and formed a purely Radical cabinet. Though from July to Oct. 1924 he had to give place to a coalition cabinet he returned to power stronger than ever. In Feb. 1925 he again dissolved parliament, threw Stjepan Radic (*q.v.*) and his colleagues into prison and, by the adoption of drastic electoral measures, secured a small working majority. Radic thereupon made his famous recantation and entered the cabinet in October. The two strongest parties in Yugoslavia were then temporarily united, but the situation became increasingly difficult. On April 4, 1926, Pasic relinquished the premiership, and died Dec. 10, 1926.

The Radical party, inspired by the doctrines of Markovic, had stood originally for social reforms and peasant democracy and had been the first really popular and broadly organized party in Serbia. Led by men like Pasic, it soon became nationalist. Russophile and devoted to the Karageorgevic dynasty. It dominated Serbia after 1903 and used its power effectively for the aggrandizement of the country. In spite of its great services to Serbia, its outlook nas too narrow to enable it to create a stable and democratic Yugoslavia or to deal successfully with social and economic problems. (J. Pz.)

PASKEVICH, IVAN FEDOROVICH (1782–1856), count of Erivan, prince of Warsaw, Russian field marshal, was born at Poltava on May 19, 1782. He entered the army through the imperial institution for pages in 1800, saw much active service and by 1828 had reached the rank of field marshal. In 1831 he suppressed the revolt of Poland. On the outbreak of the insurrection of Hungary in 1848 he compelled the surrender of the Hungarians at Vilagos. In April 1854 he commanded the army of the Danube,

but on June 9, at Silistria, he was defeated. He died on Feb. 13, 1856, at Warsaw.

PASQUEFLOWER, the name applied to certain species of the genus Anemone, of the buttercup family, Ranunculaceae (*q.v.*). They are low, stemless, densely silky-haired perennial herbs, rising from thick rootstocks and bearing long-stalked, digitately divided leaves and large purple or lavender flowers, followed by a fruiting head of silky achenes with long feathery tails (styles).

The American pasqueflower (Anemone patens), with light bluish or pale lavender flowers, is abundant on prairies from Illinois to Alberta and southward in the Great Plains to Texas; it occurs also in British Columbia. The European pasqueflower (Anemone *pulsatilla*), with violet purple flowers, widespread on the continent, grows in chalky pastures in England.

Both species are planted in gardens, especially in some of their horticultural forms, some of which have red flowers or variegated leaves.

PASQUIER, ÉTIENNE (1529–1615), French lawyer and man of letters, was born at Paris, on June 7, 1529, by his own account; according to others, a year earlier. He was called to the Paris bar in 1549. In 1560 he published the first book of his Recherches de la France. In 1565 he pleaded the cause of the University of Paris against the Jesuits, and won it. Meanwhile he pursued the Recherches. He left accounts of the jests of himself and his colleagues at the *Grands* Jours of Poitiers in 1579 (the celebrated collection of poems on a flea) and Troyes in 1583. In 1585 Henry III appointed Pasquier advocate-general at the Paris cour des comptes. He died on Sept. 1, 1615.

Pasquier's work was considerable and it has never been fully collected or indeed printed. The standard edition is that of Amsterdam (2 vol., 1723). But for ordinary readers the selections of Léon Feugère, published at Paris (2 vol., 1849) with an elaborate introduction, are most accessible. As a poet Pasquier is chiefly interesting as a minor member of the Pléiade movement. As a prose writer he is of much more account. The three chief divisions of his prose work are his Recherches, his letters and his professional speeches.

PASQUIER, ÉTIENNE DENIS, DUKE (1767–1862), French statesman, was born on April 22, 1767. He was a counsellor of the Paris parlement. Napoleon in 1810 made him prefect of police. He was captured in the strange conspiracy of the republican general Malet (Oct. 1812), who, announcing that Napoleon had perished in Russia, managed to surprise and capture some of the ministers and other authorities at Paris. He soon, however, regained his liberty.

When Napoleon abdicated in April 1814 Pasquier resigned the prefecture of police, whereupon Louis XVIII allotted to him the control of roads and bridges. He held various ministerial offices under Louis XVIII, but refused to join the reactionary cabinets of the close of the reign of Charles X. After the July Revolution (1830) he became president of the chamber of peers —a post which he held through the whole of the reign of Louis Philippe (1830–48). In Feb. 1848 Pasquier retired from active life. He died in 1862.

PASSACAGLIA (Italian variant of Spanish *pasacalle*—"street song"). Famous as a musical form in slow $\frac{3}{4}$ time, and little known as a court dance, the passacaglia appeared in the French theatre of the 17th and 18th centuries as a dance of imposing majesty. Its musical structure is identical with that of the chaconne, but futile attempts have been made to discover differences between them. The baroque composers used both terms indiscriminately, writing fine examples of the rondo, theme and variations, and passacaglia forms under both designations. The true passacaglia form consists of a series of divisions (like variations) over a ground bass (*q.v.*). Bach's great Passacaglia is an outstanding example. See CHACONNE; VARIATIONS. (L. HT.)

PASSAGE RITES. This term was devised in 1909 by the French anthropologist and folklorist Arnold van Gennep to emphasize the structural analogies among rites marking birth, initiation, marriage, death, etc., all of which were suggested as having the common purpose of ensuring a person's passage from one social status to another. The basic pattern of passage rites seems to imply the underlying theory that the individual must go through the form of dying, so as to be reborn under a new guise. The different stages of the rituals everywhere exhibit a remarkable similarity: the exclusion of the noninitiated or profane members of the group; the confinement of the candidate from a few hours up to several years; the celebration of a feast; the robing and unction of the candidate; his renaming; the symbolical fight between the forces of life and death and the victory of the former, etc.

While there is no doubt that van Gennep unveiled a fundamental aspect of social life, his term came to be used indiscriminately so that every rite is sometimes considered to be a passage rite. But, as pointed out by A. M. Hocart, "passage from one sphere to another is the result of these ceremonies, not their cause," and therefore passage rites cannot be explained as a protection against emotional stress resulting from important happenings in the life of the individual. It is the rite which makes certain happenings important and thus provokes stress, not the opposite. How can the similarity of passage rites be explained, if their origin is not emotional? The purpose of the birth ceremony is to introduce the child to his or her society and subsequent ceremonies, such as those marking initiation and puberty, marriage, parenthood, installation of a chief or priest, etc., have the similar purpose of admitting the individual into a new and better-defined status. Death ceremonies may be considered as marking the admission of the deceased to the society of the dead or of his ancestors.

Hocart thought that all passage rites could be reduced to a common prototype, *i.e.*, the ritual of kingship, since, in several archaic civilizations, a man had to be killed (really or symbolically) in order to become a king or a god. This would mean that all human societies, even those of the simpler type, should be considered, at least in this respect, as heirs to a few protohistoric civilizations such as Egypt and India. It may, however, be more likely that numerous cultures tried independently to symbolize important social events on the model of the momentous natural events of birth and death.

See also CHURCHING OF WOMEN; CIRCUMCISION; MANA; MYSTERY; PURIFICATION; RITUAL.

See A. van Gennep, *Les Rites de Passage (1909)*; *A.* M. Hocart, *Social Origins (1954)*. (C. LE.-S.)

PASSAIC, a city of Passaic county, N.J.. U.S., on the Passaic river 9 mi. above Newark and 4 mi. below Paterson. The site was settled by the Dutch in 1678 when Hartman Michielsen established a fur-trading post. During the American Revolution, Gen. George Washington's troops occupied the village and, following their retreat, Lord Cornwallis and his British soldiers were quartered there.

Acquackanonk, as it was originally known, became a river port and shipping point for foodstuffs raised on neighbouring farms and textiles from the nearby Paterson mills. Completion of the Morris canal between Newark and Phillipsburg in 1831, and the railroad brought an end to the thriving river commerce.

The present name. Indian for "peaceful valley." was adopted in 1854 and in 1873 the village was incorporated as a city. The completion of a dam in the 1850s resulted in Passaic becoming a textile centre. Cottons first predominated and then woolens moved to the fore. In 1878 the first plant for making rubber products was established. From 1880 to 1910 in line with rapid industrial expansion the population increased from 6,532 to 54,773, doubling during each decade. There was a considerable influx of eastern European immigrants, especially Poles, Slovaks and Hungarians. Passaic nas noted for handkerchiefs and in the past produced more than 1,000,000 a day. The city was the scene of serious labour struggles, notably the textile strikes of 1912–13, 1926, 1933 and 1934. By mid-20th century the textile industry was on the decline and many firms either closed or moved south. However, the rubber industry expanded and electronics achieved a strong position. During the 1920s radio tubes were produced. Experimentation in television resulted in perfecting the first successful home television receiver incorporating the modern picture tube. Pop (1960) 53.965. For comparative population figures see table'in NEW JERSEY: *Population*. (E R. D)

PASSAMEZZO, an Italian dance of the second half of the 16th century, in duple time, and resembling the pavane. It was described in 1585 as "a pavane danced less heavily and in a half step." The music of the passamezzos was in the form of variations on a given melody. The *passamezzo* antico, known also as the "passing measures" pavane, was in the minor mode, and the pas-*samezzo nuovo* in the major. The dance is described in M. F. Caroso's *Il Ballerino* (1581). The term was also held to derive from bassa *mezza,* the middle of a *basse-danse.*

PASSAU, a town and episcopal see of Germany, in the Land of Bavaria, at the confluence of the Danube, the Inn and the Ilz. close to the Austrian frontier, 89 mi. N.E. from Munich. Pop. (1959 est.) 32.491. On the site of the present Innstadt there was a pre-Roman settlement *Boiudurum.* Afterward the Romans established a colony of Batavian veterans, the castra *batava,* there. It received civic rights in 1225. The bishopric was founded by St. Boniface in 738 and included until 1468 not only much of Bavaria, but practically the whole of the archduchy of Austria. About 1260 the bishop became a prince of the empire. In 1803 the bishopric was secularized, and in 1805 its lands came into the possession of Bavaria.

Passau consists of the town proper, lying on the rocky tongue of land between the Danube and the Inn, and of suburbs, lying along the other rivers. Of the 11 churches. the most interesting is the cathedral of St. Stephen. The two linked fortresses. the Oberhaus and the Niederhaus, are the remains of the fortifications. The former was built early in the 13th century by the bishop in consequence of a revolt on the part of the citizens; the latter is mentioned as early as 737. The chief industries are the manufacture of tobacco, beer, leather. porcelain, machinery, paper, iron founding and the quarrying of graphite and granite.

PASSCHENDAELE, BATTLE OF, 1917. This protracted operation formed part of the still more prolonged offensive knon-n as and described under YPRES, BATTLES OF, 1917. But because of its unhappy significance as the final stage and ultisnately the final goal of these operations, the term "Passchendaele Offensive" is often used to denote not merely the part but the whole.

PASSEPIED, a gay, charming dance of Breton origin, in rather lively $\frac{3}{4}$ or $\frac{3}{8}$ rhythm. was a fashionable court dance (c. 1660 to 1760), in which lords and ladies emulated the pastoral characteristics of shepherds and shepherdesses. Its name probably derives from the basic step in which the feet crossed and recrossed each other while gliding forward, one foot often striking the other in crossing. The music, beginning with an upbeat in fairly rapid time, is usually syncopated in the cadence measures when three definite t o-count facets occur against two three-count measures. It appears occasionally in the suite, notably in Bach's Fifth Partita and Fifth English Suite. (L. HT.)

PASSERAT, JEAN (1534–1602), French poet, the author of some elegant and tender verse and one of the contributors to the Satire *ménippée,* was born at Troyes on Oct. 18, 1534. He studied at the Cniversity of Paris, becaine a teacher at the Collège de Plessis and in 1572 was made professor of Latin at the Collège de France, in which capacity he wrote scholarly Latin works and commentaries on Catullus, Tibullus and Propertius. He also composed agreeable poetry in the Pléiade style, some of it inspired by the Italian Catarina Delbene, his best pieces being his short ode "Du premier jour de mai" and the charming villanelle "J'ai perdu ma tourterelle.!' His exact share in the Satire *ménippée* (15941, the great manifesto of the moderate royalist party when it declared for Henry of Navarre (see FRENCH LITERATURE), is variously stated but it is agreed that he wrote much of the verse. His lines *"Sur* la *journée* de *Senlis,"* in which he commends the duc d'Aumale's ability in running away, became a celebrated political song. As a young man Passerat lost an eye and toward the end of his life became completely blind. He died in Paris on Sept. 14, 1602.

See P. Blanchemain's preface to Passerat's *Poesies françaises* (1880); *E.* von Mojsisovics, *Passerat, sein Lcben und seine Persönlichkeit (1907); Satire ménippée, ed. by* C. Read (1876 and 1878), J. Frank (1884) and F. Giroux (1897).

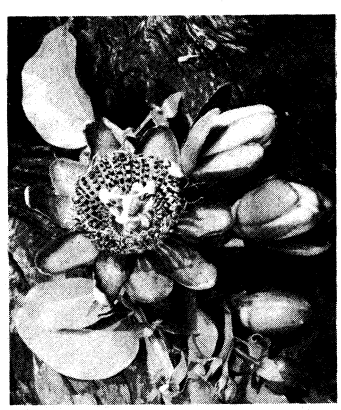
PASSERIFORMES, the largest order of birds. containing most of the highest forms. They are the true perching birds, with three toes directed forward and one backward; the latter is long and is moved by a separate tendon from that moving the front ones. There are between 5,000 and 6,000 species, mostly small birds; they fall into two sections, the Mesomyodi, with a simple syrinx (see SONGBIRD) and hence songless, and the Acromyodi with a complex syrinx and including all the true songbirds besides others. In size passerines range from the minute wrens, sunbirds and flowerpeckers (*qq.v.*) to the relatively large crows and birds of paradise (*qq.v.*). The order includes songsters such as the nightingale, mockingbird, skylark, song and hermit thrushes, cocks of the rock, birds of paradise, the cardinals, pittas, etc.

See **BIRD.**

PASSFIELD, BARON: see WEBB, SIDNEY JAMES AND BEATRICE.

PASSION, a term used in two main senses: (1) the suffering of pain and (2) feeling or emotion. The first is chiefly used of the suffering of Jesus Christ, extending from the agony in the garden until His death on the Cross. In this sense. *passio* (late Lat.) was used by the early Christian writers, and the term is also applied to the sufferings and deeds of saints and martyrs. Passion Week is the name given to the fifth week in Lent. beginning with Passion Sunday. One of the earlier forms of oratorio developed from the ancient church usage of reciting in Holy Week the story of the Passion, to appropriate plain-song music. The secondary sense of "passion" is due to the late use of *passio* to translate the Greek philosophical term *πάθος,* the classical Latin equivalent being *affectus.* The modern use generally restricts the term to strong and uncontrolled emotion.

PASSIONFLOWER (*Passiflora*), the typical genus of the family Passifloraceae, to which it gives its name. The name passionflower—*flos passionis*—arose from the supposed resemblance of the corona to the crown of thorns, and of the other parts of the flower to the nails, or wounds, while the five sepals and five petals were taken to symbolize the ten apostles—Peter, who denied. and Judas, who betrayed, being left out of the reckoning. There are more than 400 species, mostly natives of western tropical South America; others are found in various tropical and subtropical districts of both hemispheres. They are mostly tendril-bearing, herbaceous vines with alternate, often lobed, leaves. In the United States about ten native species of *Passiflora* occur. chiefly in the south and southwest. The passion vine (P. incarnata), climbing 10 to 30 ft. high, with pink and white flowers and a yellow. berrylike. edible fruit, two inches long, is found from Virginia to Missouri south to Florida and Oklahoma. It is usually called maypop The yellow passionflower (P. lutea), of similar range. is a smaller plant, with greenish-yellow flowers and purple fruit.



HANS MANN

PASSIONFLOWER (PASSIFLORA)

The inflorescence is usually of a cymose character. The flower consists of a receptacle varying in form from that of a shallow saucer to that of a long cylindrical or trumpet-shaped tube, and giving off from its upper border the five sepals, the five petals (rarely these latter are absent) and the threads or membranous processes constituting the "corona." This corona forms the most conspicuous and beautiful part of the flower of many species, and consists of outgrowths from the tube formed subsequently to the other parts; it is morphologically useful in favouring the cross-pollination of the flower by means of insects. From the base of the inner part of the tube of the flower, but quite free from it. uprises a cylindrical stalk surrounded below by a small cuplike outgrowth, and bearing above the middle a ring of five flat filaments, each attached by a threadlike point to an anther. Above the ring of stamens is the ovary itself, upraised on a prolonga-

tion of the same stalk which bears the filaments, or sessile. The stalk supporting the stamens and ovary is called the gynophore or the gynandrophore, and is a characteristic of the family.

The ovary of passionflowers is one-celled with three parietal placentas, and bears at the top three styles, each terminated by a large buttonlike stigma. The ovary ripens into a berrylike, very rarely capsular, fruit with the three groups of seeds arranged in lines along the walls, but imbedded in a pulpy arillus derived from the stalk of the seed. This succulent berry is in some cases highly perfumed, and affords a delicate fruit for the dessert table, as in the case of granadilla, P. *quadrangularis*. P. *edulis*, the purple granadilla, and P. *laurifolia*, the yellow granadilla, are, with the common sort, widely grown in tropical America for their fruit. P. *maliformis* is the sweet calabash of the West Indies. The fruits do not usually exceed a hen's or a swan's egg in size. but that of *P. quadrangularis* is a gourdlike oblong fruit attaining a weight of seven to eight pounds. (N. TR.; X.)

PASSIONISTS, a congregation of men of the Roman Catholic Church comprising priests, seminarists and lay auxiliaries. Its official title is The Congregation of the Discalced Clerks of the most Holy Cross and Passion of our Lord Jesus Christ. It was founded by St. Paul of the Cross whose name was Paul Francis Daneo. He was born at Ovado, Italy, Jan. 3, 1694; died at Rome. Oct. 18, 1775; and was canonized. June 29. 1867. The Passionists were established at Castelazzo, Italy, 1725.

The Passionist congregation endeavours to unite the active and the contemplative forms of the religious life. Passionists take the three customary vows of poverty, chastity and obedience to which a fourth is added, that of promoting in the hearts of the faithful a devotion to the Passion and Death of Jesus Christ. The vows made are *simple*, not *solemn*, and are perpetual from their final profession. Their houses are not endowed, although as a group they are allowed to possess buildings with a few acres of land attached.

During the lifetime of St. Paul of the Cross 12 houses of his institute were established in Italy and this number was greatly augmented during the ensuing years until 1810, when, by the order of Napoleon, they were suppressed together with all other religious institutions. From the time of the restoration of the congregation under Pius VII the institute has spread throughout the world, and houses of the congregation were founded in Italy, France, Germany, Austria, England, Scotland, Ireland, Spain, Holland, Belgium, Poland, the United States, Canada, Mexico, Colombia, Cuba, Argentina, Chile, Peru, Brazil, Australia, China, Rumania and Bulgaria.

See Father Pius, *The Life of St. Paul of the Cross (1868); Felix* Ward, *The Passionists* (1923).

PASSOVER, a spring festival celebrated by the Jews in commemoration of the Exodus from Egypt by a family feast in the home on the first evening, and by abstaining from leaven during the seven days of the feast. According to tradition, the first Passover ("the Passover of Egypt") was preordained by Moses at the command of God. The Israelites were commanded to select on the tenth of Abib (Nisan), a he-lamb of the first year, without blemish, to kill it on the eve of the fourteenth, and to sprinkle with its blood the lintel and side post of the doors of their dwellings so that the Lord should "pass-over" them when he went forth to slay the first-born of the Egyptians. The lamb thus drained of blood was to be roasted and entirely consumed by the Israelites, who should be ready with loins girded, shoes on feet and staff in hand so as to be prepared for the Exodus. In memory of this the Israelites were for all time to eat unleavened bread (Mazzoth) for seven days, as well as keep the sacrifice of the Passover on the eve between the fourteenth and the fifteenth of Nisan. This evening meal was not to be attended by any stranger or uncircumcised person. "On the morrow of the Sabbath" a wave-offering of a sheaf of barley was to be made.

Various theories have been from time to time proposed to account for this complex of enactments. J. Spencer in his *De legibus Hebraeorurn* (1685) saw in the Passover a practical protest against the Egyptian worship of Apis. Vatke considered it a celebration of the spring equinox, Bauer a means of removing the impurity of the old year. Lengerke recognized a double motive: the lamb for atonement, the unleavened bread as a trace of the haste of the early harvest. Ewald regarded the Passover as an original pre-Mosaic spring festival made to serve the interest of purity and atonement.

Investigations based on minute literary analysis of the Pentateuch. were begun by Graf, continued by Kuenen and culminated in the work of Wellhausen and Robertson Smith. The modem view claims to determine the respective ages and relative chronological position of the various passages in which the Passover is referred to in the Pentateuch and assumes that each successive stratum represents the practice in ancient Israel at the time of composition, laying great stress upon the omissions as implying nonexistence. The main passages and their contents are arranged chronologically in the following way:

A. In the Elohist Book of the Covenant (Exod. xxiii).
B. In the Yahwist Source (Exod. xxxiv, 18–21, 25).
C. In the Yahwistic History (Exod. xii, 21–27, 29–36, 38–39; xiii. 3–16).
D. The Deuteronomist (Deut. xvi, 1–8, 16–17).
E. In the Holiness Code (Lev. xxiii. 4–8, 9–14).
F. In the Priestly History (Exod. xii, 1–20, 28–31; xiii, 1–2).
G. In the Secondary Sources of the Priestly Code (Exod. xii, 40–41, 43–50; ix, 1–14; xiv, 16–25).

Many discrepancies have been observed by critics in the different portions of this series of enactments. Thus in the Elohist and in Deuteronomy the date of the festival is only vaguely stated to be in the month of Abib, while in the Holiness Code and in the Priestly History the exact date is given and so on.

As regards the character and significance of the two feasts it may be noted that the Passover (Nisan 15) is taken back to the beginning of the national history. It originally connoted a pastoral feast celebrating the birth of the lambs. It goes back to the desert period, whereas the Feast of Unleavened Bread is an agricultural observance and cannot have been practised before the entry into Palestine. The "sheaf of first-fruits of your harvest" mentioned in Lev, xxiii, 10. is associated in Jewish tradition with the barley harvest (Mishna, *Menachoth* x).

The folk etymology of the word Passover given in Exod. xii, 23, seems to connect the original of the feast with a threshold covenant *(see* Trumbull, *Threshold Covenant,* 1902); the daubing of the side posts and lintel with blood at the original Passover, which finds its counterpart in Babylonian custom (Zimmern, *Beit. z. Bab. Rel.* ii. 126–7) and in Arabic usage (*Wakidi,* ed. by Kremer, p. 28), implies a blood covenant.

The feast is connected both in later Jewish tradition and among the Samaritans with the sacrosanctity of the first-born. Hebrew tradition further connects the revelation of the sacred name of the God of the Hebrews with the festival, and thus connects it with the Exodus, the beginning of the theocratic life of the nation. There seems to be no direct connection between the paschal sacrifice and an agricultural festival; the Hebrew tradition, to some extent, dissociates them by making the sacrifice on 14th of Nisan and beginning the Feast of Unleavened Bread on 15th.

Wellhausen and Robertson Smith suggested that the Passover was, in its original form, connected with the sacrifice of the firstlings, and the latter points to the Arabic annual sacrifices called *'atair,* which some of the lexicographers interpret as firstlings. These were presented in the month of Rajab, corresponding to Nisan (Smith, *Religion of Semites).* But the real Arabic sacrifice of firstlings was called *fara;* it might be sacrificed at any time, as was also the case with the Hebrews (Exod. xxii, 30). The paschal lamb was not necessarily a firstling, but only in the first year of its life (Exod. xii, 5). The suggestion of Wellhausen and Robertson Smith confuses the offering of firstlings (Arabic *fara*) and that of the first yearlings of the year in the spring (Arabic *'atair*). It is possible that the Passover was originally connected with the latter *(cf.* Wellhausen, *Reste arab. Heidenturns).* As regards the Feast of Unleavened Bread, now indissolubly connected with the paschal sacrifice, no satisfactory explanation has been given either of its original intention or of its connection with the

Passover. It has been suggested that it was originally a *hag* (hajj) or pilgrimage feast to Jerusalem, of which there were three in the year connected with the agricultural festivals (Exod. xxxiv, *17 seq.)*. But the real agricultural occasion was not the eating of unleavened bread but the offering of the first sheaf of the barley harvest on the "morrow of the Sabbath" in the Passover week (Lev, xxiii, 10 *seq.)*. This occasion determined the second agricultural festival, the Feast of Weeks, fifty days later (Deut. xvi, 9; Lev. xxiii, 16). It still remains possible therefore, that the seven days' eating of unleavened bread (and bitter herbs) is a historical reminiscence of the incidents of the Exodus where the normal commissariat did not begin until a week after the first exit. On the other hand, the absence of leaven may recall primitive practice before its introduction as a domestic luxury.

According to Robertson Smith. the development of the various institutions connected with the Passover mas as follo s: In Egypt the Israelites, as a pastoral people, sacrificed the firstlings of their flocks in the spring, and, according to tradition. it was a refusal to permit a general gathering for this purpose that caused the Exodus. When the Israelites settled in Canaan they found there an agricultural festival connected with the beginnings of the barley harvest, which coincided in point of date with the Passover and was accordingly associated with it. At the time of the reformation under Josiah, represented by Deuteronomy, the attempt was made to turn the family thank offering of firstlings into a sacrificial rite performed by the priests in the Temple with the aid of the males of each household, who had to come up to Jerusalem but left the next morning to celebrate the Feast of Unleavened Bread in their homes. During the exile this was found impossible. and the old home ceremonial was revived and was kept up even after the return from the exile. There appears to have been considerable variety at first in the mode of keeping the Passover, but the earliest mention in the historical narratives (Josh. v, 11) connects the paschal sacrifice with the eating of unleavened bread.

At any rate the Samaritans have throughout their history observed the Passover with all its Pentateuchal ceremonial and still observe it down to the present day. They sacrifice the paschal lamb. which is probably the oldest religious rite that has been continuously kept up. In two important points they differ from later Jewish interpretation. The term "between the evenings" (Lev. xxiii, 5) they take as the time between sunset and dark. and "the morrow of the Sabbath" (v. 11) they take literally as the first Sunday in the Passover week; wherein they agree with the Sadducees, Boethusians, Karaites and other Jewish sectaries. The paschal lamb is no longer eaten, but represented by the shank bone of a lamb roasted in the ashes; unleavened bread and bitter herbs *(haroseth)* are eaten; four cups of wine are drunk before and after the repast; and a certain number of Psalms are recited.

The Passover among the Jews is regarded as the Festival of Freedom. It seems probable in any case that the ritual of the Mass has grown out of that of the Passover service *(see* Bickell. *Messe und Pascha,* trans. *W*. F. Skene. Edinburgh, *1891)*. Up to the Council of Nicaea the Church kept Easter (*q.v.*) coincident with the Jewish Passover. but after that period took elaborate precautions to dissociate the two.

BIBLIOGRAPHY.—The commentaries on Exodus and Leviticus; that of Kalisch on the latter book (vol. ii, London, 1871) anticipates much of the critical position. The article in Winer's *Bibl. Realworterbuch* gives a succinct account of the older views. A not altogether unsuccessful attempt to defend the Jewish orthodox position is made by Hoffmann in his *Commentary* on Leviticus (Berlin, 1906). Wellhausen's views are given in his *Prolegomena.* A critical yet conservative view of the whole question is given by R. Schaefer, *Das Passah-Mazzoth-Fest* (Gütersloh, 1900) which has been partly followed above. For the general attitude toward the comparative claims of institutional archaeology and literary criticism adopted above *see* J. Jacobs, *Studies in Biblical Archaeology* (London, 1895). *See* also I. Abrahams, *Annotated Jewish Prayer Book* (London, 1914), and Oesterley, *Jewish Background of the Early Christian Liturgy* (London, 1926).

(J. JA.: G. H. B.)

PASSOW, FRANZ LUDWIG CARL FRIEDRICH (1786–1833), German classical scholar and lexicographer, was born at Ludwigslust in Mecklenburg-Schwerin on Sept. 20, *1786,* was professor of ancient literature at Breslau, and died there on March 11, *1833.* He aroused great opposition by his advocacy of gymnastic exercises. Passow's great work was his *Handworterbuch der griechischen Sprache* (1819–24), originally a revision of J. G. Schneider's lexicon. which appeared in the fourth edition *(1831)* as an independent work, without Schneider's name (new ed. by Cronert, 1901). It formed the basis of Liddell and Scott's lexicon.

See L. and *A.* Wachler, *Franz Passow's Leben und Briefe* (1839), which contains a full bibliography.

PASSPORT, a formal document or certification issued by a national government identifying a traveler as a citizen or a national with a right to return to that nation. A passport may be required as evidence of authorization to leave a country as well as evidence of the right to return and of the right to aid and protection.

After World Wars I and II passport restrictions of many countries were increased. The adoption of international passports was proposed in the 1920s and again in the late 1940s, when meetings of experts within the Economic and Social council of the United Nations proposed that passports and frontier formalities be reduced, simplified and made uniform.

In the United States passports are issued under the authority of the department of state and, for the benefit of U.S citizens abroad, where there is no question of their citizenship, at a number of U S. consular offices. It is a federal criminal offense to leave the United States in violation of passport regulations, which require a passport to travel to any point outside the western hemisphere. In the latter *1950s* the federal government, while recognizing the right of all citizens to a passport to return to the United States, held that the issuance of passports to leave the country was a privilege that could be extended or withheld. In general, passports were denied persons under indictment or otherwise sought by outstanding federal or state legal process. Denial was extended to persons under investigation and to persons accused of family desertion and nonsupport. Passports also were denied in instances in which it was held that their issuance would be inimical to the best interests of the nation.

In the United Kingdom. passports are issued and renewed by the foreign office. A visa or vise differs from a passport in that it is issued by the state in which the visitor will travel rather than the state of which he is a citizen or national. A visa may be in the form of an endorsement of a passport or it may be a separate document. It is evidence of permission to enter the issuing state under specified. conditions and for a specified time.

In time of war, passports or safe-conduct documents have been granted by belligerent powers to protect persons and property from hostilities. In the case of the ship of a neutral power, the passport is a requisition by the government of the neutral state to allow the vessel to pass freely with the crew, cargo and passengers without molestation by the belligerents. Passports called Mediterranean passes were granted to U.S. vessels as protection against the Barbary pirates. Passports also have been issued in time of war under international law as licences or safe-conducts authorizing a person to move or to transfer his property from a belligerent country to another country.

PASSY, FRÉDÉRIC (1822–1912), French economist, co-winner with Jean Henri Dunant of the first Nobel peace prize, in *1901*, was born in *1822.* He was a nephew of the economist Hippolyte Passy (1793–1880), finance minister to Louis Philippe and to Louis Napoleon's republican government. Frédéric Passy's first work, *Mélanges kconomiques,* appeared in *1857.* He was an ardent free-trader and an admirer of Cobden.

In *1867* he founded the Ligue Internationale de la Paix, afterward known as the Société Française pour l'Arbitrage entre Nations, and devoted himself to the promotion of international peace. From *1881* to *1899* he was deputy for the Seine *département.* He died in Paris on June 12, 1912.

Passy's published works include *De la propriété intellectuelle (1859); Leçons d'économie politique* (1860–61); *La Démocratie et l'instruction (1864); L'Histoire du travail (1873); Malthus et sa doctrine (1868);* and *La Solidarité du travail et du capital (1875).*

PASTE, a term applied to substances used for various purposes; *e g.*, in cookery, a mixture of flour and water. with lard or butter added, for making pastry. The household and school paste, commonly used as an adhesive for paper, may be made by pouring hot water slowly over wheat or rye flour which upon reaching a certain temperature thickens and exhibits adhesive qualities. Compounds possessing greater adhesiveness are made by adding resin, alum, glue and similar substances. The term also refers to the prepared "body" clay used in making pottery and porcelains (*q.v.*). Specially prepared glass, known as "strass," from which artificial gems (*q.v.*) are made is also so named. Anglers use "paste" to describe the soft compositions sometimes utilized for fish bait. In mineral technology paste designates the substance in which the minerals being mined are imbedded.

PASTEBOARD: *see* CARDBOARD.

PASTEL is the name for a dry drawing medium in stick form and for a method of picturemaking utilizing this medium. The stick medium is essentially ponder colour with a minimum of nongreasy binder. usually gum tragacanth (tending to be replaced in mid-20th century by methylcellulose). Pastels are sold commonly in a range of values. the darkest in each hue consisting of the pure pigment and binder. the others of the range having varying admixtures of inert whites. A touch on the paper leaves colour; pastel thus provides a method of drawing in full colour, as in oil painting. without need to wait for drying to know the final effect, as in water colour. The disadvantage of pastel is that its life is precarious because it remains on the surface of the paper and is liable, unless protected by glass or fixative. to be rubbed off by mischance. Fixatives (sprays of glue size or gums in solution) tend to change the tone and flatten the grain of pastel drawings.

Pastel is also the name of the method of picturemaking in pastels; it cannot be called drawing because it is not linear and because it covers the entire support. Pastel may be applied to paper in short touches or lines, but in such usage it functions as crayon; also it may he rubbed and blended. The pastel technique, as developed in the 17th century and widespread in the 18th, was a rubbing technique, with the end of the finger or a stump of leather or paper as agent; accents and outlines: however. preserved a linear form and showed the stroke of the pastel stick. So distinguished a portrait draftsman as J. B. S. Chardin (1699–1779) used his pastel with a hatching stroke in his preparations and never quite buried the traces of drawing in his completed works. The same was true of Maurice Quentin de la Tour (1704–88), though his completed works had a more velvety blended surface.

A sort of protopastel technique had been used by Guido Reni (1575–1642), but the first consistent use was in the first half of the 18th century, particularly in the hands of Rosalba Carriera (1675–1757). one of the most successful artists of her time. Pastel soon became almost exclusively a vehicle for elegant portraiture. A. R. Mengs (1728–79), J. M. Nattier (1685–1766), Chardin, La Tour, Louis Tocqué (1696–1772), Hubert Drouais (1699–1767) and J. B. Perronneau (171j–83) led the field. By the time of the French Revolution pastel portraits were sometimes life size. La Tour and Perronneau produced pastels equaling in brilliance and discretion the painted portraits by J. B. Greuze (1725–1805) or the young J. L. David (1748–1825). The Swiss Jean Étienne Liotard (1702–89) was one of the few to vary the single portrait into groups and genre ("La Belle Chocolatikre" is perhaps the best-known pastel anywhere). The young John Singleton Copley (1737–1815) did some admirable pastels. William Hoare of Bath (*c.* 1707–99), Francis Cotes (1725?–70) and John Russell (1745–1806) were the great English practitioners of what might be called the classic or central pastel style, regarding which Henry Tonks wrote:

> Pastel has a character of its own and should be used with an understanding of what it can do and what it cannot do. It should not be used to imitate oil-painting. It should be considered as a method of applying color, which owing to the practical absence of a medium [binder] is higher in tone than in any other method, thinly to the surface of the paper so that as in water color the actual paper itself may occasionally play a part in the design.

Special papers for pastel have been made since the great 18th-century flowering; some were almost like fine sandpaper. some had a flocked or suèdelike finish, some were prominently ribbed or strongly marked by the drying felts. Since Edgar Degas's time (1834–1917), deep-tinted papers have been much liked.

Up to Degas, pastel had used a combination of colours and values resembling late Gothic and early Renaissance tempera (*q.v.*) painting in the use of full chroma in the darks and almost pure white in the lights. This was a brilliant but blond scheme. Degas changed pastel to a brilliance by contrast that was akin to the contrasts in oil paint fomented by Camille Pissarro, Paul Gauguin and Degas himself. He kept his strokes visibly separate, used almost exclusively those pastel sticks that had the least loading of inert whites, and showed a good deal of the support. By applying a good fixative to his first strokes and letting the work dry, he was able to superimpose a second and other layers of lines in different colours, sometimes at an angle to the lower layer or layers. Thus diaphanous and at the same time startling effects could be produced without smudging; the network of lines, sometimes on a paper already providing a ground colour, was akin to the Impressionists' divided colour in oil paint.

Since the time of Degas. pastel has been something different from the pastel of Carriera and Perronneau. Gustave Moreau and Odilon Redon made it akin to stained glass or enamel jewelry. Émile Wauters and Fritz von Lenbach. Mary Cassatt. W. J. Glackens. J. E. Vuillard. Pierre Bonnard. Edwin Austin Abbey and Robert Brackman have variously mixed the old with the post-Degas method to produce portraits, still life and occasional compositions of integrity. *See* also CRAYON DRAWING.

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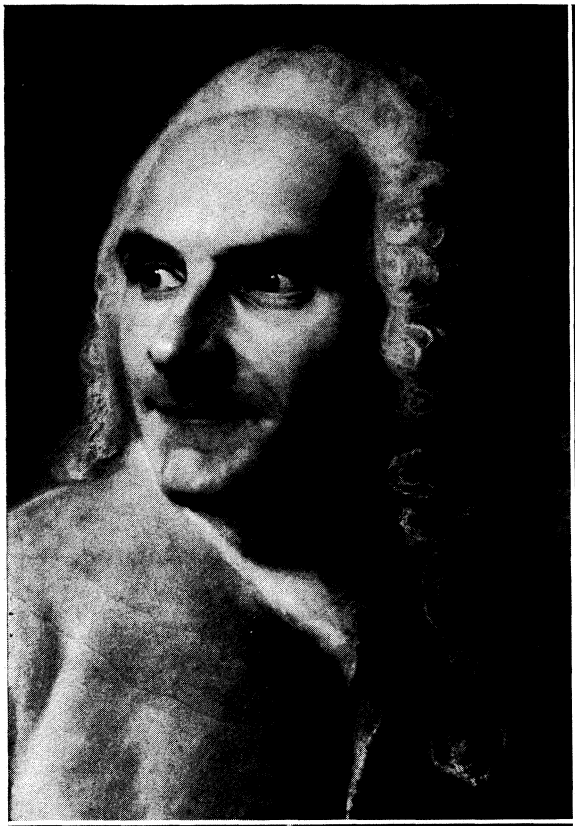
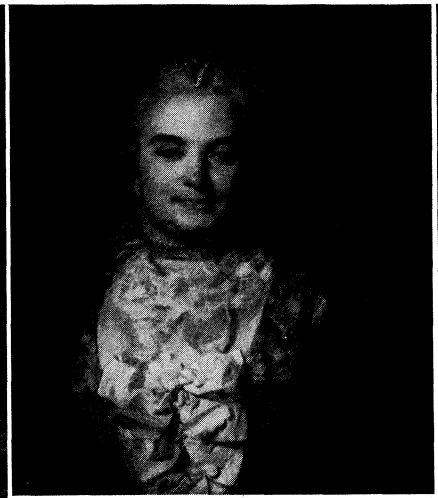
PASTERNACK, JOSEF ALEXANDER (1881–1940), Polish-U.S. conductor, was born in Czestochowa, Pol.. on July 1, 1881, the son of the conductor of the town band. He began to play the violin at the age of four and at ten he was sent to the Warsaw conservatory of music. where he learned to play every musical instrument except the harp. He went to the United States on a concert tour as a pianist when a young man, and remained as solo viola player in the orchestra of the Metropolitan Opera company of New York. At the suggestion of the conductor Arturo Toscanini, Pasternack became a conductor and was engaged to conduct the Bremen. Ger., orchestra. He was called back to the United States to conduct the orchestra of the Metropolitan Opera company. For five years he conducted the Philadelphia Philharmonic orchestra and he also was conductor of the Boston "Pops" orchestra. From 1916 to 1928 he was the musical director of the Victor Talking Machine company. In later years he conducted radio programs and summer concerts at Ravinia park, near Chicago, Ill. He died in Chicago on April 29, 1940.

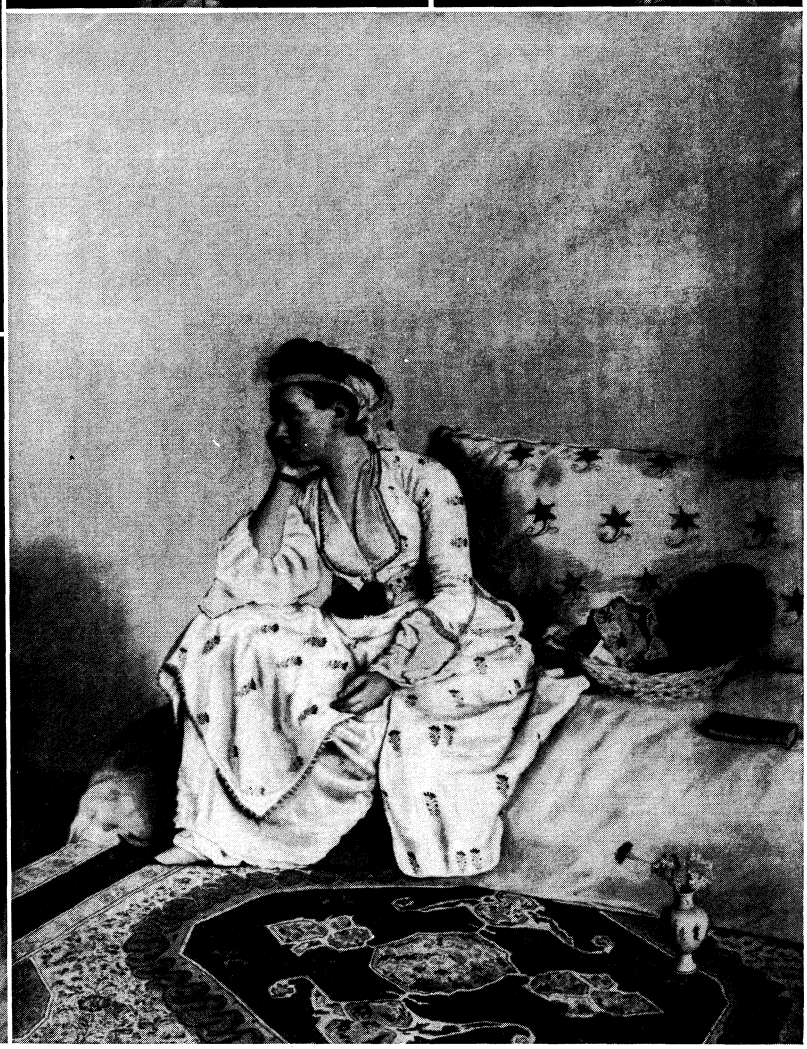
PASTERNAK, BORIS LEONIDOVICH (1890–1960), Russian poet and novelist, was awarded the Nobel prize for literature in 1958. Born in Moscow, Feb. 10, 1890, he studied philosophy at the universities of Moscow (1910–12) and Marburg (1912–13). His first literary reputation was made as a poet; he was first called a Symbolist and later a Futurist, though essentially, having absorbed the Europeans' poetic fashions and being compared to most of the models and practitioners of his time, his poetry is highly individualistic. His apolitical position was shown by the title of his collection of verse, *Poverkh Barierov* ("Above the Barriers," 1931). After the 1918 revolution he worked in the soviet commissariat of education. He also wrote prose fiction and made translations, those of Shakespeare being notable. English translations of his works include *The Collected Prose Works* (1945), *Selected Poems* (1946) and *Selected Writings* (1949; reissued 1958), which includes the autobiography *Safe Conduct* (published in Russian in 1931), as well as stories and poems.

In 1956 his novel *Dr. Zhivago* was rejected by the soviet literary periodical, *Novy Mir*. The book first appeared in Italian translation in 1957, in English in 1958. Pasternak thanked the Nobel Prize committee for its award, then later rejected it. He died near Moscow May 30, 1960.

PASTEL







BY COURTESY OF (TOP LEFT) THE MUSÉE LÉCUYER (TOP CENTRE) WILDENSTEIN AND CO., (TOP RIGHT) THE MANSELL COLLECTION. (BOTTOM LEFT) CHARLES E. PHELPS AND MARY PHELPS FAWCETT, (BOTTOM RIGHT) THE RIJKSMUSEUM, AMSTERDAM

18TH AND EARLY 19TH CENTURY PORTRAITS IN PASTEL

Top left: "Jean Restout" by M. Quentin de La Tour (1704–88), French. A "preparation" from life, more drawing than painting. Musée Lecuyer, France

Top centre: "Mme. Chevotet" by Jean Baptiste Perroneau (1715–83), French. A full-dress pastel treated as a painting

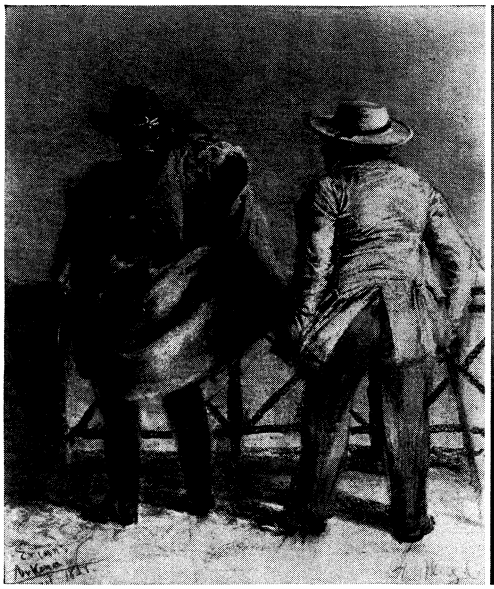
Top right: "Girl with Cherries" by John Russell (1745–1806), English. In the Louvre, Paris. A final stage in the 18th century tradition, somewhat degenerate but retaining the character of drawing

Bottom left: "Lady Temple" by John Singleton Copley (1737–1815), U.S.-English. In the collection of Charles E. Phelps and Mary Phelps Fawcett. Standard pastel practice showing both British and French influence, with some visible linear work

Bottom right: "Mary Gunning" by Jean E. Liotard (1702–89), Swiss. In the Rijksmuseum, Amsterdam. Pastel as painting. The artist, who had lived in Turkey, set his British model in a pseudo-oriental interior. Note the extension of the paper at the top

PASTEL

"Annabel Lee" by J. A. M. Whistler (1834–1903), U.S.-English. Crayon and pastel on brown paper. In the Freer Gallery of Art. Washington, D.C. Even the artist's butterfly signature is part of the design in this example of understatement



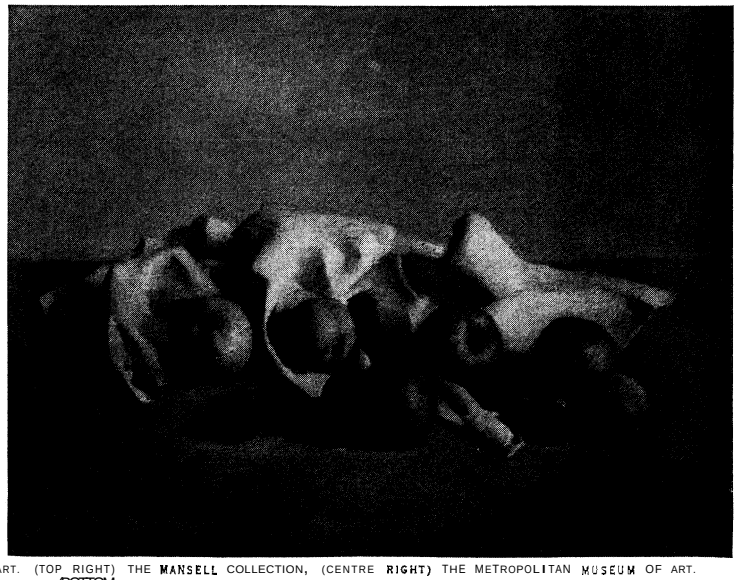
Left: "On the Terrace at Arkona" by Adolf von Menzel (1815–1905). German. In the Nationalgalerie, Berlin. A use of pastel for structure-and local colour without contour, a break from 18th century tradition. *Right:* "Fieurs des Champs dans un Vase à long Col" by Odilon Redon (1840–1916), French. In the Louvre. Pastel used for fiat tone and contour, almost without internal modeling

PASTEL DRAWINGS OF THE LATE 19TH AND 20TH CENTURIES

Right: "Mother Feeding a Child" by Mary Cassatt (1844–1926), U.S. In the Metropolitan Museum of Art, N.Y. A revival of 18th century technique: pastel thinly used and smudged

Below, left: "The Dancers" by Edgar Degas (1834–1917), French. In the Toledo Museum of Art, O. Widely spaced strokes, protected by Rxative and overlain by lines of different colour to produce coruscating contrasts and luminous depths

Below, *right:* "Still Life" by Robert Brackman (1898–), U.S. In the collection of the artist. Pastel, used in some areas wetted, and on a textured support, to approximate painting



BY COURTESY OF (TOP LEFT) THE SMITHSONIAN INSTITUTION, FREER GALLERY OF ART. (TOP RIGHT) THE MANSELL COLLECTION, (CENTRE RIGHT) THE METROPOLITAN MUSEUM OF ART. (BOTTOM LEFT) THE TOLEDO MUSEUM OF ART, GIFT OF EDWARD ORUMMOND LIBBEY, 1928, (BOTTOM RIGHT) ROBERT BRACKMAN

PASTEUR, **LOUIS** (1822–1895), French chemist and microbiologist, established the validity of the germ theory of disease. He was born on Dec. 27, 1822, at Dôle, Jura, the son of a tanner. His family soon moved to Arbois, where Louis attended primary and secondary schools. In 1838 he was sent to school in the Quartier Latin of Paris, preparatory to the École Normale, but his health broke down and he was allowed to return to Arbois. He soon left to enter the Royal College of Besançon, where in 1840 he won his bachelier *ès* lettres. He became assistant mathematical master in the college, securing in 1842 the baccalaurdat *ès* sciences with mediocre in chemistry attached to his diploma. Even in these early days the dominant note in Pasteur's life was sounded. To his sisters he wrote: "These three things, will, work and success, between them fill human existence." Throughout his entire life, work was his constant inspiration. On his deathbed he turned to his devoted pupils and, asking about their work, exclaimed: "Where are you with it? What are you doing?" ending with his favourite words, "You have to work."

In 1843 Pasteur was admitted fourth on the list to the École Normale. He now attended the lectures of J. B. Dumas at the Sorbonne and thereby received his first incentive to the serious study of chemistry. Shortly afterward, to his great joy, he became laboratory assistant to A. J. Balard. He received his degree of docteur *ès* sciences in 1847.

Crystallographic Research. — He accomplished his first startling piece of research, on racemic acid, in 1848. Eilhardt Mitscherlich had shown in 1844 that the ordinary commercial tartaric acid rotated the plane of polarized light to the right, while the paratartrate or racemic acid possessed no rotary power. Being interested in crystals, Pasteur soon realized that the paratartrate contained two types of crystals. He separated them and found that their solutions when tested with a polariscope gave two contrary deviations. He then mixed an equal number of each kind and was able to procure the desired optical neutrality of racemic acid. Thus he had proved that this mysterious acid was made up of a right-hand tartaric acid and a left-hand one, and had incidentally discovered a new class of isomeric substances.

See ISOMERISM.

Fermentation, and the Germ Theory. — In the autumn of 1848 Pasteur moved to Dijon as professor of physics, but early in 1849 was transferred as professor of chemistry at the University of Strasbourg. While there he was awarded the ribbon of the Legion of Honour for his work in connection with racemic acid. Pasteur's appointment in 1854 as professor and dean of the new Faculté des Sciences at Lille placed him in a district where his interest in fermentation could be applied to the manufacture of alcohol from grain and beet sugar, and his energies were now bent toward discovering the causes of the diseases of beer and wine. On examining the yeasts of sound and unsound beer under the microscope, he at once saw that the globules of the sound beer were nearly spherical, while those of the sour beer were elongated. He continued his researches, and, after his removal in 1857 to the École Normale as director of scientific studies, definitely proclaimed that fermentation is the result of minute organisms, and that when a fermentation failed, either the necessary organism was absent or unable to grow properly. Hitherto all explanations of fermentation had been without experimental foundation, but Pasteur showed that milk could be soured by injecting a number of the organisms from buttermilk or beer but could be kept unchanged if similar organisms were excluded. "The chemical act of fermentation," wrote Pasteur, opposing the doctrine of spontaneous generation, "is essentially a correlative phenomenon of a vital act beginning and ending with it." (See FERMENTATION.)

The recognition of the fact that both lactic and alcohol fermentations were hastened by exposure to air naturally led Pasteur to wonder whether his invisible organisms were always present in the atmosphere or whether they were spontaneously generated. By a series of intricate experiments, including the filtration of air and the famous exposure of unfermented liquids to the pure air of the high Alps, he was able to declare with certainty in 1864 that the minute organisms causing fermentation were not spontaneously generated, but came from similar organisms with which ordinary air was impregnated. Pasteur was now acknowledged the leading chemist of his day and the recipient of honours both from his own country and abroad. Lord Lister, who saw the applicability of these discoveries to surgery, was able to revolutionize surgical practice by utilizing carbolic acid in 1865 to exclude the atmospheric germs and thus prevent putrefaction in compound fractures. The pasteurization process for sterilization of food products by controlled heat treatments was developed from Pasteur's work on the fermentation of wine and beer. (See also BREWING; CIDER; DAIRY INDUSTRY; MILK.)

In June 1865, after much persuasion from his old teacher Dumas, Pasteur went to the south of France on an official government mission to investigate the disease of silkworms which was ruining the French silk industry. (See SILK AND SERICULTURE.) Three years later he announced that he had isolated the bacilli of two distinct diseases and had found a method of preventing contagion as well as of detecting diseased stock. These results not only saved the prosperity of the French silk industry but that of all silk-producing countries. Meantime, in 1863, he had also become professor of geology, physics and chemistry at the École des Beaux-Arts and, in 1867, professor of chemistry at the Sorbonne. He was elected to the Académie des Sciences in 1862, becoming permanent secretary in 1887, and to the French Academy in 1881.

In Oct. 1868 Pasteur was struck with semiparalysis, but he was able to return to Paris and continue his experiments on fermentation. The war of 1870 made him more desirous than ever of devoting himself to the perfecting of French brewing, and in 1876 his famous paper on fermentation was published. In 1873 he became a member of the French Academy of Medicine, and in 1874 he received a life pension from the National Assembly. Three years later Pasteur, who had already revolutionized the production of alcohols, established the germ theory and saved the silk industry, turned his attention to the fatal cattle scourge known as anthrax, and within two years had demonstrated the entire natural history of the disease.

Vaccination. — In 1880, however, his researches were diverted to chicken cholera, an epidemic of which destroyed 10% of the French fowls. He was soon able to isolate the germ of this disease, and by cultivating an attenuated form of the germ and inoculating fowls with the culture, he proved that they were rendered immune from virulent attacks of cholera. He now returned to his researches on anthrax, a disease upon which C. J. Davaine and Robert Koch had been working. Following the same methods that he had used in cholera, he isolated the bacillus and, by cultivating it in oxygen at a temperature of 42° C., produced a successful inoculation material which, by inducing a mild attack of anthrax, rendered the inoculated animal immune for a time against a culture of full strength. These methods Pasteur called vaccination (Latin vacca, "cow"), because of his desire to render homage to Edward Jenner, who had discovered means for protecting man against smallpox by inoculating with cowpox. (See ANTHRAX; VACCINATION.) As to the money values of these discoveries, which had brought Pasteur world fame, T. H. Huxley expressed the opinion that it was sufficient to cover the whole cost of the war indemnity paid by France to Germany in 1870. Pasteur himself chose to remain poor and to set an example of simplicity.

Perhaps the most interesting of Pasteur's investigations concerned the preventive treatment of the disease called rabies in animals and hydrophobia in man. After experiments with inoculations of saliva from infected animals, he came to the conclusion that the virus had its seat in the nerve centres, and demonstrated that a portion of the matter of the spinal column of a rabid dog when injected into the body of a healthy animal produced the symptoms of rabies. By further work on the dried tissues of infected animals and the effect of time and temperature on these tissues, he was able to obtain a weakened form of the virus which could be used for inoculation. On July 6, 1885, Pasteur was bold enough to inoculate a human being, a child who had been badly bitten by an infected dog. The experiment was successful, and since then thousands of persons throughout the world have been kept from developing hydrophobia by being given Pasteur vaccine after being exposed to rabies. See RABIES.

He died near St. Cloud on Sept. 28, 1895. His Oeuvres (7 vol.) were published (1922–39), Lettres et *discours* (1927) and Correspondance *1840–1895* (1940), all edited by R. Vallery-Radot.

See René Vallery-Radot, Vie de Pasteur (1900; Eng. trans. by Mrs. R. L. Devonshire, 1923); R. J. Dubos, Louis Pasteur, Free Lance of Science (1950).

PASTEURIZATION, mild heat treatment of a liquid food or beverage for a specified period of time in order to enhance its keeping qualities and to destroy pathogenic microorganisms. It has received wide application in the dairy, wine and beer industries. The higher the temperature applied, the shorter is the time necessary to achieve the desired results.

Pasteurization of liquid foods originated in the 1860s with the work of Louis Pasteur, who demonstrated that abnormal fermentation of wines and beer could be prevented by heating these beverages to approximately 135° F. (57.2' C.) for a few minutes. His classical work is credited with placing the wine and beer industries of France on a sound footing.

With respect to milk, the United States public health service specifically defines pasteurization as the process of heating every particle of the milk so treated to at least 143° F. (61.7° C.) and holding at such temperature continuously for at least 30 minutes (low-temperature, holding method, or LTH), or to at least 161° F. (71.7° C.) and holding for at least 15 seconds (high-temperature, short-time method, or HTST). The minimum temperatures and corresponding times are based upon extended studies of the heat resistance of *Mycobacterium* tuberculosis, considered to be one of the most heat-resistant of the nonspore-forming microorganisms that may cause disease in human beings. Such treatment also destroys a large majority of the potential spoilage microorganisms and thus results in a prolonged keeping time of the food. Bacterial endospores are unaffected.

The term pasteurization also is applied to the mild heat treatment of some solid foods, but in such instances the amount of heat applied is more difficult to define and control because of the physical nature of the food. Radiation pasteurization refers to the application of relatively low doses of beta or gamma rays to liquid or solid foods for the purpose of enhancing their keeping quality. The dose is adjusted to kill the majority or all of the potential nonspore-forming spoilage microorganisms but yet not impair the quality of the food as a result of the treatment.

See E. M. Foster et al., Dairy Microbiology (1957). (C. F. N.)

PASTO, a city of southwestern Colombia and capital of the department of Nariño, about 76 mi. from the Ecuador border on the Pan-American highway, Pop. (1951) 48,853, city; 81,-103 mun. The city is 8,500 ft. above sea level at the foot of the extinct Galeras volcano (13,999 ft.). Founded in 1539, it was a royalist stronghold in the revolution against Spain. Pasto controls traffic between Ecuador and the Cauca valley of Colombia and is the commercial centre for the surrounding agricultural and mining area. Although its population more than doubled between 1950 and 1960, it is still relatively less important as a centre of trade than in the colonial era. Then, as a part of the broad manufacturing region of Quito, it produced woolen textiles, wood products, and straw and wool hats and was the major transportation centre between Quito and Popayán. Pasto is linked by road and rail with the port of Tumaco. (R. L. GE.)

PASTON LETTERS, an invaluable collection of the correspondence of the Paston family and others, from 1422 to 1509, including State-papers and other documents. Most of these were sold by the 2nd earl of Yarmouth, the last representative of the family, to the antiquary Le Neve early in the 18th century. On his death in 1729 they were acquired by Thomas Martin of Palgrave, who married Le Neve's widow; and on Martin's death in 1771 they were purchased by John Worth of Diss, whose executors sold them to John Fenn of East Dereham. In 1787 Fenn published two volumes of selections, the originals of which he presented to George III.; in 1789 he issued two more volumes, and when he died in 1794 had prepared a fifth, which was issued in 1823 by his nephew Serjeant Frere. The originals unfortunately all disappeared; and some doubt was cast upon the genuineness of the letters, notably by Herman Merivale in the Fortnightly (1865). It was, however, defended by James Gairdner in the same periodical, and established within a year by the discovery of the originals of the fifth volume by Frere's son Philip in his house at Dungate, Cambridgeshire. Ten years later those of the third and fourth volumes were found at Roydon Hall, Norfolk, the chief seat of the Freres; and in 1889 the originals of the remaining two (those presented to George III.) were unearthed at the seat of Captain E. G. Pretyman. It is probable that they had been given to Bishop Pretyman Tomline, friend and tutor of William Pitt.

Among these discoveries were many documents not printed by Fenn; and there are still others. When the 2nd earl of Yarmouth died in 1732 many papers referring to his family were found at his seat, Oxnead Hall. Some of these came into the hands of the Rev. Francis Blomefield, who meant, but failed, to unite his collection with that of Martin. This section of the letters was scattered, part being acquired by the antiquary Ives. Most of the documents are now in the British Museum; but some are at Orwell, others in the Bodleian, others at Magdalen college, Oxford, and a few at Pembroke, Cambridge.

In 1872 Gairdner published the first volume of a new edition. Taking Fenn's work as a basis, he included in his three volumes (1872–75) over 400 hitherto unprinted letters and a valuable Introduction. As a supplement he was able to give an account of the Roydon discovery of 1875, and in later editions he printed the Roydon papers in full. Finally, in 1904, he re-edited the whole; and the six volumes of this edition, with their 1,088 documents and most erudite Introduction, are the chief authority on the subject.

The Paston family takes its name from a village about 20 m. N. of Norwich, and the first known member of the family was living there early in the 15th century. This was Clement Paston (d. 1419), a peasant holding about 100 acres. His son William (1378–1444), to whom Clement had given an excellent legal education, and who is described as "a right cunning man in the law," became in 1429 a justice of the common pleas. He bought land in Norfolk, some of it in Paston, and improved his position by his marriage with Agnes (d. 1479), heiress of Sir Edmund Berry of Harlingbury, Hertfordshire. When he died he left a large inheritance to his son John, who was already married to Margaret (d. 1484), daughter of John Mauteby. At this time England was under a weak king, and only the strong man armed could hope to keep his goods. Paston, a lawyer like his father, lived much in London, and many of the most important of the letters are from Margaret to her husband describing the state of affairs in Norfolk. In 1448 Paston's manor of Gresham was seized by Lord Moleyns, and though it was recovered, the owner could obtain no redress. More serious troubles were caused by the ambiguities of the will of Sir John Fastolf (apparently a relative of Margaret), which involved Paston not only in lawsuits, but in actual warfare, with many neighbouring magnates, among whom were the duke of Suffolk and the (3rd) duke of Norfolk. Paston died in 1466, leaving the affair still unsettled, although in 1461 the king and council had decided in favour of his claim. His son Sir John (1442–79) and the dowager Margaret carried on the struggle, which was marked by repeated captures and recaptures of Caistor Castle. A peace was patched up by Waynflete, bishop of Winchester, in 1474, and the death of the (4th) duke of Norfolk paved the way for the restoration of Caistor; but a fresh dispute arose with the duke of Suffolk. The intricate story is given in full in Gairdner's introduction. Through these quarrels and Sir John's extravagance the lands were much diminished; yet he left a goodly inheritance to his younger brother, whose name was also John (d. 1503). At this point the letters begin to be scanty and uninteresting; but the family still flourished. Robert Paston was created earl of Yarmouth in 1679. His son William died, aged 80, in 1732, leaving no heir; and his titles became extinct.

The Letters are of high historic importance, especially for the reign of Henry VI. The weakness of the king had disorganized the whole administration; the succession itself was contested; the great nobles did what was right in their own eyes; and the prevailing discontent found expression in the rebellion of Jack Cade

and the Wars of the Roses. The correspondence reveals the Pastons in a great variety of relations, friendly or hostile, with their neighbours; and abounds with illustrations of the course of public events, as well as of manners and morals. Nothing is more remarkable than the acquaintance of educated persons, both men and women, with the law—an acquaintance which they plainly found indispensable.

All editions are superseded by Gairdner's 6 vols. of 1904; but Blomefield and Parkin's *History of Norfolk* (1805–10) may be consulted, and the article *Paston* in *Dict. Nat. Biog.*, where other authorities are quoted. Some references to the 2nd earl of Yarmouth will be found in the *Lives of the Norths* (edit. Jessopp, 1890). (X.; E. E. K.)

PASTOR, LUDWIG, FREIHERR VON (1854–1928), German historian of the popes, was born of a patrician family in Aachen on Jan. 31, 1854. He attended the *Gymnasium* in Frankfurt am Main, where Johannes Janssen, the author of the multivolume *History of the German People* (which Pastor was to edit after Janssen's death), was one of his teachers. During his studies at the universities of Louvain, Bonn, Berlin, Vienna and Graz, Pastor became acquainted with the leading historians of his day. Admitted as a lecturer at the University'of Innsbruck in 1881, he was appointed professor of modern history in 1887. He became director of the Austrian Historical institute in Rome in 1901 and Austrian chargé d'affaires at the Vatican in 1920 and minister from 1921 to 1928.

He was knighted by the emperor Francis Joseph in 1908 and created a baron in 1916.

Pastor's works include more than a dozen historical monographs, but his fame rests on his monumental *Geschichte der Päpste seit dem Ausgang des Mittelalters (History of the Popes from the Close of the Middle Ages)*, published in 16 volumes betueen 1886 and 1933 and translated into all major languages; the English edition, published in London and St. Louis between 1891 and 1953, contains 40 volumes. Pastor caused Pope Leo XIII to open the Vatican archives to scholarly research; he also consulted archives all over Europe, thus providing his works with an extensive documentation.

Writing as a Catholic, he emphasized that the task of the historian was that of the objective scholar rather than that of the apologist; his treatment of the darker periods of the papacy, in particular that of Alexander VI, is frank. As the title of his work indicates, he concentrated on the history of individual popes rather than on that of the papacy as an institution. Pastor died in Innsbruck on Sept. 30, 1928.

For a list of his publications *see* W. Wuhr (ed.), *Ludwig Freiherr von Pastor, Tagebiicher-Briefe-Erinerungen* ("Diaries-Letters-Memoirs"), pp. 911–918 (1950). For other biographical evaluations, *see* the same work, pp. 918–920. (F. A. Hs.)

PASTORAL, the name given to a certain class of modern literature derived ultimately from the "idyll" of the Greeks, the "eclogue" of the Latins and their 15th century imitator, J. B. Spagnuoli (Mantuanus) and the late Greek romances. It was a growth of humanism at the Renaissance, and its first home was Italy. Pastoral *poetry*, as it appeared in Tuscany in the 16th century, was really an allegorical eclogue and the idyll could be expanded from a single scene into a drama. The first dramatic pastoral which is known to exist is the *Favola di Orfeo* of Politian, which was represented at Mantua in 1472. But this poem led the way rather to tragedy than to pastoral, and it is the *Il Sagrifizio* of Agostino Beccari, which was played at the court of Ferrara in 1554, that is always quoted as the beginning of sentimental pastoral in European literature. Torquato Tasso followed Beccari after an interval of 20 years, and by the success of his *Aminta*, which was performed before the court of Ferrara in 1573, secured the popularity of dramatic pastoral. Guarini produced in 1590 his famous *Pastor Fido*, and Ongaro his fishermen's pastoral of *Alceo* in 1591. During the last quarter of the 16th century pastoral drama was really a power in Italy. Some of the best poetry of the age was written in this form, to be acted privately on the stages of the little court theatres, that were everywhere springing up. In a short time music was introduced, and rapidly predominated, until the little forms of tragedy, and pastoral altogether, were merged in opera.

Pastoral *romance* dates from the publication, in 1504, of the famous *Arcadia* of J. Sannazaro, a work which passed through 60 editions before the close of the 16th century, and left its mark upon every literature in Europe. This remarkable romance, the type of so many succeeding pastorals, is written in musical prose, into which are inserted passages of verse. The characters live an innocent voluptuous existence, with no hell or heaven in the background: the narrative, the adventures, the dialogue are equally exalted and unreal.

In Spain the influence of the *Arcadia* made itself rapidly felt through Jorge de Montemayor, whose *Diana* (1524) was founded on Sannazaro. Gaspar Gil Polo, after the death of Montemayor in 1561, completed his romance, and published in 1564 a *Diana enamorada*. Both these works are mentioned with respect, in their kind, by Cervantes. The author of *Don Quixote* himself published an admirable pastoral romance, *Galatea*, in 1584. Lope de Vega made a pastoral of the Nativity introducing much of the Old Testament in narrative episodes related by the characters.

The typical French pastoral, the *Astrée* of Honoré d'Urfé (1610), has almost more connection with the knightly romances which Cervantes laughed at than with the pastorals which he praised. The famous *Astrée* was the result of the study of Tasso's *Aminta* on the one hand and Montemayor's *Diana* on the other, with a strong flavouring of the romantic spirit of the *Amadis*. To remedy the pagan tendency of the *Astrée* a priest, Camus de Pontcarré, wrote a series of Christian pastorals. Racan produced in 1625 a pastoral drama, *Les Bergeries*, founded on the *Astrke* of D'Urfé.

In England the chief example of the form is Sir Philip Sidney's *Arcadia* (written in 1580), published in 1590). In 1584 were published two pastoral dramas, the *Gallathea* of Lyly and the *Arraignment of Paris* of Peele. Greene became more and more imbued with the Italian spirit of pastoral. His *Menaphon* and his *Never too Late* are pure bucolic romances. In *Rosalynde* (1590) Lodge made an interesting contribution to English literature in general, and to Arcadian poetry in particular. This beautiful and fantastic book is modelled more exactly upon the masterpiece of Sannazaro than any other in our language. In 1598 Bartholomew Young published an English version of the *Diana* of Montemayor.

In Spain, France and England there was a strong native tradition of bucolic verse which blended easily, though in differing proportions, with classical impulses from Theocritus, Virgil and the Italians. The Spanish poet Garcilaso de la Vega (d. 1536) is Virgilian, the lyrics of Gil Vicente are of the soil, like the songs of Shakespeare. In the *Bergerie* of Rémy Belleau the new art of Sannazaro joins hand with the simplicity of the Old French *pastourelle*. It was probably the study of the eclogues of Clément Marot that led Spenser to the composition of what is the finest example of pastoral in the English language, the *Shepherd's Calendar*, printed in 1579. This famous work is divided into 12 months, and it is remarkable because in it Spenser turns from the artificial Latin style of pastoral and brings upon the pastoral stage actual rustics using their own peasant dialect, a departure from precedent for which Sidney blamed him.

After Spenser, Drayton is the first pastoral poet who deserves mention. His *Idea: The Shepherd's Garland* bears the date 1593, but was probably written rather earlier. In 1595 he produced *Endimion and Phoebe*, and then turned his fluent pen to the other branches of poetic literature; but after more than 30 years, at the very close of his life, he turned to this early love, and published in 1627 two pastorals, *The Quest of Cynthia* and *The Shepherd's Sirena*. The general character of all these pieces, as of the *Queen's Arcadia* of Daniel, is rich, but vague and unimpassioned. Marlowe's pastoral lyric "Come live with Me," although not printed until 1599, has been attributed to 1589. Barnfield's singular production *The AffectionateShepherd* was printed in 1594.

With the close of the 16th century pastoral literature was not extinguished in England as suddenly or as completely as it was in Italy and Spain. Throughout the romantic Jacobean age the English love of country life asserted itself under the guise of pastoral sentiment, and the influence of Tasso and Guarini was

felt in England just when it had ceased to be active in Italy. In 1606 Day dramatized part of Sidney's *Arcadia* in his *Isle of Gulls*, and about 1625 Thomas Goffe composed his *Careless Shepherdess*, which Ben Jonson designed to imitate in the opening of his *Sad Shepherd*. In 1610 Fletcher produced his *Faithful Shepherdess* in emulation of the *Aminta* of Tasso. This is the principal pastoral play in the language, and in the *Sad Shepherd*, which was perhaps written about 1635, and in his pastoral masques, we see Ben Jonson following along the track that Fletcher had pointed out. The last pastoral drama in the 17th century was Settle's *Pastor Fido* (1677).

Still more characteristic are the lyrical eclogues, usually in short measure, a class of poetry peculiar to the nation and to that age. The lighter staves of *The Shepherd's Calendar* were the model from which all these graceful productions were drawn. Nicholas Breton came first with his *Passionate Shepherd* in 1604. Wither followed with *The Shepherd's* Hunting in 1615, and Braithwaite, an inferior writer, published *The Poet's Willow* in 1613 and *Shepherd's Tales* in 1621. 'Wither's friend William Browne published in 1613–16 his beautiful collection of Devonshire idylls called *Britannia's Pastorals*. These were in heroic verse and less distinctly Spenserian in character than those eclogues recently mentioned. In 1614 Browne, Wither, Christopher Brook and Davies of Hereford united in the composition of a little volume of pastorals entitled *The Shepherd's Pipe*. The masterpieces of this native school are *L'Allegro* and *Il Penseroso*, as *Lycidas* is the masterpiece of the Virgilian manner.

This sub-Spenserian poetry led in another generation to a rich growth of lyrics which may be roughly called pastoral, but are not strictly bucolic. Carew, Lovelace, Suckling, Stanley and Cartwright are lyrists who all contributed to this harvest of country song, but by far the most copious and the most characteristic of the pastoral lyrists is Herrick. He has, perhaps, no rival in modern literature in this particular direction. His originality and observation, his interest in recording homely facts of country life, combine with his extraordinary gift of song to place him in the very first rank among pastoral writers; in Herrick's hands the pastoral becomes real and modern. From him we date the recognition in poetry of the humble beauty that lies about our doors.

Pastoral came into fashion again early in the 18th century. The quarrel between Philips and Pope gives 1708 a considerable importance in the annals of bucolic writing. Pope had written his idylls first, and it was a source of infinite annoyance to him that Philips contrived to precede him in publication. He succeeded in throwing ridicule on Philips, however, and his own pastorals were greatly admired. Yet there was some nature in Philips, and, though Pope is more elegant, he is not one whit more bucolic. A far better writer of pastoral than either is Gay, whose *Shepherd's Week* was a serious attempt to break with the Arcadian tradition and to copy Theocritus in his simplicity. Swift proposed to Gay that he should write a Newgate pastoral in which the swains and nymphs should talk and warble in slang. This Gay never did attempt; but a northern admirer of his and Pope's achieved a veritable and lasting success in Lowland Scotch, a dialect then considered no less beneath the dignity of verse. Allan Ramsay's *Gentle Shepherd* (1725) was the last, and remains the most vertebrate and interesting, bucolic drama produced in Great Britain. It remained a favourite, 150 years after, among Lowland reapers and milkmaids. With the *Gentle Shepherd* and Johnson's denunciation of the whole pastoral convention (including *Lycidas)* the chronicle of pastoral in England practically closes.

The taste of the 18th century was very agreeably tickled by the religious idylls of Salomon Gessner, who died in 1788. His *Daphnis* und *Phillis* and *Der Tod Abels* were read and imitated throughout Europe. Jean Pierre Claris de Florian, who began by imitating the *Galatea* of Cervantes, continued with an original bucolic romance entitled *Estelle*. But pastoral is a form of literature which disappears before a breath of ridicule. Neither Gessner nor his follower Abbt were able to survive the laughter of Herder. Since Florian and Gessner there has been no reappearance of bucolic literature properly so-called. Throughout Europe the Romantic interest in nature and the humanitarian interest in the poor combined in the 19th century to produce a new form, the rustic stories of Auerbach, of George Sand and of Hardy, which are the modem equivalent of the pastoral, stripped of Arcadian convention and merging in the larger *genera* of realist or romantic fiction.

PASTORAL EPISTLES, THE. This is a title given to three New Testament epistles which purport to have been written by St. Paul to Timothy (two) and Titus. From the second century onwards it was recognised that these three epistles bore specially upon church work and orders; but it was not until the eighteenth century that some German scholars devised the convenient term "Pastoral" to denote the group. "How people ought to bear themselves in the household of God" (I. Tim. iii.15) is the general subject of all three, and special stress is laid upon the responsibilities of Christian ministers in their pastoral care of the Church. The epistles contain much personal information, especially 2 Timothy, but their common aim differentiates them from a semi-private letter like Philemon. In outlook, diction and style, they stand by themselves in the New Testament canon.

1. First Timothy is a pastoral letter in the form of counsels from St. Paul to his younger colleague Timothy (i.1–2), but the plural "you" in the final greeting (vi.21) reveals the fact that all along the writer has the Church in his mind. After reminding Timothy that he had been left at Ephesus to safeguard the faith of local Christians, the writer proceeds to contrast the antinomian practices of the errorists with the Pauline gospel as the norm of faith and morals (i.3f). To this apostolic trust and tradition Timothy is bidden adhere. Then follow a series of regulations on various aspects of church-life (ii.1f); for whom and by whom prayer is to be offered in worship, the latter counsel (8f) drifting into a word on the subordination of women; the qualifications of a bishop (iii.1f), of deacons and deaconesses (9f); the general advice at the close of this section (14f) implies that even organisation and worship cannot altogether eliminate heresies and moral aberrations, so that the writer passes (iv.1f) to the need for Timothy meeting such dangers by a faithful ministry. This includes wise behaviour towards individual groups in the church (v.1f), such as widows (3–16), presbyters (17f) and slaves (vi.1f). A brief conclusion (vi.3f) contrasts the true "man of God" with the errorists who profaned religion by their quarrelsomeness and self-seeking.

Second Timothy is less loosely knit and less discursive. After (i.1f) warning Timothy against false shame, when his chief was imprisoned and suffering, he urges the younger man (13f) to follow the heroic example of a certain Onesiphorus, who had proved himself loyal to Paul and the Pauline cause, and to uphold at all costs (ii 1f) the gospel of his chief, transmitting the apostolic tradition to subordinate agents, teaching and practising it himself, and maintaining a firm position against (16f) controversial errorists of the period. After exposing their methods and spirit (iii.1f), the writer warns Timothy again (iii.10f) by his own example that suffering is inevitable in the service of the gospel, and that the apostolic gospel must be upheld (13f) unflinchingly (iv.1f). The final paragraphs (iv.6f) solemnly describe the critical position of the apostle as he faces a martyr's death, and the epistle closes with a number of personal messages.

Titus is on the whole more of a unity than either of the others. After the greeting (i.1–4), the writer recalls the duties of Titus in the island of Crete, where presbyters have to be appointed with care, and the local errorists dealt with sharply. Then come instructions on the sound doctrine which .Titus is to convey to various classes of people (ii.1f), in the light of the true gospel (10f); these general counsels are reiterated (iii.1f) in view of the outside world, believers being expected to rise above worldliness and wrangling. A few personal remarks (iii.12f) conclude the epistle.

The only passage in Titus which seems out of place is i.7–9, which reads like a later interpolation, breaking the connection between ver.6 and ver.10; it may be a marginal gloss added by the writer himself, or inserted by some editor who was interested in the monarchical episcopate. Such additions were not uncommon in writings used for ecclesiastical procedure. "It is very probable

that the Pastoral Epistles contain many interpolations in which statements about errors and even directions about discipline have been somewhat altered to suit the requirements of the middle of the second century" (Lindsay, *Church and Ministry in the Early Centuries,* p. 141). Thus it is possible that the formula "Faithful is the saying" (I. Tim. i.15, etc.) is an appended phrase. I. Tim. v.23 also reads like a marginal gloss, unless it originally lay elsewhere. That some passages have been displaced is a fair hypothesis; *e.g.* I. Tim. i.12–17 would come better between ver.2 and ver.3, whilst vi.17–21 is either a later edition or misplaced from the vicinity of ver.8, and the correct place for v.16 is after v.4. In 2 Tim. iv.9f the heterogeneous character of the text is most apparent; there is no good reason to doubt the authenticity of the contents, but it is hardly possible to take them as they stand, and the general conclusion is that we have here two or three notes written at various times, which have been put side by side by the editor, and which refer to some earlier phases in the apostle's life.

2. This raises the problem of the literary origin of the epistles. Were they written by the apostle Paul himself, or in his name by some disciple who sought to convey what he believed to be his master's mind on a religious situation of later date? The Pastorals were suspected in some quarters of the early Church; they were rejected, for example, by Marcion as being private letters, as well as by Basilides and others, including Tatian, who retained only Titus. But such rejections were probably due to dislike of their teaching and cannot be held to reflect any reasoned belief in their post-Pauline origin. The reasons which have led an increasing number of scholars to place them after the life-time of St. Paul are drawn from internal evidence of style and subject, style including diction. There are, however, differences between the vocabulary of the earlier and later Pauline letters which must be taken into account in handling the Pastorals. They remind us of no writer so much as St. Paul. Yet neither differences of subject-matter nor a fresh emphasis on certain topics, much less any supposed change of amanuensis, avail to weaken the inferences drawn from the language of the Pastorals, which is distinctive, and not distinctive of the Paul we otherwise know. An examination of the Greek vocabulary shows not only a remarkable proportion of words used for the first time by the writer, but new compounds, an absence of characteristically Pauline terms, the substitution of one word for another used in the same or a similar sense by the apostle, and an independent use of the Greek particles, which is of much significance. The philologist Th. Naegeli, in a monograph on the language of the apostle *(Der Wortschatz der Apostels Paulus,* 1905, pp. 85f), deduces from such phenomena that the Pastorals cannot have been written by him—a conclusion which is all the more significant that he does not come to this conclusion about any other Pauline letter.

The theological outlook is by itself also. It is not easy to suppose that in three epistles the apostle, for example, would ignore such fundamental truths of his gospel as the fatherhood of God, the union of the believing man with Jesus Christ, and the power of the Holy Spirit in the Christian experience. The only explanation of this seems to be that the epistles were written by a disciple of St. Paul who, in the name of his master, and on the basis of some authentic fragments of Pauline correspondence, wrote against tendencies which threatened the later church, denouncing incipient forms of gnosticism, for example, roundly and indiscriminately. The writer fully believed he was giving what was his master's mind, as an historian would compose a speech in the name of a hero—perhaps as his contemporary Luke composed some of the Pauline speeches in Acts. He felt rightly that Paul would have been anti-gnostic, and that the maintenance of the apostolic gospel was essential for the Churches. His spirit was that of the apostle himself in the prediction of Acts xx 28f. It is no longer tenable to identify the errorists with any school of second century gnostics, but it is equally impossible to find them in any party which Paul is known to have encountered in his lifetime Also, the spirit in which they are attacked is not in line with St Paul's method. His way of enforcing ethical requirements and of insisting on organisation is different from that followed by the author of the Pastorals—a shrewd man, who writes with excellent sagacity and point, but hardly with the sustained insight and creative vigour of his master. We might say that this author possesses the intuition of authority rather than the authority of intuition.

The alternatives are (i.) to regard the epistles as genuine on the whole, containing extracts from Paul's correspondence, but largely expanded and edited, or (ii.) to read them as Pauline in *toto.* The latter hypothesis has to meet the difficulty of placing them in his life-time; either they must be viewed as written after his supposed release from the first imprisonment at Rome, or they must be somehow relegated to his career as outlined in Acts. The latter view is extremely hard to present satisfactorily, for although there are gaps in his life as it is recorded, it is almost incredible that he should have suddenly written in this strain and then dropped into the strain familiar to us in the other epistles. Furthermore, the historical setting is hard to reconstruct. That Titus went to Crete, and that Timothy had a responsible position at Ephesus, is indeed likely, for apart from such tradition the setting of the Pastorals would be incredible; even a pseudonymous author would not be likely to invent freely such a framework. But to find any place for such activities during the lifetime of the apostle is not easy! Indeed the majority of those who defend the traditional hypothesis relapse on the view that the Pastorals represent a period in the apostle's life subsequent to the career described in the Acts of the Apostles. It is a moot point whether the apostle was ever released from his imprisonment, however, and even if he was, the problem of fitting the Pastorals into this closing period of his career involves considerable historical ingenuity.

To sum up—the data of the Pastorals are so conflicting and ambiguous that they seem to justify us in supposing that "a writer, believing himself to be in accord with St. Paul's teaching, and possessing some remains of his correspondence, expanded such into these letters, in order to combat erroneous speculations in the Church by opposing to them sound teaching and an objective standard of belief. He probably lived at a time when ecclesiastical organisation was growing in importance, and seems to offer a safeguard against the spread of moral and intellectual error. Timothy and Titus are thus representative figures, standing for those whom the writer really wished to admonish and instruct" (G. W. Wade, *New Testament History,* 1922, p. 303). It does not follow, however, that he wrote the epistles in their canonical order. The likelihood is that 2 Timothy was the earliest; 1 Timothy betrays a more advanced situation, and by the time he had come to write it the author had used up nearly all his Pauline fragments; in 1 Timothy he is more of an author than an editor. As the epistles had no titles, it was natural that when they were incorporated in the canon, 2 Timothy, with its richer and more detailed outlook on the last days of the apostle, should be placed second.

BIBLIOGRAPHY.—The most adequate editions in English are by Ellicott (4th edition, 1864), J. H. Bernard *(Cambridge Greek Testament,* 1899), *N. J.* D. White *(Expositor's Greek Testament,* 1910), *R. S.* J. Parry (Cambridge, 1920), and W. Lock (*International Critical Commentary,* 1924), though the expositions by A. E. Hillard (1919) and A. Plummer (*Expositor's Bible,* 1888) are also valuable for insight into the religious spirit of the epistles, as is the commentary by E. F. Brown *(Westminster Commentaries,* 1917) on the English text. All these represent the conservative position upon the authorship. In German scholarship this position is best represented by B. Weiss (Meyer's *Commentar,* 7th edition, 1902) and Wohlenberg (Zahn's *Commentar,* third edition, 1923); otherwise the German editions of importance reflect the non-Pauline authorship, *e.g.,* Holtzmann's *Pastoralbriefe* (1880), von Soden's (*Handcommentar,* 1891), and M. Dibelius' (in Lietzmann's *Handbuch,* 1913), which are the outstanding editions.

Schleiermacher's tract *Ueber den sogenannten ersten Brief des Paulus an d. Tim.* (1807) really started the critical movement, which Holtzmann stated fully; later upholders are Renan (S. *Paul* pp. xxiiif., *L'Eglise Chrttienne* ch. v.), Weizsaecker *(Apostolic Age,* ii. pp. 163f, 259f), McGiffert *(Apostolic Age,* pp. 398f, 423f), and P. N. Harrison *(The Problem of the Pastoral Epistles,* Oxford, 1921), which may be said to have settled the linguistic case against the Pauline authorship. The opposite side is put by writers like Bertrand (*L'Authenticité des épitres Pastorales,* 1888). W. *E.* Bowen *(Dates of the Pastoral Epistles,* 1900), J. D. James *(Genuineness and Authorship of the Pastoral Epistles,* 1906), and Zahn in his *Einleitung in das Neue Testament*

(sections 33f). R. A. Falconer's article in the *Dictionary of the Apostolic Church* (ii. pp. 583f) sums up the traditional position adequately, as opposed to the present writer's conclusions in the *Encyclopaedia Biblica* (5079f).

Special monographs on points of importance are C. W. Otto's *Geschichtliche Verhaeltnisse der Pastoralbriefe* (1860), W. Mangold's *Irr lehrer der Pastoralbriefe* (Marburg, 1856), W. Lutgert's *Irrlehrer d. Pastoralbriefe* (1909), and H. H. Mayer's *Ueber die Pastoralbriefe* (Gottingen, 1913), the last-named emphasizing the later church-orders implied in the epistles, a point already treated by J. Reville in his *Origines de l'épiscopat* (i. pp. 262f).

On First Timothy, since Melanchthon's special commentary (*Enarratio*, 1561), there have been a series of works, including Koelling's (1882, f) and Liddon's *Analysis* (1897); on Second Timothy, Bahnsen's *Sogenannte Pastoralbriefe* (1876), and on Titus monographs from Mosheim's *Erklärung* (1779) to Kuinoel's *Explicatio* (1812); but the epistles have been commonly edited together. (J. Mof.)

PASTORAL STAFF: see CROSIER.

PASTORIUS, FRANCIS DANIEL (1651–1719 or 1720), founder of Germantown, Pennsylvania, U.S.A., was born in Franconia, Germany, on Sept. 26, 1651. He was educated as a lawyer and practised for a short time, but after he became a member of the Pietist sect his interest shifted from law to religion In 1683 he was made the agent for two groups, both of which owned land in Pennsylvania — the Pietists, who had organized as the Frankfort Land company, and a group of Crefeld merchants. He sailed for America with a colony of German and Dutch Mennonites and Quakers, who, when they landed, settled between the Schuylkill and Delaware rivers, where Pastorius laid out Germantown.

He served as a member of the Germantown assembly, to which he was first elected in 1687, as the first bailiff, or mayor, of the town (1691 and 1692) and as town clerk. He was one of four signers of a protest, to the annual meeting of Friends, against Negro slavery, the first protest of its kind by a religious group in the colonies. Whittier later made it the subject of his poem, The Pennsylvania Pilgrim, the preface of which contained a translation of Pastorius' Latin prologue to the Germantown book of records. Among Pastorius' other writings was a primer of reading, writing and spelling, probably the first textbook to be written in Pennsylvania, and The Beehive, a compendium of information written in seven languages. Pastorius died either in Dec. 1719 or in Jan. 1720.

PASTRY, HOME MADE. General rules for the making of pastry are: wash hands in cold water. Work in a cool place. Use dry sifted flour. Mix with very cold water. Roll away from you and the same way, then, if necessary, across. Roll firmly but lightly. Lift paste to see that it does not stick to board. Flour hands, board and roller but not the paste. Add liquid by degrees: it is impossible to say exactly what amount will be required as the mixture-absorbing quality of flour varies. Mix with knife or fork. Use hands as little as possible. Pieces scraped from board, roller and hands should not be used. Trimmings may be rolled out again but after several rollings will not be as light as the original pastry.

Plain Short Crust.—For tarts, tartlets, pastries: 1 lb. flour, 6 oz. clarified dripping, margarine or half lard and half butter, 1 teaspoonful baking powder, ½ teaspoonful salt, cold water. Sieve dry ingredients. Rub in fat with floured finger-tips until flour resembles bread crumbs. Mix to a stiff dough. Roll. Bake in a moderately hot oven. For a rather richer paste use 8 oz. fat and mix with milk and water.

Rich Short Crust.—I lb. flour, 12 oz. butter or margarine, 1 teaspoonful baking powder, 1 or 2 eggs, 2 teaspoonfuls castor sugar, a pinch of salt. Sift dry ingredients. Rub in butter as in plain short crust. Mix yolks of eggs and water. Mix to smooth stiff paste. Roll. Bake in a moderately hot oven. If used for a tart, five minutes before serving brush over with egg white and sprinkle with sugar. For savoury short crust proceed as before, but omit sugar and white of egg.

Flaky Pastry.—For sweets or for meat pies and sausage rolls ½ lb. flour, pinch of salt, 6 oz. margarine and lard mixed, cold water. Divide lard and margarine into three portions. Sieve dry ingredients. Rub in one-third fat. Mix to fairly stiff paste. Roll into long thin strip. Place one-third of fat all over this in little lumps, dredge with flour and fold in three. Press edges carefully together and turn fold to left hand. Roll out again, put on the remainder of the fat as before, flour and fold. After three folds and three rolls, roll into required shape. Bake in quick oven.

Puff Paste.—For vol-au-vents, patties, pies, tarts. ¾ lb. flour, ¾ lb. butter or margarine, yolk of 1 egg, 1 dessertspoonful lemon juice, pinch of salt, cold water. Sieve flour and salt, rub in 1 oz. of fat. Put flour on board in a heap. Make a hollow in centre. Mix egg yolk and liquids. Mix into flour with a fork, then with fingers to a firm paste. Knead with floured hand until paste leaves board clean: dust with flour as necessary until you have a smooth firm paste. Fold over into the middle. Roll into a square. Hold up so that its own weight helps to pull paste into right shape. Divide fat into four parts. Cut one part into small pieces. Place on paste at regular intervals. Fold the four corners over until they meet in centre. Turn folded side down. Roll twice to form a square. Repeat with fat portions two and three. Wrap paste in cloth, leave in cold place 15 minutes. Add fourth portion of fat as before. Roll and fold into three. The paste should now be firm and spongy. Roll as required for use. This pastry may be made on previous day except for the fourth portion of fat and put away in cloth in a cold place. Bake in a hot oven. Reduce heat gradually.

Suet Pastry.—For boiled or steamed meat or fruit puddings and dumplings: ½ lb. flour, ½ teaspoonful baking powder, pinch of salt, 4 oz. suet. Sieve dry ingredients. Remove skin and strings from suet. Chop very finely on a floured board. Add to flour. Make a well in centre. Stir in flour with a knife from sides of basin. Make a smooth soft dough which leaves the sides of basin clean. Knead lightly until free from cracks. Place on floured board. Roll as required.

Cheese Pastry.—For cheese straws and biscuits: 2 oz. butter, 2½ oz. flour, 2 oz. Parmesan cheese, 1 oz. Cheshire or Cheddar cheese, yolk of 1 egg, salt and cayenne pepper. Mix flour and grated cheese together. Rub in butter, season with salt and cayenne pepper. Form into stiff paste with egg yolk and water, adding liquid gradually. Roll as required. Bake in moderate oven. (D. C. Pe.)

PASTURE: *see* GRASSLAND.

PASURUAN, formerly the name of a residency now called Malang, in the province of East Java, Indonesia; area 3,413 sq.mi. It is in the southeast part of the island, bounded on the west by Surabaya and Kediri, on the east by Besuki, north by the Java sea, and south by the Indian ocean. It is extremely mountainous. Its central portion is occupied entirely by the Tengger plateau and mountains (the highest point being Mahameru, 12,060 ft.) and the Arjuna-Kawi mountain group, with the valley of the Brantas river between them, and part of the Ijen highlands. Most of the southern coast land is hilly. The only level part is in the east. The northern coastal lands, however, form a wide plain with rich volcanic soil, of great fertility, and, with the Malang plain, one admirably suited to the growth of sugar-cane, of which culture Pasuruan is one of the leading centres in Java. Tobacco is another product, also coffee, cassava, coca and maize, while rice, coconut palms, and the usual other native crops flourish. In the forest of Pasuruan are wild cattle (banteng), which are used to improve the breed of the humped Java cattle, also for food and agricultural purposes, and the hides are made into leather. The population (1957 est.) was 3,485,021, mostly Javanese but with a considerable number of Madurese along the north coast. Pasuruan (1957 est., 56,293), on the north coast, was formerly the seat of the residency; has a sugar production experimental station, and with Probolinggo (1957 est., 64,716) further along the coast, is a port of call. Other towns are Tosari and Nongkajajar, Malang (1957 est., 300,651), the capital of the residency, on the Brantas, Bangil, a railway junction, and Pasirian, near the south coast. The railway from Surabaya to Banyuwangi passes through Pasuruan, first along the coast, and then inland, between the Ijen and Tengger plateaus, with a branch to Pasirian, and another to Kediri. Pasuruan was occupied by the Japanese in March 1942, during World War II.

PATAGONIA, a regional name applied to the southern part of South America south of approximately 39° S. lat. Physio-

graphically, it is divided into two longitudinal sections—the cordilleras of the Andes, including the islands of the Chilean archipelago, and the Patagonian tableland between the Andes and the Atlantic ocean. Thus both Argentina and Chile own parts of it. In a more restricted sense the term designates the Argentine tableland, including Tierra del Fuego (*q.v.*), and is so considered in this article. The term in this sense is usually applied to that section of the Argentine republic between the Negro river and its tributary the Limay, on the north, and the Beagle channel, on the south, together with that section of southern Chile in the region of the Strait of Magellan that lies east of the Andes (*q.v.*).

Geological History and Physiography.— The general aspect of the tableland is that of vast steppelike plains rising terrace-fashion from high coastal cliffs to the foot of the Andes; but their true aspect is by no means so simple as such a general description mould imply. Along the Negro river they rise by a series of fairly level plains from 300 ft. at the coast to about 1,300 ft. at the junction of the Limay and Neuquén rivers and 3,000 ft. at the base of the Andes. The tableland region rises to an altitude of 4,921 ft. South of the Negro river they are much more irregular. There volcanic eruptions have occurred down to fairly recent times. Basaltic sheets, apparently only recently cooled, cover the tableland east of Lake Buenos Aires and Lake Pueyrredon. On the Chico and Santa Cruz rivers they have spread to within about 50 mi. of the coast and reach almost to the coast south of the Coyle and Gallegos rivers. Basaltic massifs in places are the salient features of the landscape.

The coast consists largely of high cliffs separated from the sea by a narrow coastal plain. Thus the plateaus are formed of horizontal strata, some of sedimentary rocks, others of lava flows. Areas of hilly land, composed of resistant crystalline rocks, stand above the plateaus.

The deep, wide valleys bordered by high cliffs that cut the tablelands from west to east are all beds of former rivers that flowed from the Andes to the Atlantic. but only a few now carry permanent streams of Andean origin (the Colorado, Negro, Chubut, Senguerr, Chico, Santa Cruz). The majority either have intermittent streams such as the Chalia, Coyle and Gallegos. which have their sources east of the Andes, or, like the Deseado. are completely dry except for salt ponds in the deeper depressions and so altered by the combined effect of wind and sand as to afford little surface evidence of the rivers that once flowed in them. They serve an important purpose in the collection of the scanty surface water. Alluvial soils of considerable depth have been built up in them.

The line of contact between the Patagonian tableland and the folds of the Andes is marked by a chain of lakes, their upper ends deep in mountain canyons, their lower ends held in by glacial moraines.

From Lake Nahuel Huapi northward the lakes, except for Lake Lacar, still drain to the Atlantic. South of Lake Nahuel Huapi all of the lakes except Viedma and Argentino now drain to the Pacific through deep canyons cut across the cordillera; and the interoceanic divide follows the terminal moraines of the old glaciers to the east of the present lake beds, leaving the majority of the transverse valleys without streams.

In the Argentine province of Neuquén the Andes lower rapidly toward the south, Cerro Domuyo east of the upper basin of the Neuquén river being the last peak that exceeds 12,000 ft. The cordillera there consists of a broad zone of mountain chains and narrow valleys. The crests that have a fairly uniform elevation have been carved by erosion from the older Andean rocks. Above them rise isolated volcanic peaks.

Two great fields of inland ice fill all the central part of the cordillera from about 46° S. lat. to 51° S. lat., with a break at latitude 48° S. From these ice fields great glaciers flow down to the lake region on the eastern border of the cordillera and to the fiords of the western border.

Climate.—Patagonia is the. only desert on earth lying along an east coast poleward of lat. 40°. Aridity results from location in the rain shadow of the Andes and from the presence along the coast of a wide zone of cold water—the northward-moving Falkland current. The total annual precipitation ranges usually from 5 to 6 in. and never as much as 10 in. Nearly all the rain falls in winter.

Despite its high latitude, Patagonia does not exhibit extremes

EDGAR AUBERT DE LA RUE

BEECH TREE IN PATAGONIA. LASHED BY STRONG WESTERLY WINDS ON NAVARINO ISLAND. SEEN BEHIND ARE THE BEAGLE CHANNEL AND THE SOUTHERN COAST OF TIERRA DEL FUEGO

of temperature, largely as a result of its proximity to the ocean. The wind, which blows incessantly on the plateau at velocities of 70 m.p.h. and more, increases evaporation and thus further reduces the value of the scanty rainfall.

Tierra del Fuego, which experiences a marine type of polar climate, receives far more precipitation than the tableland, particularly the Chilean portion.

Vegetation.— The principal vegetation, except for parts of Tierra del Fuego that are covered with evergreen forest and grass, consists of a mingling of very low brush and clumps of bunch grasses. There are no trees. The vegetation is harshest and the area most desolate midway on the tableland, near the border of the territories of Chubut and Santa Cruz, but improves toward the south.

The principal range vegetation is a hard bunch grass called *coirón*, not very palatable in summer but invaluable in winter when the tips protrude through the light sno cover, guiding sheep to the grass underneath. In summer seasonal soft grasses provide pasturage for sheep.

Animal Life.—Patagonia's faunal life is quite abundant. Rodents are particularly numerous, all small in size, resistant to drought and extremely fecund. Man wages war against them, because they compete seriously with sheep for the sparse vegetation. The guanaco, a camelid, has been largely extirpated. The puma is found in considerable numbers, as is the rhea, the American ostrich, which ranges throughout Patagonia. Other animals are the perdiz, fox. mara, tucutuca, and armadillo. Tierra del Fuego is one of South America's principal nesting grounds for ducks and geese, which congregate in unbelievably large numbers in summer.

Geese increased in numbers as sheepmen destroyed foxes so that sheepmen attempted to destroy them; six geese eat as much as one sheep.

Water **Resources.**—Water is at a premium in arid Patagonia. Most of the east-west-trending canyons contain no surface water at any time, though several do intermittently and a few even the year round. Wells are sunk into the gravels of these exotic rivers and a substantial supply of water is obtained. Most ranches are situated in these canyons.

Of the small potential water power in the Andes of Patagonia almost none is developed because there is no market in the region and because distances to the cities in the pampa (1,000 mi, or more) are too great for economical transportation. The chain of lakes in western Patagonia provide a valuable water resource for the tourist industry.

Soils.—Patagonia's soils are gray desert soils resulting from the low rainfall accompanied by moderately low temperature. While generally high in plant nutrients, particularly lime, they are low in organic matter. In some areas, however, the soils suffer from an accumulation of alkaline salts. Under their natural arid conditions they are unproductive but do support enough sparse vegetation for limited grazing. The plateau is often covered with weathered lava, river and glacial material carried from the Andes, and decomposed igneous and sedimentary rock. As these weather, the fine particles are blown by the wind. When the time factor is limited, immature soils called Azonal may be formed; they are fertile and productive when irrigated.

The alluvial soils along the river bottoms of the canyons that dissect the region (the Rio Negro, Neuquén, Limay and Chubut) are examples. In some places gravel and hardpan lie close to the surface, the latter causing irrigation and drainage difficulties.

Minerals.—Patagonia appears to be poorly endowed in minerals. Coal-bearing strata have been found in many places along the eastern front of the Andes—particularly near Lake Epuyén in Chubut territory and in Rio Negro territory—but the deposits consist of subbituminous coal and are low-grade. Lignite has also been discovered in southern Patagonia. Because of the low quality of the coal and the poor transportation coal can be imported into the country to greater advantage.

The principal oil field in Argentina lies near the coast in Chubut territory; more than 70% of the country's total output comes from the Comodoro Rivadavia field, some 850 mi. S.W. of Buenos Aires.

Natural gas, also present, is transported northward by pipeline, whereas the oil is moved by tanker.

In 1945 petroleum was discovered at Cerro Manantiales (Spring Hill) in northern Tierra del Fuego across the Strait of Magellan from Punta Arenas. Though a small producing field, its output means much to Chile.

A new mining district of about 10,000 sq.mi. bordering on the San Matías gulf in eastern Argentina developed after 1950. has lead, manganese, fluorspar and tungsten. In 1951 a hematite-magnetite iron ore deposit with an estimated 160,000,000 tons of ore running 55% iron was discovered.

Agriculture and Pastoralism.— Agriculture is of minor importance in Patagonia. In the bottoms of several of the east-west-trending river valleys some irrigation agriculture is carried on. The irrigation works are simple. Alfalfa is the principal crop in terms of acreage. Fruits—grapes, apples, and pears—are quite important, particularly in the Rio Negro valley. Over most of the plateau the only crops are a few hardy vegetables—cabbage, carrots, lettuce, and turnips—grown behind windbreaks.

Sheep raising dominates all economic activity in the region; Patagonia possesses about one third of Argentina's 50,000,000 sheep. The Corriedale and Romney Marsh breeds have largely replaced the Merino because they are hardier and yield more meat. The carrying capacity on the Patagonian range is about 5 to 10 acres for each sheep, as contrasted with $2\frac{1}{2}$ acres in Tierra del Fuego.

In no other comparable area in the world are there so many sheep in proportion to the human population as in this region. Throughout the world better-endowed areas tend to turn from sheep to more lucrative pursuits. But this is not to be expected for Patagonia, which appears to be essentially and permanently a sheep-raising region. The number of sheep will probably not increase to any great extent because wind erosion and drought are ever present and overgrazing has been reducing the carrying capacity of the range.

Transportation.— The few railways in Patagonia are essentially lines leading from ports into their hinterlands. The Southern railway, entering Patagonia where it crosses the Rio Colorado from Bahia Blanca, passes through Neuquén, the capital of the Neuquén territory and extends west to Zapala. Railways south of the Rio Negro include (1) the San Antonio railway, which connects with the Southern railway of Buenos Aires at Carmen de Patagones and reaches westward from Puerto San Antonio Oeste to San Carlos de Bariloche; (2) the Central railway of Chubut, which continues from Puerto Madryn up the Chubut valley; (3) the Comodoro Rivadavia railway, which extends westward to Colonia Sarmiento; (4) the Puerto Deseado line, which runs northwestward to Colonia Las Heras via Fitz Roy; (5) the Rio Gallegos-Rio Turbio railway, the southernmost line in the western hemisphere, was built to connect the Rio Turbio coal mines near the Chilean border with the deepwater port of Rio Gallegos, 50 mi, north of the Strait of Magellan.

A road extends south along the coast to Rio Gallegos and from there to Punta Arenas, Chile. In the interior the conditions of the roads vary greatly; the Nahuel Huapi National Park region is one of the best served in this respect. (L. WE.)

History.— Most of the settlement of Patagonia has taken place in the 20th century. Vast numbers of sheep and a lack of population characterized the area until the fruit, agricultural and resort zones of the north developed after 1910 and oil was discovered on the coast.

During the Spanish colonial period there was virtually no settlement of the Patagonian coast, river valleys or Andean chain. Jesuit missionaries entered the northern area by way of Chile in the 17th century but were unable to effect a permanent settlement. In the late 18th century, a permanent coastal settlement, Carmen de Patagones, was founded at the mouth of the Negro river and became an important source of salt for Buenos Aires.

Expansion into Patagonia was little more successful in the early national period and only Punta Arenas (*q.v.*), a Chilean strait settlement, and Colonia Sarmiento, a Welsh colony in Chubut, were established. Extensive colonization began only in the 1880s, shortly after a series of vigorous military campaigns (1879–1883) had effectively removed the Indian menace. The pioneers were mainly European (Welsh, Scotch, English) and Chilean. There were three main routes of colonization: from the ports of Buenos Aires and Bahia Blanca came mostly Europeans spreading southward along the coast; from the Chilean village of Punta Arenas another finger of settlement extended up the eastern Andes, bringing sheep into the desolate plateau area; a final route led across the Andes from Chile into Neuquén and pushed southward past Lake Nahuel Huapi. Settlement aggravated the boundary dispute between Chile and Argentina.

Although hostilities were barely avoided during the last decade of the 19th century, mediation finally solved the dispute. *See* ARGENTINA: *Geographic Regions: Patagonia.*

During the 20th century, the sheep-raising industry moved away from the pampa toward the arid southern tablelands of Patagonia. Ranch headquarters sheltered in river canyons administered thousands of square miles of range. Population remained sparse and was limited to such ranch villages and tiny seaports except in northern Patagonia along the Neuquén and Negro rivers south to Chubut, which continued to attract European settlement. Foreign land companies that obtained grants from the Argentine government brought many settlers to that area. Argentines from Mendoza and San Juan also came. It was found possible to raise a variety of crops including wheat, rye and potatoes there and the basis of a fruit industry was laid. Government aid to railroad and irrigation projects from 1910 to 1930 especially advanced the Río Negro area. Westward along the Andes a lumbering industry prospered.

The lakes near San Carlos de Bariloche gained popularity as a resort, and as skiing became a popular sport a winter subsidy to the region was assured. Meanwhile the discovery of oil in 1907 at Comodoro Rivadavia provided another impetus for settlement in that area.

In 1955 the territories forming Patagonia were made into four provinces. The military zone of Comodoro Rivadavia, created in 1944 to safeguard oil deposits, was divided at lat. 46° S. between the province of Chubut and the province of Santa Cruz, the latter also including the tip of Tierra del Fuego. By 1960, the population of the three northern provinces of Neuquén, Río Negro and Chubut (*qq.v.*) was 445,798 as compared with the 52,853 of the southern province of Santa Cruz (*q.v.*). Although Patagonia comprises about a quarter of the land area of Argen-

tina, it had less than 3% of the population; the average density was less than one person per square mile.

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PATANJALI, an ancient Indian author or authors. to whom are ascribed works in Sanskrit on religious meditation (*Yoga-sutra*). grammar (*Maha-bhashya*), medicine (*Charaka-samhita*), alchemy (*Patanjala*), the Sankhya philosophy (*Adhara-karika*), liturgical music (*Nidana-sutra*) and metrics (Pingala's *Chhandah-sutra*).

The well-known "Aphorisms of Yoga" codified earlier thought, but appears itself no older than the 4th century A.D., as some aphorisms seem intended to refute the *Vijnana-vada* school of Mahayana Buddhism. It may be an earlier text remodeled. The "Great Commentary" discusses the grammatical aphorisms of Panini and Katyayana's critical annotations upon them, which it incorporates. It is of great acuity, both philosophical and grammatical. Events mentioned suggest the 2nd or 1st century B.C. for its composition. A tradition, perhaps late: appears to identify *Charaka,* a medical authority perhaps of the 2nd century A.D., with a single Patanjali, author of both the *Yoga-sutra* and *Mahabhashya,* but neither philosophically nor grammatically do these works appear in complete accord. Al-Biruni in the 11th century frequently quotes as of great renown a *Patanjala* which appears similar in content rather than form to the *Yoga-sutra,* but includes alchemy as a means to liberation; and a *Patanjala* is elsewhere cited as an alchemical authority. Patanjali and all the authors with whom he is sometimes confounded are regarded as incarnations of the divine serpent, Sesha.

See L. Renou, *Littérature sanskrite* (1936).

PATAVIUM, an ancient city of Venetia, Italy, 55 mi. E. of Verona by road (mod. *Padova,* Eng. Padua, *q.v.*). One road led S.W. to Ateste, Hostilia (where the Po was crossed) and Bononia; another E.N.E. to Altinum and Concordia. It was also accessible by canals from the sea (30 mi.). The old town (40 ft. above sea level) lay on a peninsula surrounded by the Bacchiglione except on the south, where it was protected by a canal. Of the bridges which cross the canals by which Padua is now intersected, four go back to Roman times. Remains of a public building were found in the centre of the modern city, outside which lies the ancient amphitheatre, measuring 323 ft. by 205 ft. The name of the town is probably connected with Padus (Po). Under Augustus it surpassed all the cities of the north in wealth, and in the number of Roman knights among its citizens was only equaled by Gades. Its commercial importance was especially due to its trade in wool. It was a literary centre. Livy, Q. Asconius Pedianus and Thrasea Paetus were natives of the town; and Quintilian speaks of the directness and simplicity of their diction as *Patavinitas.* After the 2nd century A.D. Patavium seems to have been outstripped by Milan and Aquileia.

Patavium was destroyed by the Lombards (601) and lost all its Roman monuments.

PATAY, BATTLE OF (1429), one of the most serious defeats experienced by England in the Hundred Tears' War with France. After the death of Henry V (1422), the English made slow progress in extending their conquests but in Oct. 1428 began to besiege Orléans, the strategic key to the Loire river: as the prelude to an invasion of the territory of Charles VII south of that river. The siege had little success during the winter, and Orléans was still holding out in May 1429 when Joan of Arc inspired its relief. The earl of Suffolk (William de la Pole), the English commander, then withdrew his army to three towns on the Loire (Jargeau, Meung and Beaugency), which he hoped to hold until reinforcements under Sir John Fastolf arrived from Paris. Fastolf reached Janville in mid-June with an army of about 5,000 men and was joined there by John. Lord Talhot and a small force. Jargeau had by then fallen, and the French were besieging Beaugency. Fastolf and Talbot went to its relief but arrived to find it on the point of surrender. They decided to withdraw immediately, not wishing to risk battle with a considerably larger French army. The French, spurred on by the encouragements of Joan. pursued the English northward and overtook them two or three miles south of Patay on June 18. Fastolf and Talbot were taken by surprise and had no time to draw up their army in a defensive position. Talbot was attempting to block the enemy advance. while the army deployed behind him, when the cavalry of the French van under La Hire (Étienne de Vignolles) and Poton de Xaintrailles rode in among his men and destroyed all chance of organized resistance. A rout followed, in which Talbot was captured and a great many English were killed. Fastolf escaped with the remnants of the army.

This defeat was a blow to England's military prestige and fighting resources. England's reputation for invincibility was lost and with it all hope of striking into southern France. France north of the Loire was now almost undefended! and Charles VII was able to ride triumphantly to Reims for his coronation.

See A. Lang, *The Maid of France* (1908); C. Oman, *History of England, 1377–1485* (1918). (J. W. SE.)

PATAYA (adjective PATAYAN). Pataya is the name applied to a prehistoric people and culture once occupying the lower valley of the Colorado river, surrounding deserts in California and Arizona, and neighbouring uplands to the east. Patayan sites date from about A.D. 600 to the present.

In southwestern United States, archaeologists have recognized three generalized cultures among the prehistoric Indians of Arizona and neighbouring states. These have been named as follows: pueblo cultures, Anasazi (*q.v.*); desert cultures in southern Arizona. Hohokam (*q.v.*); and mountain cultures of southeastern Arizona and western New Mexico, Mogollon (*q.v.*). Since the cultures of Indians living in the valley of the lower Colorado river and'surrounding areas did not fit into the other three categories, the name Pataya, a Walapai Indian word meaning "old people," was suggested. In general the Pataya occupied the area now inhabited by tribes speaking a Yuman language, such as the Yuma, Mohave, Yavapai, Walapai and Havasupai, and good evidence exists that the Pataya were their ancestors (*see* YUMAN).

Archaeologists have distinguished three main prehistoric Patayan Indian groups; the sites on which they lived can be recognized by the kinds of pottery they made. Generally they are classified into a river group, Laquish, who had an agricultural economy; a desert group, Cerbat, who lived by food gathering and hunting; and on the Colorado plateau the Cohonina, who accepted some cultural traits from the neighbouring Anasazi or Pueblo Indians.

Archaeology of the river area, centre of the culture, is very difficult to unravel because annual floods buried sites or washed them out, obliterating evidence. The Pataya cremated their dead, leaving no burial grounds on river terraces. They are the least known of the late prehistoric people of the American southwest. See also INDIAN, NORTH AMERICAN; NORTH AMERICA: *Archaeology: The Southwest;* PUEBLO.

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PATCH, ALEXANDER McCARRELL (1889–1945), U.S. army officer, a division. corps and army commander in World War II, was born Nov. 23, 1889, at Fort Huachucua, Ariz. After graduating from the U.S. Military academy, West Point, N.Y., in 1913, he saw active service in France during World War I, and during the years 1920–41 attended army schools and instructed reserve officers' training corps students and national guardsmen. Shortly after the United States entered World War II, Patch led a force overseas to defend New Caledonia. Assuming command of Allied forces on Guadalcanal in Dec. 1942, he became commander

of the 14th corps the next month and led a carefully planned offensive that drove the last Japanese troops from Guadalcanal by Feb. 1943. He took command of the U.S. 7th army in Italy on March 4, 1944, and as a lieutenant general led Allied ground forces in the invasion of southern France, starting Aug. 15, 1944. His troops advanced up the Rhône valley past Lyons in less than a month to make contact with the Allied armies that had driven eastward from Normandy. After crossing the Rhine in the spring of 1945, Patch's army advanced through Germany into Austria, and when Germany surrendered, had moved through the Brenner pass. He was commander of the U.S. 4th army when he died at Fort Sam Houston, Tex.. on Nov. 21, 1945. (JN. MR.)

PATENT. The term patent (derived elliptically from "letters patent" [*q.v.*], a general term referring to the documents whereby some privilege is conferred) is distinctively applied in general usage to governmental grants of the exclusive right to make, use or sell a product or commodity. In modern times the usage has become still further specialized, since governmental policies are in general adverse to the grant of monopolistic privileges in ordinary commerce and trade; such grants are in the main confined to products which are the result of invention or discovery, and are granted for limited times, as the U.S. constitution puts it, "to promote the Progress of Science and useful Arts."

(B. CE.)

UNITED STATES

Before the U.S. federal government was established, a few patents had been granted to inventors by individual states, as special acts of the state legislatures. Some grants of this kind had even been made by the colonial governments, the earliest in 1641. The U.S. constitution empowered the federal government to issue patents, and also to protect the copyright of authors, by providing, in article 1, section 8, that congress shall have power "to promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries." The first act of congress under that authority was passed April 10, 1790. It placed complete power to grant patents in a board consisting of the secretary of state, the secretary of war and the attorney general. The secretary of state at that time was Thomas Jefferson and all applications for patent were examined by him personally. This act was short lived, and only a few patents were issued under it, since the high officials who administered it had too many other important duties to devote adequate time to the work involved. A new law was passed, on Feb. 11, 1793, under which the function of issuing patents was placed under the secretary of state but they were granted merely on complying with the formal requirements of submitting a description, drawings, a model and the necessary fee. This system of issuing patents without any examination for novelty remained in force until 1836, by which time they were being issued at the rate of over 600 a year. Dissatisfaction with this method, which resulted in many patents for things which were not new and in numerous conflicting patents, led to a completely new act passed on July 4, 1836.

The act of 1836 established the "examination" system of granting patents, which has been followed since that time by many other countries. Applications were to be regularly examined by officials with the power to refuse patents, with provision for an appeal in case of refusal. The act established the patent office as a separate bureau in the department of state with a commissioner of patents at its head and contained many provisions which, as subsequently modified, form part of the present patent law of the U.S. The act of 1836 was amended from time to time until in 1870 the patent law was completely rewritten. Thereafter numerous acts of congress, about 60 in number, relating to patents were passed, and in 1952 the basic law was again rewritten and extensively revised (title 35, "Patents," of the United States Code).

The Patent Office.—The administration of laws concerning the granting of patents and related activities was placed in the United States patent office, a bureau of the department of commerce, in Washington, D.C. Originally in the department of state, it was transferred to the department of the interior when that department was created in 1849, and was transferred to the department of commerce on April 1, 1925, by executive order of the president.

The head of the office is the commissioner of patents. About half of the employees are examiners and others with technical and legal training. The chief function of the office is the examination of applications to determine whether the applicant is entitled to a patent. The specifications and drawings of patents are printed and published as they are issued, and a weekly *Official Gazette*, containing a claim and a selected figure of the drawing of each patent issued that week: decisions in patent cases and other information, is published.

The patent office also administers the federal trade-mark law, registering trade-marks used in interstate or foreign commerce. (See TRADE-MARKS AND NAMES.)

Subject Matter for Patents.— Patents are granted for the invention of "any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof." The word "manufacture" refers to articles which are made and includes manufactured articles and products. The word "process" is defined as meaning process or method and is not limited to processes for producing articles or products, although it has been ruled that processes involving mental steps are not proper subject matter for patent. The meaning of "machine" requires no particular explanation. "Composition of matter" includes substances composed of mixtures of ingredients as well as those produced by chemical action. New chemical compounds can be patented, as well as the processes for producing them, and there are no prohibitions or special conditions in the statute relating to the patenting of food and medicinal products. The only matter specifically excluded from the field of patentable inventions is the application of fissionable material or atomic energy to atomic weapons, which is excluded by the Atomic Energy act of 1954.

The statute uses the word "useful," which connotes that the invention must be directed to a useful purpose, and it must be capable of accomplishing that purpose. A machine which is inoperative to produce the intended result would not be called useful. However. commercial practicability is not a requirement.

Novelty and Invention.— The invention, in order to be patentable, must be new and to this end the statute provides that a patent cannot be obtained if the invention was known or used in the United States, or if it was patented or described in a printed publication anywhere, before the invention was made by the one who is seeking a patent. Mere prior knowledge in a foreign country will not prevent a true inventor from obtaining a patent. Also, prior secret knowledge and use by others will not ordinarily defeat the right to a patent.

The statute also provides that a patent cannot be obtained if the invention has been in public use or on sale in the United States, or if it has been described in a printed publication anywhere, more than one year before the date on which the inventor applies for a patent. The inventor's own printed publication or public use of the invention, as well as such publication or use by anyone else, occurring more than one year before applying for a patent. will result in the loss of the right to a patent. Publication or use during the one-year period will not affect the right to a patent if the inventor seeking the patent made the invention before the date of the publication or use.

Even if the subject matter sought to be patented is new in the sense that it is not shown exactly by the prior things known or used and includes one or more differences over them, a patent may not necessarily be obtained. It is further required that the differences between the new subject matter and the prior art be such that the subject matter would not have been obvious to a person having ordinary skill in the art. In applying this requirement, the courts have said that the new subject matter must involve "invention" over what is old. This determination has been one of the most difficult aspects of patent law and has involved the most conflicts of opinion.

Application for Patents.---Only the actual inventor can apply for a patent in the United States, except in certain special situations. If the inventor is dead. the executor or administrator of the estate can apply; if the inventor is insane. his legal representa-

tive can apply in his place. If the invention is made jointly by two or more persons. they must apply for a patent as joint inventors although it is possible to correct innocent mistakes in either omitting a joint inventor or erroneously joining a person as inventor.

The application must contain a written description of the invention, a drawing when the nature of the case admits of a drawing, an oath of inventorship executed by the inventor, and must be accompanied by the government filing fee. The description of the invention must be so complete as to enable any person skilled in the art to which it relates to make and use it, and must set forth the best mode contemplated by the inventor of carrying out the invention. Claims particularly and distinctly pointing out the subject matter regarded as the invention are required. The claims define the scope of the subject matter protected by the patent. The description and claims are called the specification.

Prior to 1870 models were required with every case admitting of a model, but this has since been discontinued as a general requirement. (A working model would be demanded by the patent office in the case of an alleged perpetual-motion machine.)

Procedure in Obtaining Patents. — After an application for patent has been filed, it is referred to the appropriate examining division of the patent office where it is examined when its turn is reached. The examiner searches through all relevant prior Cnited States patents, and also through those of other countries and printed publications which are available to him, to determine if the invention is new and patentable under the law. His decision as to the patentability of the invention on the claims presented is sent to the applicant. The applicant can ask for reconsideration, within six months: of an adverse decision, with or without amending the wording of the specification, and the application is then re-examined and reconsidered; and this procedure continues until an issue is reached. If the final decision of the examiner is adverse on any of the claims. the applicant may appeal to a board of appeals within the patent office. A refusal by the board of appeals may be reviewed by the courts, the applicant being given the option of appealing to the court of customs and patent appeals or filing a suit in the United States district court for the District of Columbia.

When two or more applications for patent for the same invention are filed by different inventors a proceeding known as an interference may be instituted to determine who is the first inventor and entitled to a patent. The first to apply does not necessarily obtain the patent. An interference between an application and an issued patent is also possible under restricted conditions.

If it has been decided to grant a patent, a notice of allowance is sent to the applicant; a final fee is due within six months and the patent is issued shortly after this fee is paid.

The proportion of applications filed which result in patents varies, but generally it is about 60%.

Nature of Patents. — The patent is issued in the name of the United States of America, under the seal of the patent office, and includes a copy of the specification and drawings. The patent in terms contains a grant to the patentee, his heirs or assigns, for the term of the patent, of "the right to exclude others from making, using, or selling the invention throughout the United States." It should be noted that the patent does not grant the positive right to make, use or sell the invention and the patentee's own right to do any of these things is dependent upon the rights of others and whatever general laws: if any, might be pertinent. The patentee may not use his own invention if doing so would infringe a prior patent of another, without the permission of the prior patentee. Nor could a patentee sell his invention if doing so would violate laws such as. for example, the pure food and drug laws.

Territorially, the right conferred by the patent extends throughout the United States and its territories and possessions. The term of the patent is 17 years from the date of its grant. This period was adopted in 1861, replacing the prior term of 14 years with the possibility of an extension for another 7 years. The term of a patent cannot be extended except by an act of congress; a temporary law passed in 1950 (later expired) provided for extending the term of patents owned by veterans of World War II.

Xo fees are required after a patent has been issued for maintaining it in force, nor does the law contain any provision for revoking a patent or granting compulsory licences if the patented invention is not worked in the United States.

Patents as Property. — A patent is recognized as a species of property and has the attributes of personal property. It may be sold (assigned) to others, mortgaged, bequeathed by will, or may pass to the heirs of a deceased inventor. The patent is assignable in law by an instrument in writing, either after it is granted or while it is in the application stage. If the application for patent is assigned. and the assignment is recorded in the patent office in time, the patent will be issued directly to the assignee. A part interest in a patent may be assigned, and the patentee may also convey a grant for a specified territorial part of the United States. An assignment, grant or other conveyance may be recorded in the patent office at any time. but if it is not recorded in three months it might not serve as protection against the subsequent sale of the patent to another.

A patent may be owned by two or more persons jointly, either as a result of the patent's having been granted to joint inventors or as the result of the assignment of an undivided part interest. Unless they have agreed otherwise. each joint owner can act independently of the others: he may make. use or sell the invention for his own profit, grant licences to others or assign all or part of his interest without regard to the other joint owners.

Since the patent gives the owner the right to exclude others from making, using or selling the invention, he may authorize others to do any of these things by a licence. A licence is a contract between the parties and it may include whatever valid conditions and limitations may be agreed upon, such as the amount of royalties to be paid. Provisions relating to maintaining resale prices or to dealing with unpatented articles are generally not legal. The patentee may not violate the antitrust laws in his dealings with patents.

Some states have laws prescribing certain formalities for the sale of patent rights.

Amendment of Patents. — After a patent is granted it can be amended or corrected in the patent office in a number of respects. Clerical errors made by the patent office whereby the patent does not correspond to the record can be corrected by a certificate of correction. Some clerical or typographical errors made by the applicant may also be corrected by a certificate of correction. An innocent mistake in erroneously joining a person as a joint inventor or in erroneously omitting a joint inventor can be corrected by the patent office by deleting the name from, or adding the name to, the patent. as the case may be.

One or more claims of a patent may be disclaimed by the patentee by filing a disclaimer in the patent office. The patentee may also disclaim or dedicate the entire term, or any terminal part of the term, of his patent.

A patent can be reissued by the grant of a new patent to replace the original one for the balance of the unexpired term. Reissues are obtained primarily when the patent is defective in claiming more or less than the patentee had a right to claim, and require the filing of a new application which is subject to examination.

Plant Patents. — Patents are also granted (since 1930) for new and distinct varieties of plants, including cultivated sports, mutants, hybrids and newly found seedlings. Tuber-propagated plants, which include the common potato, and existing plants found in an uncultivated state may not be patented. The plant must have been asexually reproduced by the inventor or discoverer before it can be patented.

The requirements and procedure for obtaining a plant patent are in general the same as those for other patents, with a few exceptions. The right granted by a plant patent is "the right to exclude others from asexually reproducing the plant and selling or using the plant so reproduced." Many new varieties of flowering and fruit-bearing plants have been patented.

Design Patents. — New, original and ornamental designs of articles of manufacture can be protected by design patents. The design patent relates only to the appearance of the article, and not to its construction or useful features. 4 design patent may be

granted for a term of $3\frac{1}{2}$, 7 or 14 years, with a different fee for each, at the option of the applicant. Applications for design patents are examined in the same manner as other applications, although there are a few differences in the requirements.

Patent Marking.—A patentee who makes or sells patented articles may mark the articles with the word "patent" or the abbreviation "pat." and the number of the patent. This requirement is not compulsory but if the patentee fails to mark the articles he cannot recover damages from an infringer unless the infringer was notified of the infringement and continued to infringe after the notice. The marking of articles as patented when they are not in fact patented is prohibited by law. While an application for patent is pending in the patent office, articles may be marked with the words "patent pending," "patent applied for" or an equivalent expression. This marking has no legal effect but only gives information to the public that an application for patent has been filed in the patent office. The use of these expressions when no application for patent has been made or when an application is no longer pending is prohibited by law.

Infringement and Enforcement of Rights.— The statute defines infringement of a patent as the unauthorized making, using or selling of the patented invention, within the United States, during the term of the patent. Active inducement of infringement by others may also constitute infringement.

If a patent is infringed, the patentee's remedy is by a suit against the infringer in the appropriate district court of the United States. The court may award the patentee damages to compensate for the infringement (which may include the profits made by the infringer) and has the power to increase the damages up to three times the amount found. The court may also grant an injunction to prevent the continuation of the infringement. The defendant in the suit, in addition to maintaining that what he is doing does not in fact infringe the patent, may raise the question of the validity of the patent. The court may find that the patent is invalid on grounds specified in the statute as conditions for patentability. A holding of invalidity operates only between the parties and does not constitute a cancellation or revocation of the patent; the patentee may conceivably sue someone else on the same patent, but such subsequent suits on patents once held invalid are not common and are rarely successful.

The question of infringement is determined by the claims of the patent. which define the scope of the rights granted; if the defendant's activities do not fall within the language of any of the claims of the patent, he will ordinarily not be held to infringe. The losing party in the suit may appeal to the court of appeals for the circuit in which the district court is located. There is no right of appeal to the supreme court, but that court may accept a case by writ of certiorari.

A person who is charged with infringing a patent by a patentee who has not sued for infringement has the right to initiate a suit against the patentee and obtain a judgment on the question of infringement as well as the validity of the patent.

The United States government may make or use any patented invention without the consent of the patentee, but the patentee has the right to compensation which may be recovered by suit in the court of claims if not paid.

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(P. J. F.)

GREAT BRITAIN

The Statute of Monopolies. passed in 1624, marked a revolt against the practice of granting to private individuals monopolies of branches of manufacture or commerce; *e.g.,* the making of playing cards, the sale of salt. etc. This statute declared such grants in general to be invalid, but excepted grants for a term of 14 years or less "of the sole working or making of any manner of new manufactures within this Realm to the true and first inventor or inventors thereof. which others at the time of making such Letters Patents and grants shall not use"—and this exception is the origin of British patent law and, indeed, of the patent laws of the world.

At first the monopoly granted was merely defined by a title and there was no provision obliging the patentee to make his invention (throughout this article the word invention is used with the statutory meaning, viz., as including an alleged invention) known to others, save that some grants required him to take apprentices and train them in the new manufacture; but in the reign of Queen Anne (1702–14) it became customary to make it a condition of the grant that the patentee should within a fixed period file a written description of his new manufacture and, in time, this description also came to embody a statement as to the monopoly claimed and so became the progenitor of the modern specification. Originally patents were issued by the lord chancellor under the great seal, and Charles Dickens draws a lively picture of the trials of the unhappy inventor bandied about by a host of officials, none of whom took the slightest interest in the invention but all of whom must be suitably feed before the grant would be made. By an act passed in 1850, however, **a** new body—the commissioners of patents—was created under whose seal grants were thereafter to be issued. One effect of this change was that whereas the great seal was recognized throughout the dominions, such recognition was not given to the commissioners' seal, so that the patent monopoly was thenceforth confined to the United Kingdom and the Isle of Man, though its effect can still be extended to the Channel Islands and certain colonies by registration. This act also provided that the specification should be filed before instead of after the grant, and created the provisional specification.

The act of 1883 created the patent office in its present form, presided over by the comptroller general of patents, designs and trademarks, but though the comptroller was given considerable powers concerning the form of specifications he had none over their contents—applicants could still claim what they would at their own risk and embody the most diverse inventions in one application—and it was not till 1907 that the system of search was inaugurated and power given to refuse patents for inventions which had been clearly anticipated.

In 1883 there was also signed at Paris the international convention by which the signatories agreed *(inter alia)* that where application had been made for a patent in a convention country, and the applicant had applied within a year for protection of his right in another convention country. he might claim the priority date of his first convention application. Nearly all countries of commercial importance are now parties to the convention, the principal exceptions being the U.S.S.R. and Argentina. (See *International,* below.) All the self-governing countries of the commonwealth have their own patent offices, their patent laws being in substance those of Britain, though there are some detailed variations. All are adherents to the convention.

The whole British patent law is now contained in the Patents act, 1949.

Patent Office Procedure.— Application for a patent may be made by a person claiming to be the "true and first inventor," or, in the case of a convention application, by the applicant in the convention country. or by the assignee or personal representative of any of such persons, and any other persons may join in the application. Normally the true and first inventor is the person who substantially originated the invention, even though he may have accepted suggestions (not amounting to separate inventions) from others. Where two persons have conceived the invention independently, the one who first applies for protection is the "true and first inventor." Since. however, the primary object of the provisions dealing with patents for invention was the creation of new manufactures within the realm, a person who introduces an invention from abroad has always been considered as its inventor, and no question has ever been asked about how he acquired it. A person, for example a patent agent, to whom an invention has been communicated from abroad may apply as a "communicatee." The application must be accompanied by a specification which in

the case of an original application may be either a "provisional specification" stating broadly the nature of the invention, or a "complete specification" describing in detail the invention and the manner of its performance with claims defining the monopoly sought. Where a provisional specification is used, a complete specification must be filed within a year (a period which may be extended to 15 months by payment of a fee) and in the case of a convention application a complete specification must be filed in the first instance. A single complete specification may be lodged in respect of two or more provisionals or convention applications for cognate inventions, but the application must relate to a "single" invention — a term to which a wider interpretation is given in the case of an invention relating to a new type of machine than to one relating to improvements in parts of a known machine; if this rule is infringed the applicant may be required to file divisional applications for the different inventions. The application must be for a "manner of new manufacture" — a phrase which covers either a process or an article. Processes which produce, improve or preserve a vendible article are considered to come within this definition. which also includes processes or methods for the control of manufacture, but processes relating to agriculture or the like, or medical or surgical treatment: are not within it, although agricultural or surgical instruments, medicinal substances. etc., may be. Processes depending mainly on the intellectual faculties. *e.g.,* literary or artistic compositions, methods of advertising, etc., are not considered to be patentable, nor are documents, charts, etc., relating to such processes.

When a complete specification has been lodged it is referred to an examiner who makes a search among British specifications not more than 50 years old (the search may in certain cases extend to documents of other classes) to ascertain whether the invention as claimed in any claim has been wholly or in part published, and the result of the search is embodied in a report. which may also draw attention to faults in drafting; *e.g.,* that the claims are not "clear and succinct." After consideration of the report the comptroller may require the applicant to amend the specification and, in default of compliance. or if the invention has been wholly anticipated, he may refuse the application. "Subject matter," *i.e.,* the existence of an "inventive step," cannot be considered at this stage, though it may be in the case of an opposition. The comptroller may also refuse a patent for an invention that is clearly impossible, *e.g.,* perpetual motion, or such that its use would be contrary to law or morality, or for certain inventions relating to food or medicine.

Searches are also made to ascertain whether the invention has been claimed in a specification of prior date, or whether the use of the invention would involve risk of infringement of the claims of a prior specification, and if so references may be inserted to such specifications. When all is in order the specification is accepted and is open to inspection, and shortly after it is published; *i.e.,* copies are put on sale. During a period of three months after publication opposition may be lodged to the grant of a patent, the grounds of opposition including most (but not all) of those on which the validity of a patent may be challenged. but the opponent must show a real interest which would be adversely affected by the grant. Sealing may take place four months after publication of the specification unless an opposition is pending. Within a year of sealing an application may be made to the comptroller to revoke a patent on any of the grounds on which the grant might have been opposed.

Where an applicant or patentee makes an improvement on an invention. in respect to which he has applied for protection or holds a patent, he may obtain a "patent of addition" even though the improvement does not show an inventive step over what is disclosed in the specification of the main patent. No renewal fees are payable for patents of addition, but they lapse with the main patent, although in certain cases the comptroller may allow them to continue as original patents.

Where a complete specification is not accepted. neither it nor any provisional specification is ever published except by order of a court. The reports of examiners are also confidential documents, but after a complete specification has been accepted lists of the specifications referred to in such reports may be obtained on payment of a fee.

The term of a patent is 16 years from the date when the complete specification was filed, but renewal fees must be paid after the fourth year, rising annually from £5 for the 5th year to £16 for the 16th year. Where a patent has lapsed because of accidental failure to pay renewal fees restoration may be granted. The term of a patent may be extended either on the ground that the remuneration of the patentee has been insufficient in view of the importance of the invention, or that the patentee has suffered loss as such as the result of hostilities.

The comptroller has many other powers and duties: for example, he may direct the mention in the specification of the name of the actual inventor (though this has no effect on patent rights); he may decide disputes betneen coapplicants or copatentees, and (by consent of the parties) certain disputes about infringement. In many cases, though not in all, an appeal lies from his decision to the patent appeal tribunal (i e., to a high court judge who is normally the judge by whom patent cases are tried), and in certain cases, as when a patent has been revoked by the comptroller, there may be a further appeal to the court of appeal. It is the general practice of the comptroller and the tribunal to give the applicant the benefit of any doubt, since the validity of the patent can. if necessary, be subsequently determined by the courts. Application forms may be obtained at post offices. The fee payable on application is £1; on lodging a complete specification £4; on application for sealing £1. An inventor may draft and lodge his own specification, and appear before the comptroller or the tribunal, but in a large proportion of cases this work is done by patent agents. So one may practise as a patent agent unless he is registered as such and registration can only be obtained after passing severe scientific and legal examinations.

The expenses of the office substantially exceeded its revenue. The office publications include the official journal giving notices of acceptances, etc., the reports of patent, design and trade-mark cases and the comptroller's annual report, a document of great interest containing, inter *alia,* important notes on the trend of invention.

Property in Letters Patent. — Letters patent are choses in action and devolve like other personal property. A register is kept at the patent office giving particulars of ownership and licences. Although no notice of a trust may be entered on the register, documents giving equitable rights are entered. The register is prima-facie evidence of what is entered therein and in general no document, which should be entered but is not, can be given in evidence save by leave of the court.

Patentee means the person entered on the register as owner of a patent. If two or more persons are entered as co-owners, then (in the absence of a special agreement) each has an equal undivided share in the patent rights and may use the invention for his own benefit. but he may not assign his share or grant a licence, save the implied licence to the purchaser of an article made by him. Consequently all co-owners must join in an assignment or licence, but the comptroller has extensive powers to require co-owners to concur in such matters. Legal assignments and licences must be by deed, and cannot be executed until the grant has been sealed, but the courts recognize and enforce agreements giving equitable rights.

There is also a species of property in unpatented inventions; *e.g.,* the right to apply for a patent can be assigned and passes by death. Agreements relating to present or future inventions are also enforced, and there may be read into a contract of employment a provision that any invention made by the employee in the course of his employment shall become the property of his employer, unless the terms of the contract negative this inference.

The sale of an article by the patentee or a licensee normally gives the purchaser or subpurchasers an unlimited licence to use or dispose of the article, but limitations may be placed on such licence and are effective if it can be shown that the purchaser knew of them when he acquired the article. This is of special importance in regard to price restrictions on resale.

Patentable Inventions and Requirements for Validity. — A patent can only be granted for "a manner of new manufacture"

and although an invention may be "new" and relate to a "manner of manufacture" it is not necessarily a "manner of new manufacture"—it may be only a normal development of an existing manufacture. It is a necessary qualification of a craftsman that he should have the knowledge and ability to vary his methods to meet the task before him—a tailor must cut his cloth to suit the fashion of the day, or an apothecary compound pill or salve according to the ailment of his patient—and any monopoly that would interfere with the craftsman's use of his skill and knowledge would be intolerable.

A patentable invention, therefore, must involve something which lies outside the probable capacity of a craftsman—which is expressed by saying it must have "subject matter" or involve an "inventive step." Novelty and subject matter are obviously closely allied, and in the days when patent actions were tried with a jury the two issues were generally put to them in the composite form, "Is what the patentee claims a manner of new manufacture?" Although these issues must be pleaded separately, both are invariably raised by a defendant, and in fact "subject matter" is the crucial test, for while there may well be novelty not involving an inventive step, it is hard to conceive how there can be an inventive step without novelty.

The existence of an inventive step of course depends on the particular circumstances of each case, but there are certain classes of evidence which are generally considered to point to inventiveness, the surprising nature of the result achieved; the fact that the invention was only reached after long research and experiment; or proof that such invention has supplied a long-felt want as evidenced by its commercial success.

Both the novelty and subject matter of a claim must be judged by the state of public knowledge and practice in the country at the "priority date," which is defined as follows: if the claim is fairly founded on matter contained in a provisional specification or convention application the priority date is the date of filing such specification or application; in any other case it is the date of lodging the complete specification. The objection of disconformity between the provisional and complete specifications which formerly, if substantiated, invalidated the patent. has gone, the only penalty now being loss of priority date. The test of whether a document is a publication which would negative novelty or subject matter has been expressed as follows: "Had the document been placed in the hands of a competent craftsman! endowed with the common general knowledge at the priority date, who was faced with the problem solved by the patentee but without knowledge of the patented invention, would he have said. 'this gives me what I want'?" "Craftsman" in this context means not the artisan but the engineer, chemist or manager who directs the work, and "common general knowledge" such knowledge as the craftsman may be presumed to have acquired from his training, or could obtain from such works of reference as he would normally use; *e.g.*, textbooks and dictionaries. Similar rules would apply in the case of other forms of publication; *e.g.*, public working or sales of articles. A document is published when it comes into a library or other place where the public or a section of the public have right of access, or into the possession of an individual who is under no obligation, legal or moral, to keep it secret. Specifications of any country or official abstracts thereof more than 50 years old at the date of filing of the complete specification are not deemed to be publications.

Publications based on information obtained from the patentee and made without his consent do not generally affect validity, nor do certain publications by the patentee himself; *e.g.*, papers read to learned societies or working for necessary trial, if a patent is applied for within a fixed period. Secret working for commercial purposes, either by the patentee or others, before the priority date, invalidates the patent.

Subject to these qualifications an invention is in general patentable if it produces a new article, a better article or a cheaper article, or affordsa useful choice. It may be a combination of old integers so placed together that by their working interrelation they produce a new or improved result. The use of a known article, machine or process for a novel purpose may also be patentable if such purpose is not analogous to that for which it was formerly used.

Somewhat special considerations apply to chemical inventions. At the beginning of the 20th century it was accepted that there was no prevision in chemistry; today the balance has swung over to such an extent that almost complete prevision is assumed of the existence and properties of new substances lying within known classes of chemical compounds, and this has resulted in the coining of the term "selection patent" for patents relating to such cases, the requirements for such a patent being that it relates to a subclass of compounds having special and advantageous characteristics, named in the specification, not generally possessed by substances outside the subclass.

Other requirements for a valid patent are that the invention must be "useful" in the sense that it achieves the results described or claimed; the specification must be "sufficient" in that it properly describes the invention and the method of carrying it out and gives the best method of performance known to the patentee; further it must give warning against the use of improper materials or methods and must contain no false statements, and the claims must clearly define the monopoly sought and must not include an invention which is the subject of a valid prior grant. The primary object of the invention must not be illegal. Failure to comply with any of these requirements may be raised as an objection to the validity of the patent in an action or petition for revocation.

Patent Litigation.—Actions relating to patents must be brought in the high court, the palatine court or the court of session in Scotland. In England they are assigned to a special judge. No action can be commenced until the patent is sealed. Normally the plaintiff is the patentee, but an exclusive licensee, or a licensee of right, may sue an infringer making the patentee a codefendant. Usually the plaintiff alleges infringement. giving certain specific instances. while the defendant denies infringement, alleges that the patent is invalid on certain statutory grounds, the most important of which have been considered in the preceding section, and counterclaims for its revocation. It may also be pleaded as a defense that the plaintiff is a party to a contract or licence relating to the patent which contains certain statutorily prohibited terms; *e.g.*, concerning the purchase or use of articles not covered by the patent.

In construing the specification the court leans neither toward nor against the patentee. The scope of the patent monopoly is determined primarily by the claims, since what is not claimed is deemed to be disclaimed, but the documents must be read as a whole, so that the term used in the claims may be explained by reference to the body of the specification.

Infringement may be by "making, using, exercising or vending" the invention. There is no doctrine of "constructive infringement" so that a claim for the use of an article for a special purpose gives no rights against the manufacturer or vendor, only the user can be sued—consequently such claims are often of little value. Only acts within the realm are considered; for instance, posting patented articles from abroad is not an infringement. Further. the use of apparatus forming part of the equipment of vessels, aeroplanes or vehicles temporarily in the country does not in general constitute infringement.

A successful plaintiff is generally granted an injunction against future infringement, an inquiry as to damages or an account of the profits made by the defendant, an order for delivery up of infringing articles and a "certificate of validity" entitling him to claim costs on an increased scale in any subsequent action on the patent. Partial relief may be given to a plaintiff who establishes infringement of a valid claim though other claims are invalid. An inquiry as to damages covers all infringements committed after the publication of the specification down to the date of the writ, but no damages are awarded for infringements committed when the defendant did not know and had no reasonable grounds for supposing that the patent existed. The fact that the patentee marks his article "patent," but without a patent number, does not displace this defense.

Any person interested may present a petition for the revocation of a patent on any of the statutory grounds of invalidity. If an order for revocation is made, either on a petition or a counterclaim,

it is generally suspended to give the patentee the opportunity of appealing, or applying to amend the specification. It is a ground for revocation that the invention was obtained from the petitioner, and when a patent is revoked on this ground the petitioner may apply for a patent with the priority date of the revoked patent. A similar rule applies where the grant of a patent is refused, or a patent is revoked by the comptroller, on this ground.

Any person who claims that he has been injured by threats or statements that articles are infringements of a patent may bring an action for an injunction to restrain such threats and for damages. Frequently the defendant responds by commencing an infringement action and the two actions are tried together.

Amendment. — An application to amend the specification of a patent is normally made to the comptroller, but if an action for infringement or a petition for revocation is pending it must be made to the court. The application is advertised and any person may appear and oppose it. Only amendments by way of disclaimer, correction or explanation are permissible and, except in the case of an obvious error, the amendment must not lead to the specification describing or claiming matter not already disclosed, or claiming anything not within the scope of an existing claim. In the case of amendment before publication or in the course of an opposition the comptroller may excuse advertisement. Much wider amendments may be made before acceptance, provided that they do not introduce new inventions. A provisional specification can only be amended by excision.

Once an amendment has been allowed its propriety cannot be questioned save on the ground of fraud, and the amended specification replaces the unamended for all purposes, but reference may be made to the unamended specification in construing the amended specification.

Abuse of Monopoly. — In certain cases the comptroller may grant compulsory licences. Since the original object of the patent laws was the establishment of new industries, the main grounds for the grant of such licences are that the patented invention is not being worked within the country to the fullest practicable extent, or that the demand for patented articles is not being met on reasonable terms, or is being met by importation in place of home manufacture. Other grounds are that the existence of the patent monopoly, or the terms imposed on licensees, unfairly prejudice the development of commercial or industrial activities. The owner of a patent of later date may also apply for a licence on the ground that the earlier patent precludes the use of his invention, but in such a case the later patentee may be required to grant a cross licence. No application for a compulsory licence may be made within three years of the date of sealing. The comptroller may also in certain cases order the revocation of a patent, but no such order was made in recent years. No order for a compulsory licence, revocation or endorsement may be made which would contravene any treaty, etc., with a convention country.

Applications for licences under patents relating to food or medicine may be made at any time and without alleging abuse of monopoly. Such licences are to be granted unless there is good reason for refusal, and are to be on such terms as will secure that the patented articles shall be available to the public on the lowest terms consistent with fair remuneration to the patentee.

Patents may be endorsed "licences of right," either on the application of the patentee or in certain cases compulsorily, and in such case any person can claim the grant of a licence on terms to be settled by the comptroller. Only half the normal renewal fees are payable for patents so endorsed.

The Restrictive Practices act, 1954, would probably have little effect on patent rights, since agreements and licences relating to patented inventions were exempted from its principal provisions.

Crown Rights. — A patent has the same effect against the crown as against a subject, but government departments have the right to use patented inventions on terms to be fixed by the court. Certain government departments may require that a specification be kept secret, and no person resident in Great Britain may apply for a patent abroad unless he has previously applied for protection in Great Britain and no requirement concerning secrecy has been imposed within six weeks of the application.

Patents and Industry. — There are about 35,000 applications for patents annually, and about half this number of grants, of which about 3,000 are kept in force for the full period of 16 years. Yet of these only three or four are subjected to the acid test of judgment by the courts, and of these judgments, in recent years at least, the majority have been unfavourable to the patentee either on validity or infringement or on both issues, especially in the case of patents for chemical inventions.

The industrial value of patent protection cannot, however, be judged by these figures. In many branches of industry, and particularly in those relating to chemistry or the various applications of electricity, the amount of research and experiment necessary for evolving and bringing to perfection new processes or products is so great that the individual inventor has been displaced by teams of technicians who may labour for years before achieving any result of practical importance, and in other branches an invention has little chance of practical success unless it is adopted by a strong manufacturing company.

Consequently patents of value gravitate toward powerful corporations, who keep a watchful eye on applications and grants bearing on their own line of industry and are chary of trespassing on ground marked out by their rivals, since to do so might involve a costly action, with the possibility that all the capital sunk in the new venture might be rendered useless by an adverse judgment. Thus the practical value of patents must be judged rather by their general deterrent effect than by the few instances when they become the subject of actual litigation. There can be no doubt, however, that the prospect of obtaining a monopoly is one of the great incentives to the technical research necessary for the maintenance of commercial prosperity, and therefore patent law still achieves its original purpose of introducing new industries. (H. F. M.)

INTERNATIONAL

The rights granted by a patent extend only throughout the jurisdiction of the country granting the patent and hence one who desires patent rights in a number of different countries must obtain a separate patent in each of them. There is no international patent. although the laws of a few countries provide that under certain conditions a patent granted in another country may be registered there and become effective.

Practically every country in the world, the exceptions being few and comparatively minor, has a patent law. These laws differ in many details. Variations exist in the subject matter for which patents are granted. the conditions which defeat novelty, the requirements and procedure in obtaining patents, the length of the term and other matters, although most of the laws follow common basic principles. (Several publications noted in the bibliography give digests of the patent laws of all the countries.)

During the decade before World War II the total number of patents granted by all countries averaged approximately 180,000 a year. This number decreased considerably during the war and the years following, going down to less than half; but by five years after the end of the war the number had risen above the prewar average. The total number of patents issued does not represent the same number of separate inventions, since one invention might be patented in several countries; nearly half the patents represent such duplications. The countries which issue the most patents are the United States, Germany, France, Great Britain, Italy, Canada, Belgium, Switzerland, Japan. Australia. Spain and Sweden, in approximately the order named. The numbers issued by these countries vary from year to year and the rank of some would shift, but the number of 40.000 for the highest and 4,000 for the lowest of the countries named gives a general idea of the range.

There are a number of bilateral treaties relating to patent matters between some countries, but the important patent treaty is the multilateral International Convention for the Protection of Industrial Property which was first signed in Paris in 1883, and which came into effect on July 7, 1884, between 11 countries. This treaty was revised at Brussels in 1900, at Washington, D.C., in 1911, at The Hague in 1925 and at London in 1934, each revision superseding the former version between the countries adhering to it. By the mid-1950s, 45 countries were parties. Under the first

article of the convention the countries constituted themselves a "Union for the Protection of Industrial Property."

The convention establishes rights in patent, trade-mark and related matters of the nationals of the participating countries and in some respects has the aspect of international legislation on these subjects. One of the basic articles of the convention provides that the nationals of each country enjoy in the other countries the same advantages that the other countries grant to their own nationals, without prejudice to any rights specially provided for by the convention.

One of the most important articles of the convention deals with what is called the right of priority. By the operation of this provision. any person who has duly applied for a patent in one of the countries of the union is entitled to apply for a patent for the same invention in one of the other countries of the union within a period of 12 months and be considered in the latter country as having applied there on the earlier date. This article is of considerable importance in facilitating the obtaining of patents by inventors in a number of countries in view of the fact that in most countries publication of the invention before applying for a patent will defeat the right to a patent.

Other articles of the convention provide that patents obtained in the different countries of the union shall be independent of each other; that the inventor shall have the right to be mentioned as such in the patent. this provision applying when the inventor has transmitted his right to a patent to another in those countries in which the owner may apply for the patent; that a period of grace shall be provided for the payment of the fees for maintaining a patent in force which are required by most countries; that the use of an invention on board ships or on land or air craft temporarily or accidentally in the territory of a country shall not be considered as infringing the rights of a patentee in that country; etc. One article prescribes certain limitations which must be observed if a patent is to be revoked, or compulsory licences granted, for failure to work the invention or for other abuse of the exclusive rights conferred by the patent. The convention also includes provisions dealing with trade-marks, trade names and the suppression of unfair competition.

Under the convention, a central office known as the International Bureau for the Protection of Industrial Property was established in Berne. Switz., under the general supervision of the Swiss government. This bureau serves as a clearinghouse on information on patent and trade-mark laws and issues a monthly periodical, La *Propriété Industrielle,* dealing with patents, trade-marks and related matters.

An Inter-American Convention Relating to Inventions. Patents, Designs and Industrial Models was signed at Buenos hires, Arg., in 1910. It was adhered to by a number of Latin-American countries and the United States. Some of its provisions are similar to the earlier versions of the International Convention for the Protection of Industrial Property. A patent convention signed at Montevideo, Urug., in 1889 was in effect between five South American countries in the latter 1950s. The Council of Europe sponsored treaties relating to uniformity of formalities required for patent applications and an international classification of patents, which were ratified by some European countries.

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PATER, WALTER HORATIO (1839–1894), English critic and essayist, associated with the Pre-Raphaelite movement in English literature; his best-known work is probably *Marius the Epicurean* (1885), a philosophical romance dealing with the life of a young Roman in the time of the Antonines, and his reactions to various spiritual influences that interested the author. Pater was born at Shadmell on Aug. 4, 1839, and was educated at King's school, Canterbury, and at Queen's college, Oxford. He then settled in Oxford and read with private pupils. In 1864 he was elected to a fellowship at Brasenose college there. Pater now began to write for reviews, his early papers including one on Coleridge in the *Westminster Review* (1866) and another (1867) on Johann Winckelmann. In the following year his study of "Aesthetic Poetry" appeared in the *Fortnightly Review,* to be succeeded by essays on Leonardo da Vinci, Sandro Botticelli, Pico della Mirandola and Michelangelo. These, with other studies of the same kind, were in 1878 collected in his *Studies in the History of the Renaissance.*

Pater was now the centre of a small circle in Oxford. The little body of Pre-Raphaelites were among his friends, and by the time that *Marius the Epicurean* appeared he had quite a following of disciples to hail it as a gospel. This fine and polished work, the chief of all his contributions to literature, was published early in 1885. In it Pater displays, with perfected fullness and loving elaboration, his ideal of the aesthetic life, his cult of beauty as opposed to bare asceticism and his theory of the stimulating effect of the pursuit of beauty as an ideal of its own. In 1887 he published *Imaginary Portraits,* a series of essays in philosophic fiction; in 1889, *Appreciations, With an Essay on Style;* in 1893. *Plato and Platonism;* and in 1894, *The Child in the House.* His *Greek Studies* and his *Miscellaneous Studies* were collected posthumously in 1895; his posthumous romance of *Gaston de Latour* in 1896; and his *Essays From the "Guardian"* were privately printed in 1897. A collected edition of Pater's works was issued in 1901.

Pater changed his residence from time to time, living sometimes at Kensington and in different parts of Oxford; but the centre of his work and influence mas always his rooms at Brasenose. He wrote with difficulty, correcting and recorrecting with imperturbable assiduity. His mind, moreover, returned to the religious fervour of his youth, snd those who knew him best believed that had he lived longer he would have resumed his early intention of taking holy orders. He was cut off, however, in the prime of his powers. He died on July 30, 1894.

Pater was so contemplative, and in a way so centred upon reflection, that he never perhaps gave full utterance to his individuality. His peculiar literary style, too, burnished like the surface of hard metal, was too austerely magnificent to be always persuasive. At the time of his death Pater exercised a remarkable and a growing influence among that necessarily restricted class of persons who have themselves something of his own love for beauty and the beautiful phrase. But the cumulative richness and sonorous depth of his language harmonized intimately with his deep and earnest philosophy of life; and those who can sympathize with a nervous idealism will always find inspiration in his sincere and sustained desire to "burn with a hard, gemlike flame," and to live in harmony with the highest. (A. WA.)

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PATERA ISLAND (LAPPA), an island on the Kwangtung coast of south China at the eastern mouth of the West river or Hsi Chiang (*q.v.*). Its geology is predominantly of igneous rocks, mainly granites and quartz porphyries. In 1958 an 800-yd. causeway built across Duck channel in the north cut off the flow of water from the Hsi Chiang, causing silt from the Canton delta rapidly to fill up inner Macao harbour and controlling the supply of fresh river water for Macao.

Negotiations between Macao and the Chinese authorities for a pipe line and pumping system became necessary. The island is now connected to Canton by motor road. Cultivation is mostly on reclaimed land.

The principal industries are agriculture, quarrying, fishing and the manufacture of fireworks. In 1958 the entire population of Patera was formed into a commune of the Chinese communist pattern. Illegal immigration from China to Macao and Hong Kong has continued.

Wanchai, the chief settlement (pop., 1959 est., 2,000), faces Portuguese Macao across the river. Until 1949 it was a station of the Chinese maritime customs, but since that time its import and export trade has decreased to a minimum. (S. G. D.)

PATERSON, WILLIAM (1658–1719), British writer on money, commerce, public finance and contemporary political and social issues, founder of the Bank of England and prime mover of the unsuccessful settlement at Darién (*q.v.*), was born at Tinwald, Dumfriesshire, Scotland, in April 1658. In his youth Paterson left Scotland to escape religious intolerance and traveled in Europe and the West Indies, gaining experience as a merchant. Returning to England he tried unsuccessfully to induce the government of James II to back an expedition to Darién. Efforts to get support for his plan on the continent also failed. By 1686 he had become a London merchant and a member of the Merchant Taylors' company. In 1694 Paterson organized the Bank of England, long desired by the London merchants. He withdrew as a director the next year, following a disagreement on bank policy. After an unsuccessful attempt to organize a rival bank in London, Paterson resumed his interest in the Darién venture. Along with a group of Scottish and English merchants who were seeking investment outlets, he secured in 1693 the passage by the Scottish parliament of the Act for a Company Trading to Africa and the Indies. William III opposed the expedition because of the state of affairs in Europe and the opposition of some of the London merchants, insofar as the expedition was becoming entirely Scottish in character.

Paterson was deprived of his position by the directors of the company because of a loss of company funds, though he was almost certainly innocent; nevertheless, he accompanied the expedition in 1698 as a private citizen, using his influence and administrative skill to save the company from the ruin that its bad management made inevitable. Paterson's own financial losses were great. His wife and only child died while at Darién, and he was gravely ill before he was forced to leave, arriving home in Dec. 1699.

After Darién, Paterson was involved in a number of programs: the development of resources by a proposed council of trade; proposals for monetary reform; continued agitation for new expeditions to the West Indies; and the parliamentary union of Scotland and England. He was responsible for the sinking-fund method of retiring the national debt which was known as Walpole's sinking fund of 1716. He continued until his death to oppose John Law's various schemes by a vigorous attack on inconvertible paper currency.

Paterson was an early advocate of free trade. Shortly before his death (on Jan. 22, 1719) the British government finally paid him an indemnity for his losses at Darién.

See The *Writings of William Paterson,* ed. *by* Saxe Bannister, 3 vol. (1859). (L. N.)

PATERSON, a city of northeastern New Jersey, U.S., and the seat of Passaic county, is located on the Passaic river, 13 mi. N. of Newark and 17 mi. N.W. of New York city. The city occupies a restricted area of 8.36 sq.mi. within the bend of the Passaic river. and is surrounded by the city of Clifton (q v.) on the south and by the boroughs of West Paterson, Totowa, Haledon, Prospect Park and Hawthorne on the west and north. East Paterson lies across the river to the northeast and east. The population of the city in 1960 was 143,663. It previously was considered by the census bureau as a part of the New York-Northeastern New Jersey metropolitan area; under the new definitions in the 1960 census Paterson was designated a central city of the Paterson-Clifton-Passaic standard metropolitan statistical area, a part of the New York consolidated area. The standard metropolitan statistical area, comprising Bergen and Passaic counties, had a population in 1960 of 1,186,873.

After the American Revolution, Alexander Hamilton, first secretary of the treasury, advocated setting up manufacturing plants to ensure industrial independence from Europe. He selected as the best site on the Atlantic seaboard the falls on the Passaic river. which have a perpendicular drop of 50 ft. This area had been sparsely settled by the Dutch since the late 17th century. After some political debate the enterprise was chartered by the New Jersey legislature in 1791 as The Society for Establishing Useful Manufactures (S.U.M.). The charter also provided for a six-mile square within which the society might establish its manufactory. The S.U.M. appointed a committee to select a site. On May 18, 1792, the committee recommended and the directors agreed to locate the manufactory at the Great falls of Passaick. The city was named after Gov. William Paterson of New Jersey, one of the framers of the United States constitution.

The S.U M. was not a successful enterprise and ultimately sold water power and building space to private manufacturers who saw possibilities of industrial development. The earliest industries were cotton mills. By 1837, when the locomotive industry was established by Thomas Rogers. machine manufacturing had become important. The cotton mills and skilled labour attracted the silk industry permanently introduced by John Ryle and George W. Murray in 1839, and at one time a grove of mulberry trees was planted to provide food for silkworms. Linen thread manufacturing was started in 1864.

Paterson, formerly the principal silk manufacturing and dyeing centre in the U.S., was the scene of many labour disputes. By mid-20th century the city had become a centre of widely diversified industrial activity and attracted enterprises of all types. It is the retail centre for the area, with more than 2,100 retail outlets and approximately 700 wholesale houses.

Paterson was a township until 1851, when it was granted a city charter. A new charter was granted in 1871 and this was considerably revised by the change to a commission form of government in 1907. After that time the city operated under a unique form of government. The people elect a mayor every three years, who appoints bipartisan governing bodies: boards of finance, public works, fire and police, health and education.

Rutgers university. the state university, has a branch in Paterson as does Seton Hall university. Paterson State college (established as Paterson City Normal school in 1855) is located in the neighbouring borough of Haledon. There is also the Danforth Memorial library with several branches, and a city museum, famous for its collection of New Jersey rocks and Indian relics. The original submarine built by John P. Holland (q v.) failed and sank in the Passaic river in 1878. It was recovered in 1927 and is on exhibit in Westside park. There are many outdoor playgrounds and various indoor recreational centres. The 570-ac. Garret Mountain reservation 502 ft. above sea level overlooks the Passaic valley. (S. HE.)

PATHAN, the name applied to the Pashto speaking tribes of southeastern Afghanistan and northwestern Pakistan. Pashto, an eastern Iranian language, has two dialects: the soft, called Pashto (or Pushto), is spoken by the tribes of Afghanistan and those of Pakistan south of the towns of Kohat and Thal; the hard, called Pakhto (or Pukhto), is spoken by the tribes of Pakistan north of these towns. The word "Pathan" is a Hindi variant of the Pakhto word Pakhtane meaning "speakers of Pakhto" and commonly refers to speakers of both dialects.

By their own traditions, the Pathans originated in Afghanistan and are descended from a common ancestor. Several tribes are known to have moved from Afghanistan to Pakistan between the 13th and 16th centuries. Each tribe, consisting of kinsmen who trace descent in the male blood line from a common tribal ancestor, is divided into clans, subclans and patriarchal families. Tribal genealogies establish rights of succession and inheritance and the right to use tribal lands and to speak in tribal council. Pathans are intensely individualistic but they abide by a code of honour, the *pakhtunwali,* which imposes on them three obligations: to grant all fugitives asylum (*nanawatai*); to proffer open-handed hospitality (*melmastia*) to even their deadliest enemies; and to wipe out dishonour by revenge (badal).

Disputes over property, women and personal injury often result in blood feuds between families and whole clans; these may be inherited unless settled by the intervention of clan chiefs or by tribal council.

Pathans are farmers, herdsmen and warriors. Most tribesmen are sedentary farmers, combining cultivation with animal hus-

bandry; some are migratory herdsmen and caravaners. Individuals are engaged in business or government service in towns throughout Afghanistan and Pakistan and large numbers have always been attracted to military service.

In the arts they are noted for their stirring drum and flute music, their vigorous, often wildly martial dancing, and their romantic or heroic stories and poetry. The most famous Pathan writers, both of the 17th century, are the warrior-poet Khushhal Khan Khattak and the philosopher Abdur Rahman. Pathans are Moslems, mostly of the Sunni sect. with a reputation for fanaticism when aroused by their religious leaders.

Pathans number about 5,000,000 in Afghanistan and 4 000,000 in Pakistan. They comprise some 60 tribes of varying size and importance and occupying particular territories. Most lie wholly within Afghanistan or Pakistan; a few, notably the Mohmand and Shinwari, overlap the Durand line boundary between the two countries In Afghanistan Pathans are the predominant ethnic group and the main tribes are the Durrani south of Kabul and the Ghilzai (Ghaljai) east of Kabul. The Muhammadzai line of the Durrani has ruled Afghanistan since 1826.

In Pakistan Pathans predominate north of Quetta between the Sulaiman mountains and the Indus river. Here a tribal border separates the so-called tribal areas from the settled areas. The former include hill tribes governed by their own chiefs but subject to the Pakistan government through political agents. Control over the tribal areas has frequently been thwarted by the refusal of tribesmen to obey their chiefs The main tribes here are. from south to north. the Kakar, Sherani and Ustarana south of the Gomal river: the Mahsud. Darwesh Khel Waziri, and Bhittani between the Gomal river and Thal; the Zaimukht, Turi, Bangash, Orakzai, Afridi and Shinwari from Thal to the Khyber pass; and the Mohmand, Utman Khel, Tarklanri and Yusufzai north and northeast of Khyber.

The settled areas include lowland tribes subject to direct administration by the provincial government of West Pakistan. The main tribes here are, from south to north: the Bannuchi and Khattak from the Kurram river to Nowshera; and the Khalil and Mandanr Yusafzai in the Peshawar valley.

See also index references under "Pathan" in the Index volume.

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PATHOLOGY, the science of disease. Human pathology is an important branch of medical science and includes the study of the causes of disease and the equally important reaction of the body to the injurious agent. Disease causes abnormal function of the body or organs, with or without changes visible to the naked eye or detectable in the tissues by the aid of the microscope. These changes are usually due partly to the agent and partly to the reaction of the body (but may be entirely due to either). They are described in the sciences of morbid physiology, morbid anatomy and morbid histology. In terms of biology, pathology is the response of living organisms to injurious agents and includes human pathology. veterinary pathology and plant pathology.

During the Renaissance the dogma of authority gradually gave place to inquiry and experiment. A lively interest in the medical sciences developed as men began to realize that the cure and prevention of 'disease could only be based upon a knowledge of the structure and function of the body in health. The functional anatomy of Andreas Vesalius, Gabriello Fallopius and Hieronymus Fabricius was followed by the discovery of the circulation of the blood by William Harvey, the father of physiology. The famous book of Giovanni Battista Morgagni, On the Seats *and* Causes of Diseases as Disclosed by Anatontical Dissections (1761), founded morbid anatomy. The next two generations of physicians went from bedside to post-mortem room and added to a growing knowledge of clinical medicine the naked-eye appearance of the organs after death. Early in the 19th century improvements in the microscope first led to the discovery of the cellular nature of the tissues; then Rudolf Virchow's book. *Cellularpathologie* (1858), founded the science of that name and finally Louis Pasteur, Otto Obermeier, Robert Koch and others initiated the'science of bacteriology, demonstrating that many important infectious diseases were due to invasion of the body by minute parasites.

Cause of Disease, Aetiology, Pathogenesis. — "At the heart of pathology there lies a battle—a battle waged between man and his unfavourable environment." Many and widely different factors may upset the delicate physiological balance of the body and cause disease. These, classified in terms of fundamental biological principles, include some which disrupt the internal harmony of the body (for example, faulty development or nutrition) and others which harm the body from without, such as injury or parasitism.

The following fundamental biological principles are the underlying causes of disease:

1. Faulty Heredity. — Abnormal genes are the basic abnormality causing certain rare diseases such as hemophilia.

2. Abnormal Development.--This is the cause of congenital abnormalities such as harelip, cleft palate and clubfoot.

3. Faulty *Nutrition.*—Starvation or vitamin deficiencies cause diseases such as nutritional edema, scurvy. beriberi and rickets.

4. Local or General Failure *of* Tissue Nutrition. — The tissues require a constant internal environment described by Claude Bernard as the milieu *interieur.* This constant "sea-water" environment bathing the tissue cells includes the correct concentration of inorganic ions in their correct proportions (the electrolyte balance), a sufficient pressure of oxygen and carbon dioxide and the adequate removal of waste products of metabolism.

The tissues are therefore dependent both on the local blood supply and on the proper functioning of the lungs, heart, blood and lymphatic vessels and kidneys. Any breakdown of the respiratory, circulatory or excretory systems will result in local or widespread damage to the tissues. Numbers 3, 4 and 5 (below) could all be considered under the general heading of diseases due to the breakdown of physiological mechanisms.

j. Morbid Physiology. — The ductless glands (*i.e.*, pituitary, adrenals, thyroid and parathyroid and parts of the pancreas, ovaries and testes) exert a profound influence upon metabolism by the chemical substances which they secrete into the blood. Upset of the delicate balance of these hormones produces diseases such as diabetes, toxic goitres, gigantism, etc.

6. Trauma, Physical or Chemical *Injury.*—This includes wounds, fractures, burns, injury by radiation — X-rays, radium, ultra-violet light, atomic bombs — and by electric shock. Chemical injury includes poisoning by animals and plants, chemicals and noxious gases.

7. Parasitism. — This term is used when a foreign organism invades and grows in the body. The majority of diseases are due to this cause. Parasites include viruses, bacteria, unicellular organisms of the class protozoa and multicellular organisms or metazoa.

Virus diseases include such scourges of mankind as influenza, smallpox, yellow fever, typhus, measles, mumps, chicken pox and German measles. Viruses cause many important diseases of domestic animals; *e.g.,* foot-and-mouth disease, rinderpest, hog cholera. fowl pest, canine distemper and rabies. There are also many virus diseases of plants such as tobacco mosaic

Many viruses are so small that they cannot be seen by the ordinary light microscope, but can be demonstrated by the electron microscope. They will pass through filters and require high-speed centrifugation to concentrate them out of suspensions. Viruses are obligatory parasites. living and multiplying within the cell upon which they are dependent for many of their enzyme systems. Tissues react to viruses in various ways.

There may be rapid degeneration and necrosis-of the parasitized cells (ulcers of foot-and-mouth disease), or on the other hand the affected cells may proliferate (as in the virus tumours of fowls). Frequently a combination of both processes is seen as in the pustular lesions of smallpox. (See VIRUSES)

The bacterial diseases include wound infections (staphylococci, streptococci, tetanus, gas gangrene. etc.), diphtheria, scarlet fever, typhoid fever. tuberculosis, plague, cholera and dysentery. (See BACTERIAL AND INFECTIOUS DISEASES; BACTERIOLOGY.)

The diseases due to protozoan parasites include malaria, sleep-

ing sickness and amoebic dysentery. The diseases due to metazoan parasites include infestations with parasitic worms such as round worms, tape worms and flukes. The hook-worm disease of the tropics belongs to this class. (See PARASITIC DISEASES; PARASITISM AND PARASITOLOGY.)

8. *New* Growths—Neoplasms, Turnours.—Cancer is usually put in a class by itself. This is partly for clinical convenience, but also because many different factors are known to produce malignant growths. In a strict biological classification of disease, cancer should probably be classed either as an abnormality of growth or as a failure of the still unknown factors which regulate the regeneration of damaged tissues that need replacement.

Defense Reactions of the Body.—The importance of finding the cause of disease is self-evident, but equally important in pathology is a study of the defenses of the body. The early pathologists naturally studied first the most pressing problems—those presented by disease and injury. The phenomena of inflammation engaged their attention, and this is not surprising because the inflammatory reaction is the standard pattern of the body's response both to injury and to many types of infection. The clinical signs of inflammation, *rubor,* et tumor, cum *calore* et *dolore,* were described by Celsus in A.D. 30. John Hunter (1794) wrote: "Inflammation in itself is not to be considered as a disease but as a salutary operation, consequent either to some violence or some disease." A. Thomson, A. P. W. Philip and C. Hastings were all experimenting with the effects of injury on the web of the frog's foot between 1813 and 1817. J. Cohnheim in 1877 described the microscopic changes seen in inflammation. Immediately after the injury there may be a momentary constriction of the capillaries followed by a period in which the blood flow becomes more rapid. Later the blood stream slows and white blood corpuscles stick on the walls of the dilated capillaries and then migrate into the tissues. But it was E. Metchnikoff (1883) who first realized that the emigration of the phagocytic white cells into the damaged tissues was the fundamental protective phenomenon in inflammation, and that the vascular reactions were merely a preliminary to this. The inflammatory reaction is the body's mobilization of defense and brings to the site of injury phagocytes and a fluid rich in plasma proteins. Inflammation is a response to products from damaged cells; it is therefore produced by all types of injury—chemical, mechanical, heat, cold, cutting off the blood supply (ischaemic damage)—and by many types of bacterial infection (*e.g.,* staphylococci, streptococci, pneumococci). These latter are often called the pyogenic infections because they cause the outpouring of large numbers of leucocytes to form pus. These organisms produce substances which cause leucocytes to move toward them—chemotaxis.

The pathology of a boil will illustrate the principles of both infection and defense. Most bacteria are harmless, in fact many are beneficial to man and to animals, but certain bacteria are able to grow in the tissues, to spread and sometimes to invade the blood stream. Such organisms are called pathogenic, and the term virulence is used to indicate their power to invade and harm the body. In the production of a boil, first the staphylococci enter by a small scratch in the skin or down a hair root and then multiply. Each coccus may divide at half-hourly intervals, so that if all the progeny survive, in 24 hours a prodigious number of staphylococci will have been produced. These invaders damage the cells of the body by diverting foodstuffs to their own nutrition, by producing by-products of their own metabolism which are harmful to man and by producing bacterial ferments which clot plasma or digest the ground substance of the fibrous tissue. Some of the products of the organism are so poisonous to tissue cells, white cells and red blood corpuscles, that they are called toxins, leucocidins and haemolysins, respectively. Thus the organisms grow, destroying cells and eliciting an inflammatory reaction in the surrounding tissues. This causes an outpouring of leucocytes and plasma. The amoeboid white cells engulf the staphylococci and attempt to kill them by digesting them within their bodies. This process is called phagocytosis. The plasma clots into a tangled meshwork of fibrin threads, and this helps to prevent the staphylococci from spreading. V. Menkin has called it "the fibrin barrier." In a few hours or days the staphylococci are killed and the dead tissues, dead organisms and living and dead leucocytes liquefy to form pus which is discharged to the exterior. Large cells from the blood and the tissues eat up the dead cells and clean up the mess, acting as scavengers or undertakers. The fibrin barrier now acts as a scaffolding along which creep cells which can lay down fibrous tissue—fibroblasts—and a wall of scar tissue is formed to repair the breach in the tissues. (See INFLAMMATION.)

Phagocytosis.—Metchnikoff called the polymorphonuclear leucocytes of the blood microphages because they were chiefly responsible for the eating up of micro-organisms. He recognized that the monocytes of the blood and certain cells in the tissues called histiocytes would ingest and destroy foreign cells. He noted that injection of red cells taken from a goose into the peritoneal cavity of a guinea pig was followed by aseptic inflammation during which large numbers of monocytes appeared, ingested the red cells and subsequently digested them. He therefore called these cells macrophages and noted that their function was to phagocytose dead and dying leucocytes and red cells found in the tissues after inflammation or haemorrhage. Macrophages form the main line of defense in typhoid fever and tuberculosis and are active against protozoan parasites such as malaria. Many tissues have histiocytes—cells which become motile macrophages when occasion demands. They are important in the lungs where they form the "dust cells."

W. Wyssokowitch (1886) injected organisms into the blood stream of rabbits and found that they were quickly taken up by phagocytic cells lining the vessels of the liver and spleen. These form a phagocytic filter designed to remove bacteria from the blood stream. Small numbers of bacteria often enter the blood stream even in apparently healthy people. The organisms cannot, however, multiply to produce the serious or fatal disease called septicaemia until these defenses have been overcome. Similar phagocytic filters are present in the lymph glands and remove organisms which have entered the lymph flowing from a site of infection. These networks of phagocytic cells, demonstrated by their ability to ingest bacteria, carmine, or trypan blue, were grouped together by Ludwig Aschoff (1913) as the reticulo-endothelial system. See also PHAGOCYTOSIS.

Immunity.— The bacteria present in the tissues during infection (*e.g.,* staphylococci) may produce poisons by the disintegration of their dead bodies; these are called endotoxins. On the other hand, when the causative organisms of diphtheria, tetanus, gas gangrene, botulism and scarlet fever are grown in a fluid culture medium, this is found to be highly toxic even when all the organisms have been removed by filtration. Each of these organisms is said to produce a specific exotoxin, and this upon injection will reproduce the symptoms and the pathological changes characteristic of that particular disease. Against such exotoxins the body takes seven to ten days to produce an adequate defense. A new globulin then appears in the plasma. This will unite with the toxin and is called an antitoxin or an antibody. When mixed in the right proportions the toxin and antitoxin will precipitate together as fine floccules of protein. In the mid-1950s it was still not known where the antibodies are formed. There was evidence which pointed to the cells of the reticulo-endothelial system as the site of their formation; other evidence suggested the lymphocytes. In chronic infections plasma cells appear in the affected zone. These cells are probably formed from lymphocytes and it was suggested that they may be making antibodies right on the spot.

When foreign cells such as bacteria or red blood corpuscles are injected into an animal, antibodies are formed which will clump these cells together. These antibodies are called agglutinins. A third factor present in the plasma called complement will then lyse the foreign cells. Complement acts on all foreign cells after they have been sensitized by their specific agglutinin or antibody. It is a complex of different substances at least one of which is a proteolytic ferment. The plasma poured out in the inflammatory exudate thus has several protective functions: it dilutes toxins; it clots to form the fibrin barrier; it may contain antitoxins. agglutinins or other antibodies; and it coats the bacteria and facilitates their phagocytosis by leucocytes. This latter property is due to substances called opsonins. (See IMMUNITY.)

Hypersensitivity or allergy is one of the outstanding problems of pathology. Each year tuberculosis causes many deaths. yet no endo- or exotoxins active against normal man or normal animals have ever been isolated from Myco. *tuberculosis*. Stranger still was the discovery by Koch in 1891 that once an animal is infected with tuberculosis it reacts with great violence to a subsequent injection of the organism or its products. This appears at first sight exactly the opposite to a protective reaction such as might be expected in an acquired immunity; it is the first example on record of allergy or heightened reaction. However, the response of the animal to the first injection of *Myco.* tuberculosis is too little and too late, so that the organism is able to spread without much difficulty. The tissues then become hypersensitive so that a second injection, even of dead organisms, causes cells to die, and this calls forth an inflammatory response — a mobilization of cellular defense. It is possible that such a cellular defense is the only adequate protection against this organism which grows slowly but relentlessly. The reactive intolerance shown by the tissues prevents the spread of infection. (See TUBERCULOSIS.) The phenomenon of allergy is seen in other diseases (*e.g.*, asthma, hay fever and urticaria).

Injury. — -A clean surgical wound illustrates the response of the body to an injury uncomplicated by infection. The skin and superficial tissues are severed by an aseptic knife. The cut vessels bleed, the blood clots and the severed tissues are "glued" together with fibrin. Tissue damage is minimal, but some cells are inevitably destroyed by the knife. These damaged cells cause some inflammatory reaction, and there is some outpouring of leucocytes and plasma. Then macrophages come and clear up the debris. Some substance liberated in the wound arouses the fibrous tissue cells that "sleep" in the margins of the wound, and these cells assume an embryonic activity, divide, creep in along the fibrin threads and replace the fibrin by fibrous tissue. This joins the severed tissues in a permanent union, the scar. New capillary blood vessels are likewise formed by outgrowths from capillaries in the margins of the wound.

Many different physical and chemical agents can cause injury. Mechanical injury fractures bones, causes wounds or may damage the brain or the organs in the chest or abdomen. In wounds and fractures, haemorrhage is an important factor. In burns. tissues undergo heat or chemical coagulation. All types of trauma expose the patient to certain dangers — primary and secondary shock. infection and imperfect repair. Primary shock is the loss of consciousness which occurs immediately after an injury. probably due to pain. Head injuries also cause loss of consciousness due to concussion of the brain. The passage of an electric current through the body may affect the heart or brain and cause unconsciousness in electric shock.

Secondary or surgical shock follows severe injuries within 2 to 24 hours. The extensive inflammatory reaction that follows a severe injury results in the leakage of a great deal of plasma and salts out of the circulation into the damaged tissues or into the blister fluid of burns. This process reduces the volume of blood in circulation and lowers the quantity of blood pumped out each minute by the heart to such an extent that the tissues do not receive sufficient oxygen. The patient lies pale, cold and only semiconscious. the pulse is rapid and weak, and the blood pressure falls. If the plasma is immediately replaced. the circulation is restored, but if not, the tissues, are irreversibly damaged by the lack of oxygen which causes still further plasma loss, and the irreversible stage of shock is produced. Other factors causing shock may include toxic products from damaged tissues. exhaustion of the adrenal cortex and leakage of sodium ions into the damaged tissues and potassium ions from the damaged tissues into the blood. Many severe diseases end in a shocklike state. Enviro'nmental stress such as exhaustion by physical effort, hunger. thirst and cold, all predispose to shock. A sudden loss of circulating blood volume in haemorrhage produces a shocklike state. The body will compensate for a slow haemorrhage by withdrawing fluid from the tissue spaces into the circulation, but the loss of red cells will produce anaemia.

Damage to Specialized Cells. — As a rule. the brunt of injury by physical agents falls upon skin. fibrous tissue and bone. These respond to damage by inflammation and then repair. On the other hand, injury by chemical and bacterial poisons often falls upon organs like the liver, kidney and brain which have highly specialized cells performing vital chemical work. These cells may be poisoned without visible signs of damage, but often obvious histological changes are produced (*e.g.*, fatty change in liver or heart, cytoplasmic or nuclear degenerations). The tissues atrophy in starvation. after disuse or in old age. Specialized cells differ greatly in their power of regeneration after injury. The nerve cells of the brain cannot be replaced. The cells of the heart muscle are usually replaced by fibrous tissue, and the heart can only grow strong again by increasing the size of each individual cell which remains. This process is called hypertrophy. Liver cells have considerable power of regeneration, but repeated damage will result in their replacement by fibrous tissue.

Disturbances of Blood **Supply to Tissues.**—The clotting of blood when it is shed is a most valuable protective mechanism. But sometimes blood may clot in the vessels during life. This is called thrombosis and is brought about by infection, damage or disease of the vessel wall and sometimes by changes in the blood which make it clot more readily. A thrombus may cut off the blood supply to a limb or to an organ (*e.g.*, the heart or brain) by blocking an artery. Or a thrombus may become detached and be carried along the blood stream to block a vessel farther on; it is then called an embolus. If the embolus blocks the blood supply to an area of tissue, that tissue will form an infarct — the cells die from lack of oxygen. The ferments in the dead cells go on working and break down the nuclei and alter the cytoplasm of the cells; this process is known as autolysis. It is as if the tissues "stew in their own juice." The dead tissue of the infarct will excite an inflammatory reaction and will eventually be walled off by fibrous tissue. If the thrombus was infected, an abscess will form.

Diseases of the arteries. kidney and heart are closely interrelated. Arterial disease may throw strain upon the heart or interfere with its blood supply, and in either case cause cardiac failure. This also occurs when certain diseases of the kidneys raise the blood pressure. Diseases of the arteries and the heart may in their turn affect renal function.

Failure of the kidneys to maintain the constant "sea-water environment" bathing the tissue cells. or failure of the circulation to maintain the supply of oxygen will have profound effects upon all the organs. Similar effects are produced by anaemia which reduces the oxygen-carrying power of the blood.

Tumours, New Growths, Neoplasms. — A mass of growing cells which appears in a particular tissue without any obvious physiological purpose is called a tumour. Some tumours grow slowly, resemble the tissue of origin and are limited by a fibrous-tissue capsule; these are called benign. Malignant tumours often differ from the parent tissue (in arrangement and in the appearance of the cells), grow rapidly, infiltrate locally into the surrounding structures and may spread to distant parts of the body via lymphatics or the blood stream.

Tumours differ from the normal tissues from which they were derived in three respects — anatomy, cytology and function.

Anatomy.—The tissue arrangement varies from a poor imitation of the tissue of origin to a complete loss of any resemblance to the normal structure. The new tissue forms a lump, spreads into the surrounding parts and distorts them. The anatomy of the bowel or bronchus may be so altered that these tubular organs are blocked.

Cytology.—The cells of malignant tumours show great variations of size and staining reactions. Cells which are much larger than normal can be seen lying adjacent to cells which are much smaller than normal. The cells may sometimes lose all resemblance to the tissue of origin.

Function. — Most physiological functions are lost by the tumour cells. For example, the important function of the skin is that it should protect against the "insults" of the environment. When a malignant growth arises from the skin, the protective function of the skin breaks down, an ulcer is formed, bacteria enter the body and the blood and tissue fluids leak out.

Some primitive functions are retained by certain malignant

growths which may produce bone, fibrous tissue, mucus or even hormones.

Experimental Production of *Tumours.*—Tumours have been produced in experimental animals by a great variety of different agents or carcinogens. E. L. Kennaway and his coworkers, during the period 1920–33, managed to isolate the carcinogen from coal tar which proved to be benzpyrene, a polycyclic hydrocarbon. Several hundred similar substances have since been shown to be carcinogenic. Other factors known to produce tumours include radiation by X-rays, radium and ultra-violet light; estrogens; certain viruses in fowls, mice and rabbits; and genetic factors in special inbred strains of laboratory animals. Most carcinogens are known to damage the cell but they need to be given in small doses over long periods of time to produce the malignant change

Recent experiments show that two or more different types of carcinogen acting together produce tumours more readily than when acting alone. It is possible that cancer in man may be due to the combined action of the many different types of carcinogen to which he is exposed. (See TUMOUR; CANCER; CANCER RESEARCH.)

Progress. — Great advances in recent years have occurred in the fields of metabolic diseases, endocrinology, vitamin deficiency and virus diseases. The new remedies — the sulfa drugs and the antibiotics (penicillin, streptomycin, etc.)—have given new insight into bacterial metabolism. Advances in physiology, biochemistry and microscopy have increased the knowledge of important pathological states including inflammation, shock, cardiovascular and renal disease, anemia, rheumatism and cancer.

Clinical Pathology. — Pathological investigations play an important part in diagnosis and in the control of therapy. The close liaison between clinician and pathologist has reappeared with the development of clinicopathological conferences and the realization that the natural history of disease can only be adequately described in terms of the clinicopathological picture.

(D. B. C.)

Practice of Pathology. — The practice of medicine includes the clinical practice of the physician who directly attends and manages the care of the patient and the laboratory practice of the physician (pathologist) who reports to and consults with the attending physician. The types of laboratory specimens examined by the pathologist include surgically removed parts, blood and other body fluids, urine, feces, exudates, etc. Not ordinarily included are X-ray films (radiology) and electrical recordings (electrocardiography, electroencephalography, etc.).

The pathologist is customarily selected by the clinical practitioner and conveys his opinions on the nature and care of the case to the practitioner. In all approved hospitals in the United States (approved by the Joint Accreditation committee of the American Medical association, American Hospital association, American College of Physicians and American College of Surgeons) it is mandatory that all specimens from patients be examined and interpreted in the light of the other knowledge available concerning the patient. Pathology practice also includes the reconstruction of the last chapter of the physical life of the patient through the procedure of autopsy (*q.v.*), which provides information, not obtainable by any other means, concerning the presence or absence of important as well as minor disease processes. Application of clinical, surgical and laboratory procedures for diagnosis during lifetime have reduced but not eliminated the number of major surprise findings at the autopsy examination, and medical progress, as well as legal and public health protection (see MEDICAL JURISPRUDENCE), is still fundamentally dependent upon this aspect of the practice of pathology.

Pathology is regarded as a medical specialty. The knowledge required for the proper general practice of pathology is too great to be attainable by single individuals, so that, wherever conditions permit it, subspecialists collaborate. Some of the laboratory subspecialists that occupy the full time practice of pathologists are neuropathology; pediatric pathology; general surgical pathology, dermatopathology, forensic pathology; biochemical pathology, microbiology and serology; and hematology and blood banking. The first five of these are subdivisions of so-called morphologic pathology (sometimes called pathologic anatomy), the next two are subdivisions of clinical pathology and the last involves both areas. In Great Britain the term morbid anatomy is commonly used to describe post-mortem pathology and clinical pathology to signify all types of laboratory investigations of disease (and health) in the living person.

Pathology is practised in hospital laboratories, private laboratories, public health agencies and private medical institutions including pharmaceutical manufacturers. Although the pathologist seldom sees the patient directly and never assumes entire management of the care, he has wide opportunity for scientific contribution to patient care through his precise laboratory tools and techniques. These facilities also favour research.

Education and Training. — Formal medical education with the attainment of the M.D. degree or its equivalent is required prior to admission to pathology postgraduate programs of the United States, Canada and Great Britain. Such training in the United States is supervised by the American Board of Pathology in collaboration with the Council on Medical Education and Hospitals of the American Medical association. The board requirements for certification (five years of study and training) establish a minimum level which, although not a legal requirement for pathology practice, becomes an effective one because approved hospitals g'enerally demand board-qualified pathologists. In Canada the postgraduate period has been similarly described and the practice opportunities correspondingly influenced. In Great Britain no board exists to set minimum specifications for the development of a pathologist but rather the Royal College of Physicians and the Association of Clinical Pathologists have been more concerned with optimum types of training and favourable conditions for practice. (S. C. MA.)

See references under "Pathology (med.)" in the Index volume.

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PATHUMTHANI is a small province (*changwat*) of Thailand located on the Chao Phraya river delta plain. Area 578 sq. mi., pop. (1956 est.), 172,331. Ithassomegoodalluvialsoils, but a large portion has acid and less productive clayey soils. Through supplementary irrigation, commercial rice is grown. The provincial capital, Pathumthani (1947 pop. 2,353), is located on the right bank of the Chao Phraya 29 mi. N. of Bangkok. It is connected by a spur of an all-weather trunk highway to Bangkok and Chiêngmai. (T. F. B.)

PATIALA, SIR BHUPINDRA SINGH, MAHARAJA OF (1891–1938), head of the Sikh community in India, was born Oct. 12, 1891, the son of Maharaja Sir Rajindra Singh, who died in Nov. 1900. On receiving full ruling powers (1910) Patiala maintained and greatly developed the progressive policy of the council of regency. He actively supported Great Britain during World U7ar I. He promoted the inauguration of the chamber of princes in 1921 and represented the princes at the League of Nations assembly at Geneva, Switz., in 1925.

PATIALA, a municipal town, headquarters of a district and capital of a former princely state, India. The town (pop., 1951, 97,869) is 127 mi. N.N.W. of Delhi.

PATIALA DISTRICT (area 2,605 sq.mi.; pop., 1951, 909,069) lies in the northwest sector of Punjab state. Wheat. barley, maize and cotton are its main crops, cotton ginning and metal industries were developed in the 1950s. The former Patiala district (area 1,590 sq.mi.) comprised the eastern part of the main tract of the former state of Patiala.

Patiala state (area 10,078 sq.mi.; pop., 1951, 3,493,685), the premier Punjab state. comprised a main tract and two detached areas. Patiala was founded by a chief of the Sikh Phulkian family about 1763. came under British protection in 1809 and was subsequently controlled through the Lahore residency. It was merged in the Patiala and East Punjab States union (PEPSU) on July 15, 1948, its maharaja being appointed rajpramukh.

On Nov. 1, 1956, by the Reorganization of States act, PEPSU was incorporated into Punjab state. (S. GL.; X.)

PATIALA AND EAST PUNJAB STATES UNION (PEPSU), a former constituent *rajpramukh* state of India, was formed on July 15, 1948, by the merger of the former princely states of Patiala (*q.v.*) and Nalagarh, and the short-lived Phulkian union (Faridkot, Kapurthala, Malerkotla, Nabha and Jind states); Kalsia state was included in the final union merger of Aug. 20, 1948. Area, 10,078 sq.mi.; pop. (1951) 3,493,685, mainly Jats. PEPSU was enclosed within Punjab state and in turn had at its centre a pocket of Punjab territory. Mohindergarh and Kapurthala districts and part of Kohistan district were separate from the main area and from each other. The capital was Patiala. On Nov. 1, 1956, by the Reorganization of States act, PEPSU was renamed the Patiala district. (S. GL.; X.)

PATINIR (PATINIER, PATENIER), **JOACHIM (DE)** (*c.* 1475–1524), Flemish painter, the first to specialize in landscape, was born eith'er at Bouvignes or at Dinant. He was received in 1515 into the painters' guild at Antwerp, where he continued to live until his death on Oct. 5, 1524. Albrecht Diirer visited him there in 1521.

Patinir seems to have made a practice of supplying landscape settings for figure compositions painted by other Flemish masters. He did not, however, paint pure landscape pictures, and all his work has a nominal religious subject. Its novelty, anticipated in different vein by Hieronymus Bosch, lay in the fact that the religious motif was much reduced in scale and immersed, as it were, in the phenomena of the natural world. The basic elements of his landscape style—the high viewpoint overlooking vast tracts, where earthy brown foregrounds merge into woodland and meadow greens and again into the hazy blues of distant mountains—do not differ' from those of his predecessors, particularly Gerard David. Yet the picturesque melancholy with which he invests the woods and rivers and the great ghostly rocks that jut up abruptly in the middle distance strike a personal note that won Patinir instant success and many imitators. Patinir's favourite subject was the "Rest on the Flight Into Egypt," of which representations may be seen in Vienna, Berlin, Madrid, Minneapolis, Minn., Philadelphia, Pa., and elsewhere. Many of his paintings are unsigned, and many paintings in his manner and commonly ascribed to him are probably not from his hand. (D. KG.; X.)

PATIO, the Spanish name for an inner court or enclosed space open to the sky. The patio recalls the classical atrium (*q.v.*), which provided a private sunlighted area for each dwelling in a crowded urban residential development. The revival of the patio has in some instances offered a needed formal or informal focal point in modern living. Contemporary architects have used the inner court with notable success in large office buildings (Connecticut General Life Insurance Co., Bloomfield, Conn., 1956), museums (Museum of Modem Art, Kamakura, Japan, 1951), urban housing complexes (Bogotá, Col., 1952) and single family residences (Hodgson house, New Canaan, Conn., 1953). The term patio is also commonly used, incorrectly, to describe any small semienclosed residential terrace. (H. MN.)

PATKUL, JOHANN REINHOLD (1660–1707), Livonian politician and agitator, was born on July 27, 1660, in prison at Stockholm, where his father lay under suspicion of treason. He was a captain in the Swedish army when, in 1689, at the head of a deputation of Livonian gentry, he went to Stockholm to protest against the rigour with which the land-recovery project of Charles XI was being carried out in his native province. Another petition addressed to the king in the diet in 1692, on behalf of the rights of the Livonian gentry, involved him in a government prosecution. Patkul fled from Stockholm to Switzerland, and was condemned *in contumaciam* to lose his right hand and his estates. For the next four years he led a vagabond life, but in 1698, after vainly petitioning the new king. Charles XII, for pardon, he proceeded to the court of Augustus the Strong, elector of Saxony and king of Poland, at Dresden and bombarded him with proposals for the partition of Sweden. His first plan was a combination against it of Saxony, Denmark and Brandenburg; but. Brandenburg failing him, he was obliged unwillingly to admit Russia into the partnership. The tsar was to be content with Ingria and Estonia, while Augustus was to take Livonia, nominally as a fief of Poland but really as a hereditary possession of the Saxon house. Military operations against Sweden's Baltic provinces were to be begun simultaneously by the Saxons and Russians. After thus forging the first link of the partition treaty, Patkul proceeded to Moscow, and, at a secret conference held at Preobrazhenskoye, easily persuaded Peter the Great to accede to the league (Nov. 11, 1699). Throughout the earlier days of the Great Northern War, Patkul was the mainstay of the confederates. At Vienna, in 1702, he picked up the Scottish general George Benedict Ogilvie, and enlisted him in Peter's service. In the same year he himself exchanged the Saxon for the Russian service. On Aug. 19, 1704, he succeeded, at last, in bringing about a treaty of alliance between Russia and the Polish republic to strengthen the hands of Augustus, but he failed to bring Prussia also into the anti-Swedish league because of Frederick I's fear of Charles and jealousy of Peter. From Berlin Patkul went to Dresden to conclude an agreement with the imperial commissioners for the transfer of the Russian contingent from the Saxon to the Austrian service. The Saxon ministers, after protesting against the new arrangement, arrested Patkul and shut him up in the fortress of Sonnenstein (Dec. 19, 1705), disregarding the remonstrances of Peter against this violation of international law. After the peace of Altranstadt (Sept. 24, 1707) he was delivered up to Charles, and at Kazimierz, Pol., (Oct. 10, 1707) was broken alive on the wheel, as a traitor to Sweden. Charles rejected an appeal for mercy from his sister, the princess Ulrica, on the ground that Patkul, as a traitor, could not be pardoned for example's sake.

PATMORE, COVENTRY KERSEY DIGHTON (1823–1896), English poet and critic, the eldest son of Peter George Patmore, himself an author, was born at Woodford in Essex, on July 23, 1823. He was privately educated, being his father's intimate and constant companion. His first idea was to be an artist, but after a brief experiment he turned to literature. In 1844 he published *Poems,* a book which was ill-received by the critics. Patmore withdrew and destroyed the remainder of the edition. But the publication of this little volume introduced its author to various men of letters, among whom were Dante Gabriel Rossetti and Holman Hunt, and he was thus drawn into the eddies of the pre-Raphaelite movement, contributing his poem "The Seasons" to the *Germ.* At this time Patmore's father became involved in financial embarrassments; and in 1846 Monckton Milnes secured for the son an assistant-librarianship in the British Museum. a post which he occupied industriously for 19 years, devoting his spare time to poetry. In 1847 he married Emily Andrews.

In 1853 he republished. in *Tamerton Church Tower,* the more successful pieces from the *Poems* of 1844, adding several new poems which showed distinct advance, both in conception and treatment; and in the following year (1854) appeared the first part of his best-known poem, "The Angel in the House," which was continued in "The Espousals" (1856), "Faithful for Ever" (1860), and "The Victories of Love" (1863). In 1862 he lost his wife, after a long and lingering illness, and shortly afterward joined the Roman Catholic Church. In 1865 he married again, his second wife being Marianne Byles; and a year later purchased an estate in East Grinstead, the history of which may be read in *How I Managed My Estate,* published in 1886. In 1877 appeared *The Unknown Eros;* and in the following year *Amelia,* his own favourite among his poems, together with an interesting, though by no means undisputable, essay on *English Metrical Law.* This was followed by *Principle in Art* (1879) and *Religio poetae* (1893). After the death of his second wife in 1880 he married Harriet Robson. In later years he lived at Lymington, where he died on Nov. 26. 1896.

A collected edition of his poems appeared in two volumes in 1886, with a characteristic preface which might serve as the author's epitaph. "I have written little," it runs; "but it is all my best; I have never spoken when I had nothing to say,' nor spared time or labour to make my words true. I have respected posterity; and should there be a posterity which cares for letters, I dare to hope that it will respect me." His best work is found

in the volume of odes called *The Unknown Eros*, which is full of entire poems in which exalted thought is expressed in poetry of the richest and most dignified melody. (A. WA.)

The standard life of Patmore is the *Memoirs and Correspondence* (1901), edited by Basil Champneys. *See* also E. W. Gosse, *Coventry Patmore* (1905); essay by Mrs. Meynell (1905) in the "Muses' Library"; D. Patmore, *Portrait of My Family* (London, New York, 1935).

PATMOS, an island of the Dodecanese group, Greece, in the Aegean sea about 28 mi. S.S.W. of Samos (37° 20′ N. lat. and 26° 3½′ E. long.; length about 10 mi., greatest breadth 6 mi.; area 13 sq.mi.). The island is volcanic, bare and rocky, rising to about 800 ft. with deeply indented coast. The harbour opening eastward divides the island into two nearly equal portions with a narrow isthmus where the ancient town stood. On the hill above remains of the citadel survived. The modern town stands on a ridge in the southern half. A steep paved road was built between the port and the monastery of St. John, which crowns the hill with towers and battlements, a fortress rather than a monastery.

Patmos is rarely mentioned in antiquity. Ionians settled there at an early date. As a remote islet it was the place of banishment of St. John the Evangelist, under Domitian, in A.D. 95. He was released about 18 months later under Nerva. There he is said to have written the Apocalypse and a grotto was identified as that in which the apostle is said to have received the heavenly vision. The *Acts* of *St. John,* attributed to Prochorus, narrates the miracles wrought by the apostle during his stay on the island, but, while describing how the Gospel was revealed to him in Patmos, it does not mention the Apocalypse.

During the middle ages Patmos seems to have been deserted, probably because of pirates. In 1088 the emperor Alexis Comnenus, by a golden bull, which was preserved, granted the island to St. Christodulus to found a monastery. This was the origin of the monastery of St. John, which acquired the greater part of the southern half of Patmos, as well as farms in Crete, Samos and other neighbouring islands. The embalmed body of the founder was interred in a side chapel of the church.

The island was subject to Turkey till it was annexed by Italy in 1912 and ceded to Greece in 1947. Pop. (1951) 2,613.

PATNA, a city, district and division in Bihar state, India. The city (pop. [1961] 362,817), lying on the right bank of the Ganges, is the state capital. These should be distinguished from Patna, formerly a princely state of 2,530 sq.mi. in the Chhattisgarh agency, India, which was merged in Orissa state in 1948. Patna was selected as the capital of Bihar and Orissa on the creation of that province in 1912. Orissa became a separate province in 1936. A high court was established in 1916 and a university in 1917. The greater part of Patna consists of the city proper, which stretches along the river bank for 9 mi. Its main street is filled by a succession of small shops and houses, broken by public institutions and cultivated fields, with little to suggest the importance of a capital. Its trade is declining and depends on local products. Its manufactures and industries are also on a small scale. West of it lies the civil station of Bankipur, and southwest of the latter the new capital. The new capital is well laid out and spacious: its main roads are 150 ft. wide and a central avenue has a length of nearly a mile and a width of 200 ft. The principal buildings are Government house, the Secretariat, the Council chambers, the High court and the Patna museum. The Patna Oriental museum is in the city proper, as are also other buildings and institutions mentioned later.

History.—Patna stands on the site of the ancient Pataliputra, the Palibothra of Megasthenes, who was sent there about 302 B.C. as an envoy to Chandragupta by Seleukos Nikator. According to his account, the city had a circuit of 25½ mi. and the royal palace was more magnificent than those at Susa and Ecbatana. Under Asoka, Pataliputra was the capital of an empire extending from the Hindu Kush to the Bay of Bengal. The seat of government was moved to Ajodhya by Chandragupta II toward the close of the 4th century A.D., and Pataliputra, which was a flourishing city in the next century, subsequently fell into ruin; the causes of its fall are obscure, but excavations show the effects of fire and flood. The Chinese pilgrim, Hiuen Tsiang, in the 7th century described it as an old city long deserted, with monasteries and temples in ruins. Patna rose to greatness after A.D. 1541, when Sher Shah made it the capital of Bihar. By 1586, when Ralph Fitch visited it, Patna was "a very long and a great town." Under the Moguls it was the seat of the viceroy of Bihar and a centre of commerce, which led to the establishment of factories by both the English and Dutch. Its seizure by the English agent, Ellis, in 1763, precipitated war with the nawab of Bengal, Mir Kasim Ali Khan. The recapture of the city by his forces was followed by the ghastly tragedy known as "the massacre of Patna"; under the nawab's orders nearly 200 English prisoners were murdered in cold blood by one of his officers, an Alsatian named Walter Reinhardt, who was known to the Indians as Samru. Patna was finally taken by the British forces under Major Knox in 1763. The ancient Pataliputra lies buried deep under the silt of the Ganges, but most interesting remains have been unearthed in the southwest suburbs as the result of excavations in 1892–99 and 1912–16. Among them is the hall of 100 columns built by Asoka, the ruins of which have been found to bear a similarity to those of the palace of Darius at Persepolis.

Buildings and University.—The oldest intact building in Patna is a mosque, with a courtyard of glazed tiles, built by Husain Shah, king of Bengal, in 1499; other noteworthy mosques are Sher Shah's mosque and the stone mosque of Prince Parwez, son of Jahangir (1626). A Sikh temple stands in the place where the great guru Govind Singh was born in 1675; in it are preserved his cradle, shoes, swords and arrows, as well as a copy of the *Granth* or holy book of the Sikhs, said to have been presented by the guru himself. The Gola in Bankipore, a curious brick building, 96 ft. high, of a beehive shape, was built in 1786 to serve as a granary for rice in case of famine; it was never filled.

The University of Patna, founded in 1917, consisted of a number of colleges admitted to the degree standard, and of colleges and schools admitted to the intermediate standard. The majority were in Patna; viz., the Patna college, Bihar National college, Patna Training college, Patna Law college, Bihar National College of Engineering, Prince of Wales Medical college and Patna New college. A senate house was opened in 1926. Patna university became a purely teaching university, the colleges being affiliated with Bihar university, created in 1952, which also has its headquarters at Patna.

PATNA DISTRICT has an area of 2,164 sq.mi.; pop. (1961) 2,942,614. Throughout the greater part of its extent the district is a level plain; hut toward the south the Rajgir hills (*q.v.*) project into it and divide it from the district of Gaya for about 30 mi. The soil is for the most part alluvial, and the country along the hank of the Ganges is fertile. The general line of drainage is from west to east; and high ground along the south of the Ganges forces back the rivers flowing from Gaya district. The result is that during the rains a belt of low-lying country 4 or 5 mi. from its bank is flooded. The chief rivers are the Ganges and the Sone. The only other river of any consequence is the Punpun, which is chiefly remarkable for the number of petty irrigation channels which it supplies. So much of the river is thus diverted that only a small portion of its water ever reaches the Ganges. The chief crops are rice, wheat, barley, maize and pulse. The Sone canal irrigates 150,000 ac. to the northwest; elsewhere irrigation is largely practised from private channels and also from wells.

Apart from Patna city, the district contains many places of historic interest. The Rajgir hills are not only associated with the life of Buddha but contain remains of prehistoric and early historic date. Mahavira, the founder of Jainism, died at Pawapuri, which is consequently a place of Jain pilgrimage. Nalanda (the modern village of Bargaon) was a famous seat of Buddhist learning and culture; it has been called "the Oxford of Buddhist India." Sir A. Cunningham states that he saw the finest sculptures of India there; and excavations begun in 1916 have disclosed a maze of *viharas* (monasteries) with seven levels of occupation and buildings of nine different periods. Between the 11th and 12th centuries A.D. the town of Bihar was the site of another Buddhist *vihara,* whence its name; it was the capital of South Bihar under the Pala kings and then under Mohammedan governors until the 16th century.

PATNA DIVISION comprises the districts of Patna, Gaya and Shahabad, south of the Ganges. Area, 11,366 sq.mi.; pop. (1951) 8,287,211. It formerly also included four districts north of the Ganges (viz., Saran, Champaran, Muzaffarpur and Darbhanga), which in 1908 were formed into the division of Tirhut.

PATON, SIR JOSEPH NOEL (1821–1901), knighted in 1867, British painter, was born on Dec. 13, 1821, in Woolers Alley, Dunfermline. He began to exhibit at the Royal academy, London, in 1856. His preference was for allegorical, fairy and religious subjects. He also produced a certain amount of sculpture, more notable for design than for searching execution. He was elected an associate of the Royal Scottish academy in

1847, and a full member in 1850; and was appointed Queen's Limner for Scotland in 1866. In 1878 the University of Edinburgh conferred upon him the degree of LL.D. He was well known as an antiquary, his hobby being the collection of arms and armour. He died in Edinburgh on Dec. 26, 1901. Among his most famous pictures are "The Pursuit of Pleasure" (1855), "Mors Janua Vitae" (1866), "Oskold and the Ellé-maids" (1874) and "In Die Malo" (1882).

PATRAS (Gr. *Patrai*), the chief seaport on the west coast of Greece, and capital of the province of Achaea and Elis, on a gulf of the same name, 70 mi. W.N.W. of Corinth. Pop. (1961) 93.755. It was rebuilt after the War of Independence. is the seat of a Greek archbishop, and has railway communications with Athens via Corinth and with Kalamata via Pyrgos. It is the port from which the bulk of currant crop is dispatched. The port, formed by a mole and a breakwater, begun in 1880, offers a fair harbour for vessels drawing up to 22 ft. Other exports ordinarily are sultanas, valonea, tobacco, olive oil, olives in brine, figs, citrons, wine, brandy, cocoons, and lamb, goat, and kid skins. The imports include colonial produce, manufactured goods and sulphate of copper for the vineyards. The castle is a mediaeval structure on the site of the ancient acropolis. The cathedral of St. Andrew is the reputed burial-place of the saint. Patras was occupied by axis troops in April 1941.

In Greek legend, Eumelus, taught by Triptolemus how to grow grain, established three townships, Aroe (*i.e.*, ploughland), Antheia (the flowery), and Mesatis (the middle settlement), united by common worship of Artemis Triclaria at her shrine on the river Meilichus. The Achaeans, because the ruling families (*patrai*) lived there, enlarged Aroe, called it Patrae, and recognized it as one of the twelve Achaean cities. In 419 B.C. the town was, by the advice of Alcibiades, connected with its harbour by long walls in imitation of those at Athens. After the defeat of the Achaeans at Scarpheia its whole armed force was destroyed by Metellus, but after Actium, Augustus restored the ancient name Aroe, introduced a military colony of veterans from the 10th and 12th legions and bestowed the rights of coloni on Rhypae, Dyme, and the Locri Ozolae except those of Amphissa. Thus Colonia Augusta Aroe Patrensis became one of the most populous towns of Greece; its colonial coinage extends from Augustus to Gordian III. The scene of the martyrdom of St. Andrew is apocryphal, but, like Corinth, Patras was an early and effective centre of Christianity; its archbishop attended the Council of Sardica in 347. In 551 it was laid in ruins by an earthquake. In 807 it defeated the Avars. Captured in 1205 by William of Champlitte and Villehardouin, the city became the capital and its archbishop the primate of the principality of Achaea. In 1387 De Heredia, grand master of the order of the Hospital at Rhodes, endeavoured to master Achaea and took Patras by storm. Later the city was governed by the archbishop in the name of the pope; but in 1428 Constantine, son of John VI., held it for a while. Captured by the Turks, it was surrendered in 1687 to the Venetians. In 1714 it again fell into Turkish hands. It was at Patras that the Greek revolution began in 1821; but the Turks held out till 1828.

See J. Herbillon, Les *cultes de* Patras (London, 1929).

PATRICIANS, the members of the old citizen families of ancient Rome (Lat. *patricius,* an adjectival form from *pater*).

IN ROMAN HISTORY

Origin of Patricians and Plebeians.—From the earliest period known to us the free population of Rome contains two elements, patricians and plebeians, the former class enjoying all political privileges, the latter unprivileged. The patricians (*patricii*) are members of the clans (gentes) which originally formed the citizen body. The plebeians (plebs) include all the rest of the free population. The origin of the plebs has been much debated and was in all probability complex. One part was evolved from the "clients," freed men or aliens who attached themselves for reasons of defense and support to the great clans or to their individual members. Very probably also, as a result of an early conquest of Rome, much of the plebs differed in racial origin from its patrician rulers. A third source was the accumulation of aliens drawn to Rome as a centre of traffic between Etruria and Southern Italy. It is significant that many plebeians had acquired wealth, presumably from trade. Many of these aliens would place themselves under the protection of the state or the king rather than that of individual citizens. If the alien came from a town possessing the *ius commercii* with Rome, he would have no need to become the client of a private patron. The whole unprivileged class, whatever its origin, tended to become consolidated. The differences between its various sections were great and their interests often conflicting, *e.g.*, the desires of the trading alien, the favoured client of the patrician and the descendant of the conquered Ligurian must often have been widely separated; compromise was an essential to united action by the three. The constitution attributed to Servius Tullius, which placed military burdens on the shoulders of the plebeians and admitted them to a share, though an inadequate share, in political power, helped to unify the class and prepared the way for the struggle for power which was to occupy the next century and a half, and which resulted in the full attainment by the plebs of the privileges zealously guarded by the patricians.

Reforms of Servius Tullius.—The aim of the reforms associated with the name of Servius Tullius appears to have been the imposition of the duties of citizenship upon the plebeians. This involved an extension of plebeian privilege in two directions. First it was necessary to unify the plebeian order by putting the legal status of the clients on a level with that of the unattached plebeians; and again enrolment in the army involved registration in the tribes and centuries; and as the army soon developed into a legislative assembly meeting in centuries (comitia centuriata), the whole citizen body, including plebeians, acquired a small share of political power, which had hitherto belonged solely to the patricians. At the close of the monarchy the plebeian possessed the private rights of citizenship, except for his inability to contract a legal marriage with a patrician, and one of the public rights, that of giving his vote in the assembly. But in liability to the duties of citizenship, military service, and taxation, he was entirely on a level with the patrician. This position was tolerable during the monarchy, when the king served to hold the power of the patrician families in check. But when these families had expelled the Tarquins, the inconsistency between partial privilege and full burdens pressed on the plebeians.

The Struggle of the Orders.—The result was the long struggle for political equality of the two orders (see ROME: Ancient History: The Republic). The plebeians in 494 B.C. formed themselves into an exclusive order with annually elected officers (*tribuni plebis*) and an assembly, and by means of this machinery forced themselves by degrees into the magistracies, and obtained the coveted right of intermarriage with the patricians. Admission to the senate followed, and the political privilege of the two orders was equalized, with the exception of certain disabilities which were attached to the patricians after the victory of the plebs. They were excluded from the tribunate and the council of the plebs, which had become important instruments of government, and were eligible for one place only in the consulship and censorship, while both were open to plebeians. Since the plebeian element in the state had an immense numerical preponderance over the patrician, these disabilities were not widely spread, and seem generally to have been cheerfully borne as the price of belonging to the families still recognized as the oldest and noblest in Rome. But the adoption of P. Clodius Pulcher into a plebeian family in 59 B.C. with a view to election to the tribunate shows that a rejection of patrician rights (*transitio* ad *plebem*) was not difficult to effect by any patrician who preferred actual power to the dignity of ancient descent. It was not so easy to recruit the ranks of the patricians. The first authenticated instance of the admission of new members to the patriciate is that of the *lex* Cassia which authorized Caesar as dictator to create fresh patricians. The same procedure was followed by Augustus. The right of creating patricians came to be regarded as inherent in the principate, and was exercised by Claudius and Vespasian without any legal enactment. Patrician rank was regarded as a necessary attribute of the *princeps,* a fact

illustrative of the tenacity with which the Romans clung to the name and form of an institution which had long lost its significance. After the political equalization of the two orders, noble birth no longer constituted a claim to political privilege. Instead of the old hereditary nobility there arose a nobility of office, consisting of all those families, whether patrician or plebeian, which had held curule office It was the tenure of office that conferred distinction. In the early days of Rome, office was open only to the member of a patrician *gens.* In the principate, patrician rank was held to be a dignity suitable to be conferred on an individual holder of office But the conferment of the rank upon an individual as distinct from a whole family *(gens)* is enough to show how widely the later conception of patrician rank differed from the ancient

THE LATER PATRICIATE

Under Constantine a new meaning was given to the word patrician. It was used as a personal title of honour conferred for distinguished services. It was a title merely of rank, not of office; its holder ranked next after the emperor and the consul. It naturally happened, however, that the title was generally bestowed upon officials, especially on the chief provincial governors, and even upon barbarian chieftains whose friendship was valuable enough to call forth the imperial benediction. Among the former it appears to have become a sort of ex *officio* title of the Byzantine vice-gerents of Italy, the exarchs of Ravenna; among the barbarian chiefs who were thus dignified were Odoacer, Theodoric, Sigismund of Burgundy, Clovis, and even in later days princes of Bulgaria, the Saracens, and the West Saxons. The dignity was not hereditary and belonged only to individuals; thus a patrician family was merely one whose head enjoyed the rank of *patricius.* With the word were associated such further titles as *eminentia, magnitudo, magnificentia.* Those patricians who were purely honorary were called *honornrii* or *codicillarii;* those who were still in harness were *praesentales.* They were all distinguished by a special dress or uniform and in public drove in a carriage.

In Western Europe.—A further change in the meaning of the name is marked by its conferment on Pippin the Frank by Pope Stephen. The Italian *patricius* of the 6th and 7th centuries had come to be regarded as the *defensor, protector, patronus* of the Church, but the conferring of the title by a pope was entirely unprecedented. It is clear that the patriciate of Pippin was a new office, as the title is henceforward generally *patricius Romanorum,* not *patricius* alone. It was conferred on Charlemagne at his coronation, and borne indiscriminately by subsequent emperors and by a long line of Burgundian rulers and minor princes. On the fall of the Carolingian house the title passed to Alberic II. The emperor Frederick Barbarossa was the last to wear the insignia (in 1167).

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PATRICK, ST., the patron saint of Ireland,[1] was probably born about the year 389. He was the son of a deacon, Calpurnius, and the grandson of a presbyter named Potitus His father was a middle-class landed proprietor and a decurion, who is represented as living at a place called Bannauenta. The only place of this name we know is Daventry, but it seems more probable that Patrick's home is to be sought near the Severn, and Rhys conjectures that one of the three places called Banwen in Glamorganshire may be intended. The British name of the future apostle was Sucat. to which Mod. Welsh *hygad,* "warlike," corresponds. His Roman name has also survived in a Hibernicized form, Cothrige, with the common substitution of Irish *c* for Brythonic *p.* (Cf. Irish *casc,* Lat. *pascha.)* Patrick was doubtless educated as a Christian and was imbued with reverence for the Roman Empire. When about sixteen years of age he was carried off by a band of Irish marauders. The latter were possibly taking part in the raid of the Irish king Niall Noigiallach, who met with his end in Britain in 405. Irish tradition represents the future apostle as tending the herds of a chieftain of the name of Miliucc (Milchu), near the mountain called Slemish in county Antrim, but Bury tries to show that the scene of his captivity was Connaught, perhaps in the neighbourhood of Croagh Patrick.

His bondage lasted for six years. During this time he became subject to religious emotion and beheld visions which encouraged him to effect his escape. He fled, in all probability to the coast of Wicklow, and encountered a vessel which was engaged in the export of Irish wolf-dogs. After three days at sea the traders landed, possibly on the west coast of Gaul, and journeyed for twenty-eight days through a desert. At the end of two months Patrick parted from his companions and betook himself to the monastery of Lérins, where he probably spent a few years. On leaving the Mediterranean he seems to have returned home. It was doubtless during this stay in Britain that the idea of missionary enterprise in Ireland came to him. In a dream he saw a man named Victorious bearing innumerable epistles, one of which he received and read; the beginning of it contained the words "The Voice of the Irish"; whilst repeating these words he says, "I imagined that I heard in my mind the voice of those who were near the wood of Foclut (Fochlad), which is near the western sea, and thus they cried: 'We pray thee, holy youth, to come and walk again amongst us as before.'" The forest of Fochlad was in the neighbourhood of Killala Bay, but it is possible that it extended considerably to the south. Despite his natural diffidence, and opposition on the part of his relatives, Patrick resolved to return to Gaul in order to prepare himself for his mission. He proceeded to Auxerre—a place which seems to have had a close connection with Britain and Ireland—and was ordained deacon by Bishop Amator, along with two others who were afterwards associated with him in spreading the faith in Ireland. The one was an Irishman called Fith, better known as Iserninus, the other Auxilius. Patrick must have spent at least fourteen years at Auxerre

Mission to Ireland.—It seems not unlikely that Pelagianism had taken root among the Christian communities of Ireland, and it was found necessary to send a bishop to combat the heresy. Pope Celestine's choice fell on the deacon Palladius, who had taken a prominent part in stamping out the doctrine in Britain. Patrick probably felt great disappointment when Palladius was sent as the chosen envoy of Rome, but now Germanus seems to have decided that Patrick was the man for the task, and he was consecrated in 432. Patrick landed at Inverdea, at the mouth of the river Vartry in Wicklow, but we are not informed as to any of his doings in Leinster at this period. According to the story, he immediately proceeded northward to the kingdom of Ulidia (east Ulster), though a certain tradition represents him as going to Rleath Landing on the shores of Strangford Lough. he commenced his labours in the plain on the south-west side of that inlet. A convert chief named Dichu granted him a site for an establishment, and a wooden barn is stated to have been utilized for the purpose of worship, whence the modern Saul (Ir. *saball,* "barn"). Patrick's activity was bound to bring him sooner or later into conflict with the High-king Loigaire (reigned 428–467), son of Niall Noigiallach. Fedilmid, a brother of the monarch, is represented as having made over his estate at Trim to the saint to found a church, and thus the faith was established within Loigaire's territory.

The story makes Patrick challenge the royal authority by lighting the Paschal fire on the hill of Slane on the night of Easter Eve. It ,chanced to be the occasion of a pagan festival at Tara, during which no fire might be kindled until the royal fire had been lit. A number of trials of skill between the Christian missionary and Loigaire's Druids ensued, and the final result seems to have been that the monarch, though unwilling to embrace the foreign creed,

[1] His career is involved in considerable obscurity. Widely varying views have been held by modern scholars with regard to his activity, some going so far as to treat all the accounts of his labours as the fictitious creation of a later age. In the present article Bury's reconstruction of the saint's life has been chiefly followed. Apart from its importance in other respects, Bury's treatment of the subject has at any rate the merit of defending the traditional view of St. Patrick's career.

undertook to protect the Christian bishop. At a later date the saint was probably invited by Loigaire to take part in the codification of the *Senchus Mór* in order to represent the interests of the Christian communities. On another occasion Patrick is reported to have overthrown a famous idol known as *Cenn Cruaich* or *Cromm Cruaich* in the plain of Mag Slecht (county Cavan).

Patrick is stated to have visited Connaught on three different occasions and to have founded churches, one of the most important being that at Elphin. As regards Ulster our information is very scanty, though we find him establishing churches in the three kingdoms of the province (Ailech, Oriel and Ulidia). Patrick's work is more closely identified with the north of Ireland than with the south. Traces of his mission, however, are to be found in Ossory and Muskerry. But his task in the south was doubtless rather that of an organizer, and a kind of circular letter has come down to us which was addressed by Patrick, Auxilius and Iserninus, to all the clergy of the island. There is some evidence that he made a journey to Rome (441–443) and brought back with him valuable relics. On his return he founded the church and monastery of Armagh, the site of which was granted him by Daire, king of Oriel, and it is probable that the see was intended by him to be specially connected with the supreme ecclesiastical authority. Some years before his death, which took place in 461, Patrick resigned his position as bishop of Armagh to his disciple Benignus, and possibly retired to Saul in Dalaradia, where he spent the remainder of his life. The place of his burial was a matter of dispute in early Ireland, but it seems most likely that he was interred at Saul.

Writings.—Two highly important documents purporting to have been written by Patrick have come down to us. The one is the Confession, which is contained in an imperfect state in the Book of Armagh (*c.* 807), but complete copies are found in later mss. The Confession, written towards the end of his life, gives a general account of his career. Various charges had been brought against him by his enemies, among them that of illiteracy, the truth of which is borne out by the crudeness of his style, and is admitted by Patrick himself. The other document is the so-called Letter to Coroticus, a British king of Strathclyde, whose soldiers had in the course of a raid in Ireland killed a number of Christian neophytes on the very day of their baptism while still clad in white garments. Others had been carried off into slavery, and a deputation of clergy which Patrick had sent to ask for their release had been subjected to ridicule. In his Letter the saint in very strong language urges the Christian subjects of the British king not to have any dealings with their ruler and his bloodthirsty followers until full satisfaction should have been made. The text of this letter occurs in a number of mss. but is not contained in the Book of Armagh. It is however certain that it was known in the 7th century. A strange barbaric chant commonly known as the Lorica or Hymn of St. Patrick is preserved in the *Liber hymnorum.* This piece, called in Irish the *Faed Fiada* or "Cry of the Deer," contains a number of remarkable grammatical forms, and late editors believe that it may very well be genuine.

From such slender material it is not easy to form a clear conception of the saint's personality. His was evidently an intensely spiritual nature, and in addition to the qualities which go to form a strong man of action he must have possessed an enthusiasm which enabled him to surmount all difficulties. His importance in the history of Ireland and the Irish Church consists in the fact that he brought Ireland into touch with western Europe and more particularly with Rome, and that he introduced Latin into Ireland as the language of the Church. His work consisted largely in organizing the Christian societies which he found in existence on his arrival, and in planting the faith in regions which had not yet come under the sway of the gospel.

AUTHORITIES.—Apart from the Letter and Epistle mentioned above our chief sources of information with regard to the life of St. Patrick are contained in the Book of Armagh. The one is the memoir by Tirechan, a bishop who had been the disciple of Bishop Ultan of Ardbraccan in Meath (d. 657). The first part of this memoir, which was probably compiled about 670, deals with the saint's work in Meath, the second with his activity in Connaught. Various additions are appended to this compilation, and there are still further additional notes. The other biography was written towards the end of the 7th century by Muirchu Maccu Machtheni, who dedicated his work to Bishop Aed of Slébte (d. 700). (*See* edition by N. J. D. White, 1920). The first portion deals with Patrick's career down to his arrival in Ireland and contains an unvarnished statement of fact. But when the story passes to Ireland Muirchu's narrative becomes full of the mythical element. Muirchu influenced later biographies. Bury has shown that both Tirechan and Muirchu drew from written material which existed in part at any rate in Irish. Among later lives we may mention the hymn *Genair Patraicc,* commonly attributed to Fiacc, which is considered by the latest editors to have been originally composed about 800. Three anonymous Latin lives were published by Colgan in his *Trias Thaumaturga* (Louvain, 1645), and there exists an 11th-century Irish life in three parts published by Whitley Stokes for the Rolls series (1887). A Latin translation of a different copy of this work, now lost, was published by Colgan. Lastly a life by an otherwise unknown Irish writer named Probus occurs in the Basel edition of Bede's works (1563) and was reprinted by Colgan.

See J. B. Bury, *The Life of St. Patrick and his Place in History* (London, 1905); J. H. Todd, *St. Patrick, the Apostle of Ireland* (Dublin, 1861); H. Zimmer, article "Keltische Kirche" in *Realency-klopadie fur protestantische Theologie und Kirche* (1901; trans. by Miss Meyer, "The Celtic Church in Britain and Ireland," London, 1902); J. Gwynn, *Liber Ardmachanus;* Whitley Stokes, *The Tripartite Life of St. Patrick* (London. 1887); N. J. D. White, "The Writings of St. Patrick" (critical edition) in *Proceedings of the Royal Irish Academy* (1904); *Liber Ardmachanus* (docs. relating to St. Patrick) edited by J. Gwynn (1913); F. R. M. Hitchcock, St. *Patrick and his Gallic friends* (1916); Muirchu, *The Writings and Life of St. Patrick,* ed. N. J. D. White (1920). (E. C. Q.; X.)

PATRIOTIC SOCIETIES, organizations formed in many countries for the purpose of commemorating historical events of the past. preserving the records and sites of such events, and. in general, fostering a spirit of patriotism and love of country. The oldest in the U.S., the Society of the Cincinnati (*q.v.*), dates back to the American Revolution. The chief societies in the U.S., with the dates of their organization. are the Society of Mayflower Descendants (1897), Colonial Dames of America (1890). Society of Colonial Wars (1893), Sons of the Revolution (1876), Daughters of the Revolution (1891), Sons of the American Revolution (1889), Daughters of the American Revolution (1890) and the Sons of Veterans (1879). The Daughters of the Confederacy (1894) and the Sons of Confederate Veterans (1896) commemorate the Confederate cause in the Civil War. Eligibility for membership in all the above is based upon the historical services of an ancestor. The Grand Army of the Republic, formed by the Union soldiers after the American Civil War, long possessed a political as well as social importance. A similar organization is the American Legion (*q.v.*).

PÄTS, KONSTANTIN (1874–1956), Estonian statesman. was born in the Pärnu district. where his father was a farmer. and graduated in law at Tartu university .in 1896. In 1901 in Tallinn he became editor of *Teatajä* ("The Announcer"), the first daily newspaper in the Estonian language. After the Russian revolution of 1917, when elections were held to the Estonian national council. Pats' Agrarian league, representing the peasant proprietors, topped the poll, and he became chairman of the council's executive committee. On the declaration of Estonia's independence on Feb. 24, 1918, he was appointed head of the provisional government, but when the Germans entered Tallinn on the following day he was sent to a concentration camp in Lithuania. After Germany's capitulation of Nov. 11, 1918, he returned to head the provisional government. In 1921–22, in 1923 and 1932–33 he was *riigivanen* or chief of state; that is, both prime minister and president of the republic, a dual role peculiar to the first Estonian constitution. A national referendum sponsored in Oct. 1933 by the League of Soldiers of the War of Liberation (*Vabadussõjalaste Liit,* usually known as VAPS) resulted in a majority for the revision of the constitution with a directly elected president.

On Oct. 21, 1933, Päts again became *riigivanen,* and in Jan. 1934, when the second constitution came into force. he became acting president. The new elections were fixed for April, but on March 12 Päts assumed supreme power, dissolved the VAPS and had 500 of them arrested. A new constituent assembly in Feb. 1937 drew up a third constitution which came into force on Jan. 1, 1938. On April 24, by 219 votes to 19, Päts was re-elected presi-

dent for. a term of six years. On the occupation of Estonia by the soviet army, on June 16, 1940, a Russian-controlled government was formed, and on July 20 Pats was arrested and deported to the U.S.S.R. where he died in 1956.

PATTANI, a *changwat* on the east side of peninsular Thailand, is between *changwats* Narathiwat on the south (which separates it from Malaya) and Songkhla on the north. With an area of 777 sq.mi., it is one of the smaller of Thailand's *changwats,* although prior to a revolt in 1800, Pattani was a much larger political unit. Pop. (1956 est.) 256,770. Much of the area consists of sandy ridges alternating with strips of lowland covered with clay soils. The ridges are old abandoned offshore sand bars and the lowlands are filled lagoons. Average annual rainfall amounts to 67 in. Houses, settlements and coconut groves occupy the ridges, while rice and other crops are grown in the lowlands. Most of the inhabitants are Moslems. The last Moslem ruler, however, was set aside in 1902. Pattani is the most important salt-producing *chaňgwat* in the peninsula.

The capital, Pattani, a fishing centre and seaport and the largest settlement, is 65 mi. north of the Malayan border; it has a roadstead harbour which also serves the *changwat* of Yala. Coconut products, rubber and tin are the chief exports. Manufactured goods and rice are imported. Pop. (1947) 28,463. (T. F. B.)

PATTERSON, DANIEL TODD (1786–1839), U.S. naval officer, whose reputation rests on his major share in the victory at New Orleans, La., in 1815, was born on Long Island, N.Y., March 6, 1786, and became an acting midshipman in June 1799. Serving on the frigate "Philadelphia" when that ship grounded, he was a prisoner in Tripoli for 19 months. In Sept. 1814 Patterson was ordered by the navy department, and requested by Gen. Andrew Jackson, to take his ships to Mobile, Ala. Patterson insisted that New Orleans was the British objective and he correctly forecast the enemy route of advance through Lake Borgne to the Mississippi. After much difficulty and delay he persuaded Jackson to move from Mobile. Jackson would not have been prepared to repel the British if Patterson had not delayed the enemy advance by a stubborn gunboat attack in Lake Borgne on Dec. 15, 1814. Patterson then used his two larger ships in the Mississippi river in a very effective bombardment of the British camp on Dec. 23 and 27, losing the "Carolina" on the latter date. In the battle of New Orleans, Jan. 8, 1815, he commanded a battery of naval guns on the west bank. Congress gave him a vote of thanks, and President Jackson afterward appointed him a naval commissioner. He commanded the Mediterranean squadron, 1832–36, and died on Aug. 25, 1839, while commanding the Washington navy yard. (J. B. HN.)

PATTERSON, JOSEPH MEDILL (1879–1946), U.S. publisher and editor, was born in Chicago, Ill., Jan. 6, 1879. He graduated from Yale university in 1901 and joined the staff of the *Chicago Tribune.* In the year 1914 he became associated with his cousin, Robert Rutherford McCormick (*q.v.*), as co-editor and publisher of the *Chicago Tribune,* which, under their direction, rose to be one of the most influential and successful papers in the United States. He acted as war correspondent in China, 1900, and in Belgium and France, 1914–15. In 1919 he founded the *New York Daily News,* the first successful tabloid newspaper in the U.S., and it soon acquired an immense circulation. Patterson died in New York city on May 26, 1546.

His works include *A Little Brother of the Rich* (1908), *Rebellion* (1911) and *Note Book of a Neutral* (1915).

PATTI, ADELINA JUANA MARIA (BARONESS CEDERSTRÖM) (1843–1919), a famous singer, mas born at Madrid on Feb. 19, 1843. Her parents, both of whom were operatic vocalists, settled in America, where their daughter was taught singing by Maurice Strakosch, who married Amelia Patti, an elder sister. Gifted with a brilliant soprano voice, Adelina Patti began her public career at the age of seven in the concert halls of New York, where, in 1859, she also made her first appearance as Lucia in *Lucia di Lammermoor.* On May 14, 1861, she sang as Amina in *La Sonnambula* at Covent Garden, and from this time her appearances in London, Paris and all the other principal musical centres of the world constituted one long unbroken succession of triumphs. In 1868 she married Henri, marquis de Caux, a member of Napoleon III's household, from whom she was divorced in 1885; she then married Nicolini, the tenor, who died in 1898, and in 1899 Baron Cederstrom. a Swede, who was naturalized as an Englishman. Her actual last public appearance was made on behalf of the Red Cross on Oct. 20, 1914, when she was in her 72nd year. Madame Patti died on Sept. 27, 1919.

PATTON, GEORGE SMITH (1885–1945), U.S. army officer, an able tactician and an outstanding practitioner of mobile tank warfare in World War II, was born in San Gabriel, Calif., Nov. 11, 1885, and graduated from the United States Military academy, West Point, N.Y., in 1909. Descendant of a Virginia family with a military tradition, Patton became a student of the American Civil War, particularly of its great cavalry leaders. This interest continued throughout his career as a soldier and contributed to the concept of bold, highly mobile, armoured operations that became associated with his name. His professional interest turned from the cavalry to the new tank arm as the result of battle experience with the U.S. tank corps in World War I. Between the two world wars, Patton forcefully espoused the cause of the tank. Having taken part in the north African campaign (1942), Patton commanded the U.S. 7th army in Sicily, employing his armour in a rapid drive that captured Palermo.

The apogee of his career came with the great sweep of his 3rd army across France in the summer of 1944, in a campaign marked by great initiative, ruthless drive and disregard of classic military rules. Patton, who died after an accident in Germany, Dec. 21, 1945, was a colourful soldier, "Old Blood and Guts" to his troops. His memoirs appeared under the title, *War As I Knew It* (1947). (H. M. CE.)

PAU, a city of southwestern France, chief town of the *départemcnt* of Basses-Pyrénées, 66 mi. E.S.E. of Bayonne on the southern railway to Toulouse. Pop. (1954), 41,730. It stands on the edge of a plateau 130 ft. above the right bank of the Gave de Pau (a left-hand affluent of the Adour), about 620 ft. above the sea. A small stream, the Hédas. flowing in a deep ravine and crossed by several bridges. divides the city into two parts. Pau is famous as a winter health resort.

Pau derives its name from the word *pal,* in allusion to the stakes which were set up on the site chosen for the town. It was founded probably in the early 11th century by the viscounts of Béarn, and was the residence, from 1512 onwards, of the kings of Navarre. The 14th-century castle is connected with the town by a bridge, built under Louis XV. On the left of the entrance is the dungeon built by Gaston Phoebus. On the northeast is the 14th century Tour de Montauzet. There is a collection of Gohelin and Flemish tapestries in the castle. A portion of the buildings of a Jesuit college founded in 1622 remains. Pau is the seat of a court of appeal and a court of assizes and has a tribunal of first instance, a tribunal of commerce and a chamber of arts and manufactures. In 1928 a railway between France and Spain placed Pau in contact with Jaca in the Spanish province of Huesca.

PAUL, SAINT. The interpretation of Christianity, and its spread into the western world, are so bound up with the apostolic ministry of St. Paul that neither can be discussed intelligently apart from the story of this man and his work. He saw the universal implications of the new faith, struggled passionately to have them recognized and applied, and endured the most severe hardship and persecution to extend the faith to the uttermost parts of the Mediterranean aorld Without the consecrated labours of this Christ-intoxicated man it is debatable whether Christianity would ever have become a world-wide religion. No figure in church history stands so high or has had such far-reaching influence as this apostle to the non-Jewish world. Centuries have not dimmed the lustre of his personality nor changed the significance of his place in Christian history. Whenever and wherever the impact of a secular world and the spread of unworthy religious practices have left the church in need of revitalization, it is to Paul that men have turned, as to a fountain from which again the pure water of the evangelical faith could be drawn and the essence of the Christian gospel republished.

Many have found in the radical transformation of this "Pharisee

of the Pharisees" the most convincing evidence of the truth and the power of the religion to which he was converted, as well as the ultimate worth and place of the Person of Christ to whom he gave, in absolute surrender, all his powers of heart and mind and spirit. Toward his ministry's close, Jesus asked his disciples: "Are you able to drink the cup that I drink, or to be baptized with the baptism with which I am baptized?" (Mark x, 38). Paul was not among the group who heard that question. He was: however, the finest embodiment of that discipleship of self-sacrifice which the "cup" and the "baptism" symbolized. For so completely did he identify himself with Christ and "share his sufferings" (Phil. iii, 10) that from the day of his conversion to the moment of his execution, almost 30 years later, he found life and liberty only in being "the slave of Christ," whose love controlled his every activity and constrained him to live no longer for himself but for him who for his sake "died and was raised" (II Cor. v, 14–15).

Clearly this is no ordinary or average man. Whatever truth lies in Carlyle's contention that "History is the biography of great men," that and much more must be said of Paul's part in the shaping of the Christian mind and his influence upon subsequent Christian development in western civilization and elsewhere.

CAREER

Background and Training.—What is known of Paul comes from his letters and from the Acts of the Apostles. "I am a Jew, born at Tarsus in Cilicia, but brought up in this city [Jerusalem] at the feet of Gamaliel, educated according to the strict manner of the law of our fathers, being zealous for God as you all are this day" (Acts xxii, 3). Thus Paul spoke to the angry mob in Jerusalem who a few minutes before would have killed him. The words speak volumes, and there is no reason to doubt their historical accuracy. Tarsus, the capital of Cilicia, a province of Asia Minor, was built at the mouth of the Cydnus river and commanded a place of considerable importance commercially because of its location on one of the most important overland trade routes of the ancient world. Tarsus was also a centre of culture, a university city, and a number of Stoic philosophers lived there. Strabo, the famous Greek geographer, contemporary of the emperor Augustus, praised the Tarsians highly for their interest in education and philosophy and compared the city very favourably with Athens and Alexandria. Clinging to oriental habits and customs, however, Tarsus never became completely hellenized.

There, shortly after the beginning of the Christian era, Paul (Sha'ul, his Hebrew name; Paulus, his Roman cognomen) was born of a Jewish family of strict Pharisaic persuasion, descended from "the tribe of Benjamin" (Phil. iii, 5) and thus closely associated with the centre of Judaism in Jerusalem. The Jews of Tarsus, like similar colonies elsewhere, were doubtless related to the business life of the city. Some were Roman citizens. Paul's family shared this distinction, whether by bestowal or purchase is not known. No foundation exists, except an unsupported tradition of Jerome (4th century), for the view that Paul's parents were from Gischala in Galilee and that his father obtained his citizenship after going to Tarsus as a prisoner of war.

Though Roman citizens, Paul's family remained loyal, as most Jews did, to their Jewish faith and practice. He was raised strictly after the manner of his people, attending the synagogue school and learning, it may be assumed with some devotion and brilliance, all that was required of him as a student of the Scriptures and the Law of his fathers. His mind was alert to the contrast between the strict moral and religious behaviour expected of him and the generally loose ethical life reflected in an environment given over to idolatry (Rom. i, 20--32). Tarsus, with its hellenistic-oriental character, furnished Paul with a background which later proved invaluable as he ventured into the Roman world to proclaim the gospel of Christ. For what better preparation than firsthand knowledge both of the soil out of which Christianity came and the pagan soil into which he wished to plant it? That he knew the latter as intimately as he did the former cannot be maintained. There is little evidence that Paul was trained in Greek culture or had firsthand knowledge of the mystery cults. It would be surprising if, in presenting the gospel to pagan audiences, he did not reflect the language and thought patterns of the time. He could not escape the terminology of his day any more than modern man, without much formal 'training, can avoid slipping into words and phrases from current science or philosophy or religion. He was not slow to observe the world about him generally, and his national pride stimulated him to rejoice that he was of the people of the Covenant and shared the privileges and promises extended to Israel. Far from weakening his monotheistic faith and his love for God's Law, or leading him to compromise with pagan thought, his early home training intensified his purpose to live and labour that God's name might be reverenced and his Law meticulously kept.

It occasions no surprise, therefore, to find Paul in Jerusalem studying under Gamaliel, the most famous rabbinic teacher of the day, a man liberal in mind and tolerant in spirit (Acts v, 34–39). That Paul applied himself assiduously to his rabbinic studies is indicated by his later devotion to the Law and his frequent use of the rabbinic method, though the latter should not be stressed unduly. One thing is certain, his Jerusalem period served to reveal to him more clearly than ever that a real Jew is not one outwardly but inwardly (Rom. ii, 28–29). There was something fundamentally beautiful and noble about the studies of Pharisaism. The concept of the Torah as embodying God's purpose for men, the eagerness and devotion with which rabbinic learning mas pursued, the many fine characters who loved the Law of their fathers immensely and found intense delight in observing it, the deep religious experience that the Law could and often did effect in its devotees and that was expected to meet the profound spiritual needs of the soul—all this reveals a system of religious life and practice that cannot but be highly valued and praised by anyone having even a superficial acquaintance with it. Pharisaism has suffered much at the hands of its critics.

Nevertheless, the Torah had become so overlaid with multitudinous oral interpretations that the Law as precept had begun to overshadow the Law as moral, its inward spiritual character subordinated to its external and legal aspects. Paul must be seen as representing the Pharisee at his best, zealously observing the Law and seeking, at the same time, the inward peace and satisfaction which such observance was calculated to provide. He was evidently well on the way to becoming a rabbi when a crisis occurred which changed the whole trend of his life radically and completely.

Conversion.— Within Judaism a new sect had appeared, followers of Jesus of Nazareth, whom they affirmed to be Messiah and themselves to be the new and true "Israel of God," the people of the New Covenant, bringing to fulfillment all that God had purposed for his people and inheriting all the promises given in Hebrew history to the people of the old covenant. Such claims, particularly that of a crucified Messiah, struck at the very conceptions which Paul's Jewish training had nourished and his rabbinic studies had so recently confirmed, and threatened the essential features of Judaism itself. To exterminate this sect and to destroy this blasphemous heresy root and branch became the supreme passion of his life (Gal. i, 13). Nothing could be more surely the will of God than that he should oppose with all means at his disposal "the name of Jesus of Nazareth" and pursue to the death all who belonged to "the sect of the Nazarenes" (Acts xxvi, 9–11). Thus he literally "laid waste the church" (Acts viii, 3).

To further this purpose he set out for Damascus fortified with documents from the religious authorities in Jerusalem, authorizing him to secure the followers of Jesus of Nazareth who had gone there and possibly to bring some back to face trial for heresy. Paul reached Damascus but not as he expected, for on the way he was confronted with Jesus of Nazareth and soundly converted to the new sect which he had been so zealously persecuting, certainly one of the amazing reversals of purpose in the whole history of mankind. Four accounts of this event appear in the Sew Testament (Acts ix, 3–19; xxii, 6–21; xxvi, 12–18; Gal. i, 12–16), differing slightly in details respecting accompanying phenomena—the light, the sound, the fall to the earth, the blindness—but agreeing substantially as to what Paul saw and heard and said, and his subsequent relationship with Ananias in Damascus. Supernatural,

mystical, psychological explanations have been given of this remarkable experience. What appears to be a sudden conversion had no doubt been the last stage of a long preparatory process. The following factors should be noted:

1. His growing disillusionment respecting the Law. Paul had an exceedingly sensitive approach to the Law, which he observed meticulously (Phil. iii, 6). It is doubtful that Pharisaism took the view that only complete fulfillment of the Law could save a man from being accursed, yet Paul believed this (Gal, iii. 10). We can only assume that his understanding of the moral law, embodied, as he held, in the Torah, was so keen that he despaired of fulfilling it. External observance and inward fulfillment were to be one and issue in victory and emancipation of soul, but this was not the case. Actions. he found, could be controlled, but not desires (Rom. vii, 7). This condition, known to himself prior to his conversion and typical, Paul believed, of all men, is described with remarkable vividness (Rom. vii). His intense, almost savage attempt to obliterate the Christian movement reflects a sense of insecurity prompted by misgivings and doubts. Like a stubborn ox he was kicking "against the goads" and hurting himself more than anyone else (Acts xxvi, 14).

2. The impact made by early Christians and particularly by the work and martyrdom of Stephen. A man does not persecute people of whom he knows nothing. We may be sure Paul knew a great deal about the Nazarenes and must have been impressed with their quality of life and conduct. They possessed inner joy, peace, confidence and courage. which he had sought without success. Stephen, whose stoning he approved and probably encouraged, was the supreme example of this. This young martyr, representing the view of hellenistic Christians, had surveyed the course of Hebrew history to show that special privilege no longer existed for the Jewish nation; that Christianity, sprung from that history, had superseded the Law and the Temple; and that all this had resulted from the coming of "the Righteous One," Jesus Christ, who had been rejected and crucified by the very people whose prophets had anticipated him. This was anathema to Paul, and yet it was the argument of a man who could die with singular assurance, committing his spirit to his Lord and praying mercy upon his murderers (Acts vii, 59–60). The argument incensed him; the death, we are persuaded, moved him, for, being the kind of man he was, Paul could scarcely look upon the cruel martyrdom of this young saint and at once erase the scene from his memory. His eagerness to discover truth, coupled with his sense of insecurity and perplexity, must have driven him to think more deeply than ever about the people whom he was persecuting and about the man Jesus. the master whom they served.

3. The probable influence of the Person of Jesus. Whether he ever saw Jesus in the flesh is not known. Some scholars think that he did, otherwise he could not have carried in his mind the impression of Jesus' character suggested by various allusions in the Epistles. He refers to having knonn Christ "after the flesh" ("from a human point of view"; II Cor. v, 16), by some interpreted to mean "the Jesus of history"; but scholars are not unanimous on the meaning of this somewhat difficult passage. That he learned much about Jesus while pursuing Jesus' followers can scarcely be doubted, since knonledge of them and their convictions was inseparable from knowledge of the character and claims of him whom they declared to be Messiah. hforeover, being a member of that strict sect of the Pharisees, the prime movers in the events that brought Jesus to his death, Paul could hardly be ignorant of what was known, or professed, concerning him. John Knox maintains that the reason Paul was able to identify Jesus as the Lord revealed to him near Damascus was that he already had knowledge of him through his contact with the primitive Christian community. "Christ had begun to make himself known to Paul—perhaps against the latter's will—as the Spirit of the persecuted *koinonia* before he made himself known in the visual experience in which Paul's conversion culminated." (John Knox, *Chapters in a Life of Paul,* p. 126, Abingdon Press, New York, 1950.)

With reasonable certainty, then, it may be affirmed that the radical redirection of life which Paul described as God being pleased to reveal his Son to him (Gal. i, 16) was not without considerable preparation; as G. A. Deissmann wrote (in *The Religion of Jesus and the Faith of Paul,* 1923), "the lightning of Damascus" struck "no empty void" but found "plenty of inflammable material" in Paul's soul.

Certain convictions followed from his conversion: (1) that the crucified Jesus of Nazareth was the living Christ; (2) that the cross was no longer a shameful thing, a stumbling block, but central to the messianic redemption. since God had vindicated him who was nailed to it; (3) that God had called Paul to undertake the apostolic ministry, must indeed have destined him to be a minister even before he was born (Gal. i, 15). These three convictions became the foundation stones of all his subsequent theology.

Of the period immediately following his conversion little is known, except that he spent about three years, partly in Damascus and partly in Arabia southeast of that city (Gal. i, 17; Acts ix, 19, 22), after which he made his first postconversion visit to Jerusalem, where he spent two weeks with Peter and saw James, the head of the Jerusalem church (Gal. i, 19). He then returned to Tarsus and worked as an independent missionary, it seems, for about ten years, in "the regions of Syria and Cilicia" (Gal. i, 21; Acts ix, 30). These silent years were formative years, when he thought deeply about the new faith and gained rich experience in teaching and preaching. The later expression of his thought as an apostle to the gentile world owed a great deal to those years before the summons came to undertake the work which was to set him apart forever as the first great missionary of the Christian church.

Missionary Activity.— The Christian movement, meanwhile, was making great progress in Antioch, and Barnabas was sent from Jerusalem to visit. He must have sensed in that large and vigorous congregation a growing missionary imperative, for he continued on to Tarsus, found Paul and returned with him to Antioch. For a year they ministered there and then together were commissioned to carry the gospel to the wider world (Acts xiii. 2 ff.). Paul was thus launched upon a missionary career that brought him ultimately to Rome itself. He was doubtless encouraged by the gentile contacts he had made in the area of Tarsus and by the success attained in the approach to non-Jews in Antioch (Acts xi, 20–21). He was beginning to see the universal implications of the faith and appears to have conceived a grand assault upon the Roman empire. That he was influenced in this by the impression made upon his mind by the empire, with its possibilities of unity and solidarity, is quite possible, and he may even have conceived of Christianity, as Sir William Ramay contended (*Pauline and Other Studies,* 1906), as the power capable of achieving this ideal. He saw what splendid opportunities the empire offered for the spread of the gospel, with its vast and comparatively safe system of communication, as well as the advantage of a common (Greek) language. He later looked upon it as providential that the gospel could be preached without hindrance under the protection of Roman law and order (Rom. xiii. 1–7), and his own experience often demonstrated this (Acts xviii, 12 ff.; xxiii, 23 ff.). Armed with a passion to extend the gospel and a vision of a pagan world desperately in need of it (Rom. i), anticipating doors of opportunity that would open in the cities and provinces of the Roman empire. Paul with Barnabas and Mark began the movement which was destined, in less than three centuries, to make Christianity the official religion of the Roman state.

The narrative of Paul's missionary tours given in Acts may be accepted with confidence. Paul wished to reach as far as possible into the west and kept his eye upon strategic cities and areas of the empire. Ill health and other factors, interpreted by him as being "forbidden by the Holy Spirit" (Acts xvi, 6, 7), sometimes prevented his proceeding according to plan; but when one considers that his journeys took him to Cyprus, to a large area of Asia Minor, into Macedonia and Greece and possibly Illyricum, and finally to Rome, his achievement is an astonishing one.

Final Phase.— Paul always maintained close touch with the Christian community at Jerusalem. He had kept its welfare in mind by collecting an offering in his gentile churches, a gesture

which demonstrated both their oneness in Christ and gentile gratitude for "spiritual blessings" received (Rom. xii, 5; xv, 27; II Cor. ix). He wished to revisit Jerusalem before going to Rome (and possibly Spain), to take this offering with him. The Judean Christians were poor, due in all likelihood to famine, persecution and their earlier experiment with communism (Acts ii, 44, 45). Paul attached great importance to this visit and took with him representatives of the contributing churches (I Cor. xvi. 1–4; II Cor. viii–ix; Rom. xv, 25–27), a gesture no doubt intended to be practical proof of their Christian fellowship, to cement the bond of love between the Jewish and gentile Christian communities and to anticipate the day when all barriers between them would disappear and they would be "one new man" in Christ Jesus (cf. Eph. ii, 11–16).

This generous and commendable plan was the beginning of the end for Paul. He was warned repeatedly that "imprisonment and afflictions" awaited him, but he was determined to carry out his purpose (Acts xx, 22 ff.; xxi, 10–14). Arriving at Jerusalem he was warmly greeted by the Christian leaders, was soon in conference with James and the elders, and mutual accounts were given of the growth of the church in their separate spheres. Paul had been under suspicion by the Jerusalem church because of reports that he sat rather loosely by the Law in his relations with Jews in the gentile world (Acts xxi, 21), teaching them "to forsake Moses, telling them not to circumcise their children or observe the customs." To allay this suspicion, and for the sake of the plan which he had so prominently in mind when he returned to Judea, he consented to observe a week of ritual purification. He was discovered by Asian Jews in the Temple, set upon, and only by the intervention of the Roman authorities, who accused him of disturbing the peace, was he spared death at the hands of an angry mob.

Learning that Paul was a Roman citizen and that the Jews were plotting his death, the Roman tribune had him taken under military escort to Caesarea, where he was tried first by the procurator Felix, then two years later by Felix' successor Festus, who, wishing to show some favour to the Jews, suggested that he might be tried in Jerusalem. Paul, knowing that certain death faced him if he accepted this proposal, appealed instead to Caesar. Accompanied by Luke and Aristarchus (Acts xxvii, 2) he set sail for Rome. After a most hazardous and stormy passage, including shipwreck, he arrived there in the spring of either 59 or 60, fulfilling a lifelong ambition but not quite as he had hoped.

Of his subsequent life little is known. There is no good reason to doubt Luke's account that as a Roman citizen he was given freedom to live for two years in his own house, under guard, could meet his friends and was permitted to preach the Kingdom of God and to teach "about the Lord Jesus Christ quite openly and unhindered" (Acts xxviii, 30–31). It is fairly certain also that his latest, and in some respects his ripest, letters were written from Rome. Scholars have been puzzled over the ending of Acts. Why is there no account of Paul's death? Was Luke's writing complete before Paul's martyrdom? Was Paul acquitted, and did he go, as he had intended, to Spain (Rom. xv, 28)? Those who accept I and II Timothy and Titus as authentic letters of Paul (and few modern scholars do) find evidence for his continued activity in the reference to "my first defense" and his rescue "from the lion's mouth" (II Tim, iv, 16–17), suggesting that his trial and release are indicated here and that he returned to the scene of his earlier labours in Macedonia and elsewhere. No other evidence exists for Paul's further ministry beyond Rome except an uncertain and ambiguous reference in I Clement (c. A.D. 95) that before his death the apostle "had reached the limits of the west," interpreted by some to mean Spain. The Muratorian Fragment (a fragmentary list of New Testament writings, with comments, dating from the end of the 2nd century) expressly states that Paul departed from Rome for Spain. No firsthand sources exist, however, upon which to build a reliable account of his movements prior to his execution. There are two possibilities: (1) that he never left Rome but was condemned and executed after his first trial; (2) that he was released, went to Spain and perhaps revisited the east, was rearrested, tried and condemned. It is reasonably certain that he died a martyr's death in Rome sometime between A.D. 62 and 64, and that very probably his approaching end is reflected in what is believed by many to be a fragment of a letter written to Timothy (II Tim. iv, 6–8).

THE MAN

Few men in ancient history are better known than the apostle Paul. His letters, with one exception written to churches, are a primary source of first magnitude, since they were written with a spontaneity and a frankness that disclose his personality in all its depth and richness and variety. Every letter "is a picture of Paul, and therein lies the unique value of the letters as sources for a historical account of this author. There can be but few Christians of later days for whose inner lives we have such thoroughly undesigned sources of information" (G. A. Deissmann, *Paul, a Study in Social and Religious History*, p. 25; 1926. By permission of Hodder & Stoughton, London.) The Acts of the Apostles, written by Luke 20 or so years later than the Pauline letters, and incorporating in the latter part a travel diary, is a supplementary source of considerable value. Letters and diary, together with other sections of Luke's history. make it possible to see Paul the man, as he was, with a high degree of confidence.

Of Paul's personal appearance these sources say very little. The Acts of Paul and Thecla, an apocryphal document written during the latter half of the 2nd century, describes the apostle as "a man of little stature, thin-haired upon the head, crooked in the legs, sturdy with eyebrows joining, and nose somewhat hooked, but full of grace, for sometimes he appeared like a man, and sometimes he had the face of an angel." This frank and not too flattering description is regarded by some as based upon an early and reliable tradition, but there is no surety of this. Certain allusions in available sources seem to support the view that Paul was not physically impressive. At Lystra he was taken for Hermes (Acts xiv, 12), a god sometimes described as small and vivacious; his enemies described "his bodily presence" as "weak" (II Cor. x, 10). He himself contrasted the treasure of the gospel with the "earthen vessels" containing it, a contrast which might well have been suggested by his own frailty (II Cor. iv, 7). He came to the church at Corinth "in weakness and in much fear and trembling" (I Cor. ii, 3). His "thorn in the flesh" (II Cor. xii, 7), variously interpreted to mean epilepsy, malarial fever, erysipelas or ophthalmia, was certainly a recurring illness which produced a physical condition to which Paul was very sensitive (Gal. iv, 14) and which sometimes hindered his movements. It seems clear that his physical condition was not all that he desired; and yet the catalogue of trials endured, adventure undertaken and work achieved makes it abundantly certain that the apostle was no invalid, that he was, on the contrary, possessed of a physical sturdiness and strength which his appearance belied (II Cor. xi, 23–29). We must not underestimate, however, the strength derived from passionate commitment to a supreme purpose, often able to overcome seemingly insurmountable obstacles. Such Paul attributed to no power of his own, but to God's grace which had made divine power perfect "in weakness" and had assured him that "when I am weak, then I am strong" (II Cor. xii, 9–10).

We have considerable knowledge of Paul's personality. His letters, particularly the Corinthian correspondence, open his very heart and mind and spirit, so much so that psychologists have even attempted to psychoanalyze, label, categorize him. More than once he has been described as a man of conflict, and this has been suggested as a criterion of judgment for his many-sided character. Paul, however, manages to escape all such narrow classifications supremely because he was too great for any one of them.

Paul was a man of resolute character, whose distinctive mark was a quality of absoluteness. Honesty of mind, integrity of purpose, zeal for truth, longing for the ultimate, passionate earnestness in the search for certainty—all these were so much part of this man that he could undertake nothing lightly nor give himself to anything halfheartedly. Thus he was loved by those who stood with him, hated by those who stood against him. It is not surprising that he stressed his independence almost to a point of exaggeration, maintaining that he owed nothing to his predecessors

in the Christian faith (Gal. i, 11–12; ii, 6). This claim cannot reasonably be that he had known nothing about the new faith and had not inherited the primitive traditions associated with the apostolic gospel but rather that all this had no secondhand quality for him, indeed had become so firsthand because of his encounter with Christ that he could speak of it as "my gospel" (Rom. xvi, 25). Similarly he viewed his apostleship as not one whit less valid than that of the original apostles. since he had received it not secondhand but by the direct commissioning of the risen Christ (Gal. i, 1, 15–16; cf. Acts xxvi, 16–18).

This insistence upon inner certitude, upon truth authenticating itself in his own experience so that it was no dogma transmitted from a secondary source, marks out Paul as belonging to that strain of Hebrew tradition to which Jeremiah, and supremely Jesus, belonged. The witness of Jeremiah. as well as the authority of Jesus. stemmed from an inner certainty based upon personal discovery; and it was precisely on this platform that Paul's insistence upon his independence rested. This accounts for his being the living embodiment of the convictions he professed, for never was there a more complete fusion of faith and personality than in him. This correspondence between profession and practice, this living example of Christlike devotion and service, inspired others to share with him the work so close to his own heart. He could not ask men to undertake a life to which he was not thoroughly committed himself (Phil. iii, 17; iv, 9), and many, like Epaphroditus, accepted the challenge of Paul's consecrated personality (Phil. ii, 30; Rom. xvi, 4).

Underlying Paul's resolute character was an intense humanity. He had his fears and frustrations, his defeats and his victories. his intolerance and stubbornness, his passionate outbursts of anger and his subsequent regrets, his sensitiveness to criticism, his joys and his sorrows, his moods of despondency and disappointment. He also possessed great powers of sympathy and understanding. keen appreciation of other people's needs, capacity for deep and lasting friendship, readiness to subordinate himself to the work of Christ and to become "all things to all men," that he might "by all means save some" (I Cor. ix, 22).

This does not mean that he was willing to compromise, to concede principles or to moderate his views in order to gain an advantage or to secure some temporary conciliation. There were instances when, without adequate understanding of his motives, we might accuse Paul of this—his submission to the vow in Jerusalem (Acts xxi. 23) or his having Timothy circumcised preliminary to his becoming a missionary (Acts xvi, 3). But this was something different from compromise or indeed from sentimental attachment to an outgrown system. Paul, through his commitment to Christ, had come to a new understanding of the Law, had come to believe that Christ was both the end of the Law and its ultimate fulfillment. The Wisdom of God had become flesh nhen the Messiah appeared. but this did not mean abandoning altogether customs which belonged to the religion of one's fathers, so long as they uere put in their proper perspective, no longer regarded as central and essential. and practised with the purpose of making possible the preaching of Christ within an unbroken church fellowship. Paul was no dissimulator precisely because he was a man of love (Rom. xii, 9), and to love, he believed. was to fulfill the Law (Rom. xiii, 10). His actions. within the context of both individual and corporate life, were dictated primarily with a view to achieving the ends of love, that is, to strengthening Christian character and building up the Christian community. His intense humanity, to some extent native to his personality, was nourished by his absorption in the new humanity, the company of those "in Christ" who, like himself, had entered a community in which all barriers had been removed and in which the chief concern was for "the brother for whom Christ died," whatever his race or class.

What sympathetic imagination and deep personal feeling are expressed in such concern! This is to be human in the best and highest sense, for it is sharing the life of him nho brought humanity to its peak of perfection. Jesus Christ, the Son of God. When Paul so superbly describes Christian love (agape), he paints a portrait of the man Jesus and, at the same time, reveals to what heights human behaviour may rise when motivated by the love of God (I Cor. xiii). Paul had his weaknesses. He longed for companionship and appreciation. He objected angrily when his actions or motives were questioned. He was proud and temperamental. But these, and many other traits of his character, were completely subordinated when he became a "new creation in Christ." His intense humanity, therefore. issued not merely from what he was but from what he became under the constraining love of Christ.

Paul frequently described himself as the "slave" or "servant" of Christ (Rom. i, 1; Phil. i, 1). He was a man under a new authority, which, paradoxically, had rendered him free. Before his conversion he was a slave of a different kind, demanding of himself, even as of others, conformity to the absolute tnoral ideal which he believed to be revealed in the Law of his fathers — the Torah. This slavery did not issue in freedom; rather it deepened the sense of imprisonment, led indeed to frustration and futility because there was no sense of inward victory, a realization only of defeat. It was his uncompromising search after absolute achievement, and his eagerness to find complete inward satisfaction, that led him to cry out in that acute autobiographical passage, "Wretched man that I am! Who will deliver me from this body of death?" (Rom. vii, 24). Such absoluteness and eagerness for inward purity are not found in every good man; many are content to remember that moral perfection is unattainable in this life. Paul could not rest his case there. He had to be right before God, and to achieve that condition there had to be inward witness that the requirements of the Law had been met. This inward witness was lacking. He did not know it, but at this point Paul was a man in search of grace, and this is what he found when he found Christ. He discovered that he was to cease taking the initiative in his own salvation and to behold, in the life and death and resurrection of Christ, the initiative God had taken. He was to understand that the divine act in Jesus Christ was Gods declaration to man that the divine-human relationship is a gift imparted on the ground of faith and issuing in a sense of inner emancipation enabling man to live according to a new law, the spirit or law of Christ, the law of love.

Thus the apostle passed from slavery to one law to slavery to another, from the Torah to the new Torah, Christ "the Wisdom of God." with the difference that now he had found "the glorious liberty of the children of God" (Rom. viii, 21; Gal. v, 1). Moreover, this love became his supreme passion and directed his whole being (II Cor. v, 14), so that he became a man controlled by Christ, with one supreme passion to preach Christ (I Cor. ix, 16). Now he was content to have one ambition only, to know Christ, to have him formed within (Gal. iv, 19), to share his resurrected life; and that life was one of power within, morally and spiritually quickening and cleansing, enabling him to share the sufferings of Christ and to partake of the future redemption (Phil. iii, 10–14). The zeal of the Pharisee had been transmuted into the zeal of Christian apostleship. It is evident in his love for the churches, in the sufferings and privations which followed his course, in his indomitable courage (II Cor. xi, 23–29; Acts xxi, 13), in his purpose to push the frontiers of Christianity to the farthest limits of the west (Rom. xv, 28), in his willingness at last to die for the sake of the gospel. Paul had come a long way in his spiritual pilgrimage, from the intolerant, bitter, persecuting religious bigot to the patient. kind, enduring, self-sacrificing temper of him whom he owned Master and Lord. In this lay his greatness, that, with unswerving loyalty and complete subordination of self in sacrificial service, all his diffuse powers were so fully brought into captivity to Christ that he lived only and wholly and magnificently for the fulfillment of God's redemptive purpose.

THE CHRISTIAN THINKER

Paul was the first great theologian of the church, but his was not the first Christian theology. When he became a Christian the primitive church already possessed convictions about God, the Messiah, the Holy Spirit, the people of God, forgiveness and redemption and beliefs associated with the practice of the two gospel sacraments; and though he constantly affirmed his independence of others in respect to what he had received, this was

to emphasize the genuineness of his faith rather than to deny his relationship to primitive tradition. He built his theology upon his own experience. plus the living gospel tradition of the church which had been passed on to him and upon which he brought to bear his own vigorous mind. He did not create a theology; he drew out rather the implications of what already existed in the mind of the early church, though few of his predecessors had the spiritual insight to anticipate, were in a position to see the necessity for, or were so well-equipped to appreciate, the far-reaching affirmations to which the apostle's study and experience of the gospel led him.

He was not a systematic thinker. Much of his thought was expressed spontaneously, stimulated by a request from some church or prompted by news of some heretical teaching or moral weakness. System, and even consistency, were difficult to maintain under pressure from many quarters at once, and Paul was neither systematic nor always consistent. Nevertheless he is original in that he was the first great interpreter of Christianity to the world at large and took responsibility for expressing the Christian faith in forms that enabled it to transcend those limitations that would have kept it sectarian. He is original also in that. despite his lack of system, he does offer the first clearly formed, though simple, theology of the Christian religion.

Paul was a courageous thinker. His ten or more silent years in Cilicia and Syria as a pioneer missionary must have been years of intense and at times agonizing thought. He was compelled, by reason of his conversion, to reconsider his whole position respecting the nature of God, man's relationship to God. the meaning of life and history, and particularly the significance of Israel's history. In doing so, he was forced by the very logic of events in his own experience to abandon many of the convictions most treasured from his youth. The world of his traditional ideas had been turned upside down, and he was forced to make a profound adjustment to an entirely new set of ideas. The action of God in Jesus was so utterly out of line with everything that he had held concerning the Messiah, the road to salvation, the absolute character of the Law, the place of Israel in God's economy, and yet so incontrovertible, that necessity was laid upon him to make the matter clear both to himself and to others. He never shrank from the pain of that mental readjustment which the reconstruction of his faith must surely have caused him. His theology, therefore, is an attempt to give rational expression to the meaning of Christian experience, particularly his own experience, and to give what he believed to be the theological implications of what God had been pleased to accomplish in history through Christ and his church. Certain fundamental concepts, outlined below, characterize Paul's theological thought.

Many opinions have been expressed concerning the sources of Paul's thought. Men have searched the pagan mystery religions, the hellenistic environment, the current philosophies (particularly Stoicism) to find parallels and dependence. This search has produced far less than the labour put into it might lead us to expect. Modern scholarship tends to find the sources for the essentials of Paul's thought mainly in his Jewish background, in the Old Testament and in rabbinic Judaism. The discovery of the Dead sea scrolls revealed the Qumran community to have had a common background of ideas and terminology with Paul in many instances, but there is little to indicate direct dependence of the apostle on the sect (see DEAD SEA SCROLLS). Whatever he borrowed, however, from any source. he transformed under the power and presence of him "in whom are hid all the treasures of wisdom and knowledge" (Col. ii, 3).

Justification by Faith. — How can a man be "justified," or "put right," before God? For Paul this was the vital question. This language of justification came from the law courts, where the judge, having found the accused innocent of the charge against him, was said to "justify" him by acquittal and restoration to society. Paul transferred this familiar legal language of Judaism to the personal realm and supremely to the soul's personal relationship to God. He had been seeking strenuously to become acceptable to God (justified) through his meticulous observance of the Law (Torah), which for him embodied the holy will and purpose of God for every aspect of human life. Only through such observance could he meet God's moral requirements and thus be at peace. The more sincere his desire and effort to find peace in this fashion, the less capable he found himself of achieving it. He concluded that no man could find himself in right relationship with God simply by moral striving. And yet so long as God was regarded as a moral being, communion with him necessitated ethical fitness. But who could be ethically fit before the "blazing throne" of God's holiness and purity? Such reasoning, supported by moral impotence, led Paul to despair of ever attaining communion with God. A man of less sensitivity to ethical ideals would doubtless have found refuge in some form of accommodation, but not Paul. The resolution of this impasse came when he experienced the love of God in the transforming power of the death and resurrection of Christ. Then he saw a completely new road to God. No longer did man need to initiate the approach by his own moral effort, for the initiative had been taken. God did not expect man by long and arduous ethical struggle to make himself fit for divine acceptance. On the contrary, the act of God in Jesus Christ means that, even while man remains in his sinful state, God manifests his love to him (Rorn. v, 8), indeed shares his love with him, and thus creates in him a new "life in the Spirit" in which man walks pleasing to God because he walks in love, partaking of the very nature of God himself. God is not, therefore, a moral judge standing over man with a moral lash and demanding ethical goodness. He is rather a heavenly Father, eager to welcome wandering sons, to confer upon them the gift of his grace, desiring only that they share a new righteousness, his righteousness of love.

At this point the apostle was driven to reassess the Law, for meticulous observance of legal precepts had never provided that emancipation of spirit which accompanied the abandonment of life to the unfathomable love of God. Now the old sense of impotence had gone, a new sense of peace and power had taken its place. Never again could the Law hold the place it first held in Paul's thinking. He often referred to it, sometimes even observed its traditions, but always there is the underlying assumption that Christ has brought the Law to its ultimate fulfillment, and that all the attributes formerly ascribed to the Law belong to him (I Cor. i, 24; Col. i, 16 ff.). "What the Law could not do" had been done by the gracious action of God in Christ (Rorn. viii, 3). It remains for man to see this action of God, to lay hold upon it by faith, to surrender the heart and mind and will to it in trust, and thus to find the soul ushered into newness of life. This is the first step in man's salvation; he is justified by faith or, as Paul puts it, "made righteous." Not that he is transformed at once into an ethically perfect being. Rather, God, on the ground of a man's faith, brings such a one into right relationship with himself, accepting the soul in advance, far in advance, of that soul's ethical perfection. For without this kind of divine acceptance there would be hope for no man and, indeed, no gospel.

Paul uses a variety of terms to describe what has happened to the man who has been justified by faith. He had been redeemed. As a slave might be emancipated from bondage to a master, so the justified man is free from the bondage of sin, because of "the redemption which is in Christ Jesus" (Rom. iii, 24–25; viii, 21; Gal, iii, 23–iv, 5). He has been reconciled. Here the apostle departs from analogy and falls back upon experience. Where moral values are emphasized, sin is held to alienate man from God, and he has no peace of soul. All men are in this state. since all have sinned (Rom. v, 12). But when man in faith beholds God's love in Christ's death (Rorn. v, 8) and understands that the alienation rests with man and not with God, that the work of reconciliation begins from the divine side (II Cor. v, 19), God is seen no longer as an angry being to be appeased but as one who freely offers his forgiving grace and bestows peace and joy upon him who has faith (Rorn. v, 1–11). Thus the justified man is both redeemed and reconciled and "transferred" to "the kingdom of [God's] beloved Son" (Col. i, 13).

The Life in Christ. — This new life into which a man enters on the ground of faith, as a consequence of his new relationship to God, Paul describes as "sonship." The justified man is now conscious that God is Father and that he has the freedom of a son in

the Father's house. This sonship is but the anticipation of the final consummation of God's purpose. It is the pledge or earnest of that bringing forth, at the last, of the "sons of God" for ahich the whole creation itself was designed (Rorn. viii. 19), when the Kingdom is delivered up to God the Father, arid God is "everything to every one" (I Cor. xv, 24–28). In the meantime those who share this life are "in Christ," and they imitate Christ by walking in love.

In this lies the central concept in Pauline thought, for to be "in Christ" sums up the full meaning of salvation It must be understood in the light of his doctrine of the Holy Spirit, and, true to his heritage, he thought of the Spirit as the divine power or energy coming into human life and enabling men to do what they could not do of themselves. This power was clearly at work in the church, evidence that the messianic community had emerged and that Christians were living the life of the Spirit, sharing the creative life of the Kingdom which Jesus by his death and resurrection had begun. Since all this stemmed from Christ himself, Paul had no difficulty in affirming that "the Lord is the Spirit" (II Cor. iii, 17). This was an experiential fact rather than a metaphysical identification, since Paul thought mainly in terms of religious experience and saw no necessity for distinguishing between his experience of the Spirit and his experience of Christ. Those who are "in the Spirit" are also "in Christ," and the truest and most genuine expression of this is to have "the Spirit of Christ" (Rorn. viii, 9), the Spirit of love. It follows that the life "in Christ" is primarily corporate, expressed in the life of the church, of which Christ is the head. Those nho are baptized and enter the church are really baptized into Christ. They live in him and he in them, with the expectation that ultimately they will be with him (Rom. viii. 23; Phil. iii, 21). Paul viewed salvation in three tenses: as an accomplished fact in the life, death and resurrection of Jesus; as made accessible to men in the present experience of life "in the Spirit"; and as yet to be brought to its consummation when the soul is "with Christ" and shares perfectly the life of which the new life here is but the foretaste.

The centrality of the concept of being "in Christ" or "union with Christ" has led many to describe Paul as a mystic and to find here the influence of hellenistic mystery cults. This is a mistaken view. Union with the god in a mystery cult meant the obliteration of distinction between the devotee and the god; it meant complete absorption in the divine. Paul was too loyal to his Jewish background ever to contemplate such union between Creator and creature. Moreover, mysticism strives to reach the divine, whereas the apostle stresses the divine reaching for and finding man. Though Paul does show signs of the ecstatic rapture associated with mystical states (II Cor. xii, 2–4), such rapture was not unknown in 1st-century Judaism, nor were spiritual warmth and emotion absent from the psalms of Israel or from the writings of the prophets, to both of which Paul must have been greatly indebted. His so-called Christ-mysticism is not mysticism at all in the strict sense, for there is no losing of his identity. This "union with Christ" is an identity. of life with Christ and with the purpose of God in Christ, which issues in the most intense form of self-giving rather than in self-losing; and the apostle achieves this identification, and at the same time sharpens his own personal existence, as he faces the dangerous and difficult life of the Christian missionary, seeking to complete "what is lacking in Christ's afflictions for the sake of his body. that is, the church" (Col. i. 24; Gal. ii, 20; Phil. iv, 12, 13). It was difficult for Paul to speak of this identification, the deep and lasting communion associated with it and the spiritual strength derived from it, without being moved to moods of exultation and rapture. To this extent he was mystical, but no more.

The Person of Christ. — Paul's theology was Christ-centred, for he had no doubt that Jesus was the Messiah. It followed that the new age had dawned, the day of God's long-promised redemption had come. The new life into which the justified man. redeemed and reconciled, had entered, with all its privileges and promises, was the work of Christ, its source and its sustainer (Rorn. viii, 1 ff.). Paul, however, had no doubt chat Christ was human, truly man. He had come "in human form" (Phil. ii, 8), had appeared "in the likeness of sinful flesh" (Rorn. viii, 3), had been "born of a woman," sharing the same subjection as others of his race (Gal. iv, 4), and had identified himself with sinful men for their redemption. As the second Adam, Christ, by his obedience, in contrast to the disobedience of the first man, had reversed the stream of death and had brought life and immortality to the human race (Rom. v, 12–21; I Cor. xv, 21–22). But the second Adam is also "the man of heaven" who became the first-born Son of God, the prototype of the Sons of God yet to appear. These Sons are the new humanity made after "the image of the man from heaven," for whom the whole creation was designed, the new humanity mhich God purposed to create through much travail and suffering (I Cor. xv. 45–44; Rom. viii, 19; Col i, 15). By the power of the resurrection this first-born Son had been "designated Son of God in power" (Rorn. i, 4), had become " a life-giving Spirit" (I Cor. xv, 45), had created the church. the fellowship of those who are united with him and in him, its Lord and Head. And since the redemption wrought by him in his church but anticipates, and is prophetic of, the redemption which is ultimately to be coextensive with creation, Christ is Lord of the universe, the power of God and the wisdom of God (I Cor. i, 24; Col. i, 15–19).

The People of God. — The church as the people or Israel of God held a place in Paul's thinking difficult to exaggerate. He could never forget that the purpose of God was to bring into being a people of the covenant. whose supreme mission would be to bring the kno ledge and the salvation of God to all people. He saw in the Christian fellowship the fulfillment of that purpose, the embodiment of that community which God had been seeking to create. In this he was not unique, for his predecessors. the earliest fellowship of believers, held that they had inherited all the promises and privileges of the old Israel and were indeed the new Israel of God, the messianic community. sharing the life of the Spirit and committed to a gospel with universal application. Jesus too had proclaimed the presence of God's sovereign rule in human life. He had invited men to receive it as the life and love of God, had actually formed a group of disciples to be the beginning of a community dedicated to live under God's rule. And he had declared that he was creating a new family of God, to include all of like mind and purpose; membership was dependent not upon race or class or any such external criterion but rather upon commitment to the will of God (Mark iii, 31–35).

All this Paul inherited and accepted and continued to affirm throughout his ministry. In that life "in the Spirit" which distinguished the church, he saw the life of the Kingdom. Through the life, death and resurrection of Christ the new spiritual order had arrived, and those who shared this divine life constituted a new race, a new type of humanity, were citizens of two worlds, their citizenship being also in heaven (Phil. iii, 20). At this point the apostle, in his description of the church, introduced a number of rich metaphors which conveyed precisely the essential character and mission of the church. Such figures as the bride of Christ (Eph. v. 23–27) or the body of Christ (I Cor. xii, 27) all point to a community one in spirit, united to Christ, embodying his life, built upon him. Such other figures as "the temple of the living God" (II Cor. vi, 16) and "the dwelling place of God" (Eph. ii, 22) indicate the sacred character of the church as that fellowship where men may expect to find mediated to them the very life of God. Paul was realistic enough to know that the church was not actually all that these metaphors suggest. Painful experience taught him otherwise. Nevertheless, the life of the Spirit in the life of the church pointed forward to that day when the reconciliation begun in the church would be complete and all-embracing, and the church would be presented "in splendor, without spot or wrinkle . . . holy and without blemish" (Eph. v, 27).

Development and Change. — Despite his absoluteness, indeed because of it, Paul had a flexible mind, ready to adjust to new truth when new facts made such adjustment necessary. A case in point concerns eschatology, the belief concerning the "last things" or the final consummation of all things. Early in his career he shared, with the early church, the belief that the return of Christ was imminent and that it would happen to the accompaniment of spectacular apocalyptic phenomena (I Thess. iv, 15–18). But as

time progressed he came to a deeper understanding of the nature of the life "in Christ" and affirmed what Jesus had taught, that the age to come (the Kingdom of God, that is) had already begun. It had penetrated the present, had ushered those who by faith had accepted Christ into present possession of a life which only awaited ultimate completion; and he contemplated the possibility of dying before that ultimate consummation took place. Again, early in his career and not entirely separate from his views on eschatology, he saw very little value in the state as such. But it is possible to detect his growing belief that the empire, though belonging to the Old Age, has a restraining power over evil and is keeping it in check (II Thess. ii, 1–12); and later still he feels that the state, in keeping order and punishing wrongdoing, is fulfilling a divinely ordained function. He went still further and came to express the hope that even demonic powers would at last find redemption and reconciliation in Christ (Phil. ii, 10; Col. i, 20). It seems clear, therefore, that Paul's mind was charitable to new ideas, open to new movements of thought, always in search of the truth that would enrich and enhance the Christian faith.

THE ETHICAL TEACHER

In Paul's thought religion and ethics go together; morality is never divorced from its theological reference. This was true for him as a Jew since morality in Judaism was grounded in the will of a living, personal, holy God. It was no less true for him as a Christian, for always the norm of his ethic was found in the will of a personal God, sometimes referred to as "the law of God," sometimes as "the law of Christ" (Rom. vii, 22; I Cor. ix, 21; Gal. vi, 2). Moreover, the goal of his ethics was always the same, that Christ may be formed within (Rom. viii, 29; Gal. iv, 19). This inseparability is demonstrated frequently in his letters, in which he invokes the loftiest theological conceptions to support and commend Christian conduct. Christian living is always the result of true Christian thinking; ethical fruits have theological roots.

The basis and primary motivation of this ethical position are found in the Christian experience of being "in Christ." In that experience Paul found the very highest category of Christian ethics, namely the indwelling Holy Spirit, the Spirit of Christ, the Spirit of love. Christian ethics are not, for Paul, a list of virtues added to the experience as a sort of addendum. The experience and the ethic are one. The man in Christ is born into a new manner of life; a spiritual inwardness takes possession of him, his ethical standards spring up spontaneously because his mind and heart and will are captive to Christ (II Cor. x, 5). The slave of Christ finds that he is free, bound by no law other than the law of Christ, the law of love, at work in his inmost being. Thus Paul found in this experience the secret of moral emancipation. That he should look upon Christian conduct as the harvest of the Spirit is not surprising (Gal. v, 22; Eph. v, 9); and when one recalls that he virtually identified the experience of the Spirit with the experience of the indwelling Christ, it is clear why that inward law of the Spirit becomes the law of love. This is one of the great contributions Paul made to the development of the Christian religion. By emphasizing the ethical aspects of the Holy Spirit's activity, he rescued primitive Christianity from mystical and emotional extravagances and made clear the view that the practice of Christian faith is always inseparable from the life of goodness.

Two basic principles of Christian ethics followed from Paul's understanding of the experience of being "in Christ": (1) the autonomy of the individual; and (2) the interdependence of Christians and, therefore, the necessity of a sense of mutual responsibility. Both are illustrated in the practical affairs of the Pauline churches. Christian freedom meant that a man is under his own self-mastery because he is under Christ. His conscience is his own and will guide him in his conduct. Nevertheless, since living within the fellowship of the Spirit is to be walking in love, such a free man will not stand firmly on his own right to act according to his own conscience; he will have regard for the conscience of the weaker brother whose spiritual insight may not be equal to his own, remembering that if Christ died for "the weak brother" the fellow Christian should at least consecrate his freedom on the brother's behalf lest "the weak brother" perish (Rom. xiv; I Cor. viii). This sense of mutual responsibility is stressed in the larger sphere of the total well-being of the church, since Christians "are members one of another." Their conduct, therefore, based on love —that is, the exercise of redemptive care and concern for others— will be motivated by desire for both the well-being of the individual and the building up of the Christian community.

This is made abundantly clear in the way Paul deals with the question of "spiritual gifts" in the Corinthian church, particularly the glossolalia, or "speaking in tongues." This phenomenon, common to many ancient religions and pagan cults, was the uttering of unintelligible sounds or babblings when the subject, under emotional excitement, seemed to lose control of his speech faculties and to become possessed by an external power. It came upon the disciples at Pentecost (Acts ii, 1 ff.) and was quite prominently manifested in the church at Corinth. Many Christians coveted this gift, since it seemed to them to be genuine evidence of possession by the Holy Spirit. Paul, however, though he shared it himself, applied to it, as to other questions, his criterion of judgment as to whether this practice really was useful in the service of the church. Did it build up individual members in the faith? His answer was negative, since unintelligible utterances could scarcely have much value unless interpreted and the matter of interpretation was dubious. Did it build up the church? On the contrary, it might well turn away those who were interested in the church by suggesting the mental instability of its members. The apostle advised his converts to be mature in their thinking on this subject and to judge the relative value of their gifts by the measure of their use in building up the members of Christ's body and attracting others to the Christian community (I Cor. xii–xiv). The same concern is seen in his handling of the abuse of the Lord's Supper that had taken place in the Corinthian church. The words of the institution of this sacrament, so clearly given by Paul (I Cor. xi, 23–26), might never have been written had he not been primarily occupied with the ethical behaviour of the church. Up to this point the Lord's Supper had been celebrated in association with the social meal or "love feast" (agape; *q.v.*), a meal to which all contributed and which all, rich and poor, were to share alike, thus representing the unity of fellowship among the members. This fine ideal, however, had been repudiated by the individualism and selfishness of many who by their conduct were making it impossible of achievement (I Cor. xi, 17–22). Paul could not commend this sort of behaviour because it was antithetical to love and quite contrary to all those spiritual blessings to which the sacrament bore witness.

In addition, however, to the primary ethical motivation of being "in Christ," issuing in conduct based upon the exercise of Christian love, there was another, secondary ethical motivation — the eschatological. It may be said to include the wrath of God, the divine judgment and the prospect of future salvation. To have part in the Kingdom of God it is necessary to break with sin, for sin brings the wrath of God upon men (I Cor. vi, 10; Gal. v, 21; Eph. v, 5). This does not mean that God wreaks his vengeance upon sinners after the manner of human vindictiveness. Rather, the apostle is stressing the working out of the moral law of the universe, which cannot be infringed with impunity. Closely related to this is his appeal to the judgment of God. Christians are to "appear before the judgment seat of Christ" (II Cor. v, 10). They must not be presumptuous or overconfident, knowing that they are to be accountable for their conduct at the last day. It is possible that here he is reverting to the teaching methods of the synagogue in order to have a sobering effect upon his readers. Future salvation is inseparable from the wrath of God and the divine judgment. It must not be supposed that this emphasis upon good behaviour for eschatological reasons meant that future redemption is a reward for good conduct. Salvation comes by grace and is the gift of God. Christians anticipating this gift might well desire to live in blameless expectation of it (I Cor. i, 8).

Ideally Paul should have left his churches alone to do what was pleasing to them. This he did not do. He was a realist. He knew that Christian freedom is achieved gradually, in proportion as the subject is committed to Christ and comes under the control of his

Spirit. Obstacles in the environment often hindered this development. He found it necessary, therefore, to give instructions and warnings to his churches. to guide the weak and to remind the strong that by good example they might both strengthen their brethren and commend Christianity to others (Rom. xii; Col. iii). The assumption behind all such ethical advice is that Christians belong to a new family relationship and must act worthily of it. This is why the apostle is sometimes very specific in his instructions and deals with quarrelsomeness, sexual impurity, selfishness, lying, stealing. right relations between husbands and wives, parents and children masters and slaves (Col. iii; Eph. iv–v), and exhorts his churches to follow all the positive virtues. Such suggested patterns of conduct, however, in no way qualified the ideal ethic of Paul, the law of Christ, the law of love which fulfills every other law of God (Gal, v, 14; Rom. xiii, 9–10).

LETTERS AND STYLE

Though Matthew, Mark and Luke are the first documents in the New Testament and contain material some of which probably existed in written form by A.D. 50, these Gospels, as we have them, are subsequent to A.D. 65–70. as also are the Acts of the Apostles and the general epistles Paul was the author of the first New Testament writings. his own letters. When the King James version of the Bible appeared (1611) 14 New Testament Epistles were ascribed to Paul. Actually, however, only ten, including Ephesians, can be credited to him, and there are many scholars who question the authenticity of Ephesians, mainly on the ground of differences in language and style. Hebrews does not belong to him. I and II Timothy and Titus (*see* PASTORAL EPISTLES), though they contain genuine fragments of his correspondence, are the work of a follower of the apostle 20 years after his death.

Chronological arrangement of Paul's letters, all written between A.D. 49 and 61, is difficult and raises two questions: (1) the date of Galatians; and (2) the place from which the Captivity Epistles were written. Some scholars assign first place to Galatians, others place it with the Corinthian and Roman letters. Ephesus and Rome have both been suggested as the place of origin of all or some of the Captivity Epistles, with the weight of evidence going to Rome. The following order is suggested:

Galatians (from Antioch), 49 or 55–57	
I and II Thessalonians (from Corinth),	50–51
I Corinthians (from Ephesus) II Corinthians (from Macedonia) Romans (from Corinth)	55–57
Colossians Philemon Ephesians(?) Philippians (from Rome)	59–61

Ancient letters were either literary, prepared with precision, formal and impersonal in character and intended for public consumption; or nonliterary, informal, intimate and casual and addressed to individuals. Nonliterary letters were much more self-revealing, as indicated by many examples recovered from Egypt. Paul's letters may be said to bear the mark of both and therefore defy placement in either category. They disclose deeply personal relations with people and at the same time reveal the inner life of the writer. But since he wrote frequently on great issues, to instruct and to give leadership to the church, the letters also show evidence of deep reflection and studied preparation They were intended to be read to churches, some indeed to be circulated among churches (Col. iv, 16). Paul would see to it that the dictated form was revised with care. Much was at stake when the apostle undertook to address a church. Usually he was dealing with some specific theological, moral or practical issue upon which the well-being of the church depended, and he wrote with a sense of personal involvement which is reflected in moods of anxiety, fear, anger, warning, conciliation, tenderness, gratitude, joy, exultation and almost every other emotion of the human heart. And all are the expression of his love for the church and his desire that nothing should sully her name or hinder her purpose.

Christianity owes a great deal to the letters of Paul. It has been seen how vital they are to a portrayal of his personality. They are equally significant for an account of the early church, its worship and its early form of organization, for little of this is found in the Acts of the Apostles. Without them we would know very little about the thinking of Paul and how his Christian thought developed over the years and equally little of the way this great protagonist of Christianity made his appeal to the Greco-Roman world. We would not know of the varied life or of the crucial issues that characterized the local church in the pagan environment and that are so vividly painted in the Corinthian correspondence. Nor would we have any means of judging Paul's relationship to his predecessors, particularly to Jesus himself. All in all, the letters are essential as a source of early Christian history; this is to say nothing of their influence in the later history of the Christian church. As to when they were collected and formed into what is sometimes called the Pauline Corpus, it is difficult to say. That they were so collected after the apostle's death, and came to be known as scripture (II Pet. iii, 16), is beyond question.

Paul's style too has been the subject of much discussion. It is obvious, and yet true, to say that "the style is the man." His words and his individuality go together and they bear witness to the depth and wealth and intensity of his thought and experience. He dictated his letters with a passionate earnestness; Christian faith and Christian practice were not matters upon which he could write with detachment, so complete was his identification with Christ and the church. He lived his letters, in sympathetic imagination being present uith the groups to which he wrote (I Cor. v. 3–4). Hence in the style we often catch something of the firm and fervent tones as he pleads or expostulates, questions or instructs, praises or blames. It may be true, as many have held, and as Paul himself seems to have suggested, that he was no orator and did not wish to indulge the art of rhetoric (I Cor. ii. 1; II Cor. x, 10; xi, 6). Nevertheless, he must surely have been on occasion a moving speaker, eloquent because filled with an all-consuming eagerness to share with others the knowledge and convictions which he himself possessed.

He was a Jew, yet he wrote and thought in Greek; and while he imitated no classical models and betrays little formal knowledge of Greek culture, either by quotation or allusion. he was at home in Greek. The book nhich clearly influenced his style was the Greek Bible (the Septuagint). Sometimes he got involved in rabbinic exegesis, not always to the clarification of the subject under discussion. At other times, under constraint to express the wonder of the gospel. his grammar got disorganized Often he piled up superlatives and even created words, so eager was he to express the truth about Christ. And yet his style does not lack care, even artistry of expression. His sense of rhythm is clear and his use of parallelism and antithesis very marked. In his hands the diatribe, the form of public speech that was popular among the Stoics and Cynics of his day and that he no doubt often heard on street corners, is used with great effectiveness (I Cor. xv, 35 ff.). Passages such as the hymn on love (I Cor. xiii), the hymn on wisdom (I Cor. ii, 6 ff), the chapter on the resurrection (I Cor. xv), the description of the new life in the Spirit (Rom. viii) are written with consummate literary skill, beauty and dignity, indicating much deliberation in choice of language and structure of sentences. This does not rule out what seems to have been a characteristic of Paul's writing and speaking, namely a remarkable ability to see the universal implication of some particular truth and to rise to poetical and even rhapsodic heights in the expression of it (Rom. viii. 31–39; I Cor. iii, 21–23).

It is not to be doubted that Paul acquired some of the religious and philosophical terminology of the pagan world of his time. It is equally certain. however, that all such borrowings were baptized into the Christian faith and became vehicles in his hands for a more adequate presentation of the gospel to his gentile audiences. Whatever Paul used, whether forms or images or metaphors or literary devices from whatever source, all weie subordinated to his supreme purpose of portraying Christ to men and introducing them to the power of the gospel.

ACHIEVEMENTS AND INFLUENCE

Paul grappled with all the problems of the church at once. At

the same time, he sought to interpret Christianity to the world. In his letter to the Romans he gave Christianity its first theological exposition of the gospel. which has remained through the centuries a vital source book for all Christian theologians.

In Galatians, sometimes called the "Magna Carta of Christian liberty," he made the first great defense of the gospel against those who would return to religion of legalism and depart from that inward liberty which is the true mark of the Christian man. So thorough was his defense that Christianity was saved from becoming a sect of Judaism and its universal outreach was forever secured.

In Colossians he came to grips with heresy. a perversion of Christian teaching which, seeking to accommodate the gospel to current cultic observances and ascetic practices. recommended the worship of angels and other spiritual beings and reduced Christ to much less than the supreme place he should hold. In this the apostle may be seen struggling to keep the stream of Christianity pure and to give Christ the pre-eminent place which belonged to him, thus paving the way for the great affirmation that nothing in the whole universe can be interpreted wisely apart from him (Col. i, 13–20).

In I and II Corinthians he is supremely the pastor. in touch with a church, directing, exhorting, concerned mainly with practical issues and with the relevance of doctrine and ethics to a living situation in the pagan environment. Out of this may be seen emerging the beginnings of early church worship and discipline and the development of a church consciousness.

Philemon introduces us to Paul's attitude to slavery. an institution which he accepted as part of the old order, but whose ultimate passing was anticipated in that Christian relationship which he suggests to Philemon in respect to his runaway slave Onesimus.

In Ephesians: that grand ecumenical letter, the goal of all Paul's thinking, as indeed the purpose of the gospel, is seen to be the final breaking down of all barriers that divide men and the reconciliation that results in all becoming one humanity. members of "the household of God." fulfilling God's redemptive purpose in history and anticipating the ultimate and final salvation (Eph. i, 10).

Men go back to Paul because they find in him the first courageous and competent handling of essential beliefs and practices of the church. That is why he has exercised. through the centuries, a critical function. Whenever the Christian faith has been in danger of losing its soul, of becoming fettered with legalisms and ceremonialisms. of allowing the tyranny of traditions and institutions to become a substitute for a man's personal approach to and trust in God, Paul has returned like a refining fire, and men have rediscovered the essence of Christianity in his doctrines of the free grace of God and the liberty of the Christian soul. Augustine, Luther, Wesley, Karl Barth, all witness to the influence of Paul's thought in crucial periods of history. It is doubtful whether. without him, Christianity would have survived in its pristine character, much less become the religion of the western world. And, had this not occurred, much would have been lost to western civilization itself.

As Samuel Sandmel has written: "One needs only a glimpse at the history of Europe and America since the veritable rediscovery of Paul by Martin Luther to discern the permanent and imperishable. It was out of a renewed emphasis upon Paul that there developed, albeit in secularized form, those attitudes toward the individual, toward freedom of the conscience, and toward the inviolability of the conscience which made the transition from the middle ages to modern times." (Samuel Sandmel. *The Genius of Paul,* p. 219. Farrar, Straus and Cudahy, Inc., New York, 1958. Copyright 1958 by Samuel Sandmel.)

See also references under "Paul, Saint," in the Index volume.

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PAUL, SAINT, OF THE CROSS (PAOLO FRANCESCO DANEI) (1694–1775), Italian religious, founder of The Congregation of the Discalced (Barefooted) Clerks of the Most Holy Cross and Passion of Our Lord Jesus Christ, called the Passionists (*q.v.*), was born in the town of Ovada, Italy (then the Republic of Genoa), Jan. 3, 1694, the second of 16 children. From earliest years. Paul showed signs of great love for prayer and contemplation and a capacity for spiritual leadership. On Nov. 22, 1720, he dedicated his life to God and was clothed in the habit of a hermit by the bishop of Alexandria. The following day he began a 40-day retreat in a room off the sacristy in the Church of St. Charles at Castellazzo. He states that during the retreat he was divinely inspired to write a rule of life for a new religious institute in the church. The rule: subsequently modified and repeatedly approved by the church, breathes a spirit of prayer, penance, poverty, solitude and devotion to Christ Crucified, issuing forth in intensive apostolic work for God's glory. The rule was simply approved in 1741 and solemnly approved in 1746 by Benedict XIV. In 1773 the splendid Church of SS. John and Paul in Rome became the headquarters of his congregation. He founded the Institute of the Passionist Nuns, at Corneto, in 1771.

Paul died Oct. 18, 1775, and was canonized June 29, 1867, by Pius IX. His feast day is April 28.

At his death, Paul had established 12 monasteries in Italy, and since then his institute has spread throughout the world. Members of the institute are popularly known as Passionists. because of a special vow they take to spread devotion to Christ in His sufferings.

See Gaétan du Saint Nom de Marie, C.P., *Saint Paul de la Croix et la fondation des Passionistes (1956).* (G. RO.)

PAUL, SAINT, OF THEBES (PAUL THE HERMIT), a shadowy figure of whom little is known and that little highly suspect, was one of the earliest hermits in the desert. For knowledge of him modern scholarship is dependent solely upon the *Life of Paul* written by St. Jerome, which is probably the source also of extant Greek and oriental lives of Paul. According to Jerome, Paul was a native of the Thebaid in Egypt who fled the Decian persecution (249–251) and thereafter lived a life of prayer and penitence in a cave, dying about 341 at an advanced age. Jerome was inclined to give priority to Paul as the first Christian hermit, an honour in modern times generally accorded to St. Anthony. However that may be, it is claimed that Anthony (born *c.* 250), when he was 90 years old, visited Paul who was then 113. The aged man asked Anthony to bring the mantle given to Anthony by St. Athanasius and to wrap him in it for burial.

Paul has been thought possibly identical with a certain Paul of Oxyrhyncus; in later art he is often represented with a palm tree or two lions. His feast day is Jan. 15.

See J. P. Migne, *Patrologia Latina,* vol. *xxiii,* pp. *17–28;* J. Bidez, *Deux Versions grecques inedites de la vie de Paul de Thebes (1900)*; *H.* Delahaye, "La Personnalite historique de St. *Paul de* Thebes," *in Analecta Bollandiana,* vol. xliv, pp. 64–69. (*G.* E. McC.)

PAUL, the name of five popes.

PAUL I (d. 767), pope from 757 to 767, was elected April 757, in succession to his brother Stephen III (II), whose policies of alliance with the Frankish king Pepin and of consolidating the new Papal States. Paul continued. The *Liber pontificalis* describes him as "mild and most merciful." He died on June 28, 767, and was buried first at St. Paul's, then at St. Peter's. (H. G. J. B.)

PAUL II (Pietro Barbo) (1417–1471), pope from 1464 to 1471, was a native of Venice and nephew of Eugenius IV, who created him cardinal in 1440. After his election as pope on Aug. 30, 1464, he immediately declared that the capitulations which cardinals

had long been in the habit of laying down as rules of conduct ior future popes could affect a new pope only as counsels and not as binding obligations. Although by no means opposed to the cultural aspirations of the Renaissance, his policies brought him into sharp conflict with some of the leading humanists. Also he failed to do anything effective against the Turkish threat. He died on July 26, 1471.

PAUL III (Alessandro Farnese) (1468–1549), pope from 1534 to 1549, received a humanistic education at Rome and Florence at the court of Lorenzo the Magnificent. He was created cardinal by Alexander VI in 1493 and became bishop of Parma in 1509. Upon his election as pope on Oct. 13, 1534, he announced his intention of calling a general council and of promoting the reform of the church. He created a number of excellent cardinals and appointed a commission which drew up a program of reform, the *Consilium de emendanda Ecclesia.* He approved the Society of Jesus and instituted the Roman inquisition. After many disappointments, Paul was able to assemble the council of Trent at the end of 1545, and the important early sessions of that council took place during his reign. Paul III maintained a policy of neutrality in the conflict between the emperor Charles V and Francis I of France, but eventually he was forced into conflict with Charles. Although Paul's early life had not been blameless and although he engaged in nepotism on a large scale, he is among the great figures of papal history. His reign marks the beginning of the transition from the Renaissance to the Catholic Reform. He died on Nov. 10, 1549.

See the study by C. Capasso, in Italian, 2 vol. (1923–24).

PAUL IV (Giampietro Carafa) (1476-1559), pope from 1555 to 1559, was born near Benevento of a noble Neapolitan family, June 28, 1476. In 1524, with St. Cajetan of Thiene, he founded the first order of clerks regular, the Theatines, and became their first superior general. Cardinal in 1536, he was elected pope, at the age of 79, on May 23, 1555. Paul showed himself full of a violent zeal ior Catholic reform. He gave extraordinary powers to the Roman inquisition, which was inexorable during his pontificate. Giovanni Cardinal Morone, only recently a candidate for the papal tiara, was imprisoned as suspect oi heresy, and Reginald Cardinal Pole was deprived of his position as legate to England while the settlement he had made was disalloned. Despite his violence Paul IV did much for the lasting reform of the city of Rome and of the church. He created capable cardinals, introduced financial reforms and required that bishops reside in their dioceses. His very severity enabled him to tear out deeply rooted abuses. Indeed it was because he continued so energetically the reform begun by Paul III that his successors could conduct it to a successful termination. Paul's profound aversion for Spain, however, and his confidence in his unworthy nephew Carlo Carafa, led him into an alliance with France and war with Spain. The army of Philip II under the Duke of Alva routed the papal forces and forced Paul to accept the peace of Cave (1557). When Paul learned of the corruption of his nephews, he banished them. He died on Aug. 18, 1559. (E. A. R.)

PAUL V (Camillo Borghese) (1550–1621), pope irom 1605 to 1621, was born at Rome on Sept. 17, 1550, the descendant of a noble Sienese family. He studied jurisprudence in Padua and Perugia and was created cardinal in 1596. In the conclave following the death of Leo XI, although the youngest of the cardinals, he was chosen as a compromise candidate on May 16, 1605. When Venice restricted ecclesiastical liberties, Paul put the republic under an interdict in 1606. A theological controversy ensued, the Servite Paolo Sarpi and other jurists attacking papal rights, which were defended by cardinals Robert Bellarmine and C. Baronius. The diplomacy of the Catholic powers led to a peace without victory in 1607. After the Gunpowder plot, James I of England imposed an oath of fidelity which Paul, urged to temporize, condemned. The French bishops, in a bold step which had happy results for the church, promulgated the decrees of the council of Trent in 1615. Paul suspended the inquiry *de auxiliis* on grace and free will, imposing on the controversialists respect for the opinions of their opponents but he failed to show equal reserve in the case of Galileo. His lavish expenditures, in part for the benefit of his family, greatly increased the papal debt. In the hope of pacifying Europe he long supported the peace of Augsburg but before his death was subsidizing the empire in the Thirty Years' War. Paul died on Jan. 28, 1621. *See* also PAPACY.

(J. V. HN.)

PAUL I, emperor of Russia from 1796 to 1801, was born on Sept. 20 (Oct. 1), 1754, the son of grand duchess, afterward Empress Catherine II. The tradition that his father was not the grand duke, afterward Emperor Peter III, has probably no foundation except gossip, and the cynical malice of Catherine. The infant was immediately taken from Catherine by the empress Elizabeth, whose ill-judged care undermined his health. Catherine's coup d'état against Peter III in 1762 was a shock from which the boy's quick but unbalanced mind never recovered. Paul believed his mother had instigated the murder of his father, and although he had been proclaimed heir, he suspected that he too would be deprived of his rights, or even killed. Paul's character deteriorated steadily, and the distrust grew on both sides accordingly. Paul occasionally expressed the desire to play an active part, but Catherine consistently kept him at a distance. In 1773, she arranged his first marriage with Wilhelmina of Darmstadt (renamed Natalia Alekseyevna), but the latter died in 1776, and within the same year Catherine arranged Paul's second marriage with the beautiful Sophia Dorothea oi Württemberg (renamed Maria Feodorovna). In 1781–82, the couple were allowed to travel through western Europe, where Paul managed to make a fairly favourable impression. In 1783, Catherine gave him an estate at Gatchina where Paul spent his time dreaming of reforms, and drilling a contingent of soldiers on the Prussian model which he admired as fanatically as Peter III had done. After the birth of Paul's eldest son, Alexander (1777), Catherine contemplated setting Paul aside in favour of Alexander, but no definite step was taken, and in 1796, Paul ascended the throne. Paul's reign was a period of frenzied despotism. At pains to change anything Catherine had done, and anxious to strengthen his autocracy, Paul attempted to curb the rights of the privileged class, and even to protect the peasants. However at the same time he turned 600,000 state peasants into privately owned seris. Obsessed by fear oi the French Revolution, Paul resorted to crazy internal measures in order to protect Russia against infection. He also joined the second coalition against France (1798), but in the end he turned against Great Britain (1800), and did not hesitate to give a Cossack force the order to invade India. His only lasting service to the country was the introduction of a statute which stabilized the order of succession (1797). However Paul was soon ready to violate his own law. Having long ago made a iavourite of his barber, I. P. Kutaisov, a Turkish prisoner, and having fallen under the spell of two of his wife's maids of honour in succession (Yekaterina Ivanovna Nelidova and Anna Petrovna Lopukhina), he started to display an ever-increasing animosity toward the empress, and against his heir in particular, finally expressing preierence for a German nephew of his wife. In March 1801, Paul's sinister moves induced Alexander to connive at a plot in his favour which was already in the making among guards officers who were embittered by Paul's harsh treatment. The driving power in the conspiracy was General Count Peter Ludwig von der Pahlen, the military governor of Petersburg who now found an energetic helper in General Count Levin August von Bennigsen. On the night of March 11 (23), 1801, the latter with a band of officers murdered Paul in his bedroom in the strongly protected St. Michael palace. (Lo. L.)

PAUL OF AEGINA (PAULUS AEGINETA) (*c.* 615–6903, the last of the great Greek compilers, was born on the island of Aegina. He traveled widely among the Arabians and flourished during the Moslem conquest.

He was the last great physician of Byzantine culture to practice and teach in Alexandria just prior to the destruction of the great city in 640 by the forces of the caliph Omar I. Although little is known of his personal life, it is certain that Paul's obstetrical skill placed him in great demand among the Arabians. Much of his material is taken from Galen, Oribasius and Aetius.

Greek manuscripts of the following works are extant: *Epitomae medicae libri septem, De succedaneis ex Galeno, De urinis libri*

VII, De mensuris et ponderibus and *Excerpta varia*. There are Arabic manuscripts in Rome, Munich and Paris. The *Epitome*, Paul's most valuable work, consists of seven books containing practically everything known about the medical arts in his time. Rhazes, in his *Kitabu 'l-Maliki*, copiously employed it, and Albucasis excerpted most of the surgical material in his *Surgical Tracts* from its sixth book. Thus Paul's surgery profoundly affected not only Arabian medicine but also medieval medicine in the west.

See also ABUL KASIM.

See D. Campbell, *Arabian Medicine* (1926); *B.* Gordon, *Medieval and Renaissance Medicine* (1960). (B. L. G.)

PAUL, HERMANN (1846–1921), German linguist, was one of the neogrammarians from Leipzig who in the 1860s and 1870s defended the thesis that changes of sounds in a language during the passage of time are completely regular and that all exceptions are explicable. He was born on Aug. 7, 1846, at Salbke near Magdeburg. He was a professor at Freiburg and Munich and founded (with Wilhelm Braune) the journal *Beiträge zur Geschichte der deutschen Sprache und Literatur*. His *Prinzipien der Sprachgeschichte* (1880; second, enlarged, edition, 1886; fifth, unchanged, edition, 1920) is an authoritative exposition of the historical method in linguistics. He died at Munich on Dec. 29, 1921.

A complete bibliography of his work is published in *Beitrage*, xlvi, 1922. *See* NEOGRAMMARIAN. (MY. F.)

PAUL-BONCOUR, JOSEPH (1873–). French left-wing politician. and France's permanent delegate to the League of Nations for 16 years. He was born at St. Aignan, Loir-et-Cher, on Aug. 4, 1873. After leaving the university and joining the bar, he apprenticed himself to politics as private secretary of P. M. Waldeck-Rousseau. His book *Le Fédéralisme kconomique* (1900) showed his interest in trade unionism. He was elected deputy as Independent Socialist in 1909 for his native *département*, and was minister of labour in 1911. He lost his seat in 1914, returned to parliament as a Socialist after World War I, but resigned from the party in 1931 and thereafter presided over a group of Independent Socialist deputies. Paul-Boncour was minister of war in Edouard Herriot's government of June–December 1932, prime minister Dec. 1932–Jan. 1933, and minister of foreign affairs in his own government, as well as under Édouard Daladier, Albert Sarraut and Camille Chautemps (Dec. 1932–Jan. 1934). He was again minister of foreign affairs under Sarraut (January–June 1936) and in Léon Blum's second ministry (March 1938). In June 1940 Paul-Boncour advocated the continuance of the war from Algiers and voted against Marshal Philippe Pétain in July. A member of the consultative assembly in 1944, he led the French delegation at San Francisco after Georges Bidault's departure and signed the UN charter on behalf of France. He was a senator during 1946–48. (D. R. GE.)

PAULDING, HIRAM (1797–1878), U.S. naval officer, was born Dec. 11, 1797, in Westchester county, N.Y., the son of John Paulding, one of the captors of Maj. John André (*q.v.*). He became a midshipman on Sept. 1, 1811, and received a sword from congress for his services on the "Ticonderoga" in the battle of Lake Champlain. He distinguished himself in South America and in the Pacific, and published two books that cover his experiences: *Journal of a Cruise of the U.S. Schooner Dolphin* (1831) and *Bolivar in His Camp* (1834). While in command of the home squadron, 1855–58, he seized Gen. William Walker (*q.v.*) and 150 filibusters at Greytown, Nic. The government of Nicaragua presented him with a sword, and he was praised in northern states, but the Buchanan administration removed him from his command. He commanded the Brooklyn navy yard from Aug. 1861 to 1865 and rendered outstanding service. Promoted to rear admiral on the retired list on July 16, 1862, he died on Long Island, Oct. 20, 1878. (J. B. HN.)

PAULDING, JAMES KIRKE (1778–1860), U.S. public official and man of letters chiefly remembered for his early advocacy and use of native American material in literature, was born in Dutchess (now Putnam) county, N.Y., on Aug. 22, 1778. Starting his public career in 1815 as secretary of the board of navy commissioners, he became in 1824 a navy agent in New York city, and from 1838 to 1841 he served as secretary of the navy under Pres. Martin Van Buren.

His literary work, however, overshadows his routine labours as a government official. As a boy of 18 he went to New York city, where he formed a lasting friendship with the Irvirigs. This association aroused his enthusiasm for literature, and he and Washington Irving founded the *Salmagundi* (1807–08), a periodical consisting mainly of light satires on local subjects. The outbreak of hostilities between England and America encouraged the assertion of Paulding's nationalism; in *The Diverting History of John Bull and Brother Jonathan* (1812) and *The Lay of the Scottish Fiddle* (1813), he satirized England's conduct toward America during the war. The same spirit of nationalism found expression in two satires on the English traveler entitled *A Sketch of Old England: by a New England Man* (1822) and *John Bull in America* (1825).

The advantages and hardships of western migration are the theme of *The Backwoodsman* (1818), a poem written to call the American author home in his search of literary themes. Novels, such as *Koningsmarke* (1823), *Westward Ho!* (1832) and *The* Old *Continental* (1846), represent Paulding's attempts to employ the American scene in fiction. His popular play, *The Lion of the West* (1831; ed. by J. N. Tidwell, 1954), introduced frontier humour to the stage by depicting a character based upon David Crockett (*q.v.*); the latter, as a consequence, inaugurated the long series of Davy Crockett publications. In his *Life of Washington* (1835), once commended by Edgar Allan Poe, lies further evidence of his staunch Americanism. Plain, even at times vulgar in style, he yet possessed a playful irony which he shared with the New York writers of his day.

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PAULET, POULET or POWLETT, an English family of an ancient Somersetshire stock, taking a surname from the parish of Pawlett near Bridgwater.

SIR AMIAS PAULET (d. 1538), knighted in 1487 after the battle of Stoke, was treasurer of the Middle Temple in 1521, when Thomas Wolsey, in revenge for an indignity suffered at the knight's hands when the chancellor was a young parson at Limington, forbade his leaving London without permission. To propitiate the cardinal. Sir Amias, rebuilding the Middle Temple gate, decorated it with Wolsey's arms and badge.

SIR AMIAS PAULET (c. 1536–88), is famous as the Puritan guardian at Tutbury and Chartley of Mary, queen of Scots. After his prisoner was sentenced at Fotheringhay, he beset the ministers of Elizabeth I with messages advising Mary's execution, but he firmly withstood "with great grief and bitterness," the suggestion that he should have her put to death secretly.

SIR WILLIAM PAULET (*c.* 1485–1572), 1st marquess of Winchester, a member of a younger branch of the family, received steady promotion in the service of Henry VIII. The king's death found him lord president of the council and one of the executors of Henry's will. The fall of the protector Somerset gave him the lord treasurership and a patent of the earldom of Wiltshire. He shared the advancement of the duke of Northumberland and was created in 1551 marquess of Winchester, but, although he delivered the crown jewels to Lady Jane in 1553, he was with the lords at Baynard's castle who proclaimed Queen Mary. Only his death in 1572 drove from office this tenacious treasurer.

His princely house at Basing was held for King Charles by JOHN, the 5th marquess of Winchester, whose diamond had scratched "Aimez Loyauté" upon every pane of its windows. The Cavalier marquess died in 1675, unrecompensed, and his son CHARLES, a morose extravagant. had the dukedom of Bolton in 1689 for his active support of William III.

CHARLES, 2nd duke of Bolton (1661–1722), was made lord lieutenant of Ireland in 1717. A third CHARLES, the 3rd duke, is remembered as an opponent of Sir Robert Walpole and as the husband of the actress Lavinia Fenton, the Polly Peachum of John Gay's opera. The dukedom became extinct in 1794, but the mar-

quessate of Winchester and the other titles passed to a distant cousin, George Paulet.

PAULI, WOLFGANG (1900–1958), Austrian physicist, born in Vienna, April 25, 1900, was awarded the 1945 Nobel prize for physics "for the discovery of the exclusion principle, also called the Pauli principle." He received his early education in Vienna and then studied under Arnold Sommerfeld at the University of Munich, where he took his doctor's degree in 1921. He spent a year as assistant to Max Born at the University of Göttingen and a further year with Niels Bohr (*q.v.*) at Copenhagen. In 1923 he was appointed lecturer at the University of Hamburg, where he remained until 1928 when he became professor of theoretical physics at the Federal Institute of Technology in Zurich, Switz. Under his direction this institution became a great centre of research in theoretical physics in the years preceding World War 11 In 1935–36 he was visiting professor at the Institute for Advanced Studies, Princeton university, and he held similar posts at the Cniversity of Michigan in 1931 and 1941 and at Purdue university in 1942. In 1940 he was appointed to the chair of theoretical physics at the Institute for Advanced Studies, Princeton; in 1946 he became a naturalized United States citizen. Following World War II he returned to Ziirich. Pauli became one of the most brilliant of the mid-20th-century school of physicists. While still a student he wrote a masterly exposition of the theory of relativity. The work for which he received the Nobel prize relates to the quantum theory and played an important part in the wave theory of the atom. Pauli was also the first to posit (1931) the existence of the neutrino *(see* PARTICLES, ELEMENTARY). He died in Zurich on Dec. 15, 1958 (W. J. Bp.; X.)

PAULICIANS, an evangelical Christian Church spread over Asia Minor and Armenia from the 5th century onwards. The Armenian patriarch John IV. *(c.* 728) states that Nerses, his predecessor, had chastised the sect, but ineffectually; and that after his death (c. 554) they had continued to lurk in Armenia. An anonymous account was written perhaps as early as 840, and incorporated in the Greek *Chronicon* of Georgius Monachus. It was also used by Photius *(c.* 867), bk. i., chs. 1–10 of his *Historia Manicheorum,* who, having held an inquisition of Paulicians in Constantinople was able to supplement it with a few additional details; and by Petrus Siculus *(c.* 868). who visited the Paulician fortress Tephrike to treat for the release of Byzantine prisoners. His *History of the Manicheans* is dedicated to the archbishop of Bulgaria, whither the Paulicians were sending missionaries.

The Paulicians were, according to the *Chronicon,* Manicheans, and were called after Paul of Samosata (*q.v.*). One Constantine, however, of Mananali, a canton on the western Euphrates, was regarded by the Paulicians as their real founder. He based his teaching on the Gospels and the Epistles of Paul, repudiating other scriptures; and taking the Pauline name of Silvanus, began to organize churches, whose numbers soon increased. From the few facts and dates supplied by Photius and Petrus Siculus it may be inferred that with the exception of a period early in the ninth century (when Sergius, the greatest of their leaders, carried on a powerful missionary propaganda) they were in conflict, frequently armed conflict, with the Byzantine Empire until the 10th century. Nevertheless the movement spread in Bulgaria and then revived and became stronger than ever in Armenia. The crusaders found them everywhere in Syria and Palestine, and corrupted their name to Publicani, under which name, often absurdly conjoined with Sadducaei, we find them during the ages following the crusades scattered all over Europe. After 1200 we can find no trace of them in Armenian writers until the 18th century, when they reappear in their old haunts. In 1828 a colony of them settled in Russian Armenia, bringing with them a book called the *Key of Truth,* which contains their rites of name-giving, baptism and election, compiled from old mss., we know not when.

Doctrine.—On Paulician beliefs we have mainly hostile evidence, which needs sifting. The *Chronicon* source gives these particulars:—

1. They anathematized Mani, yet were dualists and affirmed two principles—one the heavenly Father, who rules not this world but the world to come; the other an evil demiurge, lord and god of this world, who made all flesh The good god created angels only. The Byzantines erred in confusing these principles.

2. They denied the virgin birth of Jesus, and allegorized the Virgin as the upper Jerusalem in which the Lord came in and went out and denying that he was really made flesh of her.

3. They allegorized the Eucharist and explained away the bread and wine of which Jesus said to His apostles, "Take, eat and drink," as mere words of Christ, and denied that we ought to offer bread and wine as a sacrifice. Such allegorization meets us already in Origen, Eusebius and other early fathers, and is quite compatible with that use of a material Eucharist which Nerses II. attests among the Paulicians of the early 6th century, and for which the *Key of Truth* provides a form.

4. They assailed the cross, saying that Christ is a cross, and that we ought not to worship the tree, because it is a cursed instrument. John IV. and other Armenian writers report the same, and add that they smashed up crosses when they could.

5. They repudiated Peter, calling him a denier of Christ, and would not accept his repentance and tears. The *Key of Truth,* however, merely warns us that *all* the apostles constitute the Church universal and not Peter alone.

6. The monkish garb was revealed by Satan to Peter at the baptism, when it was the devil, the ruler of this world, who, so costumed, leaned forward and said, "This is my beloved son."

7. They called their meetings the Catholic Church, and the places they met in places of prayer, προσευχαί. The Armenian Paulicians equally denied the name of church to buildings of wood or stone, and called themselves the Catholic Church.

8. They explained away baptism as "words of the Holy Gospel," citing the text "I am the living water." So the Armenians taught that the baptismal water of the Church was "mere bath-water," *i.e.,* they denied it the character of a reserved sacrament. But there is no evidence that they eschewed water-baptism.

9. They permitted external conformity with the dominant Church, and held that Christ would forgive it

10. They rejected the orders of the Church, had only two grades of clergy, namely, associate itinerants (συνέκδημοι, Acts xix. 29) and copyists (νοτάριοι), and scorned priestly vestments.

11. Their canon included only the "Gospel and Apostle."

13 Their Christology was as follows: "God out of love for mankind called up an angel and communicated to him his desire and counsel; then he bade him go down to earth and be born of woman. . . . And he bestowed on the angel so commissioned the title of Son, and foretold for him insults, blasphemies, sufferings and crucifixion. Then the angel undertook to do what was enjoined, but God added to the sufferings also death." However. the angel, on hearing of the resurrection. cast away fear and accepted death as well; and came down and was born of Mary, and named himself son of God according to the grace given him from God; and he fulfilled all the command, and was crucified and buried, rose again and was taken up into heaven. Christ was only a creature, and obtained the title of Christ the Son of God by way of grace and remuneration for obedience.

The scheme of salvation here set forth recurs among the Latin Cathars. It resembles that of the *Key of Truth,* insofar as Jesus is Christ and Son of God by way of grace and reward for faithful fulfilment of God's command. But the *Key* lays more stress on the baptism. In this scheme the Baptism occupies the same place which the Birth does in the other, but both are adoptionist. The Armenian fathers held that Jesus, unlike other men, possessed incorruptible flesh, made of ethereal fire, and so far they shared the main heresy of the Paulicians. In many of their homilies Christ's baptism is also regarded as his regeneration by water and spirit, and this view goes beyond the modest adoptionism set forth in the *Key of Truth.* Certain features of Paulicianism noted by Photius and Petrus Siculus are omitted in the *Chronicon* source. One of these is the Christhood of the fully initiated, who as such ceased to be mere "hearers" *(audientes)* and themselves became vehicles of the Holy Spirit. As Jesus anointed by the Spirit became the Christ, so they became christs. Hence their opponents spoke of their "self-conferred priesthood" and "anthropolatrous apostacy," "calling themselves christs."

Because they regarded their Perfect or Elect ones as Christs and anointed with the Spirit, the medieval Cathari (*q.v.*) regularly adored them. So it was with Celtic saints. and Adamnan, in his life of St. Columba, i, 37, tells how the brethren after listening to St. Baithene. "still kneeling, with joy unspeakable, and with hands spread out to heaven, venerated Christ in the holy and blessed man." So in ch. 44 of the same book we read how a humble stranger "worshipped Christ in the holy man" (*i.e.,* St. Columba) ; but such veneration was due to every presbyter. The Christ is an elect one, who, as the Cathars put it, having been consoled or become a Paraclete in the flesh, stands in prayer nith his hands outspread in the form of a cross, nhile the congregation of hearers or *audientes* adore the Christ in him. It was because they believed themselves to have living christs among them that the Paulicians rejected the fetish worship of a material cross. in which orthodox Armenian priests imagined they had by prayers and anointings confined the Spirit of Christ. The later Cathars of Europe repudiated marriage on the ground that the only true marriage is of Christ with his bride the Virgin church, and perhaps this is whv Paulicians and Thonraki would not make of marriage a religious rite or sacrament.

The Cathars adhere to adult baptism, which they confer at 30 years of age or later, and they have retained in its primitive significance the rite of giving a Christian name to a child on the eighth day.

PAULING, LINUS CARL (1901–), U.S. physical chemist and Nobel laureate in chemistry for 1954, who discovered fundamental principles determining the nature of the chemical bond and the structure (shape and size) of molecules, and their application to the explanation of the properties of matter. He was born on Feb. 28, 1901, in Portland, Ore., and educated at Oregon State college (Corvallis) and the California Institute of Technology (Pasadena). He joined the staff of the California Institute of Technology in 1922.

In large measure his work led to the general realization that the nature of the chemical bond and molecular structure are the central and most fruitful theme of modern chemistry. His discoveries about the nature of the chemical bond include directed valence and the hybridization of bond orbitals, electronic structure and magnetic properties, and the effect of resonance on the shape and stability of molecules (see RESONANCE, THEORY OF).

From 1936 he and his colleagues applied this knowledge to the study of the properties of living systems. Their work includes the discovery of some of the arrangements of polypeptide chains in proteins, especially a linear helical structure called the a-helix, and the discovery that an abnormality in the molecular structure of hemoglobin is associated with the hereditary disease, sickle cell anemia. (N. DN.)

PAULINUS, SAINT, OF NOLA (MEROPIUS PONTIUS ANICIUS PAULINUS) (353–431), bishop of Nola (in Campania, southern Italy) and one of the most important and attractive Christian Latin poets of his time, was born at Bordeaux, Fr., where his family, of Roman patrician origin, was settled. His father was rich and influential and Paulinus, who was the favourite pupil of Ausonius (*q.v.*), was marked for a public career; he became successively a Roman senator, consul and governor of Campania. Though not baptized until 389, he was brought up as a Christian and was dedicated to St. Felix, whose tomb at Nola was on one of the family estates. Returning to Aquitaine, he married a Spanish lady, Therasia, with whom in 389 he retired to Spain. The death of their only child in 392 made them decide to forsake the world; they sold their possessions in Gaul and Spain, and in 395, when Paulinus was already in priest's orders, they settled at Nola to live a life of ascetism and boundless charity.

This act of renunciation created a profound impression. Paulinus' old master Ausonius uttered his reproaches in verse to which Paulinus replied in poetical epistles. This exchange belongs to the time when Paulinus was still in Spain. He also corresponded in poetical epistles with Nicetas of Remesiana. His verses, in lyric measures, show how a Christian poet could subdue rhetoric to Christian ends. His poems as a whole abound in reminiscences of classical authors such as Virgil, Horace, Ovid and Lucan, for he could not forget the methods of the schools. His charm as a poet is best seen in his poems on the feast day of St. Felix.

The collection of his letters is of equal interest, as he corresponded with famous men of his day: Augustine, Jerome and Sulpicius Severus. His prose style, often rhetorical and exuberant, never descends to puerilities. He could describe in dignified language his cold reception by the pope, or satirize the ignorance of those uho could not perceive the beauty of the life of renunciation, but his letters breathe above all the atmosphere of what has been called the cult of Christian friendship. About 409 Paulinus uas consecrated bishop of Nola, where he died June 22, 431. His feast is still celebrated on the anniversary of his death.

BIBLIOGRAPHY.—Works in J. P. Migne, *Patrologia Latina,* vol. lxi (1847) and W. von Hartel (ed.) in *Corpus Scriptorum ecclesiasticorum Latinorum,* vol. xxix–xxx (1891). *See* also A. Baudrillart, S. *Paulin, évêque de Xole* (1905) ; *P.* Labriolle, *La Correspondance d'Ausone et de Paulin de Nole* (1910) ; *P.* Fabre, *Essai sur la chronologie de l'oeuvre de S. Paulin de Nole* (1948) ; *P.* Fabre, S. *Paulin de Xole et l'amitié chrétienne* (1949) ; F. J. E. Raby, *History of Christian Latin Poetry,* 2nd cd. (1953) ; N. K. Chadwick, *Poetry and Letters in Early Christian Gaul* (1955). (F. J. E. K.)

PAULINUS, SAINT (d. 644), first bishop of the Northumbrians and bishop of York, was sent to England by Pope Gregory I in 601 to assist St. Augustine in his mission. He was consecrated in 625 and escorted the daughter of Xethelbert to the Northumbrian king Edwin (*q.v.*). As a result of his preaching, in 627 Edwin was baptized and assigned York to Paulinus as his see. In 632 Edwin was slain at Hatfield Chase and Paulinus retired to Kent, where he became bishop of Rochester. He received the pallium in 634 and died in 644. His feast day is Oct. 10.

See Bede, *Historia ecclesiastica,* ed. *by C.* Plummer, vol. ii (1896) ; R. H. Hodgkin, *A History of the Anglo-Saxons,* vol. i, pp. 273–280 (1935).

PAULO AFONSO FALLS are formed by the confluence of several branch streams about 190 mi. from the mouth of the São Francisco river on the Alagôas-Bahía border. Set amid splendid scenery in the centre of a national park, the rapids reach a height of 262 ft. The falls are the site of a great hydroelectric project, begun in the late 1940s, to supply power to northeast Brazil. *See* SÃO FRANCISCO.

PAUL OF SAMOSATA, patriarch of Antioch (260–272), was, according to the encyclical letter of his ecclesiastical opponents preserved in Eusebius's History, bk. vii, ch. 30, of humble origin. The letter just mentioned is the only indisputably contemporary document concerning him and was addressed to Dionysius and Maximus, respectively bishops of Rome and Alexandria, by 70 bishops. priests and deacons, who attended a synod at Antioch in 269 and deposed Paul. Their sentence, however, did not take effect until late in 272, when the emperor Aurelian, having defeated Zenobia and anxious to impose upon Syria the dogmatic system fashionable in Rome, deposed Paul and allowed the rival candidate Domnus to take his place.

Paul held that it was a man and not the divine Logos which was born of Mary. Jesus was a man who came to be God, rather than God become man. Paul's Christology therefore was of the Adoptionist type, which is found among the primitive Ebionite Christians of Judaea, in Hermas, Theodotus and Artemon of Rome, and in Archelaus the opponent of Mani and in the other great doctors of the Syrian Church of the 4th and 5th centuries. Lucian the great exegete of Antioch and his school derived their inspiration from Paul, and he was through Lucian a forefather of Arianism. Probably the Paulicians of Armenia continued his tradition, and hence their name. (See PAULICIANS.)

Paul of Samosata represented the high-water mark of Christian speculation; and it is deplorablc that the fanaticism of his own and of succeeding generations has left nothing but a few scattered fragments of his writings. Already at the council of Nicaea in 325 the Pauliani were put outside the church and condemned to be rebaptized. It is interesting to note that at the synod of Antioch the use of the word consubstantial to denote the relation of God the Father to the divine Son or Logos was condemned, although it afterward became at the council of Nicaea the watchword of the orthodox faction.

BIBLIOGRAPHY.—Adolph Harnack, *History of Dogma,* vol. iii; Gieseler's *Compendium of Ecclesiastical History* (1854), vol. i; Routh, *Reliquiae sacrae,* vol. iii; F. C. Conybeare, *Key of Truth;* Hefele, *History of the Christian Councils,* vol. i (1872); C. Bigg, *The Origins of Christianity,* ch. xxxv (1909).

PAULSEN, FRIEDRICH (1846–1908), German philosopher and advocate of educational reform, was born at Langenhorn in Schleswig on July 16, 1846. He mas educated at Erlangen, Berlin and Bonn. He was professor of philosophy and pedagogy at Berlin from 1878 until his death there on Aug. 14, 1908. Paulsen was the greatest of the pupils of G. T. Fechner and his major philosophical work, *Einleitung in die Philosophie* (1892; Eng. trans. 1895) which attempted an epistemological account of our knowledge of the psychophysical and gave great prominence to Fechner's doctrine of panpsychism. He also paid considerable attention to Kantian philosophy, on which he wrote several studies, including *Immanuel Kant, sein Leben und seine Lehre* (1898; Eng. trans. 1902). In general, however, Paulsen's best-known philosophical works are somewhat oversimplified and his ideas unoriginal (partly because he deliberately wrote for a wide audience); he is best remembered for the part he played in the reorganization of higher education in Germany by leading the attack on the monopoly of the *Gymnasien* in the preparation of students for the university. His educational writings include *Geschichte des gelehrten Unterrichts auf den deutschen Schulen und Universitaten vom Ausgang des Mittelalters his zur Gegenwart* (1885; Eng. trans. 1895) and *Das deutsche Bildungswesen in seiner geschichtlichen Entwicklung* (1906; Eng. trans. 1908). He also wrote a *System der Ethik, mit einem Umriss der Staats- und Gesellschaftslehre* (1889; Eng. trans. 1899).

See T. Lorenz (trans. and ed.), *Friedrich Paulsen, an Autobiography* (1938).

PAULUS, surnamed SILENTIARIUS ("the silentiary," one of the imperial ushers), Greek poet, contemporary and friend of Agathias, during the reign of Justinian. In addition to about 80 epigrams, preserved in the Greek anthology, there is extant by him a description of the church of St. Sophia. The poem was recited at the second dedication of the church (A.D. 562), in the episcopal hall of the patriarchate. The poems are of importance for the history of Byzantine art in the 6th century.

BIBLIOGRAPHY.—Ed. of the poems on St. Sophia, by I. Bekker in the Bonn *Corpus scriptorum hist. byz.* (1837), including the descriptions of the church by Du Cange and Banduri, and in J. P. Migne, *Patrologia graeca,* lxxxvi; metrical translations, with commentary, by C. W. Kortum (1854) and J. J. Kreutzer (1875); *see* also Merian-Genast, *De Paulo Silentiario* (1889) and B. L. Gildersleeve in *Amer. Journ. of Philol.* vol. xxxviii (1917).

PAULUS, FRIEDRICH (1890–1957), German army officer, field marshal in World War II, mas born at Breitenau, Hesse, Sept. 23, 1890. He served in World War I and helped plan World War II. He was chief of operations from Sept. 1940 to Jan. 1912, when Hitler entrusted him with the command of the 6th army in southern Russia. By late summer he reached Stalingrad, high-water mark of Nazi conquest. Then, cut off by the Soviet counter-offensive that started in November, Paulus and his 300.000 men were abandoned by Hitler. He surrendered remnants of his army, after a bitter defense, on Jan. 31, 1943. On the same day, Berlin announced his promotion to the rank of field marshal.

In Soviet custody, Paulus joined the National Free Germany committee to agitate against the Nazis and he later testified at the Nürnberg trials. After his release in 1953, he settled in east Germany and publicly attacked the west German government for its rearmament and pro-United States policies. Paulus died in Dresden on Feb. 1, 1957. (P. N. T.)

PAULUS (older form PAULLUS), **LUCIUS AEMILIUS,** surnamed MACEDONICUS (*c.* 229–160 B.C.), Roman general, a member of a patrician family of the Aemilian gens, son of the consul of the same name who fell at Cannae. Consul for the second time in 168, he finished off the Macedonian war at Pydna (June 22), and with the help of 10 commissioners organized the country as a Roman province. The captive king Perseus was shown at his triumph. Paulus was censor in 164, and died in 160 after a long illness. At the funeral games exhibited in his honour the *Hecyra* of Terence was acted for the second and the *Adelphi* for the first time. An aristocrat to the backbone, he was yet beloved by the people. Of the vast sums brought by him into the Roman treasury from Spain and Macedonia he kept nothing to himself, and at his death his property scarcely sufficed to pay his wife's dowry. As a general he was a strict disciplinarian.

See Plutarch, *Aemilius Paulus;* Livy xliv, 17–xlvi, 41; Polybius xxix–xxxii

PAULUS DIACONUS (PAUL THE DEACON) (c. 720–?799), the historian of the Lombards, came of a noble Lombard family in Friuli, and was educated at the royal court at Pavia. During the reigns of Ratchis and Desiderius he remained in close contact with the royal family. He taught Desiderius' daughter Adelperga and probably folloned her to Benevento after her marriage with its duke; he composed for her his first historical work, the *Historia Romana* (ed. by A. Crivelluci, 1914), an expansion and continuation of Eutropius's *Breviarium.* Probably after the collapse of the Lombard state in 774, he entered the monastery of Monte Cassino. In 782 he went to Charles the Great to plead for his brother Arichis who had taken part in an anti-Frankish rising; he thus joined the group of scholars whom Charles had gathered at his court, and became a prominent figure in the Carolingian Renaissance. His interest in classical Latin grammar is reflected in his *Epitome* of Festus' *De verborum significatu,* while his poems (ed. by K. Neff, *Die Gedichte des Paulus Diaconus,* 1908) are outstanding examples of the classical revival. He continued his historical writing with a history of the bishops of Metz, which became a model for later similar histories, and with a life of Gregory the Great. But his greatest achievement was his *Historia Langobardorum* (ed by L. Bethmann and G. Waitz, in *Monumenta Germaniae Historica, Script. rer. Langob.,* II, 1878; also ed. in *usum scholarum;* Eng. trans. by W. D. Foulke, 1907) to the death of Liutprand (744). Based on written sources such as the *Origo gentis Lnngobardorum,* and on oral tradition, which would otherwise have been lost, it is the work of a scholar and a patriot, and remains the most important source of Lombard history. The *Historia* was written in Monte Cassino where Paul had returned by 787, and where he died on April 13, perhaps in 799. His other works include a collection of homilies for the ecclesiastical year, and a commentary on the Rule of St. Benedict.

BIBLIOGRAPHY.—For editions of other works *see* M. Manitius, *Geschichte der lateinischen Literatur des Mittelalters, I,* pp. 263–272 (1911), and for other material, pp. 257–262; W. Wattenbach–W. Levison, *Deutschlands Geschichtsquellen im Mzttelalter. Vorzeit und Karolinger,* II, pp 203–224 (1953) (N R)

PAUNCEFOTE, JULIAN PAUNCEFOTE, 1ST BARON (1828–1902), English diplomat, was the third son of Robert Pauncefote of Preston Court, Gloucestershire. Born in Munich, Ger., on Sept. 13, 1828, he nas educated at Marlborough, Paris and Geneva. and called to the bar at the Inner Temple in 1852. He was for a short time secretary to Sir William Molesworth, secretary for the colonies. and held colonial appointments at Hong Kong and in the East Indies until 1874. He was then legal adviser to the colonial office. and afterward to the foreign office. of which he became permanent undersecretary in 1882. In 1885 he was one of the delegates to the Suez Canal international commission. He was created a knight of the Grand Cross of the order of St. Michael and St. George (1880) and a knight commander of the order of the Bath (1888). Salisbury sent him to Washington as British minister in 1889. He did much during his term of office to maintain friendly relations between the two countries, especially during the Venezuelan crisis. He negotiated the Bering sea fishery dispute (1890–92); he arranged a draft treaty for Anglo-American arbitration and the revision of the Clayton-Bulwer treaty on the subject of the Panama canal known as the Hay-Pauncefote treaty. He died at Washington on May 26, 1902.

PAUPER, a term meaning a poor person. In English and American usage it referred to a poor person in receipt of public relief who thereby lost certain civil rights, including the right to vote. The English poor laws mere transplanted to colonial America. The posting of the names of paupers receiving relief was common. In some states such individuals were refused the right to marry. Most of the practices later came to be considered inhumane and disappeared. The general trend was to discontinue

the use of the term "pauper" in state laws in the United States and to substitute the term "needy person." The economic depression of 1929–33 was largely responsible for eliminating any remnants of the idea that individuals should be blamed and humiliated for being poor and having to seek public aid

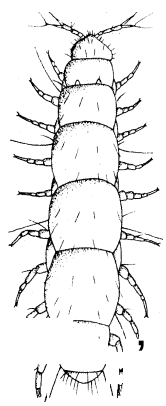
During the early part of the 20th century, U S states developed special categories of public aid for the blind. widows with children and the aged. From 1935 grants to the states under the Social Security act for assistance to the needy aged, blind, dependent children and, from 1950, the permanently and totally disabled resulted in most needy individuals' receiving state assistance as a matter of statutory right However, individuals not included in these four categories had to apply for county or state general relief.

General relief standards vary widely. Federal funds and federal standards applicable to the four categories do not apply to general relief. In some states the responsibility for general relief rests upon the counties with legal, administrative and financial conditions similar to those under earlier poor laws. The poor laws in England were liberalized during the first half of the 20th century and were finally abolished in 1948 in connection with the establishment of a national assistance program.

See POOR LAW; SOCIAL WELFARE; SOCIAL SECURITY; SOCIAL SERVICE.

BIBLIOGRAPHY.—Hilary M. Leyendecker, *Problems and Policy in Public Assistance* (1955), Anne E Geddes and Charles E Hawkins, "Public Assistance" in *Social Work Year Book* (1954). (WR J. C.)

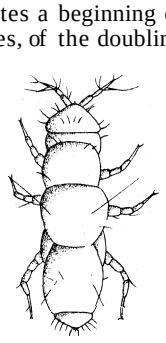
PAUROPODA, a class of many-legged, air-breathing arthropods which superficially resemble tiny centipedes or millipedes. In fact, when Sir John Lubbock announced the discovery of pauropods in 1866, he regarded them through a representative genus *Polyxenus,* as linking forms between centipedes and millipedes. The largest pauropods are only about 1 mm in length, the smallest about 0.5 mm. Their soft, pale or whitish bodies may be found in decaying vegetation upon moist soil; they are quite inconspicuous in this habitat where they feed and lay their eggs.



FROM J LUBBOCK IN TRANSACTIONS

FIG. 1.—PAUROPUS HUXLEYI ADULT SEEN FROM ABOVE (greatly magnified)

The body is composed of 12 segments, but because of the coupling of dorsal plates (tergites) of the first 10 segments, the number appears to be less than 12 when the animal is viewed from above. The adult has nine evident pairs of legs. Pauropods resemble centipedes in body form and in number of legs per segment: one pair of legs is found on each true segment except the last two, which are legless; the legs of segment one are so degenerate (vestigial) that they are hardly noticeable. Fusion of tergites indicates a beginning of the process, carried to completion in millipedes, of the doubling of segments.



FROM J LUBBOCK IN TRANSACTIONS"

FIG 2 — YOUNG PAUROPUS WITH ONLY THREE PAIRS OF LEGS (greatly magnified)

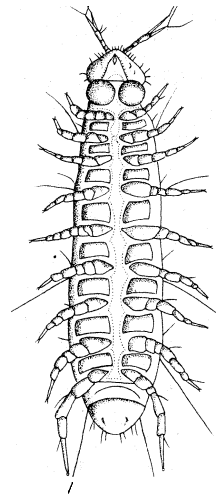
The most distinctive characteristic of pauropods is the possession of branched antennae, a characteristic separating them from other arthropods. Each antenna consists of four segments of which the end one bears two branches; the upper branch is a simple filament of many segments; the lower branch bears two filaments between the bases of which is a characteristic rounded knob (globulus) thought to be a special sense organ. Eyes are absent, but behind the base of each antenna is an eye-like spot (pseudoculus) possibly homologous with the organ of Tomosvary of centipedes. The mouthparts resemble those of millipedes.

The internal structure is relatively unspecialized; pauropods lack both special respiratory and circulatory systems. The simple alimentary canal, though it bears a pair of degenerate excretory tubules (Malpighian tubules). appears to effect excretion chiefly through its own epithelium. As in millipedes the reproductive organs open at the bases of the second legs, males having a pair of penes. From the egg arises a pupoid larva uhich in turn gives rise to a free larva having three pairs of legs. Later larval phases have been observed with five, six and eight pairs of legs.

Pauropods are classified under three families. Pauropododae, Eurypauropodidae and Brachypauropodidae.

BIBLIOGRAPHY.—A good summary is given by K W. Verhoeff in Bronn's *Klassen und Ordnungen des Tier-reichs* (1933–34); and C. Graf Attems in Kukenthal and Krumbach's *Handbuch der Zoologie* (1926).

(R. V. C.)



FROM J LUBBOCK IN TRANSACTIONS

FIG 3.—PAUROPUS HUXLEYI SEEN FROM BELOW (greatly magnified)

PAUSANIAS (5th century B.C.), Spartan regent and commander, of the Agiad family, son of Cleombrotus He succeeded his father as regent for Pleistarchus, the son of Leonidas, in 479 B C. He first distinguished himself as commander of the combined Greek forces in the victory of the Plataea (*q.v.*).

In 478 he was appointed admiral of the Greek fleet, and succeeded in reducing the greater part of Cyprus, the strategic key of the Levant, and in capturing Byzantium from the Persians, thus securing the command of the Bosporus.

Pausanias entered into treacherous negotiations with the Persian king and alienated the Greek forces by adopting oriental clothes, and the haughtiness and inaccessibility of a Persian com-

Pausanias was recalled by the ephors and, though acquitted on the charge of Medism, was not again sent out officially.

He returned, however, and seized Hermione and Sestos, but was dislodged by the Athenians.

For some time he lived at Cleonae in the Troad, carrying on negotiations with Xerxes, but was again recalled to Sparta, where he incited the helots to revolt. When his schemes were almost matured, the evidence of a confidential slave led to the discovery of his plot by the ephors.

Pausanias fled to the sanctuary of Athena Chalcioecus on the Spartan Acropolis; there he was starved to death The date is probably 471–470 B C.

See Herodotus v, 32, ix, 10–88; Thucydides i, 94–96, 128–134, ii, 71, 72, iii, 58; Diodorus Siculus xi, 30–47, 54; Cornelius Nepos, *Pausanias;* Justin ii, 15, ix, 1, 3; Pausanias iii, 4, 14, 17; Polyaenus viii, 51, Aristodemus ii, iv, vi–viii; Athenaeus xii, 535E, 536A; Plutarch, *Cimon* 6, *Themistocles* 23, *Aristides* 11–20, 23.

PAUSANIAS, Greek traveler and geographer of the 2nd century A D, was probably a native of Lydia. It has been stated with perfect justice by J. G. Frazer that "without him the ruins of Greece would for the most part be a labyrinth without a clue, a riddle without an answer"

Before visiting Greece he had traveled widely in Asia Minor, Syria, Palestine, Egypt, Macedonia, Epirus and parts of Italy. His *Description of Greece* takes the form of a tour starting from Attica. It is divided into ten books. (i) Attica and Megara; (ii) Corinth and Argolis; (iii) Laconia; (iv) Nessenia; (v) and (vi) Elis, including Olympia; (vii) Achaea; (viii) Arcadia; (ix) Boeotia; and (x) Phocis, including Delphi. He probably planned to write on the remaining regions as well. The books seem to have been written in the order in which they stand, over a period of about 15 years. No event after about AD. 176 is mentioned.

The work has no formal preface or conclusion The author's aim may be inferred from his statement at the close of his account of Attica: "Such (in my opinion) are the *most famous* of the Athenian *tradztions* and *sights;* from the mass of materials I have

aimed from the outset at selecting the really notable." In the hope of giving variety to the topographical details the author intersperses them with lengthy historical disquisitions. In the subsequent books his account of each important city begins with a sketch of its history; in his descriptions he adopts a topographical order. He gives a few glimpses into the daily life of the inhabitants, ceremonial rites and superstitious customs. He frequently introduces history, legend and folk-lore; but it is only rarely that he allows something of the scenery to be seen.

He was inspired by interest in the ancient glories of Greece and seems to have had little love for Roman rule. He is most at home in describing the religious art and architecture of Olympia and Delphi and was interested in visiting the battlefields of Marathon and Plataea, in viewing the Athenian trophy on the island of Salamis, the tombs of famous men and the colossal lion guarding the tomb of the Thebans on the Boeotian plain.

At Olympia he takes note of the ancient quoit of Iphitus inscribed with the terms of the Olympia truce, the tablets recording treaties and the memorials of victories. At Delphi he marks the trophies of the Athenians, the united Greeks. the Spartans, the Thebans and the shields dedicated in memory of the repulse and defeat of the Gauls at Delphi. At Athens he sees pictures, portraits and inscriptions recording the laws of Solon, on the Acropolis the great bronze statue of Athena, and outside the city the monuments of famous men and of all the Athenians who fell in battle, except the heroes of Marathon, "for these, as a meed of valour, were buried on the field."

In the topographical part of his work, he is fond of digressions on the wonders of nature, the signs that herald the approach of an earthquake, the tides, the icebound seas of the north and the noonday sun which at the summer solstice casts no shadow at Syene (Aswan). His main interest is in works of art: he prefers the works of the 5th and 4th centuries B.C. to those of later times.

In all parts of Greece the accuracy of his descriptions has been proved by the remains of the buildings; but he made appalling mistakes especially when he followed other authors. His style, despite rhetorical artifice, is undistinguished. Pausanias' work was little known in antiquity, but now it is an invaluable guide to the ruins of ancient Greece.

See "Teubner Series" text by F. Spiro (1903); "Loeb Series" ed. by W. H. S. Jones, H. A. Ormerod and R. E. Wycherley (1918–35). Commentary with trans. by J. G. Frazer (1898). (E. Ba.)

PAVANE (Italian PADOVANA, from Padua), a slow 16th century dance in duple or quadruple rhythm. It became important as the first of the 15th century basse danses (popular dances) to enter aristocratic court circles. It traveled to France by way of Spain where its vogue undoubtedly added Spanish characteristics as a result of performances on solemn occasions in the churches of southern Spain. Thus arose the possibly disputable claims of its Spanish origin, and the still widely believed derivation of its name from *pavo* ("peacock"). A stately processional, its basic movements consisted of step close, step close and step, step. step, close, alternately forward and backward. Customarily followed by the lively Galliard, it retained its popularity as a dance until about 1650. (L. Ht.)

PAVIA (anc. *Ticinum*), a town of Lombardia region, Italy, capital of the province of Pavia, on the Ticino about 2 mi. above its junction with the Po, 22½ mi. S. of Milan by rail, 253 ft. above sea-level. Pop. (1951) 57,021. On the right bank of the river lies the suburb of Borgo Ticino connected with the town by a covered bridge (1351–54). The bastions have been transformed into boulevards and gardens.

Monuments. — The church of San Michele Maggiore, originally constructed under the Lombard kings, was burnt in 1004, and the present building dates from the latter part of the 11th and the first half of the 12th centuries, and was completed in 1155. The lower part of the facade is adorned with three fine portals and with reliefs in sandstone, and has arcading under the gable. The dome is octagonal. The interior is vaulted and has eight pillars and a mosaic pavement of the 12th or 13th centuries.

The cathedral of San Martino, begun in 1488 by Cristoforo Rocchi, is a vast "central" structure, unfinished until the dome and façade were completed in 1898 according to Rocchi's still extant model.

The church of S. Pietro in Ciel d'Oro, which as it stands was consecrated in 1132, is very similar to S. Michele. The Lombard king Liutprand (711–744), whose bones nere found in 1896, was buried here. In 1923 the remains of Boethius were also placed here.

The Arca di S. Agostino (after 1362) is a sumptuous tomb containing the relics of S. Augustine of Hippo.

The church of S. Maria del Carmine is externally one of the most beautiful brick Gothic churches in northern Italy. S. Francesco has a façade after that of Chiaravalle near Milan. The church of S. Maria di Canepanova with its small dome was designed by Bramante. Near it are three tall, slender brick towers of the Gothic period. S. Teodoro, with a 12th century exterior, has frescoes by Bartolommeo Suardi (Bramantino) after 1507. Outside the town lie the churches of S. Salvatore and of S. Lanfranco Beccari (d. 1189) (12th century) with the saint's tomb by Giovanni Antonio Amedeo (1447–1522), a native of Pavia.

The university was refounded by Galeazzo II. in 1361 on the site of a law school probably founded by Lanfranc, afterwards archbishop of Canterbury (d. 1089), though we find Pavia a centre of study as early as A.D. 825, and it duly celebrated its 1100th anniversary in 1925. The present imposing building was begun by Lodovico il Moro in 1490. Christopher Columbus was once a student there. Volta made there his first electrical experiments. For poor students there are two colleges, the Borromeo and the Ghislieri, founded by S. Carlo Borromeo (1563) and Pope Pius V (1569).

Pavia has iron-foundries and artificial silk and other factories. It is also an important agricultural centre. It lies on the main line from Milan to Genoa (which crosses the Po by a bridge half a mile long), with several branch lines. Barges pass down the Po to the Adriatic or to Milan by canal. Five miles N. of Pavia is the Carthusian monastery of Certosa di Pavia, one of the most magnificent in the world. Its founder Gian Galeazzo Visconti laid the first stone in August 1396, and the nave was then begun in the Gothic style, but was not completed until 1465. The rest of the church with its external arcaded galleries and lofty pinnacles (including the fine dome) and the cloisters were executed in the Renaissance style under Guiniforte Solari (1453–81) with details in terra-cotta of great beauty and richness. Giovanni Antonio Amedeo was chief architect in 1481–99, and the lower part of the facade was finished in 1507. It is perhaps the finest piece of elaborate and richly adorned Renaissance architecture in existence. In the south transept of the church is the tomb of the founder. In the north transept is the tomb of Lodovico Sforza, il Moro and his wife by Cristoforo Solari. An elegant portal leads into the small cloister; the terra-cotta ornaments surmounting the slender marble pillars are the work of Rinaldo de Stauris (1463–78), who executed similar decorations in the great cloister. This cloister is 412 ft. long by 334 ft. wide and contains 24 cells of the monks, little three-roomed houses each with its own garden. Within the confines of the monastery is the Palazzo Ducale which since 1901 has been occupied by the Certosa museum.

History. — By the conquest of Pavia and the capture of Desiderius in 774 Charlemagne completely destroyed the Lombard supremacy. It was then the centre of the Carolingian power in Italy, and a royal residence was built in the neighbourhood (Corteolona on the Olona). It was in San Michele Maggiore that Berengar of Friuli, and his successors down to Berengar II. and Adalbert II., were crowned "kings of Italy."

Under the reign of the first the city was sacked and burned by the Hungarians. At Pavia was celebrated in 951 the marriage of Otto I. and Adelheid (Adelaide). Laid in ruins by Henry II., who was attacked by the citizens on the night after his coronation in 1004, it none the less closed its gates on Conrad the Salic in 1026.

The jealousy between Pavia and Milan having in 1056 broken out into open war, Pavia had recourse to the emperors, and for the most part it remained attached to the Ghibelline party till

the latter part of the 14th century. From 1360, when Galeazzo was appointed imperial vicar by Charles IV., Pavia became practically a possession of the Visconti family and in due course formed part of the duchy of Milan. For its insurrection against the French garrison in 1499 it paid the penalty in 1500. Having been strongly fortified by Charles V., the city was in 1525 able to bid defiance to Francis I., but two years later the French under Lautrec sacked it. In 1655 Prince Thomas of Savoy vainly besieged Pavia with an army of 20.000 Frenchmen.

The Austrians under Prince Eugène occupied it in 1706, the French in 1733 and the French and Spaniards in 1743; and the Austrians were again in possession from 1746 till 1796, when it was seized by Napoleon. The revolutionary movement of February 1848 was crushed by the Austrians who held it until 1859.

See C. Dell' Acqua, *Guida illustrata di Pavia* (Pavia, 1900), and refs. there given; L. Beltrami, *La Chartreuse de Pavie* (Milan, 1899); *Storia documentata della Certosa di Pavia* (Milan, *1896*). (T. A.)

Battle of Pavia (1525).—In 1524 Francis I of France, at the head of some 30,000 men, moved into Italy, took Milan and laid siege to Pavia. This city was hard-pressed when Lannoy. Charles V's viceroy of Naples, marched to its relief at the head of a nuinerically slightly inferior force. On Feb. 25, 1525, an attempt was made to join hands with the garrison, but Francis so skilfully deployed his artillery that he took the Spanish attacking column in flank, and drove it back in confusion. Imagining the victory to be his, he set out in pursuit, only to be met by an epoch-making tactical surprise which ended in the destruction of his army, and the capture of himself.

One of Lannoy's generals was the Marquis de Pescaire, a man of genius. He had under his command 1,500 Spanish arquebusiers, and having grasped the true value of the fire-arm had instructed them "without word of command . . . to wheel round, to face about from this side to that, now here, now there, with the utmost rapidity" (Brantôme). When the French cavalry charged they were met by this novel system of defense which threw them into complete confusion. Meanwhile the advance of the French cavalry and infantry had masked their guns, and whilst Francis was held in front by the arquebusiers, Antonio de Leyva, at the head of his garrison, made a sortie from Pavia and fell on his rear.

As the battle of Ravenna (1512) marks the advent of artillerv as the neapon of demoralization, so does that of Pavia mark the superiority of hand firearms over lance and pike. In spite of the lessons of Alfonso d'Este at the first and of Pescaire at the second, it took many years of bloodshed before European armies grasped their meaning.

See also Index references under "Pavia" in the Index volume.

See Brantôme, *Hommes Illustres;* J. F. C Fuller, *British Light Infantry in the Eighteenth Century; The Cambridge Modern History,* vol. ii, 1903. (J. F. C. F.)

PAVIA Y ALBUQUERQUE, MANUEL (1828–1895), Spanish general, born at Cadiz, Aug. 2, 1828. Lieutenant in 1846, captain in 1855, and major in 1862. he joined the staff of Marshal Prim in 1865, shared in the unsuccessful revolutionary movements of 1866, and after two years of exile, in the successful revolution of 1868.

After the abdication of Amadeus, Pavia put down the Carlists and the chief cantonal insurrections of the south. He hoped to realize with Castelar a dictatorial, military, and political republic which would rally round its standard all the most conservative groups. The plan was interrupted by the military *pronunciamiento* for the purpose of dissolving the Cortes of 1873. On Jan 3, 1874, Pavia made his *coup d'état;* master of the situation after the *pronunciamiento* but free from personal ambition, he sent for Serrano to form a Government with Conservatives and Radicals of the revolution. He died on Jan. 4, 1895.

PAVLOV, IVAN PETROVICH (1849–1936), Russian physiologist. achieved world renown for his researches on blood circulation. the action of the digestive glands and the formation of conditioned reflexes He was awarded the Nobel prize in 1904 for his work on the physiology of digestion, but his name is known far beyond scientific circles for his systematic experimental studies of conditioning of dogs and other animals. These studies, begun in 1902, profoundly influenced the experimental psychology of learning, while his discovery of techniques for creating "experimental neuroses" in dogs did much to pioneer the scientific approach to the study of human mental disorders. Although Pavlov was unrivaled in the surgical skills and objective methods of animal experimentation, his theory of the cerebral processes in conditioning was much criticized, and his later extension of conditioning principles to account for complex human mental processes, such as language, lacks validity.

He was born in Ryazan on Sept. 14, 1849, the son of a priest. After four years spent at the Ryazan seminary, he studied science, then medicine, at the University of St. Petersburg (Leningrad). Having graduated as doctor of medicine (1883), he worked in Germany (1884–86) under two great physiologists. Karl F. W. Ludwig and Rudolf Heidenhain. On returning to St. Petersburg, his first major appointment was to the chair of pharmacology at the Military Medical academy in 1890. In 1891 he directed the construction of the first surgical department in the world to be set up in a physiological laboratory, at the new Institute of Experimental Medicine.

In 1895 he became professor of physiology at the Military Medical academy. His honours included election as member of the Russian Academy of Sciences (1906), foreign member of the Royal society (London. 1907) and honorary fellow of the Royal College of Physicians (London! 1928). His first publications, on blood circulation, date from 1878, and his major work on the physiology of digestion appeared in Russian in 1897 and subsequently in German. French and English. The account of his 25 years of experimental work on conditioning became available in English first through G. V. Anrep's translation (1927) and W. H. Gantt's (1928).

From 1928 until his death Pavlov concentrated upon applying his conditioning principles to the problems of the psychiatric clinic, as is described in a second book translated by Gantt (1941).

Pavlov died in Leningrad on Feb. 27, 1936. After his death, his conditioning theory and account of cerebral activity retained considerable influence over research in the U.S.S.R. on the higher nervous activity of man. The essence of the Pavlovian approach to the study of complex mental processes is its emphasis on objective experiment, its rejection of the subjectivity of older traditional psychology and of the mind-body dualism supposedly inherent in it.

Pavlov's works available in English include *The Work of the Digestive Glands,* translated by *W.* H. Thompson (1902); *Conditioned Reflexes,* translated and edited by G. V. Anrep (1927); *Lectures on Conditioned Reflexes* translated by W. H. Gantt (1928); and *Conditioned Reflexes and Psychiatry,* translated and edited by W. H. Gantt (1941). *See* also A. G. Ivanov-Smolenski, *Essays on the Pathophysiology of the Higher Nervous Activity* (English translation, 1954). Gantt's two translations are introduced by useful biographical sketches.

See also CONDITIONING; NEUROSES, EXPERIMENTAL; LEARNING; etc. (K. R. H.)

PAVLOVA, ANNA (1881–1931), Russian ballerina, the most celebrated dancer of her time was born Jan. 31, 1881, in St. Petersburg. She studied at the Russian Imperial Ballet school under Ekaterina Vazem and Paul Gerdt, graduating as soloist in 1899. Seven years later, after triumphs in *Swan Lake* and *Giselle,* she mas named prima ballerina. She participated in Diaghilev's first Paris season, 1909, but, dissatisfied with her position in the company, she soon withdrew.

In 1910, with Mikhail Mordkin as her partner, she appeared with sensational success at the Palace theatre, London, and Metropolitan Opera, New York city.

Forming her own company, Pavlova began the series of world tours which continued until her death. Before World War I. she returned regularly to the Mariinsky theatre, St. Petersburg. She appeared in all the principal countries of North and South America, Europe, Africa and the orient, bringing the art of ballet to numerous communities where it was unknown, and inspiring many

young dancers. She made her home in London with her husband and manager, Victor Dandré. She died Jan. 23, 1931 at The Hague.

Pavlova's repertoire consisted chiefly of classic ballets, including *Chopiniana, Don Quixote* and *Coppélia.* Her iavourite was *Giselle.* Her superb performance of the famous solo. *The Dying Swan,* created for her in 1905 by Michel Fokine, was legendary.

See Victor Dandré, *Anna Pavlova* (1932); Arthur H. Franks, *Pavlova, a Biogruphy* (1956). (LN. ME.)

PAWNBROKING is the business of advancing loans on the security of goods or chattels. The precise definition of the trade depends on the legislation by which it is regulated. In Great Britain, for example, pawnbroking relates to loans not exceeding fro in a single transaction; lending in excess of this figure is governed by the Moneylenders' acts of 1900 and 1927. There are precise conditions as to the right of the borrower to redeem articles pledged, and of the pawnbroker to dispose of forfeited goods.

From the middle ages to the 20th century pawnshops have attracted the custom of a declining aristocracy. Jewellery and plate form the typical collateral for such loans. In the 19th century the small middle class joined the aristocracy in these transactions as principal borrowers. At the same time, a far poorer class of customers has been in the habit of pledging clothing, bedding and cheap personal effects. In Great Britain the latter is termed by pawnbrokers the "industrial," the former the "city." trade.

The trade of the pawnbroker is one of the oldest known to mankind. It existed in China 2,000 to 3,000 years ago. Greece and Rome were familiar with its operation: they laid the legal foundations on which modern statutory regulation is built. The forces which nurtured pawning, particularly among the poor. were need, habit and convenience. The industrial trade in the 19th and 20th centuries nas fed neither by extreme poverty nor by severe unemployment, but by the continuing pressure of family incomes low enough to stimulate borrowing, while regular enough to enable borrowers to redeem pledges. Moreover, occasional interruptions of earning by unemployment and sickness contributed substantially to the growth of pawning. The convenience of having a pawnshop near by and the habit which grows from the first failure to live within current income strengthened the bond between pawnshop and borrower. It is said that the first half of the 20th century witnessed an important growth of borrowing in Great Britain by the middle class, for example, black-coated workers.

In the 20th century, after a long period of income redistribution and growing social service benefits. it became difficult to assess the relative importance of the various motives which led people to the pawnshop. The meaning of the word "necessity" is very elastic; its boundaries can be made to extend to any reduction in the real income of the indigent. But as long as low incomes. temporary difficulties and shiftlessness among poor and rich alike continue to stimulate demand for borrowing, there will doubtless be willing lenders. The disappearance of the pawnbroker would in many instances enforce readjustment and a new discipline among the poor; in other cases it might promote the growth of different forms of small-scale lending beyond the reach of present legislation. The same thing applies to those who have insufficient or inadequate articles to pledge: this situation might breed an equivalent to the "dolly shop." Such dolly shops specialized in the very small loan. too small to be a commercial proposition under the usual conditions.

It would be impossible to estimate to what extent illegal forms of lending still exist. but they can hardly be of anything like the same magnitude, at least in Great Britain. as they were in the past. In the first half of the 19th century, for example. there are said to have been many hundreds of unlicensed pawnshops in London. They made very small loans at very high rates of interest, without always taking in pledges. In Germany this type of business evaded legislation by assuming the form of resale, the debtor selling his pledge to the lender and repurchasing it after an interval at an enhanced price. In the late 1870s attempts were made by legislation to stop this practice by declaring transactions of this nature to fall under pamnbroking regulations. The Netherlands tried to meet an analogous need by setting up a special type of public institution prepared to make very small loans of short duration with a minimum of formalities.

HISTORY OF PAWNBROKING IN THE WEST

Pawnbroking in the west traces its origin to three different institutions which existed in the middle ages: private pawnbrokers, public pawnshops and *montes pietatis.*

Private Pawnbrokers. — The first person to satisfy the needs of his contemporaries for small consumption loans was the private pawnbroker. Csury laws in most countries prohibited the taking of interest. Pawnbroking was therefore carried on chiefly by classes exempt from these laws by religion or regulation: Jews everywhere, Caorsins in France. Kauersins in Germany and Lombards in England and the Low Countries (the three golden balls. traditionally the pawnbroker's trade sign, once denoted the establishment of a Lombard merchant). In these transactions. the pledge represented legal evidence of debt, as is known from an Augsburg municipal law of 1276 regulating the trade of Jewish pawnbrokers. To the expansion of economic activity between the 12th and the 14th centuries corresponded a considerable increase in pawnbroking. Not only the poor and needy but also the well-to-do made use of pawnshops and were ready to pay rates of interest ranging up to 86% a year. Such rates were stigmatized as exorbitant exploitation and gave rise to periodic riots and violence against Jewish and other pawnbrokers. Attempts were made by public authorities to limit rates of interest. Florence in 1413 laid down a maximum rate of 15% but found control of transactions at that level impossible and had to raise it to 20% five years later. In another determined attempt the Florentine authorities in 1469 refused to renew the licences of moneylenders of any kind, but this merely drove intending borrowers to seek accommodation outside the town at rates of 30% or more. By this time the church was adapting its law to the realities of the secular world. While maintaining its prohibition against pure interest, it condoned remuneration given to lenders for damage suffered or profit forgone.

Public Pawnshops. — Much as public authorities deprecated the practices of private pawnbrokers, they realized the social need to which pawnshops ministered. Exploitation could be effectively prevented only by provision of alternative facilities for obtaining consumption loans. and as early as 1198. Freising, a town in Bavaria. set up a municipal bank which accepted pledges and made loans against moderate interest charges. Salins in Burgundy followed in 1350, and Michael of Northburgh. bishop of London, established a similar institution in 1361; municipal pawnshops were founded at Frankfurt (1402), Florence (1473), Nuremberg (1498) and Augsburg (1591). In all these establishments charges in the form of limited interest or fees were levied merely with a view to covering costs; if profits were made, they went to public funds. However much they embodied a modern concept of social service. all these pawnshops enjoyed only a comparatively short existence; their moderate charges did not cover the risks incurred in this type of business.

Montes Pietatis. — Provision of social services in the middle ages was even more a task for the church than for public authorities. Canon law enjoined the faithful to refrain from usury, but the church saw the need for institutions to make lawful loans to indigent debtors. The Friars Minor (Franciscans) in Italy were the first to establish *montes pietatis (mons* denoted any form of capital accumulation), which were charitable funds to grant interest-free loans, secured by pledges, to the poor; the money was obtained from gifts or bequests. Barnabas, a Franciscan, raised the first *mons pietatis* at Perugia in 1462; others were founded at Turin (1519), Rome (1539), Bruges (1572) and Avignon (1577). Here again, the charitable intentions of the founders were frustrated by the economic difficulties. In order to prevent premature exhaustion of funds *montes pietatis* saw themselves compelled to charge interest, usually at rates between 4% and 12%, and to sell by auction any pledges which had become forfeit. These modifications raised the question of how far *montes pietatis* themselves offended against the usury laws. The fifth Lateran

council in 1515 recognized montes *pietatis* as charitable institutions. and Pope Leo X issued a bull to this effect which authorized any charges necessary to cover expenditure. However, a number of these *montes*, especially that in Rome, developed into large-scale clerical banks. receiving deposits at interest and lending money to popes and foreign princes.

18th and 19th Centuries. — Many states reverted to public pawnshops as a means of preventing exploitation of the poor in the 18th century. The structure of national states had been sufficiently strengthened to bear the financial and administrative weight of institutions incurring considerable financial risks. Municipal establishments often enjoyed national backing, as for instance the Imperial Pawn office in Vienna, set up in 1713 with funds donated by Charles VI.

In Russia the mint made loans on gold and silver plate from 1733 onward, and state mortgage banks were authorized in 1754 to lend on the security of pledges. The Spanish Netherlands (the future Belgium) had a tradition of interlinked public pawnshops in the main towns going back to 1618, making loans at 15% or less, not only for public assistance but also on a commercial basis, and receiving deposits at 6¼%. A local pawnshop in Paris in 1777 was converted by Louis XVI into a municipal institution on the strong recommendation of Jacques Necker, the minister of finance, who wanted an instrument for fighting social unrest.

Public pawnshops everywhere suffered a decline toward the late 18th century because to the liberal thought of the period limitation of interest represented restriction, and the use of public funds stood for state monopoly. Thus, it was thought, trade would be prevented from finding its own level through the operation of free competition. The armies of revolutionary France carried this doctrine into practice wherever they went. Not only was complete freedom of trade in pawnbroking introduced in France, but in Italy and the Spanish Netherlands Napoleon confiscated as enemy property both the capital and the stock of pledges found in public pawnshops. However, France itself in 1804, and most of the other states as soon as they had freed themselves from French domination, reverted to a system of public pawnshops, having found complete freedom in this business harmful to debtors. The only state which made an attempt at a later date to reintroduce unrestricted pawnbroking, subject neither to licence nor limitation of interest rates, was Prussia where this system prevailed from 1869 to 1879.

At mid-20th century the public pawnshop predominated in the majority of countries on the European continent, sometimes alone, sometimes side by side with private pawnbrokers. A typical example was the Paris Municipal pawnshop, an establishment with 4 main and 22 subsidiary offices, employing a staff appointed by the state from candidates proposed by the municipality. Working capital was obtained through deposits, for which interest was paid at rates varying from 1% to 3%. Its profits, like those of other French municipal pawnshops, were applied to charitable purposes. On a similar scale was the Vienna Municipal pawnshop (known as the Dorotheum), which acquired 18 branches all over Austria by absorbing a large number of other Austrian municipal pawnshops unable in the 20th century to continue on their own. In Switzerland, where federal law in 1907 created a framework within which pawnbroking remained a matter for regulation by individual cantons; one canton (Berne) managed its own pawnshop, two (Basle and St. Gallen) transferred this task to municipalities, others to banks or establishments set up for the purpose (*e.g.*, at Zurich, Geneva, Lausanne, La Chaux de Fonds and Lucerne), while two cantons (Basle and Solothurn) had licensed small private pawnbrokers.

Holland until the early 19th century looked upon pawnshops as sources of municipal revenue, but a royal decree in 1826 made them into charitable institutions and placed them under state supervision. Apart from one public pawnshop leased to a private contractor, Dutch establishments were managed by the municipalities.

Many countries conduct pawnbroking in semipublic institutions, again 'on a nonprofit or often a purely charitable basis. This at least was the intention with which the royal chaplain in Madrid established a mons *pietatis* in the early 18th century, but it quickly degenerated into a mere moneylending establishment. Pawnshops in the larger cities of Spain and Portugal were later amalgamated with the public savings banks. The Assistenthuis at Copenhagen, Den., existing in a country otherwise served by private pawnshops, was financed by the Royal Naval hospital. In Russia pawn banks established in 1772 were affiliated to the foundling hospitals in St. Petersburg and Moscow.

MODERN CONDITIONS AND REGULATIONS

Whether in a public or semipublic pawnshop, the problem arises how, in the absence of a profit motive, the institution is to be safeguarded against losses arising from overvaluing of pledges or default by borrowers. The modern solution is usually an appraisal of articles offered as pawns by assessors acting under oath; in some countries, assessors are held personally liable for any difference which arises between the valuation price and the proceeds of an eventual sale by public auction. This practice leads to deliberate undervaluation by assessors anxious to avert compensation claims. The loans granted may not exceed 75% to 80% of the assessed value plus the interest expected to accrue.

Europe. — Modern developments provided pawnshops with new tasks, and many institutions adapted their business methods to new requirements. The Monti di Pietà in Rome and Milan established physical laboratories, using the most modern techniques of radiography and microphotography, for determining and certifying the precious metal content of plate and other articles, whether submitted as pledges or merely to provide owners with an authoritative statement of their value. French municipal pawnshops accepted in pawn new merchandise which could be sold after three months if the borrower made a special request to this effect. From 1891 onward the Paris Municipal pawnshop accepted as pledges recognized stocks and bonds (as did the State Loan office in Berlin at most times in the 20th century) and after 1918 motorcars, with the result that its premises had to be expanded to include a huge garage. So reasonable are the charges of the Paris establishment that many well-to-do people prefer pawning their silver when leaving town for the summer to hiring the necessary space in a safe deposit. The practice of depositing valuables with the pawnbroker for this purpose is also known in Great Britain.

Great Britain. — In English-speaking countries exclusively, and in many other countries at least to some extent, pawnbroking is carried on by private individuals as a trade licensed and supervised by the authorities. The nature of this trade and the basis on which it operates may be treated in terms of the kind of goods that are pawned, the type of customer it attracts and the typical size of loan that is made.

In Great Britain between 60% and 75% of the number of pawnshops are engaged in the industrial trade; *i.e.*, three-quarters or more of their lending is advanced on "napery and drapery." The characteristic loan, in common with other prices, became higher in nominal terms after World War II. It did not, however, often exceed £2 and the characteristic sum was in the range of 10*s*. to 15*s*. In the city trade the situation is very different and the average loan much higher. The industrial pawnbroker makes some loans on jewellery, usually of relatively low value: and on a wide range of personal effects. There are also pawnbrokers who engage in a mixed trade, with a substantial proportion of pawnbroking of the nonindustrial kind.

Historically, the person who was the backbone of profitability in industrial pawnbroking in Great Britain was the habitual borrower. The basis of the trade in its heyday, from about the middle of the 19th century until 1913–14, consisted of a very large volume of pledging, backed by a very high rate of redemption and turnover. It is still typical of this trade. although on a reduced scale. that the regular pawner should bring in goods on Monday and Tuesday and redeem them on Friday or Saturday. Many articles which are eventually redeemed remain in pledge for considerably longer periods, but there is a large substratum of weekly trade. At the beginning of the week funds are raised; at the end of the week, when wages are received, goods are redeemed. There are also seasonal fluctuations; a great deal of clothing, for example,

is redeemed just before bank holidays and pawned again after them. Investigations of German pawnbroking revealed a similar weekly periodicity with increases in business activity during the summer holiday season, just before quarter days and after holidays. Much pledging takes place at the time of the year nhen families stock up with fruit, potatoes and coal, whereas the beginning of aintry weather serves as a signal for much redemption of wearing apparel.

The fundamental attractions of pawning as a means of borrowing money, apart from any consideration as to the rates of interest which may be charged. are that sums may be raised on personal effects which might be less suitable as security in other forms of borrouing, and that these may be constantly "turned over" nithout final sacrifice of the article. The charges allowed to be imposed are limited in Great Britain by statutory regulation, namely, the acts of 1872 and 1922. The latter introduced only a quite minor modification in permitted charges.

No pawnbroker in Great Britain, however. confines himself to the business of pawnbroking strictly defined. There is always a section of his activity which is concerned with straightforaard retail trade. This, in turn. tends to be of different types. Part of it consists in the sale of secondhand articles represented by forfeited pledges from the same pawnshop or bought at public auction of forfeits. Some will be the sale of new goods. In the industrial trade these are usually clothing and rather cheap personal effects; in the city and mixed trades, there is jewellery and a heterogeneous collection ranging from umbrellas to binoculars. In many cases the pawnbroker's retail interests developed independently and extensively so that the pawnbroking establishment became a minor appendage of the business as a uhole. Indeed, the two sections have become entirely separated in some cases

Since the charges which a pawnbroker may make are regulated, the absolute amount of his gross profit is determined by the volume of lending. This will be governed by the average size of the loan and the rate of turnover of monies lent: *i.e*, the rate at which goods are redeemed. This involves the related point of the profit or loss which may accrue on articles sold after forfeiture. It is precisely because charges and average loan in the industrial trade, taken together, yield small absolute profits, particularly with charges remaining fixed in a world of rising money incomes and prices, that the basis of high profits would have to be a large volume of pledging coupled with a high rate of redemption of goods. The Hamburg. Ger.. pawnshop, a municipal institution, investigated over a period the actual rate of redemption of all pledges received. It discovered that between 70% and 80% of all pawns were redeemed within the statutory time, though many not by the original borrowers but by purchasers of pawn tickets. For 15% to 20% of the pledges, an extension of the contract was arranged by mutual agreement. Less than 4% of the total stock of pawns was forfeited and subsequently sold by the pawnshop.

For Great Britain, it has been estimated that the gross profit rate on total lending during the year rarely exceeds 7% and tends usually to be less. while the gross margin on loans outstanding probably ranges between 30% and 50%. The same author calculated that the typical pawnbroker in the industrial trade averages annual gross loans of betueen f10,000 and £15,000, with a minimum of £5,000 and a maximum of £20,000.

The number of pledges taken in a week by a single industrial pawnbroking establishment is estimated to vary from 300 to 600, the number held at any time from 1.500 upward, with a minimum value at pledge prices of about f1,200. The total volume of annual lending by all pawnbrokers in Great Britain is estimated to be about £20,000,000 on 2j 000.000 pledges with about 3,000,000 pledges representing £2,500,000 outstanding at any one time. This would imply a total of 400.000 persons availing themselves of panning facilities in a year, with an average indebtedness at any time of about £6.

Pawnbroking has been among the most stringently regulated of trades. This regulation has rarely been completely abandoned, even when the general climate of the economy has been freest from the atmosphere of restriction. Apart from the influence of general policies. special reasons have been adduced for controlling this particular trade. Licensing and control of pawnbroking owe their origin to the desire to legislate in usury *as* such. to the fear that the pawnbroker might be a receiver of stolen goods and to an attempt to control interest rates in a sector where the customer was thought to be peculiarly susceptible to exploitation by virtue of his ignorance and poverty. Pawnbrokers themselves were acutely interested in regulation of the trade, both as regards reform of the hostile provisions included in the acts relating to it in Great Britain until 1872, and also perhaps in order to prevent the trade from being associated by public opinion with the dolly shop and similar institutions.

The national and local associations of pawnbrokers in the 19th century engaged in vigorous campaigns to gain support for legislation more favourable to their trade. It is interesting to note, however, that there was a division of opinion among pawnbrokers between those who favoured freedom of trade and those who adhered to the view that regulation of charges was advisable. Changing economic conditions induced pawnbrokers to seek authority to make higher charges than those permitted by the act of 1872. A relatively small additional charge was authorized by an act of 1922. There has been a good deal of discussion in the trade about the advisability of seeking further changes in the law relating to charges. This question is particularly important for industrial pawnbrokers.

The number of pawnshops in England and Wales was about 650 at the beginning of the 19th century. In 1848–49 there were 1,837 in Great Britain (England. Scotland and Wales). These figures exclude very substantial numbers of unlicensed establishments. The number of licences issued in 1913–14 (one per pawnshop) was 5,087. A steady decline followed; the number issued in 1949–50 amounted to 1,654. The decline after 1938 affected with particular severity some of the major industrial towns. The percentage fall in the number of pawnshops has been well above the average for the country as a whole in Birmingham, Sheffield and Rotherham, and Glasgow, for example; it has been below the average in Liverpool and very slightly above it in London. The major decline has been in the industrial trade; pawnbroking with a substantial element of city trade fared quite differently. Indeed, the characteristic features of the trade are the growth in relative importance of straightforward retailing and the fall in the share of industrial pawnbroking in the trade as a whole. The volume of pledge trade has fallen much more than the money value of pledges. The latter has been cushioned by rises in the amount of individual loans. Nevertheless. both volume and value are very much smaller than in, say, the 40 years preceding World War I. The decrease in the importance of pawnbroking in Great Britain is attributable to changes in both demand and supply conditions.

Demund Conditions.—Certain types of social policy helped to reduce the demand for loans by mitigating the effects of temporary interruption of earning power. Old-age pensions have probably been relatively unimportant because many of the recipients had few articles to pawn and little means of redeeming them. Family allowances, since they enabled beneficiaries to carry on until payday. are more likely to be significant. Slum clearing which removed former borrowers some distance from the pawnshop impaired the appeal of convenience and at least reduced the frequency of their visits to the pawnshop. Full employment and high wages, enabling young people to grow up in an environment removed from memories of unemployment, helped to break the traditional connection betn-een the pawnshop and the poor.

Multiple stores selling relatively cheap clothing and other consumer goods may have further reduced demand for loans by enlarging opportunities for the easy acquisition of durable and semi-durable consumer goods. Instalment buying and schemes operated by retail stores may have contributed further, although credit trading of various kinds was known long before the decline set in. There has been a change in consumer attitude, expressed in a strong disinclination to become involved in traditional modes of living by habitual pawning.

Supply Conditions.—Pawnbroking in the smaller industrial es-

tablishments is an arduous occupation. A suitable staff is hard to obtain, the more so because the trade is unpopular. All expenses have risen, while interest charges'are held at the old levels. Returns do not compare favourably with what might be earned in straightforward retailing.

Since the trade attracts practically no new recruits retirement or death of a pawnbroker usually means the disappearance of a pawnshop. Some pawnbrokers allow their pledge business to lapse and concentrate wholly on pure retailing; sometimes individual branches of multiple pawnshops close down. Some pawnbrokers persevere. however, from habit and attachment or because they are too old to move from what may be a fairly comfortable living. This tendency is strengthened by the fact that they might find it extremely difficult to realize their rather specific assets for an acceptable sum.

The experience of pawnbroking in Great Britain after World War I suggests that the factors which are resulting in a falling number of pawnshops are sufficiently deep-rooted to persist in greatly varying general economic circumstances. While the city trade, and mixed pawnbroking which includes a high proportion of high-value pledges, have a substantial basis, industrial pawnbroking as such has not. A worsening of the economic condition of the poorer sections of the community may improve the business of the present industrial pawnbrokers and slow down the rate of decline in their numbers.

United States.—In the U.S. pawnbrokers, through their association, have sought statutory sanction from the federal legislature for a draft code of conduct which would outlaw undesirable practices on the part of pawnbrokers. These endeavours. however, remained unsuccessful in the early 1950s. Nowhere, however, has pawnbroking been more carefully investigated, both from the social and statistical points of view, than in the U.S. In the field of small loans, the importance of pawnbrokers is rivalled only hy unlicensed lenders. whose activities defy both the public authority and the social investigator, and who charge "what the traffic will bear." Pawnbrokers, on the contrary. are subject to regulation and licence everywhere, not under federal law but under state law; hence there is no national uniformity. The earliest state to license pawnbrokers was New York in 1803; the first full statutory regulation of pawnbroking emerged in Pennsylvania in 1823. One state (Ohio) in 1911 authorized municipal pawnshops, but the act remained a dead letter; pawnbroking is undertaken by private enterprise throughout the U.S. However, the idea that consumption loans represented a social service led to a number of semiphilanthropic establishments in this sphere, such as the Pawners' Bank of Boston (later renamed the Collateral Loan society), founded in 1859. and the Provident Loan society of New York, set up by wealthy citizens in 1894 along the lines of the British Charity Organization society. Such establishments were not purely charitable, but they limited their profits and charges to a moderate rate. With kindred institutions in other states, they eventually formed a National Federation of Remedial Loan Associations to raise their activities to the level of a social service. Private pawnbrokers operating on purely business lines constituted themselves into the National Federation of Provident Loan Associations to protect their own interests, above all in dealing with proposed legislation.

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(A. L. M.; W. M. SN.)

PAWNEE, an Indian tribe on the Platte river, Neb., from before the 16th to the latter part of the 19th century. They spoke a language of the Caddoan stock, and lived by farming and hunting, raising corn, squash and beans and hunting grazing animals, principally the bison. In their permanent villages they lived in large earth-covered lodges. but on bison hunts they used skin tepees. For hunting, travel and transport they used horses obtained in the 17th and 18th centuries from Spanish settlements in the southwest. In the 19th century the Pawnee tribe was composed of relatively independent bands—the Kitkehahki, Chaui, Pitahauerat and Skidi—each divided into more or less endogamous villages with hereditary chiefs and priests. They had a Crow (lineage) type of kinship system, matrilineal descent and matrilocal residence after marriage. which was contracted for a given couple by their maternal uncles. Class distinctions favoured chiefs, priests and shamans. The Pawnee religion was elaborate, including star symbolism and human captive sacrifice. Pawnee culture was broken by the start of the 20th century and the population reduced from about 10,000 to about 600. (G. I. QY.)

PAWPAW (*Asimina triloba*), a North American shrub or low tree of the custard apple family (Annonaceae), native from western New York to Nebraska and southward to Florida and Texas. On rich alluvial soil it grows from 10 to 50 ft. high, with large leaves, sometimes 12 in. long and 6 in. wide, and brown to dark red flowers 1 to 2 in. across. The fleshy fruits, two to five inches long, mature in autumn. Those with orange-coloured pulp are edible and possess a flavour reminiscent of the banana, while in contrast the pale white or yellowish pulps are usually bitter and unpalatable. These two types of fruit are known to legions of American boys who seek the edible forms each fall, yet no botanical distinction between the plants bearing them is made by taxonomists.

PAWTUCKET, a city of Providence county, Rhode Island, U.S., on the Blackstone river (known there as the Pawtucket or the Seekonk), is 4 mi. N. of Providence and adjoins Central Falls. Pop. (1960) 81,001.

The city lies on both sides of the river, which in the heart of the business district makes a picturesque plunge of 50 ft. over a mass of rocks. The name, Pawtucket. is an Indian word meaning "fall of the waters." At one time the river provided power for textile mills. Textiles have been the leading manufactured product for over a century. Almost every branch of the narrow fabric textile industry is represented. There are also plants for dyeing, finishing and spinning. Other manufactures include wire and cable products, machine tools and textile machinery.

The river was continuously improved by the federal government after 1867; there is a 16-ft. channel all the way to Narragansett bay. A six-lane highway bridge over the river at Pawtucket was completed in 1958.

The first settlement within the present city limits was made on the west side of the river about 1671 by Joseph Jencks, an iron worker. His manufactory, destroyed in 1676 during King Philip's War, was rebuilt and soon the village became a centre for skilled and inventive iron mongers. In 1790, Samuel Slater found there the mechanical skill and financial support necessary to reproduce the Arkwright machinery for the manufacture of cotton goods. His mill, the first successful factory of its kind in the United States. was preserved as a memorial to the introduction of cotton textile manufacture.

The part of Pawtucket east of the river was originally in Massachusetts and was transferred to Rhode Island in 1862; the section west of the river was annexed to Pawtucket from North Providence in 1874; and in 1885 the town was chartered as a city. For comparative population figures *see* table in RHODE ISLAND: *Population.* (G. *H.* Bs.)

PAX, Roman personification of peace, probably recognized as a deity for the first time by Augustus, in whose reign much was made of the establishment of political calm. An altar of Pax Augusta was dedicated in 9 B.C. and a great temple of Pax completed by Vespasian in A.D. 75 (Platner-Ashby, *Topographical Dictionary,* s.v. *Pax, Ara Pacis*). (R. B. LD.)

PAX, the name given in ecclesiastical usage to a small panel or tablet decorated usually with a representation of the Crucifixion, which in the Roman ritual was kissed at the eucharistic

service by the celebrating priest, then by the other clergy and the congregation. The use of the "pax" dates from the 13th century and is said to have been first introduced in England in 1250 by Archbishop Walter of York. It took the place of the actual "kiss of peace" which was in the Roman mass given by the bishop to the priests. and by them to the deacons and so to the laity, between the consecration and communion, and which survives in symbolical form at High Mass. In the Greek Church the kiss *(eireyn, aspasmos)* takes place before the consecration. and now consists in the celebrant kissing the oblation and the deacon kissing his stole *(see* F. E. Brightman, *Liturgies Eastern and Western* [1896]).

See the *Catholic Encyclopaedia, s.v.* "Pax."

PAXO (PAXI), one of the Ionian Islands *(q.v.)*, Greece, about 8 mi. S. of the south end of Corfu, is a hilly mass of limestone j mi. long by 2 broad, and not more than 600 ft. high. Pop. (1951) 2.664. It produces excellent olive oil. Gaion (or. less correctly, Gaia), the principal village, lies on the east coast, and has a small harbour. Toward the centre. on an eminence, stands Papandi, the residence of the bishop, and there are many churches with picturesque belfries. On the west and southwest coasts are remarkable caverns (Davy, *Ionian Islands,* i, 66-71). Ancient writers apply the plural form Paxi to Paxos and the smaller island now known as Antipaxo (Propaxos of the *Antonine Itinerary).* Paxos is the scene of the legend, in Plutarch's *De defectu oraculorum,* of the cry "Pan is dead."

See PAN.

PAXTON, SIR JOSEPH (1801–1865) English landscape gardener and architect, designer of the Crystal Palace. was born near Woburn, Bedfordshire, on Aug. 3, 1801. In 1832 he was employed in the arboretum of the Horticultural society's gardens at Chiswick. In 1826 he became superintendent of the duke of Devonshire's gardens at Chatsworth and manager of his Derbyshire estates.

Paxton's masterwork was the Crystal palace, London's Hyde park. which housed the international exposition of 1851. It was the realization of an unprecedented new conception of building, being the first of such dimensions (it covered four times the area of St. Peter'sj built of plate glass, iron, timber and prefabricated elements produced in various factories and assembled in London. It arose within six months. The grandeur of its conception far outdistanced the technical possibilities of its time. Its significance was immediately grasped by Paxton's contemporaries: "The Crystal Palace is a revolution in architecture from which a new style will date . . . It is a Midsummer Night's Dream seen in the clear light of midday" (Lothar Bucher, 1851). The Crystal palace was later transplanted to Sydenham (1854), and burned down in 1936. Paxton was an M.P. for Coventry from 1854 until his death at Sydenham on June 8, 1865.

See Violet *R.* Markham, *Paxton and the Bachelor Duke (1935).*

(S. GN.)

PAYA, a tribe of Indians living in northeastern Honduras on the upper part of the Patuca river. Formerly they probably occupied the north coast from Trujillo to Cape Gracias. The linguistic relationship of the Paya tongue is uncertain; there is a tendency to regard the Payas, with their neighbours, the Jicaque, as the northern frontier of South America penetration in Central America.

See Karl Sapper, "Die Payas in Honduras," in *Globus,* bd. lxxv, Heft 2.

PAYMENT, the performance of an obligation. the discharge of a sum due in money or the equivalent of money. In law, in order that payment may extinguish the obligation it is necessary that it should be made at a proper time and place, in a proper manner, and by and to a proper person.

Payment may be made at any time of the day upon which it falls due, except in the case of mercantile contracts. where the creditor is not bound to wait for payment beyond the usual hours of mercantile business. If no place be fixed for payment, the debtor is bound to find. or to use reasonable means to find, the creditor. unless the latter be abroad. Payment must be made in money which is a legal tender, unless the creditor prefers to waive his right to payment in money by accepting some other mode of payment, as a negotiable instrument or a transfer of credit. If the payment be by negotiable instrument, the instrument may operate either as an absolute or as a conditional discharge. In the ordinary case of payment by cheque the creditor accepts the cheque conditionally upon its being honoured; if it be dishonoured, he is remitted to his original rights. If payment be made through the post, in a letter properly directed. and it be lost, the debt is discharged if there was a direction so to transmit the money. Payment must be made to the creditor or his agent. A bona fide payment to an apparent agent may be good, though he has in fact no authority to receive it Such payment will usually be good where the authority of the agent has been countermanded without notice to the debtor. The fact of payment may be presumed, as from lapse of time. Thus payment of a testator's debts is generally presumed after 20 years. A written receipt is only presumptive and not conclusive evidence of payment. If payment be made under a mistake of fact, it may be recovered, but it is otherwise if it be made under a mistake of law. Money paid under compulsion of law, even though not due, cannot generally be recovered where there has been no fraud or extortion. For appropriation of payments *see* DEBTOR AND CREDITOR LAW.

Money may be paid into court to abide the result of pending litigation, as where litigation has already begun, as security for costs or as a defense or partial defense to a claim. Payment into court does not necessarily (except in actions for libel and slander) operate as an admission of liability. Money may sometimes be paid into court where no litigation is pending, as in the case of trustees. The payment of wages to labourers and workmen otherwise than in coin is prohibited. *See* under LABOUR LAW: *Truck Acts.* Domestic or agricultural servants are excepted. *See* also LIMITATION, STATUTES OF

Scotland. — The law of Scotland as to tender of payment agrees with that of England, except that Bank of England notes are not legal tender, and that part payment if accepted in full satisfaction extinguishes the whole debt. Scots laws, however, recognize two presumptions in regard to payment *Debitor non praesumitur donare,* an unascribed payment if accepted by the creditor must be imputed to account of the debt, but where there are several debts the creditor may choose which debt he will impute the payment to. *Donatio non praesumitur* is applied as meaning that where a stranger pays the debt he is presumed to have paid it with the debtor's money. Payment or satisfaction is also presumed from lapse of time, *i.e.,* (1) three years from the last entry in merchant's accounts; *(2)* five years from the tenant's removal in the case of rent; (3) six years in the case of bills; and (4) 20 years in the case of obligations contained in holograph writings. Where a debt is constituted by writ or is the result of a credit transaction, payment cannot be proved by witnesses

United States. — In the United States the law as a rule does not materially differ from English law. In some states, however, money may be recovered, even when it has been paid under a mistake of law. The question of legal tender has been an important one In 1862 and 1863 congress passed acts making treasury notes legal tender *(see* GREENBACKS). After much litigation, the supreme court of the United States decided in 1871 *(Knox* v. *Lee)* in favour of the constitutionality of these acts, both as to contracts made before and after they were passed. These notes are legal tender for all purposes except duties on imports and interest on the public debt. Gold coins were withdrawn from circulation in 1933. They were legal tender before that date. All standard silver dollars are legal tender to any amount. Small silver coins were legal tender only to $10 in one payment and nickels and pennies to 25 cents until 1933, when those limits were removed. It falls exclusively within the jurisdiction of congress to declare paper or copper money a legal tender. By the constitution of the United States, "no State shall . . make anything but gold and silver coin a tender in payment of debts" (art. i. s. 10). A number of U.S. states have by statute or decision departed from the general rule that a receipt in full is insufficient to make an agreed part payment discharge the entire debt. And in this con-

nection it should be noted further that a certified check, though it is commonly accepted as such, is not in fact legal tender.

PAYMENT BY RESULTS. A term used to describe various methods of wage remuneration in which some inducement is held out to the wage earner to increase his pay by increased production. The simplest method is to pay a straight rate per piece, so that the worker draws remuneration in strict proportion to the number of units of output produced by him. Such payment per piece may be accompanied by an agreement to pay a minimum wage whatever the output.

The premium-bonus system is an interesting form of payment by results. The essence of this system is to fix by agreement between employer and employed a basis time for the completion of a definite unit of work. At the same time, the workman is guaranteed a time rate of wage. If the worker accomplishes the unit of work in less than the basis time, he receives, over and above his guaranteed time-rate of wage, an agreed bonus for the time saved. Thus, while the employer gains through a fall in the labour cost of the unit of work with any increase in output, the employee increases his earnings, although not in proportion to the increase of output. *See* also WAGES: *Trends in Wage Levels in the United States*.

PAYN, JAMES (1830–1898), English novelist, was born at Cheltenham on Feb. 28, 1830. He edited *Chambers's Journal* with much success for 15 years. He moved to London in 1861. In the pages of the *Journal* he published in 1864 his most popular story. *Lost Sir Massingberd*. Payn wrote about 100 novels. among the best known being *Carlyon's Year* (1868), *By Proxy* (1878) and *The Talk of the Town* (1885). In 1883 he succeeded Leslie Stephen as editor of the *Cornhill Magazine* and continued in the post until the breakdown of his health in 1896. He died in London on March 25, 1898.

A biographical introduction to his *The Backwater of Life* was furnished by Sir Leslie Stephen.

PAYNE, JOHN HOWARD (1791–1852), U.S. playwright and actor. one of the most notable of the school of American playwrights that followed the techniques and themes of the European romantic blank verse dramatists, was born in New York city, June 9, 1791. A precocious actor and writer, he wrote his first play, *Julia, or, The Wanderer,* when he was 15. The play was successful enough to cause him to be sent to Union college, Schenectady, *N.Y.*, but family financial difficulties made it necessary for him to leave two years later. At the age of 18 he made his first stage appearance in the play traditional for such debuts, John Home's *Douglas*. Although his portrayal of Young Norval was successful, Payne encountered much opposition from established actors—chiefly George Frederick Cooke, a brilliant but eccentric star—and in 1813, at the height of the War of 1812, Payne sailed for England. At first interned as an enemy national, he was later released and triumphed at Drury Lane as Young Norval, repeating his success in other European capitals. In Paris Payne met tno men who were to have an important influence on his career. the actor Talma, who introduced him to French drama, from which many of his more than 60 plays were adapted; and Washington Irving, with whom he was to collaborate on two of his best plays.

Payne's finest play, *Brutus: or, The Fall of Tarquin,* was produced at Drury Lane on Dec. 3. 1818. Although Payne received only £183 for it, *Brutus* was on the boards for 70 years and served as a vehicle for three of the greatest tragedians of the 19th century: Edwin Booth. Edwin Forrest and Edmund Kean. Other important plays were *Clari: or, The Maid of Milan,* which included Payne's famous song "Home, Sweet Home"; *Charles II* (1824), written with Irving; and *Thérèse* (1821), a French adaptation. Because of weak copyright laws, Payne received little return from his successful plays. and in 1842 he accepted a consular post in Tunis, where he died, April 9, 1852.

Although Payne was no innovator, his plays were strong, both in language and structure, and he exerted an important influence on later playwrights. Arthur Hobson Quinn suggests that *Brutus* may have been partially responsible for the emergence of the romantic drama in France under Hugo. (S. W. H.)

PAYNE, PETER (c. 1380–1455), English Lollard and Taborite, the son of a Frenchman by an English wife, was born at Hough-on-the-Hill near Grantham, about 1380. He was educated at Oxford, where he adopted Lollard opinions, and had graduated as a master of arts before Oct. 6, 1406, when he was concerned in the irregular proceedings through which a letter declaring the sympathy of the university was addressed to the Bohemian reformers. From 1410 to 1414 Payne was principal of St. Edmund hall, and during these years was engaged in controversy with Thomas Netter of Walden, the Carmelite defender of Catholic doctrine. In 1414 he was compelled to leave Oxford and taught for a time in London.

Ultimately Payne took refuge in Bohemia, where he became a leader of the reformers at Prague. He joined the sect of the "Orphans," and had a prominent part in the discussions and conferences of the ten years from 1420 to 1430. Payne was one of the Bohemian delegates to the council of Prague. He arrived at Basle on Jan. 4, 1433, and his unyielding temper and bitter words probably did much to prevent a settlement. The Bohemians left Basle in April. The party of the nobles, who had been ready to make terms, were attacked in the diet at Prague by the Orphans and Taborites. Next year the dispute led to open war. The nobles were victorious at Lipau on May 29, 1434, and it was reported in England that Payne had been killed. When soon afterward the majority of the Orphans joined the moderate party, Payne allied himself with the more extreme Taborites.

In Feb. 1437 the pope desired the emperor Sigismund to send Payne to be tried for heresy at Basle. Payne took refuge with Peter Chelcicky, the Bohemian author. Two years later he was captured and imprisoned at Gutenstein but was ransomed by his Taborite friends. Payne took part in the conferences of the Bohemian parties in 1443–44 and again in 1452. He died at Prague in 1455. Payne was also known as Clerk at Oxford, as Peter English in Bohemia and as Freyng, after his French father, and Hough from his birthplace.

BIBLIOGRAPHY.—The chief facts of Payne's English career are given in the *Loci e libro veritatum* of T. Gascoigne, ed by Thorold Rogers (1881) For his later life the principal sources are contained in the *Monumenta conciliorum generalium, saeculi v, saeculi xv* or *saeculi quintodecimi,* vol. I–III (1857–94). For modern authorities consult Palacky, *Geschichte von Bohmen,* vol vii–ix, and Creighton's *History of the Papacy*. The biography by James Baker, *A Forgotten Great Englishman* (1894), is too partial.

PAYSANDU, a department of western Uruguay, bordering the Uruguay river. Although the riverside and hinterland areas of Paysandu were developing agriculturally in the second half of the 20th century, ranching continued to be the department's major activity. Cattle and sheep are raised, and agricultural products include flax, wheat, sunfloner seeds, corn and forage crops. Surrounding farms supply vegetables and poultry to the departmental capital, Paysandu (*q.v.*). Several foreign agricultural colonies were notably successful, especially in southwest Paysandú. Area of the department 5,474 sq.mi., pop. (1954 est.) 101,012.

(M. I. V.)

PAYSANDÚ, a city and port of western Uruguay on the Uruguay river, is 300 mi. N.W. of Montevideo. Capital of the department of Paysandú (*q.v.*), it disputed with its rival to the north, Salto, the claim of being Uruguay's second largest city. One advantage of Paysandu (pop. [1954 est.] 44,000) over Salto, also a river port, is that ocean-going ships must transfer cargo at Paysandu to smaller craft because farther north the Uruguay river becomes too shallow for the draft of the larger vessels. Cereals, flax and livestock products are loaded and merchandise for northwest Uruguay is unloaded at the port of Paysandú; it is built at various levels so that ships can dock despite changes in the level of the river There are rail, road and air connections to the north and southwest to Montevideo.

Paysandú has a relatively varied industrial economy with tanneries, textile factories, flour mills, distilleries and breweries processing regionally produced raw materials. In the second half of the 20th century, modern buildings were changing Paysandú's once provincial aspect.

The city was founded in 1772 by Father Policarpo Sandú

and 12 families of Christianized Indians. Indians translated the Spanish word padre ("father") into the Guarani Indian dialect word pay, from which stems the city's name. (M. I. V.)

PAZ SOLDÁN, MARIANO FELIPE (1821–1886), Peruvian historian and geographer, was born at Arequipa, on Aug. 22. 1821. He studied law, and after holding some minor judicial offices. was minister to New Granada in 1853. In 1860 Castilla made him director of public works. In 1861 he published his great atlas of the republic of Peru, and in 1868 the first volume of his history of Peru after the acquisition of its independence. A second volume followed, and a third, bringing the history down to 1839, was published after his death by his son. In 1870 he was minister of justice and worship under President Balta, but shortly afterward retired from public life to devote himself to his great geographical dictionary of Peru, which was published in 1877. During the disastrous war with Chile he sought refuge at Buenos Aires, where he was made professor in the National college. and where he wrote and published a history of the war, *Historia* de la *Guerra del Pacifico* (1884).

He died at Lima on Dec. 31, 1886.

PEA, English pea, or garden pea, an herbaceous annual of the family Leguminosae that is grown for its edible seeds; the botanical name is *Pisum sativum.* The stems are one to five feet long, hollow, and trailing or climbing. Leaves are pinnately compound, ending in tendrils that enable the plant to climb, and with large leafy stipules at their bases. The flowers are papilionaceous (see LEGUMINOSAE), showy, white or purple, about one inch across: each has nine united stamens and one free; the single pistil has a bearded style. Flowers are self-pollinated, and nectar is secreted at the base of the stamens. The fruit is a characteristic legume, a one-celled, many-seeded pod two and one half to five inches long which splits into halves when ripe; the five to ten seeds are attached by short stalks to the halves of the pod. The seeds are more or less globular and smooth, dimpled, or wrinkled. Ripe seeds of white-flowered forms are cream. yellow or light green; in purple-flowered forms they are brown, gray or flecked with dark colour. The cotyledons are large and roughly hemispherical. Upon germination and emergence of the seedling the cotyledons remain below the soil surface.

The genus *Pisum* is very closely related to *Lathyrus* which is distinguished botanicallp from *Pisum* by its flattened rather than tubular style. It is therefore not surprising that some species of both *Pisum* and Lathyrus are called peas. The fragrant ornamental sweet pea is L. *odoratus* and the Tangier pea is L. tingitanus. Many other legumes that are less closely related to *Pisum* also are called peas of various kinds. among them: the chick-pea, *garbanzo* or Spanish pea (Cicer *arietinum*), the compea (*Vigna* sinensis) (see BEAN), and pigeon pea (*Cajanus indicus*). The common field type of *Pisum* that formerly was classified as P. arvense is now recognized as a form of P. *sativum,* not a distinct species.

Pisum sativum appears to have originated in middle Asia, with secondary centres of development in the near east, in Ethiopia and possibly in Mediterranean lands. Like most food plants, its origin is prehistoric. Remains of the seeds have been found on the sites of Swiss lake-dwellings of the Bronze Age dating back perhaps 5,000 years. There is no evidence that the Egyptians grew this plant; seeds of it have not been found in anp Egyptian tomb. The Aryans are believed to have carried peas to Greece and Italy, whence the ancient Greeks and Romans carried them to the lands under their domination. Remains of the seeds have been found in excavations on the site of ancient Troy.

Some varieties produce pods that are edible; before the seeds enlarge appreciably the flat pods are tender, succulent and sweet. This type of pea is more popular in Europe and the orient than in America. Wrinkled seeded varieties are often called sweet peas because they contain more sugar and less starch than the smooth and dimpled seeded varieties. Split peas for soup consist of only the cotyledons of smooth peas harvested mature dry. In the U.S. peas are no longer grown extensively for marketing in the pod because of the high cost of harvest by hand and competition of the quick-frozen product.

The garden or English pea and field pea (P. *sativum*) are cool season plants that cannot tolerate hot weather. Garden peas have been developed to their highest perfection in England, where they can be grown all summer. The best English varieties are not adapted to the warmer climate of the United States. and the principal varieties grown in the United States are inferior in quality to the best English varieties. Peas can be grown in the lower latitudes (such as the southern United States) only as late fall: winter or early spring crops. The plants will tolerate some frost but not hard freezing.

In Great Britain and northern Europe early peas are grown from November onward through the winter by elaborate cultural methods involving artificial protection and transplanting of seedlings to sheltered locations, but such methods are not used in America, where fall and winter sowings are made far enough south so that hard freezing rarely occurs. Spring sowings in the United States are normally made about a month to six weeks before the average date of the last freeze and are finished before the frost-free date. Peas thrive on a wide range of soils, but the soil should be rich, well drained, well limed, well prepared and kept free of weeds. Inoculation of the seed with pure cultures of nitrogen-fixing bacteria is a generally profitable and common practice. In many pea-growing districts of the United States the soils are so generally infested with a wilt fungus that only wilt resistant varieties can be grown successfully.

For home garden and marketing fresh, either dwarf or tall-vined, large-podded sorts are sown in rows two to four feet apart, depending on the variety. One to two bushels of seed per acre are sown. When grown for home or fresh market the tall varieties are supported on twigs or brush, or on light trellises of twine. In the United States peas for canning or freezing are sown in rows seven or eight inches apart, at the rate of about four bushels of seed per acre. Since they are not cultivated or hoed, the soil must be thoroughly prepared and comparatively free from weeds. These peas are sown with a grain drill and harvested with a mowing machine or special pea harvester, and the entire plants are then passed through a "viner"—a machine that removes the peas from the pods and separates them from all leaves and debris. The shelled peas are hauled to the processing plant and canned or frozen within a few hours. Field peas are for use dry and are also sown in rows seven or eight inches apart. The entire plants are harvested before the seeds shatter from the dry pods, and they are allowed to dry in small shocks or windrows in the field, then threshed and cleaned—all by machinery.

In the U.S. the annually harvested acreage and production of peas is approximately as follows: dry peas. 325,000 ac. and 3,500,000 cwt.; for marketing fresh in the pod, 8,000 to 10,000 ac. and 300,000 cwt.; for freezing, 125.000 ac. and 150.000 tons, shelled; for canning, 325,000 ac. and 350,000 tons, shelled.

(V. R. B.)

BEABODY, ELIZABETH PALMER (1804–1894), U.S. educationist and participant in the Transcendental movement, was born at Billerica. Mass., on May 16, 1804. Educated at a small private school by her gifted mother, as were her sisters Sophia (Mrs. Nathaniel Hawthorne) and Mary (Mrs. Horace Mann), she began her own teaching at 16. Later she was an assistant in A. Bronson Alcott's famous Temple school. of which she published a Record (1835) Although overshadowed by Margaret Fuller. she was one of the leading feminine figures in the Transcendental movement. her West street bookshop becoming a sort of club. In 1860 Miss Peabody opened in Boston the first kindergarten in America. She went to Europe in 1867 to study Friedrich Froebel's methods at first hand, and thereafter through training classes, lectures, magazine contributions and her editing of the Kindergarten *Messenger* (1873–77) she spread the new theories. Her writing reflects her dominant interests. She died at Jamaica Plain, Mass.. on Jan. 3. 1894.

PEABODY, JOSEPHINE PRESTON (1874–1922), American poet, was born in Brooklyn. N.Y., in 1874, and educated at Radcliffe college. In 1898 she published The Wayfarers: *A* Book *of Verse.* Her later publications include *Fortune* and *Men's* Eyes: New Poems with a Play (1900); *Marlowe,* a drama (1901);

Pan: A Choric Idyl (1904); *The Piper,* a play (1909); The Singing *Man* (1911); *The Wolf of Gubbio,* a play (1913); *Harvest Moon* (1916); *The Chameleon* (1917), and *Portrait of Mrs. W.,* a play (1922). *The Piper* won the Stratford-on-Avon prize and was produced at the Memorial theatre at Stratford in 1910. It was subsequently played in New York. Her plays are all poetic in form. She died at Cambridge, Mass., on Dec. 4, 1922.

See *Diary and Letters of Josephine Preston Peabody* (1925); *Collected Poems of Josephine Preston Peabody* (1927); and *Collected Plays of Josephine Preston Peabody* (1927).

PEABODY, a city of Essex county, Mass., 13 mi. N.E. of Boston. The area that now constitutes Peabody was originally part of Salem (*q.v.*) then part of Danvers (*q.v.*) when that community was separated as a district from Salem in 1752. South Danvers became a town in 1855 and in 1868 adopted the name of Peabody to honour George Peabody, the philanthropist who was born and buried there. In 1882 part of Peabody was annexed to Salem. In 1916 Peabody was incorporated as a city. It is a manufacturing centre for leather, shoes, leather machinery and cotton goods. In the early 20th century a number of immigrants, largely from Greece, Ireland, Russia and Poland, settled there. For comparative population figures *see* table in MASSACHUSETTS: *Population.* (J. F. Co.)

PEACE, CHARLES (1832–1879), English criminal, was born at Darnley. He started his career as a Manchester portico -robber, but in 1876 shot P. C. Cook, who attempted to capture him when burgling a house at Whalley Range. Though a man named Habron was sentenced for this (afterwards pardoned on Peace's confession) the police correctly ascribed to Peace the shooting of Arthur Dyson at Banner Cross in a quarrel over a woman. Peace then disappeared from police ken for years; he was in fact living in Evelina road, Peckham, as "Mr. Thompson, a gentleman of independent means," and at nights carried out the series of widespread burglaries which entirely baffled the police. He was arrested almost by accident on Blackheath, the police at first not knowing who he was, and hanged for the murder of Dyson in Feb. 1879. His plea that the killing was accidental in both cases was rejected, popular feeling being bitter against him. After his death he became a legendary figure.

See *The Master Criminal, The Life Story of Charles Peace* (1910); R. W. Postgate, *Murder, Piracy and Treason (1926).*

PEACE, a river of western Canada, which rises as the Finlay river in the Rocky mountains in British Columbia near 55° N., breaks through the mountains and flows northeast into Slave river, near Lake Athabasca in Alberta. The district between 56° 40' and 60° N., and between 112° W. and the Kocky mountains, is usually known as the Peace River district.

In the area of Grande Prairie and Dunvegan some grovelike openings in the forests and a slightly longer growing season than that of the immediately surrounding districts attracted farming settlement. The entire valley is noted for its fertility. The most important crop is wheat, and oats and vegetables are also grown. There are deposits of coal, gypsum and salt in the area.

The Peace River district was connected by railway with Edmonton, and the town of Peace River, Alta., was joined by highway with Dawson Creek, B.C., where the Alaska highway begins.

PEACE, DISTURBING THE: *see* DISTURBING THE PEACE.

PEACE, INTERNATIONAL has been regarded since the beginning of history as a blessing and its opposite, war, as a scourge. Yet it is only since the end of the middle ages that philosophers and statesmen have reflected systematically on the problem of peace. Attempts to put international peace on a secure basis on a world-wide scale through deliberate political action had to wait until the beginning of the 19th century.

Both movements, the speculative and the practical, were stimulated by political catastrophes which demonstrated the urgent need for making international peace secure. Men started to speculate about new forms of international organization after the rise of the territorial state had deprived the Holy Roman empire of its political functions as the international organization of Christendom. Where could a substitute for this lost political unity, safeguarding at least a modicum of peace and order, be found? This question mas posed by Erasmus in the 16th century, by Sully, Émeric Crucé, Hugo Grotius and William Penn in the 17th, and by the Abbé de St. Pierre, Rousseau, Bentham and Kant in the 18th. Their answer was generally couched in terms of international law or of an international organization based upon international law.

The political measures of modem times to make international peace more secure had their starting point in the experience of the Kapoleonic Wars. That experience had a dual impact upon the international order of the modern world.

The Napoleonic Wars destroyed the balance of power which had been the foundation of international peace and order since the end of the middle ages and threatened to replace it with a universal empire which, while it might assure peace temporarily, might destroy freedom forever. The Napoleonic Wars also brought to victory the idea of nationalism which threatened to destroy the old dynastic order and to usher in an unending series of international crises and wars.

To these political factors which stimulated the search for a practical solution to the problem of international peace must be added three others: spiritual, moral and intellectual.

From the time of the Stoics and the early Christians there has been present in western civilization a feeling for the spiritual unity of the western world which, in order to realize itself, is in need of a political organization commensurate with it. The Roman empire was such a political organization of universal scope. It remained throughout the history of the western world a symbol of its spiritual unity, which inspired Charlemagne no less than Xapoleon and which provided throughout the middle ages the ultimate justification for the policies of the Holy Roman empire and of the papacy. Thus it is not surprising that at the very moment the Holy Roman empire was dissolved in 1806, Napoleon tried to revive it, and that only a decade later practical attempts commenced to find a substitute for the international order which the Holy Roman empire had sought to provide.

The moral root of modern attempts to find a stable foundation for international peace must be sought in the increased humaneness and civilized conduct, of which the great political and social reforms of the 19th and 20th centuries are the outstanding practical realization.

Religion, the philosophy of the Enlightenment and the political theory of liberalism all postulate respect for human life and the promotion of human welfare. To extend the reign of law, peace and order from the domestic to the international sphere was a logical conclusion from these postulates.

The intellectual factor underlying this development is to be found in the rise of the commercial and scientific spirit in the 18th and 19th centuries. To that spirit war is an irrational disturbance of the rational order of things. According to Kant "the commercial spirit cannot co-exist with war." Similarly, Herbert Spencer believed that war had become obsolete in an industrial society. Thus it was widely believed that permanent peace on the international scene could be established through the same concerted rational effort which seemed to have brought such spectacular benefits to mankind in other fields.

The convergence of these four factors at the beginning of the 19th century initiated the practical search for alternatives to war and sustained it thereafter. This search for permanent peace has been carried on through three different media: (1) limitation of the destructive and anarchical tendencies of international politics; (2) transformation of international politics by eliminating its destructive and anarchical tendencies altogether; and (3) accommodation of divergent interests by depriving the destructive and anarchical tendencies of international politics of their rational objectives.

To establish peace through limitation several devices have been used: disarmament, collective security, judicial agencies, peaceful change, international government. Peace through transformation has been sought through the establishment of a world state. Diplomacy has served the purposes of peace through accommodation.

Disarmament is the reduction or elimination of certain or all

armaments for the purpose of stopping the armaments race. Two distinctions must be kept in mind: that between general and local disarmament, and that between quantitative and qualitative disarmament.

General disarmament refers to a kind of disarmament in which all the nations concerned participate: examples are the Washington Treaty for the Limitation of Naval Armament of 1922, signed by all major naval powers: and the world disarmament conference of 1932 in which virtually all members of the community of nations participated. We speak of local disarmament when only a limited number of nations are involved; the Rush-Bagot agreement of 1817 between the U.S. and Canada exemplifies this type.

Quantitative disarmament envisages an over-all reduction of armaments of most or all types. as did the world disarmament conference of 1932. Qualitative disarmament aims at the reduction or abolition of certain types of armaments only, such as atomic weapons.

The first modern attempt at disarmament occurred in 1816 when the tsar of Russia proposed to the British government the "simultaneous reduction of the armed forces of every kind." Many similar proposals throughout the 19th century, especially by France, culminated in the Hague peace conferences of 1899 and 1907, both of which passed resolutions affirming the desirability of the restriction of armaments. It must be noted that most of the attempts at securing international peace through disarmament failed and that the two which succeeded, the Rush-Bagot agreement of 1817 and the Washington Treaty for the Limitation of Naval Armaments of 1922, were an integral part of a political settlement which carried in itself the assurance of peace. In other words. as the armaments race is a symptom of political conflict which is likely to lead to war, so is disarmament the symptom of the disappearance of political tension which by itself gives assurance for the preservation of peace. Diplomacy by itself, especially if it is of the local and qualitative type, gives no such assurance, for at best it would be able to alter the methods by which war is to be waged (but not the incidence of war itself).

Collective Security assumes that nations generally increase their armaments and go to war either because they are in fear of aggression or because they trust that aggression will succeed without too great a risk. If the community of nations could provide its members with security through collective action, the main motive for war would disappear. In a system of collective security, security is the concern of all nations which will take care collectively of the security of each of them as though their own security were at stake. If nation A threatens nation B's security, C, D, E, F and G will take measures on behalf of B and against **A** as though A threatened them, and vice versa.

The ability of a system of collective security to preserve peace rests on three assumptions: (1) the collective system must have at its disposal at all times sufficient strength to deter any potential aggressor; (2) the nations which dispose of such overwhelming strength must have the same interest in defending the status quo; (3) these nations must subordinate their conflicting political interests to the overriding concern for collective defense. The history of collective security, as it was provided for by the covenant of the League of Nations and the charter of the Cnited Nations, shows that these three conditions are rarely present at the same time. First of all, history shows that aggression is generally threatened or committed not by one but several nations which, at least initially, are of approximately equal if not superior strength to those who are willing to resist aggression. The reason for this state of affairs must be sought in the fact that what is required for the security of one group of nations may be incompatible with, or actually threaten the security of, another group of nations. Finally, collective security presupposes a moral transformation which makes individual nations forego their national egotisms and the national policies serving them for the sake of collective policies serving the supranational objective.

Judicial Agencies have been devised as a means to preserve peace on the assumption that international conflicts have led to war because there were no facilities available to nations to settle their conflicts peaceably. Nation A wants something of nation B which nation B is not willing to concede. Hence, **A** will try to get what it wants from B by force of arms. If there were a method, acceptable to A and B and fashioned after the model of national judicial agencies, of settling that conflict peaceably, war would become superfluous as the supreme arbiter among nations.

Thus during the second half of the 19th century the arbitration movement gained strong popular support for proposals to establish international arbitration courts with compulsory jurisdiction to settle all international conflicts. Many nations concluded treaties for the judicial settlement of at least certain types of disputes. The movement culminated in the establishment of the Permanent Court of Arbitration by the Hague Convention for the Pacific Settlement of International Disputes of 1899 and 1907, of the Permanent Court of International Justice in 1919 and of the International Court of Justice in 1946.

However, none of the disputes settled by these courts can be said to have implied the risk of war had it not been settled by an international tribunal. Furthermore. all nations likely to get involved in political disputes of a serious nature were careful to circumscribe strictly the type of dispute they were willing to submit to judicial settlement. Only nations which were unlikely to get involved with each other in disputes of this kind, such as Colombia and El Salvador, Denmark and Portugal, the Netherlands and China, Belgium and Sweden, agreed to submit all disputes to arise between them to judicial settlement without any qualification. Finally, and most importantly, while disputes between two individuals to be submitted to a national court concern the application or interpretation of the law as it is, disputes between states which are likely to lead to war typically have as their object the very survival of the legal order which one state wants to change in opposition to another defending it. Issues of this kind, however, are of legislative nature and judicial agencies are unable to cope with them.

Peaceful Change, then, **is** the issue which is raised by the inability of judicial agencies to settle peacefully disputes which concern not the application of the existing legal order, but its transformation. National societies. especially those of a democratic character, are continually engaged in processes of peaceful change. These processes are made possible by three factors: (1) the ability of different trends in public opinion to express themselves freely and compete with each other for maintenance or change of the status quo; (2) the ability of social and political institutions to absorb the pressures of public opinion and to translate them into legal measures and institutions; (3) the ability of the state to protect the result of these competing social pressures against violent change.

These factors are largely absent on the international scene. No free interplay of different trends in public opinion exists to the same extent between nations as it does within them. International social and political institutions are of a rudimentary character; more particularly, the operation of international legislative bodies, making majority decisions with binding effect upon the minority, is precluded by the principle of sovereignty, at least for matters of a political nature. For the same reason there can be no supranational organization of compulsion which is not based upon the voluntary co-operation of individual states.

In consequence, the institutional devices introduced into the covenant of the League of Nations and the charter of the United Nations in order to facilitate peaceful change proved to be ineffectual. Article 19 of the League covenant reads: "The Assembly may from time to time advise the reconsideration by Members of the League of treaties which have become inapplicable and the consideration of international conditions whose continuance might endanger the peace of the world." Article 14 of the U.N. charter refers in general to "the peaceful adjustment of any situation, regardless of origin, which it (the general assembly) deems likely to impair the general welfare or friendly relations among nations." Article 19 of the covenant was formally invoked only once. by Bolivia against Chile in 1920, but was not acted upon because Bolivia retracted its request. It was further weakened by authoritative interpretation of the assembly. The general assembly of the United Nations made recommendations by virtue of article 14

of the charter in a number of cases, such as the treatment of Indians in the Union of South Africa, the situations in Greece and Korea, and the problems of Spain and Palestine. Of these only the resolution of Nov. 29, 1947, recommending the partition of Palestine was a genuine attempt at peaceful change. Yet the actual partition of Palestine was the result of a war between the Arab nations and the Israelis, a fact which the general assembly of the United Nations had to recognize in succeeding recommendations.

Peaceful change administered by an international organization comes up against a basic fact of international life: national sovereignty. If the international organization respects national sovereignty and, hence, only recommend; peaceful change, the effectiveness of the recommendation will depend upon the agreement of the parties concerned; yet if the parties concerned agree anyway, the recommendation is at best not a decisive factor and at worst superfluous. If the parties do not agree, change must then be imposed upon them by the international organization and will be peaceful only if it can be imposed under the ideal conditions—hardly attainable, as we have seen—of collective security.

International Government is different from the above-mentioned devices to establish international peace in that the latter are intended to provide specific remedies for a particular problem while international government recognizes that peace and order can be secure only in an integrated society existing under a common authority and common conception of justice. International government, then, is the attempt to establish such an authority and to create such a conception of justice in a society of sovereign states. Such an attempt followed each of the three world wars of the 19th and first half of the 20th century. The Napoleonic Wars called into being the Holy alliance; World War I the League of Nations; and World War II the United Nations. None of these international organizations was able to put international peace on a more secure basis for identical reasons, inherent in the nature of international government.

The Holy alliance, the League of Nations and the United Nations were conceived as international governments by the great powers; this is obvious from the membership of the Holy alliance as well as from the membership and the functions of the council of the League of Nations and the Security council of the Cnited Nations. The ability of these international organizations to protect the peace of the world, then, depended upon the ability of the great powers to work in unison for the achievement of that objective. Yet in all three organizations the particular interests of individual great powers prevailed over the interest which they were supposed to have in common: the preservation of peace.

All three organizations had as their basic political objective the maintenance of the status quo as it had been established by the preceding world war. However, not all the great nations had the same understanding as to what the maintenance of the status quo meant in view of their particular interests, nor were all of them equally interested in the maintenance of that status quo. Thus it came about that first the usefulness and then the very existence of the Holy alliance was destroyed by the conflict between Great Britain and Russia which lasted throughout the better part of the 19th century; that the ability of the League of Nations to become an effective instrument for the preservation of peace was jeopardized first by the political conflict between Great Britain and France, then between France and Germany, and finally between Great Britain and France on the one hand and the Soviet Union on the other; and that the United Nations as a peacemaker was paralyzed from the very beginning by the conflict between the western world under the leadership of the United States and the Soviet bloc.

The attempts to secure peace by an international government of sovereign nations have all been the victims of a contradiction inherent in these very attempts. The establishment of effective government of sovereign nations seems to be a contradiction in terms which can be eliminated only by a direct attack upon national sovereignty itself.

The World State, then, seems to many to offer a logical solution to the problem of international peace. In the same way, so it is argued, in which domestic peace has been made secure by the subjection of local and regional governments to a common authority, so international peace, to be secure, must be built upon the foundations of a government for all mankind to which national governments must yield their sovereignty.

Any world government, if it is not a tyrannical one, must rest on a triple foundation: supranational loyalties, expectation of justice and overwhelming power. That is to say, whenever a conflict arises between loyalty to a particular nation and loyalty to the world government, the latter must be reasonably certain that the conflict will be resolved in its favour. Furthermore, the peoples of the world must be united in the reasonable expectation that the world government will at least approximate justice in its dealings with them. Finally, the world government must have at its disposal such overwhelming physical strength as will make unlikely from the outset physical resistance to its decisions on the part of any group subject to its rule.

To realize these three preconditions for a world state capable of preserving peace two methods have been suggested and partly put into practice: one constitutional and one functional. A number of organizations have worked out constitutions for a world state; generally on a federal basis. Once such a constitution has been ratified by the representatives of the nations of the earth, its actual operation is expected to call into being the three foundations upon which an effective world state must rest. On the other hand, there are those who believe that before a world state can be brought into being, humanity must experience its community of interests and develop the foundations for a world state through active co-operation for the specific limited objectives. Once humanity has learned to co-operate for the improvement of health or the increase in agricultural production regardless of national boundaries, its political unity will grow almost organically from common needs successfully met and the common interest in their continuing satisfaction. Hence, this functional approach puts its main reliance for preparing humanity for a world state upon the so-called specialized agencies of the United Nations and similar organizations.

Diplomacy, however, has remained the chief instrumentality through which states have actually attempted to preserve international peace by reconciling hostile interests which threaten to lead to war. Diplomacy is the oldest and, as it were, the natural method for the settlement of international disputes; for sovereign entities, such as nations, which by definition are not subject to a higher authority, must naturally try to settle their disputes peacefully by way of negotiation, that is, through diplomacy. The decisive factor in such diplomatic negotiations is the interest of the negotiating parties in the success of the negotiations. This interest generally takes two different forms. On the one hand, the negotiating parties expect from the peaceful settlement the protection and promotion of their vital interests, while both are willing to compromise on secondary issues, thus each giving up something and receiving something. On the other hand. the interest of the parties in concluding an agreement and, more particularly, in keeping it depends upon the political and military pressures which one side is able to exert upon the other in support of a peaceful settlement. This has been one of the traditional functions of competitive armaments, alliances and the balance of power. Diplomacy as a method of preserving peace has been deprecated in the measure in which the newer methods, mentioned above, have captured the popular imagination. That deprecation is based on moral as well as practical grounds. Yet whereas diplomacy is defective on both counts, governments, while experimenting with the newer methods, have continued to put their main reliance upon the traditional methods of diplomacy. It is worthy of note to what extent, for instance. the United Nations. which was widely supposed to provide a substitute for the traditional methods of diplomacy, was transformed into an instrument of diplomacy, used by individual nations for the protection and promotion of their particular interests. However, the search for a more effective method of preserving peace than diplomacy can provide. which has occupied humanity to an ever increasing extent since the beginning of the 19th century, reflects the new and equally ever increasing

urgency which the problem of peace has assumed. For political, technological and moral revolutions transformed war from the rational instrument of foreign policy which it once was into an instrument of universal destruction. And it became one of the great paradoxes of the 20th century that, on the one hand, the preservation of peace had become a matter of survival for western civilization, while, on the other hand, the traditional instruments of preserving it had become less effective; and more effective ones had not yet been devised. (H. J. MU.)

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PEACE CONFERENCES. For conferences for the promotion of peace held before 1914 *see* HAGUE CONFERENCES. For conferences subsequent to World War I *see* relevant headings; *e.g.*, PARIS, CONFERENCE OF; VERSAILLES, TREATY OF; WASHINGTON CONFERENCE; WASHINGTON, TREATIES OF; LOCARNO, PACT OF, etc. See also CONFERENCE, INTERNATIONAL; WAR. For World War II peace conferences, *see* AUSTRIA: *History;* ITALY: *History;* JAPAN: *History,* etc. *See* also KOREAN WAR.

PEACE CORPS, an agency, of the U.S. government established by order of Pres. John F. Kennedy on March 1, 1961. It became a permanent agency under the department of state the following September when congress approved the Peace Corps act. When he delivered his special message to congress on the subject, President Kennedy said:

I recommend the establishment of a permanent Peace Corps—a pool of trained American men and women sent overseas by the United States Government or through private organizations and institutions to help foreign countries meet their urgent needs for skilled manpower. . . .

The Peace Corps offered an opportunity for individual citizens to volunteer to work directly with the people of other countries, sharing their lives and speaking their language. Within a year of the agency's establishment more than 900 volunteers were in training or were on assignments overseas. They included nurses, teachers, doctors, mechanics, foresters, farmers, engineers and a host of other specialists, Peace Corps volunteers were sent only where they were needed and wanted. All projects originated in the requests of countries desiring the aid of Peace Corps personnel. Most projects were in the fields of education, health and rural development.

Any U.S. citizen 18 years of age or older, including married couples without dependent children, might apply for the Peace Corps. There was no upper age limit but all candidates were required to meet high physical standards. Each volunteer received an allowance sufficient to permit him to live on the same plane as his counterparts in the host country. The usual length of service was two years after which the volunteer received a lump-sum payment to help him make the transition to other work. Service in the Peace Corps did not exempt a volunteer from military service.

PEACE PIPE: see CALUMET.

PEACH, CHARLES WILLIAM (1800–1886), British naturalist and geologist who made valuable contributions to the knowledge of marine invertebrates and of fossil plants and fish, was born on Sept. 30, 1800, at Wansford in Northamptonshire. He received an elementary education at Wansford and at Folkingham in Liicolnshire, and for several years assisted his father in the operation of an inn and farm.

In 1824 the earl of Westmorland appointed him riding officer in the revenue coast guard at Weybourne in Norfolk. Seaweeds and other marine organisms attracted his attention, and he began to collect them. His duties during the next few years led him to move to several different places in Norfolk and in the course of his rambles he met the Rev. James Layton, curate at Catfield, who lent him books an4 assisted in laying the foundations for his future studies. He was finally sent to Gorran Haven in Cornwall where he continued to pursue his studies and supplied many specimens to British naturalist G. Johnston, who was then preparing his *History* of *the British Zoophytes* (1838). It was there also that Peach found fossils in some of the older rocks previously regarded as unfossiliferous. This discovery proved the presence Bala beds (Ordovician) in the neighbourhood.

In 1841 he read a paper before the British association at Plymouth entitled "On the Fossil Organic Remains Found on the Southeast Coast of Cornwall," and in 1843, he brought before the Royal Geological society af Cornwall an account of his discovery of fish remains in the Devonian slates near Polperro.

Peach was appointed to a position in the customs at Fowey 1845; and four years later, he went to Scotland, first to Peterhead and in 1853 to Wick. He studied the Old Red Sandstone, the boulder clay of Caithness and the Carboniferous plants of Scotland. During a stay at Durness he first found fossils in the Cambrian limestone (1854). In the field of natural history his contributions included the discovery of many new species of sponge?, coelenterate and mollusks. He died at Edinburgh on Feb. 28, 1886.

PEACH, a fruit tree of the species *Prunus persica* (also called by some botanists *Amygdalus persica*). This plant is included in the same genus with plums, cherries and apricots, a group also known as the stone fruits or drupe fruits. A fruit of this type develops from a single ovary that ripens into a fleshy, juicy exterior, making up h e edible part of the fruit, and a hard interior called the stone or pit. Usually a single fertilized ovule develops into the seed, which is enclosed within the stone. The flesh of the fruit in the peach may, be white or yellow or red. In many varieties, called freestones, the ripe flesh separates readily from the stone, Varieties in. whish the flesh adheres firmly to the stone are known a s clingstones.

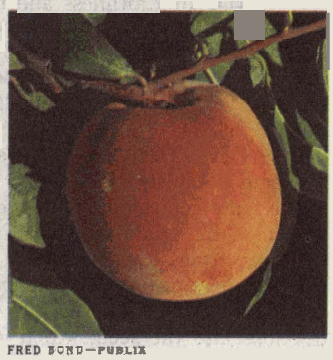
The tree is of medium size, seldom reaching 25 ft. in height. Under most conditions of culture it is usually kept to 10 to 12 ft. in height by pruning. The leaves are firm in texture, glossy green, lanceolate and long-pointed. The flowers are axillary and arranged singly or b groups of two or three at nodes along the shoots of, the previous season's growth. The five pink or white petals, five sepals and three whorls of stamens are borne at the summit (on the outer rim) of a short hollow tube (the floral receptacle) which forms the base of the flower. The pistil consists of a single carpel with a relatively long style and an enlarged hairy basal portion, the ovary, which becomes the fruit. While the skin of most ripe fruits of the peach is downy or fuzzy, there

PEACH BLOSSOMS (PRUNUS PERSICA)

FRED BOND—PUBLIX

are some smooth-skinned peaches called nectarines, which are otherwise indistinguishable from ordinary peaches. The glabrous character of the nectarine is hereditary, and peach seeds carrying this factor when planted may give rise to nectarines. (See NECTARINE.)

Many early writers regarded Persia as the original home of the peach, as is suggested by the species name *persica,* but some authorities conclude that the peach had never been truly wild in Persia. It has long been cultivated in China and was written about some 2,000 years before its introduction to the Roman world. Reference to the *Tao,* meaning "peach," has been found in Chinese writings of the 5th century B.C. It is known that a type of white-fleshed peach is native to China, but it is not exactly clear where the yellow-fleshed peach originated. There is little evidence that yellow-fleshed peaches were indigenous to China proper outside of the province of Yunnan. The yellow peach has been reported as growing wild in parts of the northwestern frontier province of India, and plantings of the peach occurred in Turkistan and Persia.



FRED BOND—PUBLIX

RIPE PEACH (PRUNUS PERSICA)

It is probable that the peaches known to Europeans came from regions close to the centres of Roman and Greek civilization. There is some evidence that the peach reached France and Spain at about the time it was introduced into Greece, spreading later from southern to northern Europe. Few other fruits are grown under such varied conditions and in such extended areas. Peaches thrive in China, in all parts of southern Europe and in sheltered places in the northern latitudes.

The first Spanish explorers brought the peach to the new world, and as early as 1600 peaches were found in Mexico. Explorers, settlers and Indians were responsible for a wide distribution of the fruit in the western hemisphere. With its general distribution in Europe, Asia, South Africa; Australia, South America and the United States, there has been a continuous selection of varieties best adapted to the various regions and climatic conditions as well as to the preferences of consumers.

Commercial peach-growing in the United States began early in the 19th century, when large seedling orchards were planted in Maryland, Delaware and New Jersey. Many of the varieties grown in those early days were apparently better suited for making brandy than for general consumption as canned or fresh fruit. Later in the 19th century, when the planting of budded varieties became more widely practised, large commercial orchards of varieties propagated from clones were developed. From the beginning the peach spread rapidly and widely until it was cultivated in practically every state in the United States.

The peach ranks next to the apple in importance among the deciduous tree fruits. The United States leads in the production of peaches in North America, producing more than half the world supply of this fruit. In the five-year period 1953–57, the average annual production of peaches was about 62,000,000 bu. The world production was about 122,000,000 bu. In Europe, Italy and France led as producing countries, and in South America Argentina produced sizable quantities, with Chile second. Commercial crops are also grown in Asian countries, the Republic of South Africa and Australia.

In the United States, California leads among the states in the production of both freestones and clings. In that state a large commercial industry has been developed in the production and canning of firm-fleshed clingstone varieties, and freestone varieties are used for fresh fruit and for drying. Taken together, the California varieties make up more than half the total peach production of the United States. Other states leading in the production of freestone varieties are South Carolina, Georgia, Michigan, Pennsylvania and New Jersey.

While this fruit is not grown commercially in regions subject to severe winter temperatures, some varieties or seedlings are able to withstand ldw temperatures. The most important limiting factor in peach production is cold injury to the wood and buds during the winter or frost injury at blossoming time. Peaches cannot be grown successfully where winter temperatures normally may be expected to fall to −10° to −15° F. Only the most hardy varieties will withstand these temperatures. Moreover, peaches do not produce satisfactorily where the winters are too mild. Most varieties require some chilling to break the rest which the tree has during dormancy. If there is not sufficient cold to break this rest, the trees leaf out slowly or not at all and the blossoms will drop off. In regions with warm winter climates only those varieties with a low chilling requirement succeed.

The peach does well on various soil types ranging from the coarse-textured sand or gravelly loams and shales to silt loam, but in general grows best on well-drained sandy or gravelly loams. Fine-textured soils that have a tendency to waterlog or have poor subsoil d&&@ $* unsatisfactory. The site selected for a peach orchard is most important. In the more northern latitudes and regions where low winter temperatures and spring frosts are hazards, the site should be sufficiently elevated in relation to the surrounding land to permit cool air to drain away to lower levels. Large bodies of water may have a moderating effect in regulating temperatures and reducing frost hazard.

Peach trees should be pruned annually to prevent them from becoming too tall and leggy. Pruning back upright shoots to outgrowing laterals will help spread the tree and keep it open to sunlight. In general, peaches grow best when the soil around the trek is cultivated. Grass reduces the moisture supply and depletes the soil of nutrients. Mulching with organic material will keep down competition of the grass and conserve moisture. On most soils the trees will respond to nitrogen-carrying fertilizers or farm and organic manures, and satisfactory growth will not be obtained without added nitrogen. On coastal plain soil trees may require potash.

Most peach varieties develop many more fruits than will size properly. Some shedding of young fruit will take place naturally about a month to six weeks after full-bloom, but the number remaining must be reduced further by hand thinning. This should be done as early after natural drop as possible to obtain good size.

Peaches are attacked by many insects and diseases and by soil nematodes or eelworms. Few fruits of good quality are obtained without the use of pesticides. Fortunately most fungus diseases and insect troubles of the fruit can be controlled by chemical sprays. Organic insecticides and fungicides developed since World War II have made more effective control possible. Spray schedules on what to use and time of application are obtainable, in the U.S., from state agricultural experiment stations. Some virus diseases of the patch are serious and cannot be controlled by spraying. Peach yellows, a serious virus disease, formerly threatened the peach industry, but eradication of the source of infection controlled the disease. Most of the known virus diseases are spread by insects, and eradication of diseased trees or hosts of the vector is a means of control.

By 1917, more than 2,000 varieties of the peach were described as being grown in some parts of the United States. Most of those varieties had been replaced by mid-20th century with better-coloured, high-quality varieties. Yellow-fleshed varieties are preferred in North America for commercial use. The Elberta, introduced in 1870, is the leading freestone. Some white-fleshed varieties are favoured for the home fruit garden. Peach trees are relatively short-lived as compared to some other tree fruits. In some regions orchards are replanted after 8 to 10 years, while in other regions trees may produce satisfactorily for 20 to 25 years or more, depending upon their resistance to diseases, insects and winter damage from cold.

Federal and state agencies in thi United States and Canada have been carrying on extensive improvement programs since the early 1920s. As fast as new varieties are found that are superior in size and colour, they replace the older, inferior sorts. Peach

varieties do not grow true to seed but must be propagated by using buds of the desired variety on seedling or other variety stock. Varieties are available that will ripen over a ten-week period. With the rather wide regional distribution of commercial peach production in the United States, fresh fruit is made available to the consumer over a long season from early May to late September. Some of the leading freestones or soft, melting cling varieties used commercially or for home planting are as follows in order of ripening:

Dixired—very early, five to six weeks before Elberta, bright red skin, medium size, yellow-fleshed melting cling, fair to good quality.

Redhaven—early, four to five weeks before Elberta, medium size, yellow flesh. freestone, firm attractive red skin, excellent for canning and freezing.

Triogem—early, three weeks before Elberta, attractive red skin, medium size, firm yellow flesh, freestone, excellent quality.

Halehaven—midseason, two weeks before Elberta, large, firm yellow freestone, skin sometimes dull red, flower buds hardy, sets heavily. good quality.

Sunhigh—two weeks before Elberta, large size, attractive red skin, yellow flesh, freestone, firm, good quality.

Belle of Georgia—ripens ahead of Elberta, white flesh, freestone, high quality, soft, of value principally as a white variety.

Elberta—the leading peach variety in the United States, midseason, widely distributed, large size, yellow flesh, fair to good quality, firm, ships well, used for canning and drying.

Rio Oso Gem—late ripening, week after Elberta, fruits large, red skin, attractive firm yellow flesh, good quality.

The more important firm-fleshed clingstones grown in California for canning include Halford, Gaume, Paloro, Peak and Fortuna. *See* also FRUIT FARMING; HORTICULTURE.

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PEACHAM, HENRY (*c.* 1576–*c.* 1643), English author best known for his *Compleat Gentleman* (1622), important in the tradition of courtesy books, was born at North Mimms, Hertfordshire, c. 1576. He was educated at Trinity college, Cambridge, and was successively schoolmaster, traveling tutor and author. Of his time as master of the free school at Wymondham, Norfolk, he wrote "whiles that it was free, Myselfe, the Maister, lost my libertie." His first book, *The Art of Drawing With the Pen, and Limning in Water Colours* (1606), dealt with a lifelong interest; his translation (1610) into Latin verse of King James's *Basilicon Doron* contained his own pen-and-ink drawings. *The Period of Mourning* (1613) honoured the memory of Prince Henry, and *Thalia's Banquet* (1620) proved Peacham's ability to turn an epigram. *The Truth of Our Times* (1638; ed. by R. Cawley, 1942) is full of acute observations on the London life he knew so well; he recalled seeing the acting of the great Richard Tarlton "when I was a Schoolboy in *London.*" *The Worth of a Peny* (1647; in E. Arber's *English Garner*, vi, 1883) is Peacham's "complaint to his purse." But his chief work remained *The Compleat Gentleman* (ed. by G. S. Gordon, 1906). It was a full expression of his theories on education, and its table of contents exhibits the variety of his interests: cosmography, geometry, poetry, music, sculpture, drawing, painting, heraldry. Dr. Johnson drew the heraldic definitions for his *Dictionary* from the 1661 edition.

Peacham was royalist to a fault, writing in 1639 *The Duty of All True Subjects to Their King as Also to Their Native Countrey;* and he spoke proudly of having sketched the king's portrait as he sat at dinner. Though he attacked Puritans in *Thalia's Banquet*, he had some natural sympathy with them, deploring lavishness of every kind. He concludes *The Truth* with a quotation from Hippocrates: "All things moderately, and in measure."

See M. C. Pitman, "Studies in the Works of Henry Peacham," *Bulletin of Historical Research*, xi (1934). (R. R. *Cy.*)

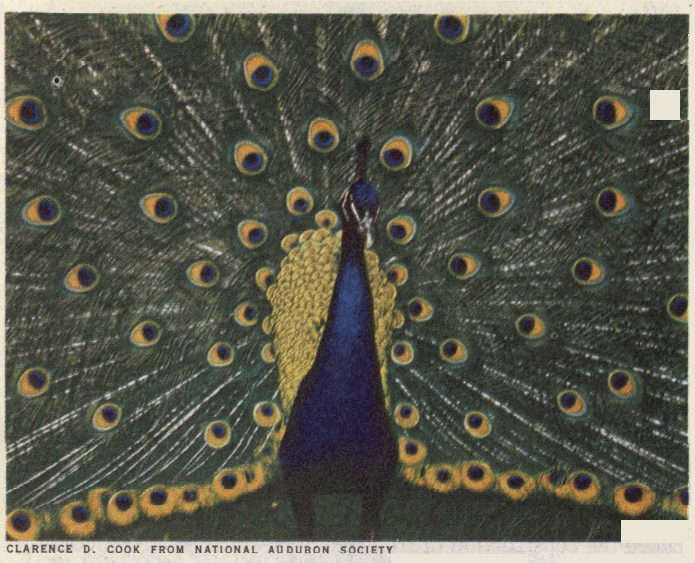
PEACOCK, THOMAS LOVE (1785–1866), English novelist and poet, was born at Weymouth on Oct. 18, 1785. He was educated at a private school at Englefield Green and after a brief experience of business determined to devote himself to literature. His first books were poetical, *The Monks of St. Mark* (1804), *Palmyra* (1806), *The Genius of the Thames* (1810), *The Philosophy of Melancholy* (1812)—works of no great merit. He also made several dramatic attempts, which were never acted. He sewed for a short time as secretary to Sir Home Popham at Flushing. In 1815 he showed his real bent by writing his novel, *Headlong Hall.* It was published in 1816, and *Melincourt* followed in the ensuing year. During 1817 he lived at Great Marlow, enjoying the almost daily society of Shelley, and writing *Nightmare Abbey* and *Rhododaphne*, by far the best of his long poems. In 1819 he was appointed assistant examiner at the India house. His novel *Maid Marian* appeared in 1822, The *Misfortunes of Elphin* in 1829 and *Crotchet Castle* in 1831; and he would probably have written more but for the death in 1833 of his mother. He also contributed to the *Westminster Review* and the *Examiner.* His services to the East India company, outside the usual official routine, were considerable. He was especially concerned with steam navigation to India, and after representing the company before parliamentary committees on the subject, superintended the construction of iron steamers which proved successful. He also drew up the instructions for the Euphrates expedition of 1835. In 1836 he succeeded James Mill as chief examiner, and in 1856 he retired upon a pension. During his later years he contributed several papers to *Fraser's Magazine*, including reminiscences of Shelley, whose executor he was. He also wrote in the same magazine his last novel, *Gryll Grange* (1860). He died on Jan. 23, 1866, at Lower Halliford, near Chertsey, where so far as his London occupations would allow him, he had resided for more than 40 years.

Novels.—Peacock's position in English literature is unique. There was nothing like his type of novel before his time; though there might have been if it had occurred to Swift to invent a story as a vehicle for the dialogue of his *Polite Conversation.* Of his seven fictions, *Nightmare Abbey* and *Crotchet Castle* are perhaps on the whole the best, the former displaying the most *vis comica* of situation, the latter the fullest maturity of intellectual power and the most skilful grouping of the motley crowd of "perfectibilians, deteriorationists, statu-quo-ites, phrenologists, transcendentalists, political economists, theorists in all sciences, projectors in all arts, morbid visionaries, romantic enthusiasts, lovers of music, lovers of the picturesque and lovers of good dinners," who constitute the dramatis personae of the Peacockian novel. *Maid Marian* and *The Misfortunes of Elphin* are hardly less entertaining. *Gryll Grange* contains the most beautiful of his poems, "Years Ago." the reminiscence of an early attachment. The ballads and songs interspersed through his tales have much charm; his longer poems have less interest.

Peacock's works were collected, though not completely, and published in three volumes in 1875, with an excellent memoir by his granddaughter, Mrs. Clarke, and a critical essay by Lord Houghton. His prose works were collected by Richard Garnett in ten volumes (1891). The Halliford edition (H. F. B. Brett-Smith and C. E. Jones, 1925–34) contains the whole of Peacock's works. *See* A. B. Joung, *The Life and Novels of Thomas Love Peacock* (1904). For an interesting personal notice, see *A Poet's Sketch Book* by R. W. Buchanan (1884).

(R. G.; X.)

PEACOCK, the male of the largest and most splendid of the pheasants, *Pavo cristatus*, a native of India and Ceylon. The female is the peahen; collectively, both are peafowl. The male has a crest and whitish bare areas on the sides of the head; the plumage is brilliant metallic green and blue. The upper tail coverts are enormously elongated, forming the train of about six feet in length, bronzy-green and blue in colour and ornamented with brilliantly coloured eye spots or ocelli. A white variety is common in captivity. In courtship display, the train is erected vertically above the bird's back, being supported by the tail feathers. At the climax of the display the tail feathers are vibrated, giving the feathers of the train a shimmering appearance and imparting a rustling sound. In captivity the bird often displays outside courtship periods, seemingly showing off, hence the saying, "proud as a peacock." The female is much more dully coloured and lacks the ornamental feathers. The peacock is polygamous, each male seek-



CLARENCE D. COOK FROM NATIONAL AUDUBON SOCIETY

PEACOCK (PAVO CRISTATUS) DISPLAYING

ing to acquire a harem of four or five hens. During the breeding season the male utters a raucous, harsh cry. The hen lays from four to six whitish, sometimes spotted eggs in a hidden nest.

This beautiful bird, seen in almost every zoo, has long been famous, especially since it is readily semidomesticated. The Phoenicians introduced it to the Pharaohs of Egypt, and Alexander the Great took it to Greece. The feathers were exported from India in quantities for ornamental use, although a superstition against the eye spots on the feathers as being evil somewhat lessened their popularity. In Rome and later in medieval Europe, peafowl were raised for the table. The emperor Charlemagne is said to have served thousands at a single state banquet. After the turkey was brought to Europe from Mexico, it quickly supplanted the peacock as a table bird.

A related species, the green peacock (P. *muticus*), inhabits Burma, Indochina, Malaya and Java. The name is also applied to other less closely related pheasants such as the Congo peacock (*Afropavo congensis*) and the peacock pheasant (*Polyplectron*). See PHEASANT.

See also *W.* Beebe, *Pheasants, Their Lives and Homes (1936).*

(DN. A.)

PEAK DISTRICT, a heavily dissected plateau in north Derbyshire, Eng., forming the southern extremity of the Pennines. It includes an area of about 500 sq.mi., mainly peaty moorland drained by tributaries of the Mersey and the Derwent. Kinder Scout (2,088 ft.) is the highest point, with summit areas of Millstone Grit. Many of the rivers, notably the Wye and the Dove, have cut through this to the underlying massive limestones and their gorgelike valleys are very picturesque. Caverns and potholes occur frequently. (See DERBYSHIRE.) In 1950–51 the Peak District National park was farmed, and in 1954 a warden service for patrolling the access land was inaugurated. The district is a popular walking and camping area with the Midland townspeople.

PEALE, the name of a family of notable U.S. painters during the late 18th and early 19th centuries.

CHARLES WILLSON PEALE (1741–1827), whose portraits of the leading figures of the Revolutionary period are the most remembered of his remarkably diverse accomplishments, was born in Queen Annes county, Md., on April 15, 1741. His career in art began in 1763. John Hesselius, a successful Maryland painter, gave him lessons and John Singleton Copley advised and influenced him. From 1767 to 1769 he studied in London with Benjamin West, absorbing West's neoclassical style and the new ideals of social and political justice associated with neoclassicism. In an allegorical portrait of Pitt he sounded a warning to tyrants, and he refused to uncover when the coach of King George III passed in the streets.

On his return to America, Peale became at once the fashionable portrait painter of the middle colonies. He moved to Philadelphia in 1776, entered wholeheartedly into the Revolutionary movement and served with the city militia in the Trenton-Princeton campaign. From 1779 to 1780 he represented the "Furious Whig" party in the Pennsylvania assembly, an activity which damaged his professional career. In 1781 he opened a portrait gallery of Revolutionary heroes. In 1784 he founded the institution which became famous as Peale's museum, a pioneering venture in museum exposition and a new expression of his liberal philosophy, which was intended to illustrate nature and natural law. The first scientific expedition organized in the United States brought to it in 1801 the first complete skeleton of the American mastodon. The museum grew to vast proportions and was widely imitated by other museums of the period and later by P. T. Barnum.

In his long life, Peale painted about 1,100 portraits, including virtually all his great contemporaries. His seven life portraits of Washington of 1772, 1776, 1777, 1779, 1783, 1787 and 1795 were repeated many times by himself and other painters of his family. He died in Philadelphia, Feb. 22, 1827.

His brother, JAMES PEALE (1749–1831), became well known as a miniaturist and a painter of portraits, landscape and still life. He served as an officer of the Continental army, and painted a small group of Revolutionary battle scenes.

REMBRANDT PEALE (1778–1860), a son of Charles Willson Peale, was born in Bucks county, Pa., on Feb. 22, 1778. He studied first with his father, then at the Royal Academy in London in 1803 and between 1808 and 1810 in Paris, where he was offered the post of portrait painter to Napoleon's court. In 1814 he founded the Peale museum in Baltimore. Ambitious to rise above portrait work, he painted a number of formal subject pieces culminating in his huge "Court of Death" of 1819 (Detroit Institute of Arts), a picture whose exhibition brought the artist $19,000 in the first year.

In 1823, invoking both study and inspiration, he painted a head of George Washington, whom he had painted from life in 1795. This strong but idealized likeness enjoyed great popularity and was repeated by him many times. He sold his museum in 1822 and thereafter devoted all his time to art, painting in New York, Boston, Philadelphia and other cities. His portraits include many distinguished figures, that of Thomas Jefferson being perhaps his masterpiece, as well as the best portrait of the president. His writings include *Notes* on Italy (1831), Graphics (1835), Portfolio of an Artist (1839) and reminiscences appearing in C. E. Lester's Artists of America (1846) and the Crayon (1855–57). He died in Philadelphia, Oct. 3, 1860.

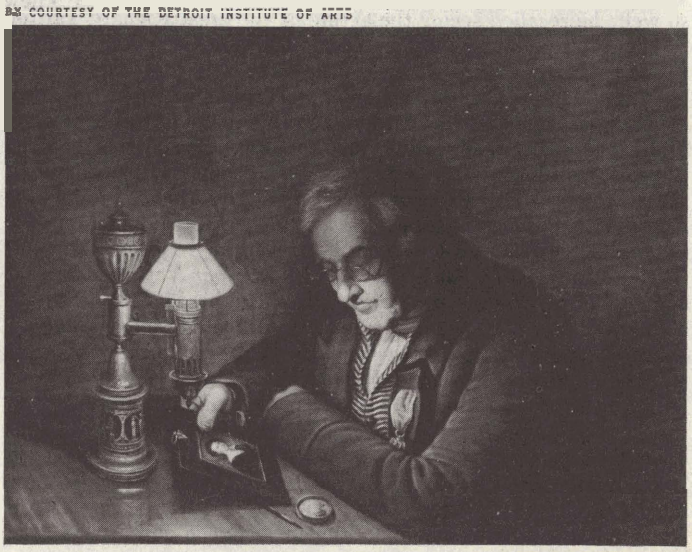
Rembrandt's brother, RAPHAELLE PEALE (1774–1825), was a master of trompe-l'oeil and founder of the art of still-life painting in the United States.

See Charles C. Sellers, *Charles Willson Peale,* 2 vol. (1947) and *Portraits* and *Miniatures* (1952).

(C. C. SS.)

PORTRAIT OF JAMES PEALE (THE "LAMPLIGHT PORTRAIT"). BY CHARLES WILLSON PEALE. IN THE DETROIT INSTITUTE OF ARTS, DETROIT, MICH.

BY COURTESY OF THE DETROIT INSTITUTE OF ARTS



PEANO, GIUSEPPE (1858–1932), Italian mathematician and logician, whose interests were concentrated on the foundations of mathematics and on the development of a formal logical language. Born at Cuneo, Aug. 27, 1858, he became professor of infinitesimal calculus at the University of Turin in 1890 and also at the Accademia Militare from 1887 to 1901. His *Formulaire* de *Mathématiques* (*Formulario Mathematico*), published from 1894 to 1908 with collaborators, sets forth: the fundamental postulates of mathematics in Peano's notation, part of which was adopted by Bertrand Russell and Alfred Whitehead in their *Principia Mathematica* (see LOGIC, HISTORY OF). His name is particularly associated with the axioms for the integers (see NUMBER: Ordinal or Inductive Definition), and with the "discovery of the "Peano curves" filling a square (see TOPOLOGY: Continuous Curves).

He also is known as the creator of an international language, the *latino sine flexione*, based upon words most common in western European languages. He compiled a *Vocabulario* de *interlingua* (1915) and was president of the Academia pro Interlingua. He died at Turin, April 20, 1932. (O. OE.)

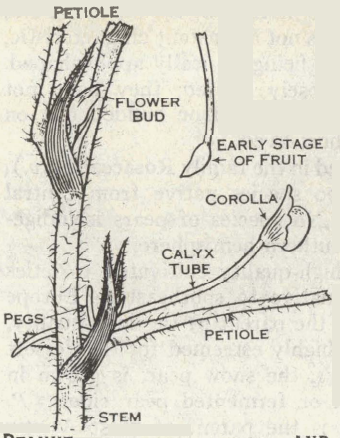
PEANUT (GROUNDNUT, EARTHNUT, GOOBER), is the fruit or pod of Arachis hypogaea (family Leguminosae). The plant is an annual ranging from an erect or bunch form one and one-half to two feet high with short branches to a spreading or runner form one to one and one-half feet high with branches up to two feet long that lie close to the soil. The stems and branches are sturdy and hairy; leaves are pinnately compound with two pairs of leaflets. The flowers are axillary and sessile; what appears to be a flower stalk is a slender calyx tube up to one and one-half inches long; the golden yellow petals are about $\frac{3}{8}$ in. across. The pods are most commonly one to two inches long, two or three seeded, oblong, roughly cylindrical with rounded ends, contracted between the seeds, and have a thin, netted, spongy shell. The seeds vary from oblong to nearly round; seed coat colours range from white to dark purple, but mahogany red, rose and salmon predominate.

After pollination and the withering of the flower an unusual stalklike structure called a peg is thrust from the base of the flower toward the soil. In the pointed tip of this slender, sturdy peg the fertilized ovules are carried downward until the tip is well below the soil surface. Only then does the tip start to develop into the characteristic pod. The pegs sometimes reach down several inches before their tips can develop fruits. The fruits appear to function as roots to some degree, absorbing mineral nutrients directly from the soil. The pods may not develop properly unless the soil in which they lie is well supplied with available calcium, regardless of the nutrients available to the roots.

The peanut is native to tropical South America. India, China, French West Africa and the United States are the largest producers. In the United States most peanuts are grown in three distinct districts. The Virginia-Carolina district grows the large Virginia type almost entirely. The Georgia-Florida-Alabama district grows Southeastern Runner, Virginia and Spanish types. The Oklahoma-Texas district grows the Spanish type.

The peanut is grown mainly for its edible oil except in the United States, where it is produced mainly for grinding into peanut butter (half the harvested crop); for roasted, salted nuts; and, for use in candy and bakery products. Only about 10% of the crop is crushed for oil. In the southern United States the peanut is used extensively as feed for livestock. The tops of the plants, after the pods are removed, usually are fed as hay, although the entire plant is sometimes so used. Large acreages are grown to be fed to swine by turning the swine into the fields to root the nuts out of the soil and feed upon them at will.

Profitable growing of peanuts requires at least five months of warm weather with a growing-season rainfall (or irrigation equivalent) of 22 to 24 in. or more. In Asia the peanut is grown extensively under irrigation. The best soils are well-drained sandy loams one to one and one-half feet deep underlain by deep, friable sandy clay loam or clay loam subsoils. In the United States the shelled seeds are planted in rows 30 to 36 in. apart. Seeds of the small Spanish type are placed three to four inches apart; the larger varieties are seeded six to eight inches apart in the rows. The seeds are treated with a fungicide to control diseases during germination and seedling emergence, and dusting with fungicides to control leaf diseases is usually necessary in humid areas. Careful weed control is essential.



PEANUT FLOWERS, PEGS AND FLOWER BUD IN LEAF AXILS. ABOVE, PEG TIP FROM THE SOIL

Injury to the plants by weeding tools or by throwing soil upon them greatly increases the probability of infectiaa and damage by certain soil-inhabiting fungi when such fungi are present. Keeping the surface layers of the soil trash-free and using suitable chemical weed killers help minimize loss from diseases caused by these fungi.

The peanut is susceptible to leaf spot diseases of fungus origin and to insects which defoliate the plants, thereby reducing yields and quality of nuts. These blights are readily controlled by timely dusting or spraying with appropriate chemicals. Attacks by certain insects and nematodes in the soil, which impair quality of the nuts, are less successfully controlled.

At harvest the entire plant, except the roots below plow depth, is removed from the soil. The nuts are best cured by allowing the harvested plants to wilt for a day, then placing them for four to six weeks in stacks three to four feet in diameter and six feet high, each stack built around a sturdy stake driven upright into the soil. The pods are placed toward the inside of each stack to protect them from weather. Too rapid drying of the huts impairs seed viability and eating quality. To an increasing extent in the United States, labour shortages necessitate curing the plants in windrows in the field, from which the pods are picked by mobile machines. For picking the pods from stacked plants the stacks are hauled short distances to stationary picking machines. The cured and picked pods are finally cleaned and graded at central establishments. (V. R. B.)

PEAR. The pear is one of the most important temperate zone fruits of the world. Among tree fruits of the temperate zone it is exceeded in world-wide importance only by the apple, surpassing in total production such fruits as peaches, plums and cherries.

The pear is closely related both botanically and culturally to the apple. It is distinguished from the apple by the presence of clusters of hard, bony cells in the flesh. These so-called grit cells are entirely lacking in apples: In the pear flower, the bases of the five styles are separate; in the apple they are united. In general

PEAR BLOSSOMS (PYRUS COMMUNIS)

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the pear fruits are pyriform in shape, narrow at the stem end and broadening toward the calyx: This is not a constant characteristic, however, some of the oriental pears being typically apple-shaped. Although apples and pears are closely related, they have not been successfully hybridized. When grafted or budded one on the other, the union is usually short-lived.

Botanically, the pears are included in the family Rosaceae (*q.v.*), genus *Pyrus*. There are 15 to 20 species native from central Europe eastward through China. No species of pears is indigenous in the new world or in the southern hemisphere.

The species from which most high-quality cultivated varieties are derived is ***Pyrus communis,*** native to southeastern Europe and western Asia. This species is the parent of the high-quality, "buttery"-textured varieties most highly esteemed for the dessert quality of the fruit, *Pyrus nivalis,* the snow pear, is grown in Europe for the making af perry, or fermented pear cider, P. *pyrifolia,* the Chinese sand pear, is the parent of most Asiatic varieties, characterized by coarse-textured flesh and prominent grit cells. This species is included in the ancestry of some of

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RIPE PEAR (PYRUS COMMUNIS)

the varieties most widely grown in the eastern United States. The sand pears and other oriental species are on the average more resistant to the fire blight disease (see below) than varieties developed from P. *communis,* and sand pear or hybrid varieties can be grown in sections where this disease prevents the growing of higher-quality kinds.

Other oriental species, including *P. ussuriensis,* P. *betulaefolia* and P. *calleryana* have been tested extensively as root stocks for pear varieties.

History of Pear Growing.—The pear has been cultivated since long before the Christian era. Homer, nearly 10 centuries B.C., listed pears as one of the fruits in the garden of Alcinous, indicating that they were known to the Greeks of his day. Improved varieties propagated by grafting were known prior to the time of Christ. About 5,000 varieties have been named in European publications since that time and about 1,000 in the United States. The pear was brought to the new world by the English and other north Europeans as soon as the colonies were established. Also at an early date, the Mission fathers from Spain took them to Mexico and California. In the western states, the pear thrived better than it did in the eastern colonies, because of the reduced prevalence of diseases in the drier western regions.

World Pear Production.—In Europe, the pear is relatively more important than in the U.S. Total production in Europe usually averages about 120,000,000 bu. annually, or about one-third the apple production. Production in the United States averages about 30,000,000 bu., or about one-fourth the apple production. France usually leads all European countries in pear production with average yields near 30,000,000 bu. Western Germany ranks second in Europe with yields around 20,000,000 bu., followed by Italy, Switzerland and the Balkan countries. Much of the production in France, Switzerland and western Germany is devoted to perry-making, but high-quality dessert varieties are also widely grown. Much of the European production is from scattered plantings in yards and on land used for grazing and other purposes.

Other countries having important pear production include Japan, the Republic of South Africa, Australia, New Zealand, Chile, Argentina and Canada. The industries in these countries are not extensive in size, but the orchards receive good care.

In the United States, the principal centres of pear production are in California, Oregon and Washington, these three states producing about four-fifths of the United state; crop, Principal producing centres in California are in the Santa Clara valley, immediately south of San Francisco, in the Sacramento valley south of the city of Sacramento, in tbe foothills of the Sierra Nevada in the north central part of the state and in mountain valleys in Lake and Mendocino counties, north of the San Francisco region. In Oregon the two principal producing areas are in, the Rogue River valley in the southwestern part of the state and in the Hood River valley in the north central portion. In Washington, the Yakima valley, in the south central, and the Wenatchee area in the north central part of the state lead in pear growing. All of these western areas have dry, moderately warm summers, with water supplied by irrigation.

New York and Michigan lead in pear production in the eastern United States. Principal production in New York is in the counties directly south of Lake Ontario, in the western part of the state, In Michigan, the pear orchards are mainly in the southwestern counties adjacent to Lake Michigan. The protection of the lakes reduces the hazard from bath winter cold and spring frosts.

In addition to these intensive areas of production, pears are grown as home orchard trees and with some commercial acreage in most of the states of the union.

Varieties.—In most of the pear areas of the world outside of Asia, the variety known in North America as Bartlett and in Europe as Williams is the leading kind. Maturing in July and August in northern hemisphere countries, it is shipped from the western states throughout the country in the United States and in Europe also it is the leading variety for fresh use. Quantities of it are shipped from Australia, Argentina and Chile to northern hemisphere markets, arriving in the late winter months. Other important varieties in order of their ripening are Buerre Hardy, Buerre Bosc, Coyenne du Cornice, Anjou and Winter Nelis. All of these are of European origin, derived from *P. communis.*

In eastern United States the Kieffer is widely grown. It is a low quality variety apparently a chance cross of the Asiatic sand pear with a European variety. This and other sand pear hybrids are somewhat resistant to the fire blight disease that is highly destructive to European varieties in most of the eastern and southern states. In Asiatic countries, local varieties from native species, considered low in quality by most Europeans and Americans, are largely grown,

Climatic and Soil Requirements.—Pears are somewhat less resistant to winter cold than are apples. Most varieties are not adapted where minimum temperatures are likely to reach −20° to −30° F. Pears bloom earlier in spring than apples, hence are more subject to damage from spring frosts. Highest quality fruits are produced where summer temperatures are moderately high, and diseases are less serious where the summers are *dry.* Like other deciduous fruits, they require a period of winter cold and are not productive within 25° north or south of the equator even at elevations where the year-round climate is cool.

The pear thrives best in well-drained, moderate-textured soils that permit deep rooting: It can be grown, however, on heavier and mare poorly drained soils than can most other tree fruits. Thus there is a basis for the general belief that pears may be planted in heavier soils than apples, peaches, grapes and cherries,

Insects and Diseases.—In common with all widely grown fruits, the pear is subject to insect and disease injury. Codling moth or apple worm (*Carpocapsa pomonella*) is a serious pest on pears wherever grown. Several species of red spider or mites do

much injury to pear leaves. Other insect pests include the pear leaf blister mite, pear Psylla, pear thrips, several species of scale and a wide range of leaf-eating insects. In practically all areas where high quality, clean fruit is grown, three to six sprayings per year to control insects are necessary.

In humid climates the pear is subject to a number of fungus diseases, Controllable by proper spraying. These include pear scab (*Venturia pyrina*), pear leaf spot (*Mycosphaerella sentina*) and pear leaf blight, (Fabraea *maculata*). These diseases attack the leaves, causing defoliation. Scab and leaf blight also attack the fruit, causmg roughened, scabby spots on the fruit surface, and deform the fruit if it is infected early in its development. Properly 'timed spraying with fungicides is effectivein controlling these diseases.

The most serious disease of pears in the United States is fire blight,, caused by a bacterium (*Erwinia* amylovora). The bacteria invade the bark and succulent tissues, killing the invaded tissue. When infection occurs in the main body of the tree, large branches or the whole tree may be killed. Roots are also subject to infection. The bacteria live over winter in cankers in older bark. In the spring, these cankers ooze sap containing the bacteria and are extensively visited by insects. These insects then fly to blossoms, carrying the bacterial infection with them. Thus fruiting spurs are invaded, and the bacteria may wash down to infect new areas. In warm, humid, rainy summer climates, the disease has not been successfully controlled on susceptible va- rieties. The antibiotic streptomycin and also copper-containing sprays applied during and following bloom are helpful in keeping down infection. In addition, blighted twigs are cut out as they appear in early summer. Only varieties having marked resistance to fire blight are to be recommended for planting in most sections of the United States east of the Rocky mountains. Only in New Zealand has the disease come to be of economic importance outside of North America.

The United States department of agriculture and some of the state experiment stations conduct extensive breeding work to develop varieties of pears resistant to fire blight and of high quality.

Packing and Marketing—In the pacific coast states, pears for shipment east are all packed in boxes and individually wrapped. The fruit is cooled as rapidly as possible after harvest. If it is to be held for any appreciable time, the fruit should be placed in cold storage at a temperature of 30°–32° F. For highest quality, pears should be removed from. cold storage while still hard and green and ripened at a temperature of 65°–70° F. When ripened at much lower or much higher temperatures, the quality is distinctly poorer. Bartletts should be held in cold storage not longer than 45–60 days. Beurre Bosc may be held in storage up to three months, and Anjou and Winter Nelis, if carefully handled and stored promptly at 30°–32° F., may be held in cold storage six months or even slightly longer.

When properly ripened, the better quality varieties are among the finest fruits for eating out of hand. Large quantities of Bartletts or Williams are canned commercially. There is a limited production of dried pears in California. Pears are suitable for preserving and pickling, but mqst 'of them are used as fresh, raw fruits or canned or stewed. In Europe, large quantities are used for perry, but that drink has never attained popularity in the United States.

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PEARL, RAYMOND (1879–1940), U.S. biologist, biometrician, demographer and pioneer expositor of the biological approach to the study of health and disease in man. He was born at Farmington, N.H., on June 3, 1879, and studied at the University of Michigan, Ann Arbor, and in Leipzig, Naples and London. In London, working with Karl Pearson (*q.v.*), Pearl began his contributions to biometry with studies on morphologic variations and correlations in man and animals. These studies were continued at the Maine agricultural experiment station, where he was biologist and head of the department of biology from 1907 to 1918. In this period be conducted fundamental studies on the physiology of reproduction in domestic fowl.' From 1917 to 1919, he was chief of the statistical division of the U.S. Food administration.

In 1918 Pearl was invited to organize the department of medical statistics and biometry at the new school of hygiene and public health, Johns Hopkins university, Baltimore, Md. In 1925 he was appointed director of the school's Institute of Biological Research. His investigations centred on fertility and population growth, human 'longevity and tho: relationship of physique to health and disease. He founded two journals: *Quarterly Review* of Biology in 1926 and *Human Biology* in 1929. Pearl's bibliography lists some 700 articles and books. Of the books, the most important and lasting are: *Introduction* to *Medical Biometry and* Statistics (1923), considered a model for such textbooks; *Studies in Human Biology* (1924), a summary of Pearl's investigations on public health problems and a guide for biostatistical research; Alcohol *and Longevity* (1926), a critical review of the reported findings regarding alcohol *on* the biological system and a clear description of its noxious and beneficial effects; *The Natural History* of Population (1939), in which he discussed the population problem and laid solid biological foundations for later population studies.

Pearl died at Hershey, Pa., Nov. 17, 1940. (A. Co.)

PEARL. A pearl is a concretion formed by a mollusk; it consists of the same material (nacre, or plother-of-peat11 as the mollusk% shell. Every mollusk endowed with a shell can produce pearls. Pearllike chitinous formations also have been found in insects and horny ones occur in horn-bearing mammals. Thus a pearl might be defined broadly as a concretion of organic origin.

In common usage, however, pearls are understood to be the concretions of mollusks. The characteristics that make such pearls desirable and'often highly prized as jewelry are their iridescence and translucence. The more perfect the shape (symmetrical ball- or droplike) and the deeper the pearly lustre, the greater the pearl is esteemed. Only those pearls' found in mollusks 'whose shells are lined with nacre are really fine pearls. Pearls from other mollusks are either reddish or whitish, porcelaneous or lacking in pearly lustre.

An unblemished pearl is one of the most ancient symbols of perfection. Pearls were so highly esteemed in classical Rome that only persons of a specified rank were permitted to wear them. Pliny speaks of pearls as "the richest merchandise of all, and the most sovereign commodity in the whole world." The trade in pearls was conducted by a special corporation whose members were known as *margaritarii*.

In spite of the modern development of the cultured pearl industry, the demand for naturally occurring pearls of high quality has continued, and fine specimens still command prices amounting

Nacre, or mother-of-pearl, in the shell of the green turban (*Turbo marmoratus*). True pearls are formed of nacre that is secreted by mollusks in layers around a particle of foreign matter that has become lodged in the fleshy mantle

RUTHERFORD PLATT

to thousands of dollars. However, the peak prices that prevailed in 1928 and 1929 had not been reached again by the early 1960s.

The chief component of the nacre that constitutes the pearl is aragonite, a calcium carbonate distinguished by its orthorhombic crystalline system, its hardness and its lustre. Occasionally a pearl may contain calcite, also a calcium carbonate but differing from aragonite in crystalline structure and other physical characteristics. Nacre contains a small amount of conchiolin, the albuminoid that is the main constituent of the mollusk's outer shell.

The mollusk's shell-secreting cells are located iri the mantle, or epithelium, of its body; when a foreign particle penetrates the mantle, shell-building cells attach to the particle and build up layers of pearl around the invading material. If the foreign substance penetrates deeply enough into the mantle or other soft body part, a sac or cyst of tissue is first formed around it; the pearl building takes place within this sac. The cyst process begins as an indentation in the mantle or body tissue and proceeds in a pouch formation with an ultimate closure at the neck. When the sac is located in the mollusk's body so as not to be subjected to any deforming pressure, it tends to be globular or pear-shaped and the pearl that develops inside it consequently assumes either a spherical or a pearlike form. The nacreous layers that comprise a round pearl of good quality are generally built up concentrically.

Pearl formation does not always occur in soft tissue areas where the expanding pearl sac encounters no appreciable resistance. Pearl cysts lodged in muscular tissue, for example, are unable to overcome the resistance of tough muscle fibres and assume irregular shapes. The pearls produced are consequently oddly formed and are termed baroque pearls. If the depth of penetration of the foreign body is not great and the particle lodges between the shell and the mantle, the shell-secreting cells deposit a sacless pearl formation that is attached to the shell. A pearl-bearing sac situated close to the outer surface of the mantle may come in contact with the shell and also become attached to it. Shell-attached pearls that grow into half spheres flat on one side are called blister pearls.

Although the term pearl is somewhat loosely applied to the calcareous concretions found in various types of mollusks, the appellation true pearl is used only to describe the cyst pearl composed predominantly of nacre and formed free within the mollusk's body without attachment to its shell. The true pearl is characterized by its lustre and by a delicate play of surface colour called its orient.

True pearl-hearing mollusks, of which there are both salt-water and fresh-water varieties, are popularly called pearl oysters, which is something of a misnomer, since these mollusks are not of the Ostreidae family of bivalves that includes the *Ostrea edulis,* or edible oyster. Concretions found in the common edible oyster are generally black or purple in colour, sometimes with an admixture of white, and almost never exhibit lustre. They are not true pearls.

The salt-water mollusks most important in natural pearl production belong to the genus *Meleagrina* (or *Pinctada),* formerly and perhaps better known as *Margaritifera,* which belong to the family Aviculidae or Pteriidae. The *Meleagrina* alone yields the most highly prized of all true pearls, the oriental pearl.

Sources of Natural Pearls.—Ranking first among oriental pearls for superior form, lustre and orient are those produced by the *Mohar,* a variety of the *Meleagrina vulgaris* species of mollusk found in the Persian gulf. The richest pearl harvest of the gulf is taken from the waters of the great bight that curves from the peninsula of Oman to that of Qatar, where the pearl banks lie at depths of 8 to 20 fathoms. Pearls of fine quality are also fished from the pearl banks of the Island of Bahrain.

The Persian gulf pearling fleet is, for the most part, based on the Trucial coast, and fishing is carried on from May through the early part of September. The pearl divers work in pairs, one man remaining at the surface to attend the two lines used; one line, to which is attached a stone weighing about 40 lb., carries the diver downward with baskets to contain the mollusks he gathers, while the second line serves as a signal cord. A diver remains below for 60 to 80 seconds before signaling to be drawn to the surface with his catch. The great pearl market of the Persian gulf has long been the Iranian port city of Lingeh, whose name has become synonymous with the finest of Persian gulf pearls. *(See* also PERSIAN GULF.)

Another important source of oriental pearls produced by the *Meleagrina vulgaris* is the Bay of Bengal in the neighbourhood of Ceylon, particularly in the Gulf of Mannar. These pearls are marketed in the Indian city of Madras, which confers its name on the pearls marketed there. Also marketed in Madras are numbers of African pearls that are taken chiefly from the pearl banks that lie in the coastal waters of east Africa from the Island of Zanzibar to Inhambane in Mozambique. Since the days of the Ptolemies, pearls have also been fished in the Red sea. though the industry there has dwindled to insignificant proportions.

In southeast Asia, the pearls of the Celebes are noted for their lovely colouring, while Australian waters yield pearls of a beautiful silvery white that are produced by *Meleagrina margaritifera* and *Meleagrina maxima.* The islands of the South Pacific also produce fine pearls, and the islanders are noted for their skill and daring as pearl divers. They use no sinkstone and both men and women take part in the fishing. In the Americas, salt-water pearls greater in size than oriental pearls, though less finely formed, have been fished in the Caribbean. The Gulf of California, the Gulf of Mexico and the waters of Mexico's Pacific coast have yielded dark-hued pearls with a metallic sheen, as well as white pearls of good quality.

Fresh-water mussels, notably the species known as *Unio margaritifera,* which inhabit the rivers and streams of the temperate zone of the northern hemisphere, have produced pearls of great value. The fresh-water pearls of the United States have come principally from the Mississippi river and its tributaries, although rivers in other parts of the country have been rich sources also. The most famous of all American fresh-water pearls, the pink "queen pearl," which weighed 93 gr. (46.5 g. or 1.64 oz.), was found in Notch brook near Paterson, N.J., in 1857. It was purchased by the jeweler C. L. Tiffany, from whom it passed to a French gem dealer and was sold to the empress Eugenie.

Although pearling has declined greatly in Great Britain, pearls from the rivers of Scotland, particularly the Spey and the Tay, and those from the river Conway in northern Wales were once in great demand. Pearling is still a profitable and carefully fostered industry in central Europe, however, and the forest streams of Bavaria, in particular, are the source of choice fresh-water pearls.

In China, fresh-water pearling is an ancient industry. As long ago as 2000 B.C., the pearl was a reckoned item in the collection of taxes or tribute, and it is listed in *Rh'y,* a dictionary believed to have been compiled earlier than 1000 B.C., as a product of the western part of the empire.

Cultured Pearls.—To the Chinese belongs the distinction of having been the first producers of cultured pearls. The discovery that pearl production in the fresh-water mussel could be stimulated by introducing a foreign object inside the creature's shell is said to have been made by Ye-jin-yang, a native of Hoochow, in the 13th century A.D. Certainly the Chinese have been adept for hundreds of years at cultivating pearls by opening the mussel's shell and inserting into it small pellets of mud, or tiny bosses of wood, bone or metal, and returning the mussel to its bed for about three years to await the maturation of a pearl formation. Curious pearl-encased statues of the seated Buddha have been produced by placing tiny metal statues of Gautama inside the shells of mussels. The cultured pearls of China have been almost exclusively blister pearls that required the addition of a half sphere of mother-of-pearl to achieve the joined round pearl form known as the doublet.

The production of whole cultured pearls was perfected by the Japanese; the research that led to the establishment of the industry was started in the 1890s by K. Mikimoto. After long experimentation, Mikimoto concluded that a very small mother-of-pearl bead introduced into the mollusk's tissue was the most successful stimulant to pearl production. It possessed the added virtue of providing a pearl entirely of nacreous content.

Cultured pearls closely approximate natural pearls. However, if the covering of nacre is too thin it will deteriorate upon prolonged contact with the human body and eventually will reveal the mother-of-pearl matrix. Japan has more than 300 sea farms de-

voted to production of cultured pearls. The largest of these extends for 20 nautical miles in Ago bay.

Examinations. — Numerous scientific instruments are available for ascertaining the nature and quality of a pearl. The core of a pearl can be observed in the strong light of the nacrescope. or pearl illuminator. Another instrument, the endoscope, provides an enlarged image of the hole drilled through the pearl for stringing. When the illuminator is used with the endoscope, the beam of light. which is first directed on the walls of the drill hole and then follows a path through the pearl, reveals the structure of the pearl from its heart out. The genuine pearl is of concentric construction, while the cultured pearl is shown to be composed of parallel layers of nacre upon its mother-of-pearl matrix. In the case of undrilled pearls, X-ray photographs aid the gem expert in determining the nature of the pearl structure.

Properties. — The colour of pearls varies with the mollusk and its environment. Colours range from black to white, with the rose of Indian pearls being valued most highly. Other colours are cream, gray, blue, yellow, lavender, green and mauve. All occur in delicate shades.

The size range also is wide. Pearls weighing less than one-quarter grain are called seed pearls; as many as 9.000 seed pearls may together weigh one ounce. The largest naturally occurring pearls are the baroques; Henry Thomas Hope owned a baroque weighing 1.860 gr.

Special care must be accorded pearls since they are comparatively soft and easily damaged by acids. On Mohs' scale of hardness: pearls are ranked as $3\frac{1}{2}$ to 4, compared with 1 for talc and 10 for diamonds. This ranking indicates pearls can be scratched with a pin, coin or knife. Consequently they are worn almost exclusively in protected positions. such as in earrings and as necklaces. Pearls also can be damaged by friction; to avoid enlarging the drill holes, pearl necklaces should be restrung regularly and knotted between pearls to keep them from sliding on the string. Since pearls are composed mainly of calcium carbonate, they should not be placed in contact with acid; small amounts of weak acid occur in perspiration, hence pearls should be wiped off after being worn. Small amounts of acid may cause pearls to change colour; large amounts may cause them to decompose. Pearls also are adversely affected by heat.

The surface of a pearl is rough to the touch. A common method for distinguishing between natural or cultured and imitation (man-made) pearls is to pull a string of them across the teeth. The natural or cultured pearls feel rough; the imitation pearls feel smooth. Imitation pearls, which were first made in France in the 17th century, are manufactured by dipping alabaster glass beads in a pearl solution of fish-scale essence and lacquer and repeating until the desired qualities are attained.

History. — The history of the pearl is a long one. It is mentioned in the literature of ancient India as well as that of China (see *Sources of Natural Pearls* above). In Vedic literature the pearl is mentioned as being known in India before the influx of the Aryans (*c.* 1500 B.C.). Archaic Greek and Etruscan jewelry (*c.* 400 B.C.) featured borders of pearls surrounding a central setting of coloured gem stones. Fine pearls were fished in the Persian gulf when Macedonia was a power, and pearls were prized gems in imperial Rome. Oriental pearls were not widely known in medieval Europe until trade with the east was restored by the maritime city-states of Italy, when they became increasingly popular with Europeans. Both river and oriental pearls were used profusely for personal adornment. During the Renaissance, airily light earrings were made by suspending pearls from fine gold wires, and brooches were fashioned with pendant pearls. Portraits of the period show ropes of pearls encircling the neck and winding around the shoulders of the wearer. The goldsmith of the Renaissance found beauty in the baroque pearl. His imagination saw in it not the misshapen product of a sea mollusk but rather an animal form from nature, or the body of a hero or a god from the pages of classical mythology. He broke with the ancient tradition that demanded of the pearl the classic regularity of the sphere and skilfully incorporated the baroque into the individualistic freedom of his design.

With the advent of the modern era, pearls lost none of their popularity. The age turned to the safety of symmetry, however, and the regularity of the globed jewel was again preferred to the eccentricity of the baroque.

Pearls noted for their size. beauty and historical associations are ranked among the famous jewels of the world. La Reine des Perles, a 27.5-carat oriental pearl, was among the crown jewels of France stolen in 1792, while La Regente, an oval pearl weighing 34 carats. once was owned by the French imperial court. A beautiful Caribbean pearl presented to Philip II of Spain in 1570 is presumed to have been destroyed by fire in the Escorial in 1734. See also JEWELLERY.

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(E. L. *Y.*)

PEARL HARBOR ATTACK. The Japanese attack on Pearl Harbor, Hawaii, on Dec. 7, 1941. was the culmination of worsening relations between the United States and Japan extending over a decade. U S. policy in the far east was closely tied to friendship with China and to dislike of Japanese aggression against that state. As early as 1931 the Tokyo government had extended its sway over the Chinese province of Manchuria. By 1937 it had entered upon formal warfare with the Chinese Nationalists. In 1938 the United States government extended its first loan to China; in 1939 it denounced the commercial treaty of 1911 with Japan; in the summer of 1940 it began to restrict the export to Japan of materials useful in war. Between June 1940 and the fateful crisis of Dec. 1941, the tension constantly mounted. In July 1941, by which time the Japanese had occupied all of Indochina and had entered into an alliance with Germany and Italy, the U.S. government severed all commercial and financial relations nith Japan. The militarists in the Tokyo government were steadily gaining in influence; they bitterly resented U.S. aid to China, which had by this time been stepped up; and they saw in the German invasion of the U.S.S R. an unrivaled opportunity to pursue a policy of aggression in the orient without danger of an attack upon their rear by the forces at the disposal of the Kremlin. Nonetheless, negotiations looking to some kind of understanding between the United States and Japan took place through the autumn of 1941, and not until near the end of o-vember did it become clear that no agreement was possible. By this time the Japanese government had decided that upon failure of the negotiations. it would attack the United States without first declaring war; the plan for a surprise assault on Pearl Harbor had already been worked out. The order for this assault was issued on Nov. 5; on Nov. 16 the task force of about 30 ships, including 6 aircraft carriers: under Vice-Adm. Chuichi Nagumo, began its rendezvous in the Kurils; and on Nov. 26 it sailed on its mission.

It was instructed, however, that it might be recalled in case of a favourable outcome of the negotiations in Washington, D.C.

The U.S. Pacific force had been stationed at Pearl Harbor since April 1940. In addition to nearly 100 naval vessels, including 8 battleships, were substantial military and air forces at this key U.S. base. As the tension mounted, Adm. Husband E. Kimmel and Lt. Gen. Walter C. Short, in command at Pearl Harbor, were warned of the possibility of war, specifically on Oct. 16 and on Nov. 24 and 27. The dispatch of Nov. 27, to Admiral Kimmel, beginning, "This dispatch is to be considered a war warning," went on to say that "negotiations have ceased," and directed the admiral to "execute an appropriate defensive deployment." Kimmel was also ordered to "undertake such reconnaissance and other measures as you deem necessary." The communication of the same day to General Short declared that "hostile action is possible at any moment," and, like its naval counterpart, urged "measures of reconnaissance."

In response to these warnings, the measures taken by the army and navy commanders were, as the event proved, far from adequate. General Short ordered an alert against sabotage and con-

centrated most of his fighter planes at the base on Wheeler field in order more effectively to prevent damage to them. He also gave orders to operate five of the mobile radar sets that had been set up in the island from 4 A.M. to 7 A.M.: considered to be the most dangerous period. (Radar training, however, was in a far from advanced stage.) Admiral Kimmel, despite the fact that his intelligence had not been able to locate substantial elements in the Japanese fleet, especially the first-line ships in carrier division 1 and 2, did not expand his reconnaissance activities to the northwest, the logical point for an attack. He moored the entire fleet (save that part which was at sea) in harbour, and permitted a part of his personnel to go on shore leave. Neither of these officers suspected that the base at Pearl Harbor would be subjected to attack. Nor, for that matter, is there any indication that their superiors in Washington were in any way conscious of the approaching danger. In the ten days between the war warning of Nov. 27 and the Japanese attack itself no additional action was taken by Washington.

With the morning of Dec. 7, at 4:37 A.M. word came through that the Japanese ambassadors in Washington had asked for an interview with the secretary of state at 1 P.M. This was a clear indication that war was at hand. The message took some time to decode. It was not in the hands of the chief of naval operations till about 10:30. It was delivered at the war department between 9 a d 10 A.M. General Marshall. the chief of staff, was out horseback riding and did not see the dispatch till arriving at his office about 11:15 A.M. The chief of naval operations, Admiral Stark, even then, did not think that the communication called for any additional instructions to Kimmel. However, General Marshall did decide to send a new warning, and gave orders to the military command to communicate also with the navy. He did not telephone, fearing that his words might be intercepted. He sent his dispatch by telegram. There was a mix-up in communication, and the warning did not reach Hawaii till after the attack had begun. It is important to note that it had not been filed until noon, only an hour before the Japanese planes moved in on the great base.

At Pearl Harbor itself, there were incidents that, properly interpreted, might have given a brief warning. Four hours before the decisive moment a Japanese submarine was sighted by the destroyer U.S.S. "Ward". No report was made. About two and a half hours later, the commander of the U.S.S. "Ward" sent a message saying that he "had attacked, fired upon and dropped depth charges upon submarine operating in defensive sea area." While Admiral Kimmel waited for "confirmation!' of this report, the Japanese opened hostilities. In these same morning hours, an army private, practising on the radar set after its normal closing time: noticed a large flight of planes on the screen. When he telephoned his lieutenant, he was told to forget it, for a flight of B-17s from the United States was expected at that time. Once again, an opportunity was missed.

It was at 7:55 A.M. that the first dive bomber from the Japanese aircraft carrier arrived over Pearl Harbor. It was followed by a massive group of nearly 200 aircraft, including torpedo planes, bombers and fighters. Within a quarter of an hour the various airfields at the base were subjected to savage attack. At Wheeler field, in particular, where General Short had drawn up his planes, the destruction was fearful. Of the 126 planes on the ground, 42 were totally destroyed, 41 were damaged, and only 43 were left fit for service. Only six U.S. planes got into the air to repel the attackers on this first assault. At the same time a massive movement was directed against Admiral Kimmel's fleet, so conveniently moored at the base. The battleship U.S.S. "Arizona" blew up with a tremendous explosion. 'The U.S.S. "West Virginia" was riddled with bombs and torpedoes, and settled on an even keel on the bottom of the harbour. The old U.S.S. "Oklahoma," hit by four torpedoes within five minutes, rolled completely over, with her bottom and propeller rising ,above the waters of the harbour. The old target ship U.S.S. "Utah" was sunk. Hardly a vessel in the squadron escaped damage. The antiaircraft on the various vessels were fairly prompt in getting into action; the army fired away with what it had; but the force of the attack was in no serious way blunted.

At 8:50 A.M. the second wave of the attack began. Less successful than the first, it none the less succeeded in inflicting heavy damage. The battleship U.S.S. "Nevada" was hit by seven or eight bombs and was grounded at the head of the channel. The battleship U.S.S. "Pennsylvania" was hit and the two destroyers moored near her reduced to wrecks. The destroyer U.S.S. "Shaw" was split in two by a great expiosion. Shortly after 9 A.M. the Japanese withdrew.

No one could doubt that the Japanese had gained a great success. They had inflicted on the U.S. navy casualties to the number of 2,718, of which over 2,000 were fatalities. Army casualties exceeded 600 men, of whom more than 200 were killed. The attack had resulted in the total destruction of three battleships, in the capsizing of a fourth, in heavy damage to a fifth, and in lighter damage to three others. Two light cruisers were heavily damaged, and a third suffered less severe hurt. Three destroyers were put out of action, a repair ship badly punished, and a minelayer sunk. Heavy damage was inflicted on both army and navy planes on the ground. To accomplish these results the Japanese had sacrificed less than 100 men, 29 planes and five midget submarines. Their task force escaped without being attacked.

There was, however, one consoling feature to the tragedy. As a result of the dispositions made by Admiral Kimmel, two aircraft carriers were not in the harbour; they mere engaged in reinforcing other stations. notably Midway and Wake islands. In connection with this same operation, seven heavy cruisers and a division of destroyers were at sea. Of cardinal importance was the absence of the carriers. They were the only two vessels of this type in the area, and were to play a highly important role in future battles. The great disaster at Pearl Harbor led to numerous investigations. Almost immediately after the assault, the president appointed a commission headed by Justice Owen J. Roberts of the supreme court to examine the facts and to fix responsibility for the disaster. At a later date both army and navy boards reviewed the problem. In 1946 a full-scale congressional investigation took place. Probably no episode in U.S. military history has been so thoroughly examined, and on none has a wider divergence of opinion been expressed.

The most extreme view of the disaster is not to be found in any of the numerous investigations, but was disseminated long after the tragedy by Rear Adm. Robert A. Theobald of the U.S. navy in *The Final Secret* of *Pearl Harbor*. This view is that President Roosevelt "by unrelenting diplomatic pressure" "enticed" Japan "to initiate hostilities with a surprise attack by holding the Pacific fleet in Hawaiian waters as an invitation to that attack." Such a position is not taken by any responsible historian. It involves judgments as to motives which simply cannot he substantiated.

The president did indeed pursue a policy of support to Nationalist China which acted as a substantial irritant to the Tokyo government. and did much to provoke it to action. But at the same time there is substantial evidence that he sought to postpone a clash, rather than to incite one, and even in the closing days of the negotiations he made an appeal to the Japanese emperor, which if listened to, might have had that effect.

The success of the attack on Pearl Harbor was primarily due to a false estimate of the enemy's capabilities and intentions. The authorities in Washington knew that the Japanese forces were moving southward into the Gulf of Siam. They did not believe that coincident with this move they could or would mount an attack on the Hawaiian base. It seemed logical, too, that the Japanese would avoid such action because it would inevitably bring the United States into the war; operations in the far east directed against the British and the Dutch might not have this effect. True: the possibility of an air attack on Pearl Harbor had been frequently discussed in the course of the year. But, as matters came to a crisis, for the reasons mentioned above, it fell into the background.

It is a difficult matter (and one on which divergent opinions will long be held) to apportion responsibility between Washington and the commanders on the spot. The Roberts commission, the

body appointed by the president on Dec. 17, 1941, in a report presented only a few neeks later, placed the principal blame for the disaster upon Admiral Kimmel and General Short. The army and navy commissions which later examined the problem took a contrary view, throwing the blame on the war and navy departments. The majority report of a congressional committee, rendered in 1946, while not avoiding criticism of the chief of naval operations and the army chief of staff, laid stress on the lack of preparation in Hawaii. Two members of this committee strongly dissented, severely blaming the authorities in Washington, and a third took a kind of middle ground.

Those who defend the position of the Hawaiian commanders make the following points. General Short replied to Marshall's warning of Nov. 27, "Department alerted to prevent sabotage." When this reply passed over the chief of staff's desk, he neglected to notice that it mentioned only this one kind of preparation (as did Gen. Leonard T. Gerow, his subordinate). At no time in the next ten days was this neglect repaired. As for Admiral Kimmel, the point has been made that he was inadequately informed as to the seriousness of the crisis. In the months before Pearl Harbor the armed services, through the breaking of the Japanese code, were able to get much information as to Japanese purposes. Not a small part of this related to the position of the naval forces in Hawaii. Kimmel himself has claimed that had he been put in possession of this material he would have taken far stronger measures than he actually did. In defense of his failure to undertake more vigorous measures of reconnaissance, he urged the importance of his training program, and the limited nature of his resources.

The critics of Washington also asserted that by the evening of Dec. 6 the president had clear evidence that war was impending, and that he should have taken prompt measures to alert the war and navy departments. This view attached little importance to the warnings of Nov. 27.

Those who were critical of the commanders on the spot took the view that the warnings given were sufficient, and that a deplorable lack of imagination was shown in acting on them. Everyone who read the papers knew that war was imminent. Why was not the possibility of an air attack taken into account? Why were Short's airplanes drawn up in such fashion as to be most exposed to enemy attack? Why was the radar training program not more advanced? Why did Admiral Kimmel so handle his schedule that the Japanese could count on all the battleships being in port on Sunday? Why were normal week-end leaves and liberties granted? Why was not some attempt made to improve reconnaissance? Why was not the report on the Japanese submarine taken more seriously? Those uho emphasize the responsibility of Kimmel and Short also call attention to the fact that the war warnings of Nov. 27 brought much more vigorous action on the part of the commanders in the Canal Zone and the Philippines.

Whatever judgment may be rendered on this matter, more important than the question of responsibility is the question of the historical significance of Pearl Harbor. And here the verdict is easier to come at. Great as was the Japanese success in the short run, great as was the humiliation inflicted on the United States, the "sneak attack," in the longer perspective, was a monstrous error on the part of the government in Tokyo. Even from the tactical point of view it was a blunder. For in their purpose of destroying the fleet, the Japanese neglected the great oil supplies on Hawaii, the destruction of which would have immobilized the United States for months to come. But, more important, the Japanese attack brought the U.S. government into the war, unified the American people, and made the ultimate defeat of the Japanese militarists inevitable. There was much antiwar sentiment in the United States in the fall of 1941. Had the Japanese commanders directed their attention against the British and Dutch, it must have been at least doubtful whether President Roosevelt could have led the American people into the war in the Pacific. As in so many other instances in the history of the 20th century, in spite of the weaknesses of the democracies, the autocratic states made errors even more vital than the errors of the democracies. Pearl Harbor was atoned for in four and a half years of war; but the blunders of the Tokyo militarists resulted in utter and total defeat. This is the most memorable fact of all with regard to the "sneak attack" of Dec. 7, 1941.

BIBLIOGRAPHY.—The most voluminous source of material on the Pearl Harbor attack is the hearings of the Joint Committee on the Investigation of the Pearl Harbor Attack, 79th Cong., 1st. Sess. (39 vols.) followed by the report of the committee itself, 79th Cong. 2nd. Sess. Doc. 244. There are to be found the report of the Roberts Commission, the Army Pearl Harbor Board, the Naval Court of Inquiry, and the Hewett Inquiry,. ivith masses of testimony as to the attack itself. Of secondary materials the following may be mentioned. Walter Millis, *This is Pearl! the United States and Japan, 1941* (1947); Walter Lord, *Day of Infamy* (1957); Rear Admiral Robert .4. Theobald, *The Final Secret of Pearl Harbor* (1944); Admiral Husband E. Kimmel, *Admiral Kimmel's Story* (1955); George E. Morgenstern, *Pearl Harbor: The Story of the Secret War* (1947); Charles A. Beard, *President Roosevelt and the Coming of the War, 1941* (1948). An admirable brief analysis is to be found in Samuel Eliot Morison, *The Rising Sun in the Pacific* in vol. 3 of his History of United States Naval Operations in World War II (1948); and in Mark S. Watson, *Chief of Staff: Prewar Plans and Preparations,* pp. 494–520 (1950). The three volumes by Theobald. Kimmel and Morgenstern are distinctly polemical, and should be used with caution. Charles A. Beard's account is also slanted, but contains much material of great interest on the various hearings.

(D. Ps.)

PEARL RIVER, a river of the southeastern United States, rises in east-central blississippi, near Louisville, and flows southwest, south, and then slightly southeast to the head of its delta, south of Bogalusa, La. From there the East Pearl river continues southward for 34 mi, and passes into Mississippi sound near Grand Island. West Pearl river parallels East Pearl in the delta, several miles to the west, and enters the Rigolets, a tidal channel connecting Lake Pontchartrain with Lake Borgne. The two mouths of the Pearl are interconnected by a maze of channels.

The Pearl is approximately 490 mi. long and has a drainage basin of about 7,600 sq.mi. Chief tributaries are the Yokahockany and Strong rivers and the Bogue Chitto. Three locks on the West Pearl, completed in 1953, provide a 7-ft. channel from the mouth to Bogalusa. 58 mi. upstream. Navigation on the East Pearl and on the Pearl above Bogalusa is no longer important. Until the early 20th century. however, the river below Jackson, Miss., was a main route for transporting lumber. Columbia. Monticello and Jackson, Miss., and Bogalusa. La., are the chief river cities. Jackson obtains its domestic water supply from the Pearl. In 1958, the Mississippi legislature approved the issuing of revenue bonds for a 21-mi.-long reservoir north of Jackson, to provide water, flood and pollution control and recreational facilities for the Pearl river valley.

The lower course of the Pearl, and the East Pearl, form the boundary between Mississippi and Louisiana. Prior to 1812, when Louisiana was granted statehood, the Pearl was the eastern boundary of the province of A'est Florida. Honey Island swamp lies in the mid-delta area of the Pearl River valley, southwest of Picayune, Miss. This heavily forested swamp, criss-crossed by a maze of channels, is noted for its wildlife and fishing. (M. W. M.)

PEARSE, PATRICK HENRY (1879–1916), Irish leader and poet, was born in Dublin on Nov. 10, 1879. Educated at the Christian brothers schools and the Royal University of Ireland, he became editor of the *Claidheamh Soluis,* the weekly organ of the Gaelic league. He was secretary to the publication committee of the league and an energetic member of its executive. After touring Belgium to study bilingual methods, he published several *Fiana,* tales from Irish manuscripts. Pearse's chief interest was education and he approved Augustine Birrell's Irish Education bill, as it gave the Irish control over their own education. He founded St. Enda's school at Cullensmood, Dublin, moving it in 1910 to the Hermitage, Rathfarnham. After a tour in America, Pearse joined the Irish Volunteer movement and was commander in chief of the Irish forces in the rebellion of 1916. On April 30, 1916, he sent out an order to his troops to surrender. He himself was arrested and executed on May 3, 1916.

See his *Life* by Desmond Ryan (1919).

PEARSON, KARL (1857–1936), British mathematician, one of the founders of modern statistics, was born in London, March 27, 1357, and educated at University college school, London, and Kings college, Cambridge. He practised law from 1881–

84, when he received an appointment as professor of applied mathematics and mechanics at University college, London. There he taught until his retirement in 1933, becoming lecturer in geometry (1891), head of the department of applied mathematics (1907) and professor of eugenics (1911). Pearson was the founder and editor (1902–36) of the statistical journal *Biometrika,* editor of *The Annals of Eugenics* (1925–36) and director of the Biometric and Francis Galton Eugenics laboratories.

Pearson's early lectures, published as *The Grammar of Science* (1892), became one of the classics in the philosophy of science. Beginning in 1890 his interests began to shift to the application of statistics to biological problems of heredity and evolution; his greatest contribution was the methodology he developed for the handling of certain types of problems in the biological and social sciences. From 1893–1912 he wrote a series of 18 papers entitled *Mathematical Contributions to the Theory of Evolution,* which contained much of his most valuable work, including the chi-squared test of statistical significance. *See* PROBABILITY AND STATISTICAL THEORY: *Statistical Tests.* He died on April 27, 1936, in London.

Among his other works were *The Ethic of Free Thought* (1888); *The Chances of Death and Other Studies in Evolution* (1897); *The Life, Letters and Labours of Francis Galton* (1914, 1930); *Tables for Statisticians and Biometricians* (19'14, 1931); *Tables of the Incomplete Gamma Function* (1922); *Tables of the Incomplete Beta Function* (1934).

See also *E. S.* Pearson, *Karl Pearson (1939).* (S. S. W.; **X.**)

PEARSON, LESTER BOWLES (1897–), Canadian statesman, won the Nobel prize for peace in 1957. He was born at Toronto, Ont., on April 23, 1897. Educated in the public schools of Peterborough and Hamilton, he served in World War I in the Royal Flying corps. Invalided home, he entered the University of Toronto (B.A., 1919) and earned B.A. and M.A. degrees at Oxford university (1923, 1925). He was a lecturer (1924–26) and assistant professor (1926–28) of history at the University of Toronto before becoming a first secretary in Canada's newly formed department of external affairs. After a series of diplomatic posts and service on loan as secretary to two royal commissions. he became secretary (later counsellor) of the Canadian high commissioner's office in London. Canada's ambassador to the United States, 194.5–46, and undersecretary of state for external affairs, 1946–48, he was often spokesman for Canada at the United Nations. He served in 1947 as chairman of the political committee of the UK general assembly. In 1947 he was instrumental in securing UN passage of the Palestine partition resolution.

He entered politics in 1948, becoming secretary of state for external affairs in the Liberal government of Louis St. Laurent and member of parliament for Algoma East. Re-elected three times! he became a private member of the house of commons in opposition when his party was defeated in June 1957. He was awarded the Nobel prize for his efforts at resolving the 1956 Suez crisis. In 1958 Pearson succeeded St. Laurent as leader of the Liberal party. (W. D. A. O'H.)

PEARY, ROBERT EDWIN (1856–1920), **U.S.** arctic explorer who reached the north pole in 1909, was born at Cresson, Pa., on May 6, 1856. He graduated at Bowdoin college, Brunswick, Me., then joined the civil-engineering branch of the U.S. navy and took part in the survey of the Nicaragua canal route from 1885 to 1887. In 1886, with one companion, he journeyed inland from Disko bay over the Greenland ice sheet for about 100 mi., reaching 7,500 ft. above sea level. He returned in 1891 with seven companions, including his wife and F. A. Cook. After wintering in Hvalsund he sledged for 1,200 mi. to the northeast of Greenland, discovering Independence fjord and evidence of the insularity of Greenland. The "Arctic Highlanders," an isolated tribe of Eskimo, were befriended and studied; they were of the greatest assistance to Peary 'on later expeditions. He returned to Hvalsund in 1893 with a larger party, and sledging journeys were made to northeast Greenland again in 1894. Summer trips in 1896 and 1897 were mainly occupied in transporting three masses of meteoric iron irom Greenland to the United States. In 1898 he announced his intention of reaching the north pole, and from 1898 to 1902 reconnoitred routes from bases at Etah in Inglefield Land and Fort Conger on Ellesmere Island. Meanwhile the Peary Arctic Club of New York was formed to raise funds for the support of his further expeditions, thus relieving Peary of financial worries. A ship, the "Roosevelt," was built to his specifications and carried his next expedition, early in 1905, through Smith sound to Cape Sheridan, Ellesmere Island. The sledging season nas unsuccessful owing to adverse weather and ice conditions and the party only reached lat. 87° 6 N. Peary returned to Ellesmere Island in 1908 and early the following March left Cape Columbia on his successful journey to the north pole. He was accompanied on the last stage of the journey by Matthew Henson, his Negro aid, and four Eskimos, one of whom was drowned during the return. F. A. Cook's claims to have forestalled him by a year, though generally discredited, marred the enjoyment of Peary's triumph. He died on Feb. 20, 1920, in Washington, D.C. Peary's published works include *Northward over the "Great Ice"* (1898), *Nearest to the Pole* (1907), *The North Pole* (1910) and *Secrets of Polar Travel* (1917). (L. M. Fs.)

PEASANT, a countryman, either working for others, or owning or renting and cultivating by his own labour a small plot of ground (Fr. *paysan;* Lat. *pagensis,* belonging to the country).

PEASANT MOVEMENT. World War I and. paradoxically, the Russian Revolution gave a strong impetus to the political consciousness of a class which had seemed to be falling into insignificance. Through the centuries the peasants had occasionally played a forceful part in social convulsions, but since the Industrial Revolution western political life was dominated by leaders in commerce and industry; and that trend was only sharpened by the rise of the workers' movement. Eastern Europe had little industry: the bulk of its people were peasants, who had little share of material wealth and little influence in public life. And so it was natural that the stirrings of 1917 in that region should raise a peasant movement, with a social and political philosophy all its own.

Political Traditions of **the** Peasantry. — Between the French Revolution and 1848 the peasants of western and central Europe were gradually freed from all feudal servitudes. But the peasants derived only an indirect benefit from reforms achieved mainly by the urban middle classes, who needed freedom of action for the new capitalist enterprise.

The growing division between town and country was widened into a gulf by the rise of "scientific" socialism. The viewpoint of socialist economics was essentially the same as that of capitalist liberalism, except that the socialists wanted production to be planned. organized and controlled upon the largest scale. Marx gave credit to capitalism for having at least rescued considerable sections from the "idiocy of rural life"; he and his disciples placed the nationalization of the land and collectivised farming in the forefront of their program. This gave rise to the organization of many conservative agrarian groups in central and western Europe, which found in the peasants credulous recruits. The electoral effects gradually led to a watering down of socialist agrarian programs.

Populism.—The economic and political incentives which had interested the western bourgeoisie in rural emancipation had little meaning in the eastern half of the continent. Politically, that region was still in the autocratic stage. Its economic life rested on primitive agriculture and artisan manufacture. But the social incentive stirred up reformers in the east perhaps more deeply than in the west.

The younger intellectuals, imbued with 18th century humanitarian philosophy, centred all their ideals on freeing the peasants. But what for western liberals had been an end in itself, for the Russian reformers was merely a steppingstone to a free and full village life. Marxism was essentially a policy for transforming industrial society; in the east, socialism was for the peasants. Hence eastern socialists were forced to work out alternative ideas and programs suited to the problem of their own peasant populations. "Populism" became the expression of that trend. *(See* RUSSIA: *History.)*

The kernel of populism was the rejection of Marxist economic determinism. Marxism looked upon capitalist concentration of production as only a stage on the way to a socialist society. The Russian Populists put their faith in the existence of the village community (*mir*). They contended that a capitalist-proletarian phase was neither necessary nor possible in a backward agrarian country, as it would merely ruin the peasants, the only customers for industrial products. Above all, they believed that a rural democracy offered the masses the promise of a better life than industrial society. All they needed was more "land and liberty." and the backbone of the Populist program was a plea for the equal distribution of land among the peasants.

The later exponents of this program were the Social-Revolutionaries, the strongest party of the left up to the Bolshevik revolution. That the Populist doctrine had its roots in the natural conditions of the region is proved by the way it spread to the other agrarian countries of eastern Europe. It was perhaps natural that Serbia and Bulgaria should come under its influence, for both stood intellectually in close dependence on Russia. The decisive test is supplied by Rumania, a Latin country, strongly averse to Slav influence, yet there also the new doctrine engendered a strong rural current that joined with the others in denouncing Marxism.

The Peasant Renascence. — The Populist movement had remained largely theoretical because the peasants were restrained by a rigid political and social tutelage. Political activity and claims for the distribution of land were treated as revolutionary activity. The only outlet for their grievances were occasional uprisings, like those of 1905 in Russia and 1907 in Rumania, which were mercilessly repressed. But World War I and the Russian Revolution completed in the east the change begun by the French Revolution in the west. Sweeping reforms transferred the bulk of the land to the peasants, thus holding out to them the hope of economic independence. At the same time the peasants secured political rights, and were roused to a consciousness of their interests and their power as a class. Their movement was still loose and vague: its possibilities lay in the fact that more than half the population of the globe lived under a typically peasant "family economy," and that even in Europe there were more peasants than industrial workers.

In India the Congress party was led to take over the program of the Kisan Sabhas which had come into being after the 1930s; in China the strength of the Communist movement derived largely from its support of the peasants. There were stirrings in other far eastern countries, and also in South America and the middle east.

Doctrine and Program. — Unlike socialism, which had a fully developed doctrine before it had an organized following, the peasant movement sprang up separately in the various countries, though out of similar convulsive events. Hence its sociology was still in the making. and the programs of the several parties showed substantial variations. Its philosophy and policy were taken over and adapted to its own use elements from all the main political creeds. It can be summed up as a cross between liberalism and socialism: it stands firmly for democratic government and it holds tightly to the small family holding, which to the peasant is not merely a means of living but a way of life. For the rest, it generally accepts state control of public services and of primary and other big industries, though it wants small industries scattered about the country to combine work on the land and in the factory according to seasonal needs. It is generally anticapitalist, but would eliminate bankers and middlemen gradually by setting up co-operatives either for specific purposes or embracing the whole life of a village community. It believes in a rural society based on an educated, land-owning peasantry; and combining through a network of co-operative undertakings the virtues of small property with the means of large-scale enterprise.

The radicalism of the eastern peasant movement came from the peculiar conditions of the region. In the west, agrarian parties were a mixture of all rural classes, with big landowners to the fore, as in the German Landbund; the eastern parties were exclusively peasant. Secondly, oppression in the east had prevented the growth of a peasant middle class, so the movement was supported by a more uniform mass of small peasants. Thirdly, peasant antagonism toward town and capitalism had different effects in the two halves of Europe. In the west, finance and industry had entered a phase of international organization by means of cartels, trusts, etc.. and the outlook of the towns was cosmopolitan; as a reaction the countryside was conservative and nationalist. In the east, industry and finance were bound up with local nationalism. and the peasant who paid the bill of protectionism favoured a liberal and even a radical policy in all respects.

The Peasant Parties. — The peasant movement that sprang up after 1918 was peculiar to the eastern half of Europe. In the industrial countries of the west, even in Holland and Denmark, the peasants had been drann into conservative agrarian parties because of a general antagonism to industry and finance, partly through clerical influence. and largely by the fear of the socialist demand for land nationalization. But just as western socialism had stirred up industrial groups in the east and shaped their outlook, so the eastern peasant movement caused stirrings in the west. In France a peasant party was founded four weeks before the elections of 1928; in Germany, also before that year's elections, the left wing of the old *Landbund* formed a new Christian National Peasant party, and at the same time the Bavarian *Bauernbund* changed itself into a German Peasant party which dominated the parliamentary situation in Bavaria. Attempts to establish peasant parties were made in Holland and elsewhere.

Some of the eastern peasant parties were founded before World War I, but became important only after it. The Bulgarian Agrarian union, founded in 1899 as a professional body, became political in 1901: it polled 14.45% of the votes in 1911, 31% in 1919, 38.16% in 1920, 52.0% in 1923. In June 1923 a military coup led to the murder of Alexander Stambolisky and other party leaders. While in power, the party carried through broad co-operative measures and a law for compulsory civic service *(see* International Labour organization pamphlet, *Legislative Series*, 1920).

The Czechoslovak Republican Party of Farmers and Small Peasants, founded in 1896, at first conservative, veered leftward, led by Antonin Svahla, Rudolf Beran, and Milan Hodza. Czechoslovakia took the lead in adopting an 8-hour day for agriculture and working out practical ties between peasant producers' co-operatives and urban consumers' co-operatives. Alone of the eastern countries, it included members of the national minorities in the cabinet. All these steps were due to the party's initiative.

Poland had several peasant parties, reflecting its unsettled political outlook. The Polish Populist party, known as *Piast* (significantly the name of the first Polish royal dynasty, which was of peasant origin) was led by Wincenty Witos. Twice premier, he was rather conservative, admitted land reform only with compensation, and was open to clerical influence. The Liberation party, led by Stanislaw Thugutt, was radical, demanded land reform without indemnity, favoured regional autonomy for the minorities, and was anticlerical. A similar program was supported by the Peasant party led by Jan Dabski, representing chiefly the small peasants.

It is noteworthy that while the political movement was divided by regional, clerical and personal influences, the peasants worked together in their co-operative affairs, brought to high achievement by Stanislaw Mikolajczyk. The Rumanian National Peasant party, formed by the fusion of several groups, was the only substantial opposition; in Nov. 1928 it formed the first truly parliamentary government in Rumania, led by Iuliu Maniu, Nicholas Lupu, Ion Michalache, and the economist Virgil Madgearu.

In Yugoslavia the Croat Peasant party, founded in 1904, dominated Croatia after World War I and gained strength in Bosnia and Dalmatia. Stjepan Radid, Pavle Radid, Dr. Vladimir Maček and other leaders held office in various coalition governments. Remarkable for its organization and comprehensive activities, and especially for its spiritual cohesion, it was built upon a clear rural creed rather than upon agrarian interests.

There were also rising peasant parties in Finland, the Baltic

states and elsewhere.

International Organization.— A number of international agrarian bodies had existed before, but they had not been limited to peasant groups nor had they been set up for political action. Soon after World War I an attempt was made by Bavarian and Austrian farmers to unite the peasant groups of central Europe, the Bavarian Georg Heim being one of the initiators. The movement was conservative and anticommunist and, while some of the leaders kept neutral, others had a strong clerical bias. The attempt came to nothing. Though no peasant party existed in Russia, the Communists encouraged some of the refugees living in Moscow to set up there a Peasant International. Formed in *1923,* it held its first congress in *1925,* but made no visible impression on the peasant movement. On the initiative of the Bulgarian Stambolisky, an international bureau for research and information was set up in Prague in *1921,* the Czech, Bulgarian, Polish and Serbian parties being members. In May *1928,* the bureau was joined by the Croat, Rumanian and other parties, including the newly-formed French and Dutch parties. At the same time, eight parties of central and eastern Europe formed a regional group within the bureau itself with a joint executive, to work for the solution of political and social problems in the peasant interest; and to resist jointly any attempt at dictatorship, from the left or from the right.

The Interwar Period.— The potential strength of the eastern peasant movement was attested less by the actual power it enjoyed than by the strong efforts made to check it. As noted above, Stambolisky and other Bulgarian leaders were murdered in *1923* and the party broken up. The Croat leaders were repeatedly imprisoned, and ultimately Stjepan Radid died of wounds, and his nephew Pavle Radid and others were killed outright. The Rumanian leaders were persecuted and the party was denied the power to which its electoral strength entitled it.

In Poland, Witos was imprisoned for a short time and then had to flee the country. All these parties and leaders had stood firmly for democratic government and social reform. Their persecution everywhere ended in dictatorship, because the peasant groups also had to face the competitive antagonism of socialist parties. In Bulgaria, Rumania and Yugoslavia these were insignificant, but they were strong in Poland and Czechoslovakia. The division between the two sections of the working mass paved the way for reaction.

War and Aftermath.— World War II and the Nazi occupation found the peasants united with others in resistance; there was no defection among their groups and leaders. But after victory the movement again became the target of violent reaction, this time from the Communist left, backed by Russian military power. Against all Marxist teaching and Soviet policy, the new regimes in the eastern countries, including the Soviet zone of Germany, handed over the land to the mass of poorer peasants, in tiny uneconomic holdings, to undermine the solidarity of the peasant class. At the same time, all the peasant parties were suppressed, their leaders killed, imprisoned or driven into exile. The latter group revived in Washington, D.C., the activities of the International Peasant union in *1947.* Significantly, in Poland, Bulgaria, Rumania, Hungary and Czechoslovakia, the Communist regimes found it expedient to set up new peasant parties under their o n patronage.

Up to *1948* these regimes sought to keep the peasants quiet and at work by denying any intention to collectivise farming. But after *1948* collectivisation was pressed forward ruthlessly in all the "peoples' democracies." It was later pushed forward in China, where in *1948* the Communists had ridden to victory on the back of a discontented peasantry.

After Stalk.— This trend was sharply reversed after the death of Stalin. Nikita Khrushchev, who had formerly invented a scheme for the extreme concentration of farming in "agro-tonns," took the initiative in lowering taxes, reducing the compulsory deliveries. and giving higher prices for produce taken from the peasants by the state. Admitting that central planning had proved "wrong and inefficient," a decree in March 1955 also gave collective farms more power to run their own affairs. In China, also, in March *1957* peasants were given some ease, but later, new oppressive measures sought to end peasant resistance.

The Soviet reversal set off a more thorough retreat in the satellite countries. Apart from concessions to the peasants in the form of lower prices and reduced taxes Yugoslavia, Rumania, Hungary and Poland, the very policy of collectivisation was eased or virtually abandoned. In Poland, two thirds of collectivised farms were said to have been broken up and returned to individual holdings. In Indonesia and in Indochina the Communist leaders formally disclaimed any idea of nationalizing agriculture and promised to distribute land to the peasants.

The simple fact is that wherever the Communists gained power the Marxist agrarian idea had to be imposed by force and had to rely on force for its survival; western socialists who wanted to remain democratic in every instance had to abandon it. Whatever else the Soviet and other Communist regimes may have achieved, the agrarian problem has defeated them.

The peasants have not been allowed to revive their own parties, and no peasant has held office in the Soviet Politburo. But even in collectivised areas the peasants are still a class.

In the first general election of *1952* in India the Communists gained in depressed agricultural areas, not in cities. India began to experiment widely with a middle-of-the-way system of "community development." Side by side with essential heavy industries she encouraged cottage and village industries, and promoted agricultural improvement, with the village as a relatively self-contained economic and administrative (*panchayat*) unit. This policy followed closely the ideas of Gandhi, but it was also strikingly close to the outlook and program developed independently by the peasant movement in eastern Europe. It revealed how essentially peasant qualities are rooted in the peculiar conditions of rural work and life. 4s the peasant revival of the *1920s* showed, the peasants of eastern Europe, and other continents, were more closely linked by common peasant traits than they were divided by national differences.

See David Mitranp, *Marx Against the Peasant (1952).* (D. Mi.)

PEASE, EDWARD (1767–1858), the founder of a famous industrial Quaker family in the north of England, was born at Darlington on May *31, 1767.* With George Stephenson he took a prominent part in constructing the railway between Stockton and Darlington. He died July *31, 1858.*

PEAT, a product of decayed vegetation found in the form of bogs in many parts of the world. The principal areas of the peat deposits of the world are as follows: U.S.S.R., *65,000* sq.mi.; Canada, *37,000* sq.mi.; Finland, *30,000* sq.mi.; Sweden, *19,000* sq.mi.; and United States, *11,200* sq.mi.

The plants which give origin to these deposits are mainly aquatic, including reeds, rushes, sedges and mosses. *Sphagnum* is present in most peats, but in Irish peat *Rhacomitrium lanuginosum* predominates. It seems that the disintegration of the vegetable tissues is effected partly by moist atmospheric oxidation and partly by anaerobic bacteria, yeasts, molds and fungi, in depressions containing fairly still but not stagnant water, which is retained by an impervious bed or underlying strata. As decomposition proceeds the products become waterlogged and sink to the bottom of the pool; in the course of time the deposits attain a considerable thickness, and the lower layers, under the superincumbent pressure of the water and later deposits, are gradually compressed and carbonized. The most favourable conditions appear to be a moist atmosphere and a mean annual temperature of about 45° F. The peat bogs of Great Britain and Ireland vary in thickness from *5* to *30* ft.; and those of North America vary from *5* to *25* ft.

Peat varies from a pale yellow or brown fibrous substance, resembling turf or compressed hay and containing conspicuous plant remains, to a compact dark brown material, resembling black clay when met and some varieties of lignite when dry. Two typical forms may be noticed: hill peat (the mountain or brown bogs of Ireland), found in mountainous districts, and consisting mainly of *Sphagnum* and *Andromeda;* and bottom peat (the lowland or red bogs of Ireland), found in lakes, rivers and brooks, and containing *Hypnum.* The latter kind always contains much

water, up to 90%, which it is necessary to remove before the product can be efficiently employed as a fuel, and for most other purposes. A specimen dried at 100° C. had the following composition: carbon, 60.48%; hydrogen, 6.10%; oxygen, 32.55%; nitrogen, 0.88%; ash, 3.30%; the ash is very variable—from 2% to 15% and even more—and consists principally of clay and sand, with lesser amounts of ferric oxide, lime, magnesia, etc. On air-drying the peat loses from 8% to 20% of its moisture. In a good, dry season peat may be air-dried down to 17% or 18% moisture, while under moderate conditions it may be saved with 25% to 30% moisture. Average air-dried peat containing 25% moisture may be taken as having a calorific value of about 6,000 B.T.U. The specific gravity has been variously given, owing to the variable water content and air spaces; when dried and compressed, however, it is denser than nater. The yield per sq.km. (0 386 sq.mi.) for a depth of five metres (16.4 ft.) has been determined in Germany as approximately 800,000 tons of air-dried peat.

Peat-winning presents certain special features. The general practice is to cut a trench about 1 ft. deep with a peculiarly shaped spade, termed in Ireland a "slane," and remove sods from 3 to 4 ft. long. When one layer has been removed, the next is attacked, and so on. If the deposit be more solid step-working may be adopted, and should water be reached recourse may be had to long-handled slanes. The sods are allowed to drain, and then stacked for drying in the air, being occasionally turned so as to dry equally; this process may require about six weeks.

Machine Working.—Mechanical power has been applied, especially in Sweden and Germany, to the winning of peat, the operations involved being:—(I) The excavation and elevation of the raw peat from the bog. (2) The maceration and mixing of the raw peat by means of rotating and fixed knives and a single or double screw conveyor nhich forces the peat through a nozzle or nozzles in a stream which is cut into lengths for sods. (3) The transport of the formed sods and their deposition on the bog. (4) The collection and stacking of the air-dried peat. In the most recent German practice the operations indicated in (1) (2) and (3) are combined in one machine electrically driven.

Several processes have been invented for the carbonization of peat and recovery of the by-products. Among these is the Ziegler process which is, or was, in operation at Oldenburg in Germany, Rodkino in Russia and Beuerberg in Bavaria. The uncondensed gases from the coking plant at Beuerberg gave:—

Carbon dioxide	15.5 per cent
Oxygen	1 „
Carbon monoxide	20.4 „ „
Methane and other hydrocarbons	12.4 „ „
Hydrogen	28.6 „ „
Nitrogen	21.9 „ „
	99.9

The "coke" contained:

Carbon	73.89 per cent
Hydrogen	3.59 „ „
Oxygen	14.52 „ „
Nitrogen	1.49 „ „
Sulphur	0.20 „ „
Ash	2.50 „ „
Moisture	3.80 „ „
	99.99

and the calorific value of the semi-coke was 12,000 B.T.U. The volume of the gases amounted to 6.759 cu.ft. per ton.

The manufacture of producer gas from peat, in regard to which a number of methods exist, mostly based on the Mond process, has proved more or less successful. The briquetting of peat has also been carried out. The briquettes contain approximately 18% of moisture and are said to yield a high quality charcoal. One of the chief factors operating against the commercial success of peat as a fuel in competition with coal and other fuels has been the cost of drying the peat.

With the "Peco" process it is claimed, however, that the peat can he dried down to almost no water content, and that about 80% of the peat is recovered. But in practice the most suitable water content' for briquetting is 10%. Perhaps Ireland is the largest producer, with an output in the neighbourhood of 6,000,000 tons annually of air-dried peat.

See The *Winning, preparation and use of* peat, by the Fuel Research Board (1921); The *Utilization* of ***Peat*** Fuel, Department of Mines, Canada (1912). (R. R.)

PEBA, a name for the nine-banded armadillo. *See* ARMADILLO.

PEBAN, a group of tribes of South American Indians doubtfully to be regarded as constituting an independent linguistic stock. The Pebas (who have given their name to the group), the Yameos, and Yaguas, who form the stock, are on the northern side of the Amazon in the region of the Brazilian-Peruvian border.

PECAN. This is the most important nut producer of the genus *Carya*, and the tree native to temperate North America that has attained most extensive orchard culture. Pecan kernels rank with the finest of oily nuts. The tree is the largest of its genus, occasionally reaching maximum heights of about 180 ft. and trunk diameters of 8 ft. in deep, fertile soils. The nuts have brown. mottled shells, varying greatly in thickness; size varies from 45 to zoo per lb., and shape from long-cylindrical with pointed apex, to short and roundish, or intermediate. At maturity the fleshy hulls of the short-clustered fruits dry, split along suture lines and separate into four approximately equal sections, thus gradually freeing the nuts. Harvesting begins in late September, but may continue until late winter in southern orchards.

The original range of the pecan tree may not have extended into the northern Mexican highlands before men took nuts there from Texas. Native trees have been found from near the Rio Grande in southwest Texas, north and east to extreme southeast Nebraska, eastern Iowa, west-central and southern Indiana, and occasionally up the Tennessee river to near Muscle Shoals in Alabama. Limited cultivation of grafted varieties had begun in Louisiana by

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LEFT. BRANCH OF A PECAN TREE SHOWING NUTS ENCLOSED IN HUSKS. RIGHT: MATURE PECAN NUTS

1847; some important varieties were introduced before 1890, and thereafter the crop assumed increasing commercial importance from the Carolinas to New Mexico and Mexico. Georgia, Alabama and Mississippi soon became the most important producers of grafted pecan nuts. exceeding the total annual production of the states of Texas and Oklahoma nhich have the greatest numbers of native seedling trees. United States pecan production averages roughly from 100,000 000 to 200 000 000 lb. per year. Canada has been the principal importer of U.S pecans.

For good kernel development, even the earliest maturing pecans need high summer temperatures both day and night, so nuts are seldom matured on trees in northern California, northern Indiana, or north of tidewater Virginia and Maryland in the eastern U.S. Results in inland central and southern California have been a lit-

tle better, but walnuts outyield pecans there. The pecan has been introduced into many countries, but without becoming important in production outside the U.S. and northern Mexico. It is cultivated to a limited extent in Australia (New South Wales) and South Africa (Natal).

Pecan varieties are suited, for reasons of climatic requirement, to particular zones within the U.S. Important southeastern varieties are Brooks, Candy, Curtis, Desirable, Elliott, Farley, Mahan, Moore, Stuart and Success. In the central Texas group are Barton, Burkett, Clark, San Saba Improved, Squirrel, Texhan and Western. Clarksville, Giles, Greenriver, Hirschi, Major, Peruque, Posey, Starking and Witte ripen in midwestern orchards. Duvall and Sweeney were introduced from Maryland. For culture somewhat north of pecan limits, there are hicans (pecan-hickory hybrids) of which Burton, Des Moines, Henke and Jay Underwood are among the fruitful varieties, and McCallister, a useful pollinator.

See also HICKORY; NUT. (J. C. McD.)

PECCARY, the name given to the new world representatives of the swine (Suidae), from which it may be distinguished by the fact that the upper canine teeth (tusks) are directed downward, simple cheek teeth, sacculated stomach and three-toed hind feet. Peccaries range from New Mexico and Texas to Patagonia. The collared peccary (Tayassu *tajacu*) is a dark-gray animal with a white band across the chest from shoulder to shoulder. It is about 3 ft. long, living in small herds of eight to ten, and has an extensive range in Central and South America. The white-lipped peccary (T. *pecari*) is about 6 in. longer, blackish in colour, with white lips. Peccaries form the family Tayassuidae (see ARTIODACTYLA; SUINA). Extinct peccaries are known as far back as the Miocene in North America, but only in superficial deposits in the southern continent. This indicates that the group entered North America in the Upper Oligocene and subsequently reached their present habitat. (J. E. HL.)

PECHENEG or PATZINAK (Latin Bissenus), a nation which played a considerable part in the medieval history of eastern Europe. The Pechenegs were of Turkish origin, akin to the Cumans (*q.v.*), whose language, according to Anna Comnena, they spoke. They were probably a federation formed of the earlier Bukuk and Kangaris. In the 9th century A.D. they were living between the Volga and the Urals, having as their neighbours the Burtas on the west, the Khazars southwest, and the Ghuz southeast. About 860 the Khazars and Ghuz combined and drove them west, only a remnant remaining in their old territory, which was now occupied by the Ghuz. The remainder drove the Magyars, who were the western neighbours of the Khazars, over the Dnieper, themselves settling near the Don. In 889 they again drove the Magyars westward into Moldavia, arriving on the Dnieper in 895. In that or the following year they allied themselves with Khan Symeon of the Bulgars, inflicted a third and crushing defeat on the Magyars and drove them into their present homes in Hungary.

The Pechenegs made their own headquarters on the two banks of the Dnieper, where for a century they harassed Kiev and the trade route between that state and Constantinople, lurking near the rapids at mhich convoys disembarked, then charging on horseback and raining arrows on the crews. In addition, they ravaged Walachia, Bulgaria and the lands of the eastern Roman empire, perhaps the most formidable of their many incursions being that of 934, when, allied with the Magyars, they destroyed Varander. In 972 they had slain Svyatoslav of Kiev; but in 1036 Prince Yaroslav defeated them so heavily that they ceased to trouble Russian territory. Their incursions westward grew correspondingly more severe. Between 1020 and 1030 they invaded Bulgaria almost every year; from 1018 to 1053 they were at war with Byzantium without intermission. Then Constantine Monomachus granted them lands for settlement in northeastern Bulgaria, but their depredations continued.

The great westward raid of the Ghuz in 1064 passed through their territory, and many Pechenegs were probably then slain or absorbed by the Ghuz. Others fled into Hungary, where Ladislaus I defeated them in 1067. Colonies of the survivors were settled as guards on Hungary's western frontiers. In 1080 the emperor Alexius again defeated them, and their power was finally broken in 1091 by the crushing defeat which they suffered at Lebunien. Remnants of them, however, still lurked about the Balkans, and one band, imitating their old tactics on the Dnieper, attacked Peter the Hermit's party of crusaders north of Belgrade in 1096. The Sops in the plain of Sofia are believed to be their descendants.

The Pechenegs were ruled by a khan and organized in 8 hordes and 40 minor units, each under its khan of lower degree. They mere purely nomadic; on their raids they took their women and children with them, forming their camps out of rings of wagons. They wore long beards and mustaches and were dressed in long kaftans. The food of the wealthy was blood and mares' milk; of the poor, millet and mead.

They were originally "magicians," *i.e.,* fire worshipers; but a form of Islam early became current among them and the nation was temporarily converted to Christianity in 1007–08. They were the most dreaded and detested of all the nomads; Matthew of Edessa calls them "the carrion-eaters, the godless, unclean folk, the wicked, blood-drinking beasts." Other anecdotes are current of their shamelessness, and many of their cruelty; they invariably slew all male prisoners who fell into their hands. The modern Sops are short-legged and yellow-skinned, with slanting eyes and projecting cheekbones. The women's costumes show a profusion of gold lace.

See J. Marquart, *Osteuropäische und ostasiafische Streifzüge* (Leipzig, 1903), where the main original sources are given. (C. A. M)

BECHORA, a river of northern U.S.S.R., which rises in the Urals, almcst on lat. 62° N. and flows west and then north, aith a double north and south loop about 66° 20' N. It enters the Gulf of Pechora on the Barents sea by a delta after a course of 1,126 mi. Its main tributaries are the Izhma, Tsilma and Sula on the left, and the Ilych, Podcherem, Shugor and Usa on the right; the river and its tributaries provide 3,545 mi. of navigable waterways, of which 2.335 are fit for rafts and timber floats only and 580 are suitable for steamer navigation. The drainage basin of 126,255 sq.mi. is, however, mainly coniferous forest. and north of lat 67° N. bleak tundra. the Great Land Tundra on the east, and the Small Land Tundra on the west.

The scanty population consists mainly of Nomad Samoyede reindeer breeders and Zirian hunters.

During the brief summer there is steamer connection between Pustozersk and Kuya on the right of the delta, and Archangel. Short portages connect the Pechora waterway with the Kama and the Volga, and with the Vychegda and Northern Dwina, and longer portages, used mainly by Samoyedes, link it across the Urals with the Ob.

The chief freightage on the Pechora waterways consists of reindeer products, furs and fish going southward and grain and manufactured goods going north. Seals are caught in Pechora gulf, and fishermen migrate there from June to Aug., the Pechora salmon being specially valuable.

PECKHAM, JOHN (c. 1225–1292), archbishop of Canterbury, was probably a native of Sussex. About 1250 he joined the Franciscan order. He took his degree at the University of Paris, under St Bonaventure and for many years taught there, coming into contact with the greatest scholars of the day. About 1270 he went to teach at Oxford and in 1275 was elected provincial minister of the Franciscans in England, but soon afterward he was called to Rome as theological lecturer in the schools of the papal palace.

In 1279 Peckham returned to England as archbishop of Canterbury. He died at Mortlake on Dec. 8, 1292.

Peckham was always a strenuous advocate of the papal power, and the characteristic note of his primacy was an insistence on discipline which offended contemporaries.

In philosophy Peckham represents the Franciscan school which attacked the teaching of St. Thomas Aquinas on the "Unity of Form." He wrote much on scientific, scriptural and moral subjects, and defended the Franciscan rule and practice. His hymns are characterized by a lyrical tenderness.

PECKHAM, RUFUS WHEELER (1838–1909), associate

justice of the United States supreme court from 1896 to 1909. is chiefly remembered as the author of the majority opinion (*Lochner* v. *New York*, 198 U.S. 45 [1905]) which evoked one of the sharpest dissents by Justice Oliver Wendell Holmes (*q.v.*). Peckham held that the 14th amendment prevented the states from curtailing a man's liberty to engage in or contract concerning economic activity—in the Lochner case, the liberty of a baker to contract for working hours longer than ten per day. Holmes replied in dissent that the "Fourteenth Amendment did not enact Mr. Herbert Spencer's *Social Statics.*" Peckham is representative of the school of constitutional jurisprudence that felt it was the court's function to scrutinize carefully and form its own conclusion as to the reasonableness of a state regulation *(see* SUPREME COURT OF THE UNITED STATES, THE: *Role in American Life: Self-Lirnitution).* This judicial approach in cases involving economic regulation did not disappear until the 1930s, when the Holmes point of view became the almost unanimous opinion and such legislation as the minimum-wage law was held to be constitutional.

Peckham, a member of a distinguished New York judicial and legal family, was born in Albany, N.Y., on Nov. 8, 1838. and was educated in Albany and Philadelphia. In 1859 he was admitted to the bar and began practising law in Albany; in 1883 he was appointed a justice of the state supreme court and in 1886 became a member of the court of appeals of New York, the highest court in the state. Nominated to the U.S. supreme court by Pres. Grover Cleveland after the nomination of his brother, Wheeler Hazard Peckham, failed of senate confirmation, he took office on Jan. 6, 1896. Peckham died at Altamont, near Albany, on Oct. 24, 1909.

(A. DM.)

PECOCK (or PEACOCK), **REGINALD** (*c.* 1395–c. 1460), British prelate and writer, was probably born in Wales, and was educated at Oriel college, Oxford. Having been ordained priest in 1421, he secured a mastership in London in 1431, and soon became prominent by his attacks upon the religious position of the Lollards. In 1444 he became bishop of St. Asaph, and six years later bishop of Chichester. He was an adherent of the house of Lancaster and in 1454 became a member of the privy council. In attacking the Lollards he put forward religious views far in advance of his age.

Pecock asserted that the Scriptures were not the only standard of right and wrong; in general he exalted the authority of reason. Owing to these views the archbishop of Canterbury, Thomas Bourchier, ordered his writings to be examined. This was done and he was found guilty of heresy. He was removed from the privy council and he only saved himself from a painful death by privately, and then publicly (at St. Paul's Cross, Dec. 4, 1457), renouncing his opinions.

Pecock, who has been called "the only great English theologian of the 15th century," was then forced to resign his bishopric, and was removed to Thorney abbey in Cambridgeshire, where he doubtless remained until his death.

The bishop's chief work is the famous *Repressor of over-much weeting* [blaming] *of the Clergie,* which was issued about 1455. In addition to its great importance in the history of the Lollard movement the *Repressor* has an exceptional interest as a model of the English of the time, Pecock being one of the first writers to use the vernacular. In thought and style it is the work of a man of learning and ability.

A biography of the author is added to the edition of the *Repressor* published by C. Babington for the Rolls Series in 1860. Pecock's other writings include the *Book or* Rule *of Christian Religion;* the *Donet,* "an introduction to the chief truths of the Christian faith in the form of a dialogue between father and son"; and the *Folewer to the Donet.* The two last works are extant in manuscript. His *Book of Faith* has been edited from the manuscript in the library of Trinity college, Cambridge, by J. L. Morison (Glasgow, 1909). *See* also John Lewis, *Life of Pecock* (1744; new ed., 1820).

PECOS, a river in the southwestern United States, rises in Mora county in north-central New Mexico in the high peaks of the Sangre de Cristo Range. It is about 735 mi. long and drains about 30,000 sq.mi. of wild and rugged land which in places is devoid of population and communications. The Pecos flows south-southeast through eastern New Mexico and west Texas, emptying into the Rio Grande as it leaves Pecos canyon 40 mi. N.W. of Del Rio, Tex. After leaving the mountains, the Pecos flows over land of desert character and the stream channel is dry much of the year. A valley 1,000 ft. deep and from 5 to 30 mi. wide extends almost to Rosuell. N.M.

Near Roswell, the river widens into a basin which closes somewhat to a broad, shallow valley at the Texas-New Mexico border. Below this valley and in the last 125 mi. of its course, the Pecos has cut a narrow canyon over 1,000 ft. deep into the Edwards and Stockton plateaus. As the stream emerges from this canyon it empties into the Rio Grande river. Flow of the Pecos is regulated by two reservoirs. The Alamogordo at Fort Sumner, with storage capacity of 122,100 ac.ft. was completed in 1938. McMillan dam near Lakewood, N.M. stores 38.660 ac.ft. and was completed in 1906. About 150.000 ac. are irrigated from these units. Pecos tributaries are the Hondo, Gallinas, Felix, Seven rivers and Black rivers, all in New Mexico Santa Rosa, Fort Sumner, Roswell and Carlsbad, N.M. and Pecos, Tex. are important towns on or near the river. (M. J. L.)

PÉCS (German, *Fünfkirchen*), capital of Baranya county, Hungary, on the southeastern flank of the Mecsek hills. It is believed to date back to Roman times and has been the see of a bishop since 1009. It was occupied by the Turks from 1543 to 1686 and several of its churches were altered and used as mosques. The town is regularly laid out with an inner old town in the form of a square and four suburbs. A beautiful cathedral, reputed one of the oldest churches in Hungary as well as one of its finest medieval buildings, is the principal architectural asset The 14th century university, which lapsed after the battle of Mohács, has been revived. Pop. (1960) 114,713.

PECTIN, the commercially concentrated extract of a group of pectic substances found in the cell walls and intercellular layers of certain plant tissues. The chief use of commercial pectin is in the preparation of jellies, jams and marmalades but its property of forming thick solutions gives it numerous other uses in the food, confectionery, pharmaceutical and textile industries.

Pectic substances consist of an associated group of three polysaccharides: an arabinan, which on acid hydrolysis yields L-arabinose; a galactan, giving D-galactose on hydrolysis; and, most significantly for the physical properties of these substances, a pectic acid whose carboxyl groups are in part esterified with methanol and in part neutralized as salts of calcium and magnesium. Pectic acid is a polysaccharide in which units of D-galacturonic acid are joined in α-D-(1 $\rightarrow$ 4) linkages *(see* CARBOHYDRATES). The calcium salt of pectic acid is water insoluble and in the maturation of tissues, as in the ripening of fruits, complex enzymic changes occur in which the calcium salts are converted, in part, to methyl ester groups. The pectic substances are extractable with warm aqueous solutions of dilute acids. The extract may then be concentrated and sold as a liquid or converted to a powder. The product is known as pectin. The chief sources of commercial pectin are citrus waste and apple pomace. Sugar beet cossette (chip) pulp is employable and makes a usable product after suitable modification to remove an acetate ester group present. Pectin forms a viscous aqueous solution and in the presence of acids, as those of fruits, and added sugar, this solution will produce a jelly. Very small amounts (less than 1%) of pectin will suffice. It has been found that if the methyl ester (methoxyl) content is decreased, less sugar is required to give a gel which is formed by the addition of calcium ions.

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PECTORAL, a word applied to various objects worn on the breast (Lat. *pectus*); thus it is the name of the ornamental plate of metal or embroidery formerly morn by bishops of the Roman Church during the celebration of mass, the breastplate of the Jewish high priest and the metal plate placed on the breast of the embalmed dead in Egyptian tombs. The "pectoral cross," a

small cross of precious metal, is worn by bishops and abbots of the Roman, and by bishops of the Anglican, communion.

See "Pectoral" in The Catholic Encyclopaedia.

PEDAGOGUE, a teacher or schoolmaster, in English since the late 16th century a term usually implying pedantry, dogmatism and narrow-mindedness. It is among the least scurrilous insults Thomas Nashe paid to his arch-enemy, Gabriel Harvey, in the epistle dedicatory to Have With You to Saffron *Walden* (1596); Sir Edward Hoby also applied it to his theological antagonist, John Floyd, in Counter-snarle (1616); the opprobrium of the term is implicit in Samuel Pepys' phrase in his diary (July 25, 1660): "A Welsh schoolmaster, a good scholar but a very pedagogue."

The Greek paidagogos (paid, "boy"; agogos, "leader") was not strictly an instructor, but rather a slave in the Athenian household who looked out after the safety and conduct of the sons of the master of the household and took them to and from school and the gymnasium. The Romans adopted the *paedogogus* or *pedagogus* toward the end of the republic (1st century B.C.). The Roman pedagogus probably took some part in the instruction of the boys (see SCHOOLS, ANCIENT). Under the empire the pedagogus was specifically the instructor of the boy slaves in the household of the emperor. rich nobles and other persons.

PEDAL CLARINET, a contrabass instrument invented by G. A. Besson (1820–75). It is pitched an octave below the bass clarinet, its compass descending to the D below the lowest note of the double basses. Besson also invented an apparatus for lowering the compass still further by the interval of one fourth. Music for the pedal clarinet is written a ninth higher than it sounds. It is used primarily in marching bands and has a rich, full tone, except for the lowest notes which tend to be rough in quality.

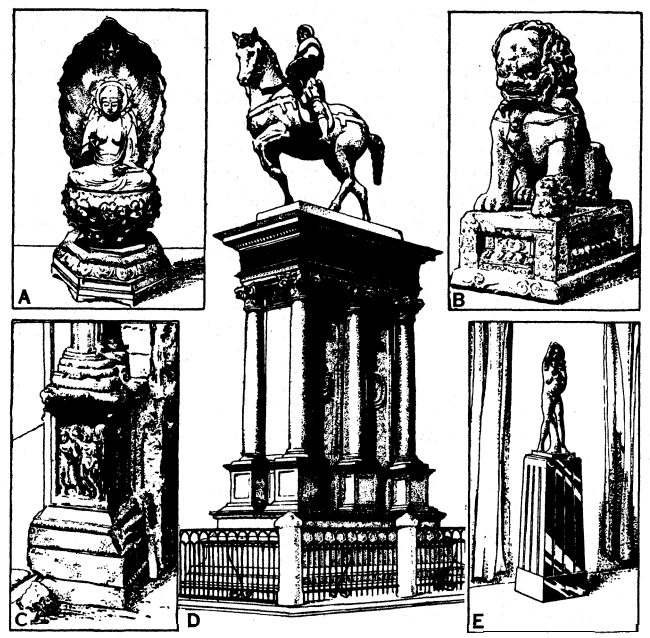
PEDERSEN, CHRISTIERN (c. 1480–1554), Danish humanist, one of the first to rediscover Denmark's national literary and historical heritage and to encourage the development of a vernacular style. Born near Helsingfors, he studied at Greifswald and took orders in 1505. In 1508 he went to Paris and there produced the first edition (now lost) of Saxo Grammaticus' Gesta Danorum, under the title *Historia* danica (1514). He also edited Peder Laale's proverbs and published a Latin-Danish lexicon. Returning to Denmark, he supported the Reformation and became secretary to Christian II, following him into exile in 1525. In Holland he translated, from the Vulgate, part of the New Testament (1529) and the Psalms (1531) and also adapted some of Luther's tracts. In 1532 he set up as a printer at Malmo, publishing Danish versions of French romances and the legends of Charlemagne. He had a share in the translation of the Bible published in 1550 as "Christian III's Bible," and based on Luther's translation, which marked an important stage in the development of Danish literature as well as in the progress of the Reformation. He died on Jan. 16, 1554, in Helsinge.

See Pedersen's Danske *Skrifter,* ed. by C. J. Brandt and B. T. Fenger, 5 vol. (1850–56).

PEDERSEN, HOLGER (1867–1953), Danish linguist of exceptional competence in a number of fields, especially Celtic, was born at Gjelballe, near Lunderskov, on April 7, 1867. After receiving his doctorate in 1897 with a masterly dissertation (*Aspirationen* i *Irsk*) he proceeded, while professor at Copenhagen, to enrich linguistic scholarship with an incredible number of articles and books, all highly original. Nurtured in the exacting methodology of the 19th-century neogrammarian (*q.v.*) movement, he went far beyond its limits and was either participant in, or critic of, most succeeding schools of linguistic thought; he even anticipated some new trends, but conscientiously avoided frills and fads.

The result of Pedersen's Celtic researches are contained in numerous articles and in his monumental Vergleichende Grammatik der keltischen Sprachen, (2 vol., 1909–13), also his Concise Comparative Celtic Grammar (with Henry Lewis, 1937). About 30 books in four languages (Danish, English, French, German) treat authoritatively Albanian, Armenian, Russian, Indo-European dialects, Lithuanian, Hittite, Tocharian, Czech, Turkish phonology, the relations between Indo-European and Semitic, between Indo-European and Finno-Ugric, the origin of runes, and the history of linguistic science. Holder of honorary degrees in nine countries and recipient of countless other scholarly honours, Pedersen closed a long and fruitful career in Copenhagen, where he died on Oct. 25, 1953. (R. A. Fs.)

PEDESTAL, a square, polygonal or circular block used as a support. Pedestals were originally employed only to carry statues or votive offerings, but the Romans, in the course of their many experiments in the decorative use of the orders, occasionally placed columns upon pedestals; this is notably the case in connection



BY COURTESY OF (B) THE MUSEUM OF THE UNIVERSITY OF PHILADELPHIA, (E) LORD & TAYLOR

TYPES OF PEDESTALS FROM ANCIENT TIMES TO THE PRESENT DAY
(A) Statue of Buddha, 700 years old, from Gaya; (B) Chinese lion, Ming dynasty: (C) type of Roman architecture under Septirnus Severus, A.D. 146–211; (D) statue of Bartolomeo Colleoni, Venice, begun by Verrocchi, 1481; (E) modern mahogany pedestal by Auguste Guenot

with such isolated columns as that of Trajan (A.D. 114) and in the case of the engaged columns of triumphal arches, where the proportions seemed to demand them. Similarly, in superposed orders, as in the Colosseum at Rome (A.D. 80), the parapet walls of each story were projected out under each column as pedestals. The Renaissance designers attempted to develop a separate pedestal for each order, with all its dimensions in proportion to those of the column (see ORDER). This has no basis in Roman usage.

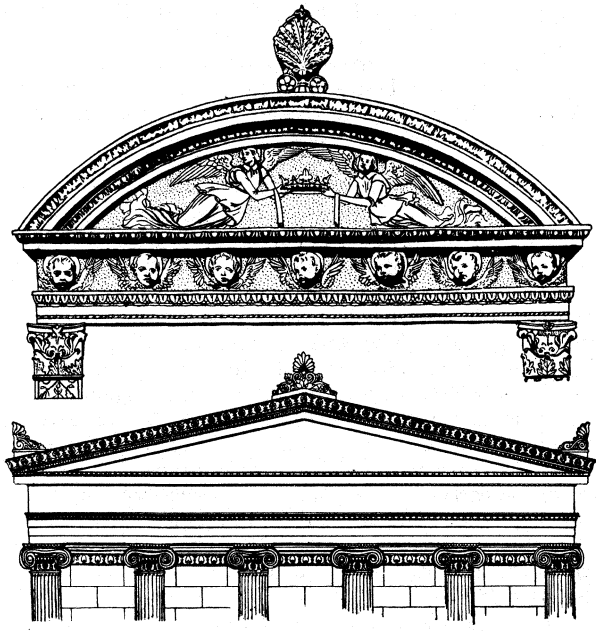
PEDICULOSIS or PHTHIRIASIS, the medical term for the presence of lice (pediculi), either on the head (Pediculus *capitis*), body (*P.* corporis, or vestimentorum), or pubes (P. pubis). This infestation of man and animals produces primary and secondary symptoms and disorders, the latter the result of scratching and subsequent invasion by bacteria. Vegetable as well as animal organisms are infested with lice. See LOUSE. (F. L. A.)

PEDIMENT, in architecture, is a triangular gable end, crowned with a raking cornice which follows the slope of its upper edges; or a similar form used decoratively. In common usage, the term is restricted to the classic styles; in others, the word gable is used.

The pediment was given a great importance by the Greeks as it was the crowning feature of every temple front. In Greek work, the entablature over the columns is carried completely through, horizontally under the pediment; and the tympanum (*q.v.*), or triangular wall surface, between this horizontal cornice and the raking cornice above was often decorated with sculpture. (See GREEK ARCHITECTURE.) The Romans not only used the pediment in this manner, as the end of a roof, but also adopted it as a purely decorative form to crown doors, windows and especially niches. Where many such decorative pediments occur in a row, the Romans frequently made them alternately triangular and seg-

mental in shape; in this they were copied by the High Renaissance in Italy.

Following certain late Roman precedents, in which the line of the raking cornice is broken back in the centre, the designers of the baroque period developed all sorts of fantastic broken, scrolled and reverse curved pediments; in some cases they even reversed the direction, so that the high part of the broken or sectional pediment was toward the outside of the composition rather than toward the centre, and in the Churrigueresque, or late Renaissance



FROM BUHLMANN, "CLASSIC AND RENAISSANCE ARCHITECTURE" (NEFF AND HELBURN)

PEDIMENTS: (UPPER) ITALIAN RENAISSANCE "FLORENTINE" PEDIMENT. BY THE DELLA ROBBIAS; (LOWER) GREEK. THE ERECHTHEUM, ATHENS

of Spain, little sections of pediment were used to indicate line patterning.

PEDIMENT, in geology, a low-angle slope'of $\frac{1}{2}°$–7°, and of slightly concave form, found at the base of hills in regions where the rainfall comes in heavy storms. There is frequently a sharp break of slope between the pediment and the steeper hillside above it. There may or may not be a soil cover. Water passes across the pediment by laminar sheet flow, but if this is disturbed the flow becomes turbulent and gullies develop. Many tropical towns sited on pediments (which offer easier building sites than the steep hillsides above or the river marshes below) show severe gullying where the water flow has been concentrated between walls and buildings. The pediment is the most important element in the tropical landscape, both for building and farming; under natural conditions it is the most permanent part of the landscape, but it is also the part most easily destroyed by human interference.

(J. C. PH.)

PEDIPALPI, a name having two different meanings: (1) the first postoral appendages of Arachnida, Gigantostraca and Xiphosura; (2) an order of Arachnida (*q.v.*) now subdivided into three orders, Schizomida, Thelyphonida or whip scorpions (*q.v.*), and Phrynichida. (A. PH.)

PEDLAR: see HAWKERS AND PEDLARS.

PEDODONTICS is the practice of dentistry for children; it is the dental counterpart to pediatrics in medicine. Seven qualifications for a pedodontist have been listed by the American Board of Pedodontics: The pedodontist should be able to manage the behaviour of a very young patient and control his relations with the child's parent; he should be a master of the operative and restorative procedures that are practised for the deciduous (first) teeth and the immature permanent teeth; he should possess a thorough knowledge of the physical and chemical properties of the materials employed in all types of dental treatment and utilize them with skill; he should be able to remove children's teeth skillfully and perform the minor oral surgery that may be required; he should be able to practise scientific root-canal treatment for infected teeth and confirm bacteriologically the removal of infecting microorganisms; he should be able to diagnose and treat any juvenile dental problem of growth, development or health; and he should be able to instruct the family in proper dental-health practice and to institute measures for the prevention of defects of the teeth or the mouth.

During the years when dentistry was developing from a mechanical trade, learned by apprenticeship, to a health profession, the teeth of young children were neglected consistently. The "baby" teeth, it was thought, would be replaced promptly by the adult or permanent teeth, hence the first set of teeth was unworthy of the expenditure of the dentist's time and the family's resources. From 1840, when the first dental school in the world was established in Baltimore, Md., until 1916, when teaching in dental schools in the United States was reorganized to include the human biologic sciences, children's teeth generally were treated by removal whenever they ached. The teaching of scientific techniques in dental schools for the comprehensive treatment of the teeth and mouths of children came even later.

Since the age commonly recommended by pedodontists for the first visit to the dentist is $2\frac{1}{2}$ to 3 years, children's dentists must be able to approach very young children, gain their trust and secure their co-operation. Otherwise, dental treatment would be impossible. Oversolicitous and frightened parents often must be guided also. Some aids from children's psychologists and psychiatrists have helped dentists to work out routines that assure a pleasant experience and the completion of a surprising amount of treatment, even during the preschool child's first appointment with the dentist.

On the child's first visit, many pedodontists include a planned introduction to the equipment and instruments of the dental office; secure a sample of saliva to be used in obtaining a count of acid-producing microorganisms; complete the cleansing and polishing of the teeth, much as in an adult's dental prophylaxis; and instruct the child in proper toothbrushing. In those areas in which the water supply is deficient in fluorine, a series of applications of a fluoride solution to the dried surfaces of the teeth sometimes is instituted. Such a series, begun at three years of age, has been shown to cause a 40% reduction in the number of new cavities otherwise expected to develop in the deciduous teeth.

A comprehensive examination also may be completed during the initial visit. The crowns of the teeth are checked for obvious cavities and for faults in the enamel. A number of dental X-ray films are exposed and developed, and these radiographs reveal the extent of development and the position of the permanent teeth in the bony arches; anomalies of development such as missing teeth, extra teeth or teeth calcifying in unusual positions; areas of diseased bone about abscessed teeth; and small cavities beginning on the tightly contacting surfaces of the adjacent crowns of the teeth, particularly the molars that provide so much mastication until 10 to 12 years of age.

The tongue, tonsils, glands of the neck and soft tissues about the teeth and lining the mouth ordinarily are inspected to determine their condition. Finally, the occlusion (or bite) of the teeth is examined. Such habits as sucking the fingers, thrusting the tongue, biting the lip or breathing through the mouth cause obvious deformities in the arrangement of the teeth. Frequently, the pedodontist obtains impressions of the upper and lower arches and prepares a plaster model of the mouth in order better to study the occlusion of the teeth, plan treatment or refer the child to the orthodontist. Later, for the benefit of the child whose salivary examination indicates the presence of a large number of lactobacilli, a dietary history may be obtained and the entire family placed on a diet low in sugar for a few weeks to change the bacterial flora of the mouth. The process of dental caries generally can be halted by such periodic dietary restrictions.

One of the responsibilities of the pedodontist is to participate as a member of the team of specialists that provides treatment for handicapped children, tuberculous and palsied children, children with muscular dystrophy, children who are mentally retarded

and children experiencing developmental peculiarities. Most often such treatment must be performed in a hospital in order to utilize general anesthesia. For the patient with a cleft palate, the pedodontist provides all the general dental treatment that accompanies the services of the oral surgeon and other dental specialists, along with those of the speech therapist, the pediatrician and the psychologist.

See also DENTISTRY; ORTHODONTICS. **(KH. A. E.)**

PEDRELL, FELIPE (1841–1922), Spanish composer and musicologist. was born at Tortosa on Feb. 19, 1841. His education was mainly self-acquired. As a choir boy in the cathedral at Tortosa, he became thoroughly familiar with old Spanish church music. Juan Antonio Nin y Serra, his first master, directed his attention to the folk music of Spain by suggesting that he use songs heard at home in his practice compositions. Pedrell's first musical work appeared in 1871 and some years later he began to teach musical history and aesthetics at the Madrid conservatory. He continued to teach until 1894 when he returned to Barcelona because of ill health.

Pedrell became interested in the writings of Antonio Eximeno (1729–1808) who held that nationalism was the true source of music—that the compositions of a country should flow from its national song. This idea led to a lifetime of prolific researches, two valuable results of which were the publication of the complete works of Tomas Luis de Victoria (*q.v.*), and a catalogue of the music in the municipal library at Barcelona. He also collected and published old Spanish church, theatre and folk music, some of the writings of Eximeno (1921), and wrote numerous critical and historical works on music. Among his compositions, generally too serious to gain popularity, were the operas *Los Pirineos* (1894); *La Celestina* (1903); and *El Comte Arnau* (1921), this last based on a classical Catalan ballad. In addition, Pedrell composed chamber music, songs and cantatas. Although generally unrecognized in Spain, he exercised a marked influence on the course of its musical development and especially of its modern composers. Of his students, the most outstanding was Manuel de Falla (q v). Pedrell died in Barcelona on Aug. 19, 1922.

PEDRO II (DOM PEDRO DE ALCANTARA) (1825–1891), second emperor of Brazil, was born in Rio de Janeiro on Dec. 2, 1825. On April 7, 1831. when he was not yet six years old, his father, Pedro I, abdicated in his favour, and for nine years the country was governed by a regency. He was declared of age on July 23, 1840, and was crowned July 18, 1841. He might have perpetuated his dynasty had he been more attentive to political exigencies. On his accession uprisings occurred in several provinces; these were promptly suppressed in São Paulo and Minas Geraes (1842) but held out in Rio Grande do Sul until 1845. The new government persisted in the policy of intervention in Uruguay which had caused the abdication of Pedro I. In 1852 Brazilian troops were chiefly responsible for the defeat of Rosas of Argentina; in 1864 a Brazilian army made Flores *de facto* dictator of Uruguay; and it was owing mainly to Brazilian arms and resources that Solano López, the dictator of Paraguay, was defeated in the Paraguayan War (1864–70). The government had to combat intermittent provincial rebellions (notably that in Pernambuco, 1849), and was faced with diplomatic crises with England, France and the United States. But it left a record unparalleled in South America for conscientious and enlightened rule. The slave trade was prohibited in 1850; in 1871 a law provided for the gradual emancipation of the slaves, and in 1888 an imperial disposition abolished slavery throughout Brazil. The emperor consistently sponsored public improvements, fostered public instruction, and earnestly patronized art and science. He travelled widely, visiting Europe in 1871, 1876 and 1886, and the U.S. in 1876, affiliating himself closely with foreign intellectual life In 1889 a crisis arose. The nobility were alienated by the antislavery measures and other legislation aimed at reducing their prerogatives; the military was demoralized by inactivity; the emperor showed little interest in matters of state On Nov 15, Manuel D. da Fonseca (q *v*) led a Republican revolt. supported by the army and navy. There nas no resistance, the empire ended, and the emperor embarked with his family for Europe Nov. 17. A Federal republic was proclaimed. (W. B. P.)

PEEBLES, a royal and small burgh and the county town of Peeblesshire, Scot., at the junction of Eddleston water with the Tweed, 23 mi. S. of Edinburgh by road. Pop. (1951) 6,013. Area 1.5 sq.mi. The burgh consists of the new town, on the south of the Eddleston, and the old on the north. Portions of the town walls still exist, and there are cellars constructed in the 16th and 17th centuries as hiding places against border freebooters. The old market cross stands in High street. The Chambers institution incorporates the mansion where the notorious "Degenerate Douglas," or "Old Q," 4th duke of Queensberry (1724–1810), was born. Of St. Andrew's church, founded in 1195, nothing remains but the tower, restored by William Chambers, the publisher, who was buried beside it in 1883. Cross kirk was erected by Alexander III, in 1261, to contain a supposed remnant of the true cross discovered there. The building remained till 1784, when it was nearly demolished to provide stones for a new parish church. Peebles was a favourite residence of the Scots kings when they went to hunt in Ettrick forest. It was created a royal burgh in 1367 and was the scene of the poem of *Peblis* to *the Play,* ascribed to James I of Scotland. Peebles lost its importance after the union of the crowns. There are several large woollen mills, and the town is an agricultural centre. The Buchan family (Lord Tweedsmuir) is associated with Peebles, and Mungo Park practised medicine there (1801–03). In June the "Beltane queen" is crowned, this being a survival of the ancient religion.

On the north bank of the Tweed stands Neidpath castle, of which the ancient peel tower dates probably from the 13th century. Its first owners were Tweeddale Frasers, from whom it passed to the earls of Tweeddale. It was besieged and taken by Cromwell in 1650. The 3rd earl of Tweeddale (1645–1713) sold it to the duke of Queensberry in 1686. The earl of Wemyss succeeded to the Neidpath property in 1810.

PEEBLESSHIRE or TWEEDDALE, county in the centre of the southern uplands, Scotland, bounded north and northeast by Midlothian, east and southeast by Selkirkshire, south by Dumfriesshire and west by Lanarkshire. Area 347.3 sq.mi. Pop. (1951) 15,232, of whom 57 persons could speak both English and Gaelic. It is mainly an agricultural county. but the wool and tweed industry is important at Peebles and Innerleithen. The hills are highest in the south, where they belong to the Silurian uplands of southern Scotland, succeeded by an Ordovician belt. The uplands are intersected by the valley of the Tweed, which rises at Tweed's Well in the extreme southwest corner of the county, and by those of its tributaries, chief among them being the Lyne and the Leithen water. Peeblesshire derives its alternate name of Tweeddale from the fact that for the first 36 mi. of its course of 97 mi. the Tweed river flows through the shire. South of the Tweed the highest points are Broad Law (2,754 ft.) and Cramalt Craig (2,723 ft.) on the confines of Selkirkshire; north of the river the heights exceed 2.000 ft. in few places. In the northwest a part of the Pentland hills is included, showing Upper Silurian and Lower Old Red Sandstone rocks. Much glacial boulder clay, in the gravel and sand, rests upon the higher ground, while morainic deposits are found in the valleys.

The character of the soil varies considerably, peat, gravel and clay being each represented. The low-lying lands consist generally of rich loam composed of sand and clay. The farming is pastoral rather than arable, sheep being important—blackface breed on the hills and Cheviots around the more sheltered farms. Wheat and barley are grown on lower grounds bordering the rivers and there is some dairy farming. Approximately a tenth of the county was arable land at mid-20th century.

Occupation in the Early Iron Age is indicated by the remains of numerous hill forts around Peebles, and there are standing stones near the confluence of the Lyne and the Tweed. The Romans left traces of their military rule in the camp at Lyne, locally known as Randal's walls. In mediaeval times a series of peel towers was erected; the best preserved is Neidpath castle.

Peeblesshire is closely associated with the legend of Merlin (q v.), and it provided background and other material for Sir Walter Scott. John Buchan and other writers. The rebuilt cottage of the Black Dwarf (David Ritchie) is southwest of Peebles,

and *St. Ronan's Well* is generally thought to have been inspired by the mineral springs at Innerleithen.

In 1955 Peebles combined with Roxburgh and Selkirk to form a joint constituency returning one member to parliament. It forms a sheriffdom with the Lothians; there is a sheriff substitute at Peebles. The chief towns are Peebles (1951 pop., 6,013), the only royal burgh, and Innerleithen (2.361). These are the only two burghs and they are both small.

PEEK, GEORGE NELSON (1873–1943), **U.S.** industrialist and government official. was born on Nov. 19, 1873, in Polo. Ill., and attended Northwestern university, Evanston, Ill. He entered private industry in 1893 and served as an executive with agricultural implement companies until 1923. In 1918 he was with the War Industries board as commissioner of finished products. The following year he acted as chairman of the industrial board in the U.S. department of commerce. As president of the American Council of Agriculture, 1925–28. Peek gained a knowledge of farm problems which proved valuable when he was appointed administrator of the newly formed Agricultural Adjustment administration in May 1933. In 1934 and 1935 he acted as special adviser on foreign trade to Pres. Franklin D. Roosevelt while serving as head of the Export-Import Bank of Washington. Peek wrote several articles and pamphlets dealing with national agricultural policy and foreign trade.

Peek died at Rancho Santa Fe, near San Diego, Calif., on Dec. 17. 1943.

PEEKSKILL, a city of Westchester county. N.Y., U.S., on the east bank of the Hudson river, 41 mi. above New York city. Peekskill is the shopping centre for northern Westchester and Putnam counties. Its name was derived from that of the adjacent creek, or "kill," on which Jan Peek. an early Dutch settler, conducted an Indian trading post from 1667 to 1677. The village was strategically important during the American Revolution, and large sections of it were burned by the British on March 23, 1777. It became a city in 1940.

For comparative population figures *see* table in NEW YORK: Population. (M. H. LE.)

PEEL, ARTHUR WELLESLEY PEEL, 1ST VISCOUNT (1829–1912). English statesman, who was an outstanding speaker **of** the house of commons. was the youngest son of Sir Robert Peel (*q.v.*). He was born in London on Aug. 3, 1829, and educated at Eton and at Balliol college. Oxford. He entered parliament in 1865, and after holding various offices became speaker in 1884. He was re-elected in 1886 and 1892, and on his retirement in 1895 received a viscountcy. He died at Sandy, Bedfordshire, on Oct. 24, 1912.

He was succeeded by his son WILLIAM ROBERT WELLESLEY PEEL (1867–1937), 2nd Viscount and 1st Earl (cr. 1929), who was prominent in London politics. Born in London on Jan. 7, 1867. and educated at Harrow and at Balliol college, Oxford, he entered parliament in 1900, and gained prominence as leader of the municipal reform party (1908–10) and as chairman of the London County council (1914–16). In 1919 he was appointed undersecretary of war, and after holding various other offices became secretary of state for India (1922–24 and 1928–29) and lord privy seal (1931). He died at Petersfield, Hampshire, on Sept. 28, 1937. **(A.** BRI.)

PEEL, SIR ROBERT, 2ND BART. (1788–1850), English statesman who was described by Lord Rosebery as the "model of all prime ministers." was born on Feb. 5, 1788, at Chamber hall, near Bury. Lancashire. His grandfather, Robert Peel. was a calico printer, who took to cotton spinning and became a wealthy businessman. His father. Robert Peel (1750–1830), carried on the family business and also interested himself in politics. He was M.P. for Tamworth, a supporter of Pitt and a warmhearted humanitarian. He became a baronet in 1800.

Young Robert Peel both benefited and suffered as a result of his Lancashire business background. It provided him with a considerable private fortune, which permitted him to devote most of his lifetime to politics; at the same time, it led to frequent taunts that he was a parvenu: Like his father, he was a Conservative in politics, but many traditionalist Conservatives, associated with the landed interest, thought of him disparagingly as "the Spinning Jenny."

If he was always Lancashire underneath, he had an impressive veneer of Harrow and Christ Church, Oxford. where he took a first class both in classics and mathematics. On leaving Oxford he was entered at Lincoln's Inn, and in 1809, at the age of 21, entered the house of commons. He sat at first for the close borough of Cashcl. Tipperary, then for Chippenham, Wiltshire.

He made his mark in the house by strict attention to all his parliamentary duties, by diligent industry, mastery of procedure and by a style of speaking which owed its force not to rhetoric but to detailed knowledge of parliamentary business, lucidity of exposition and tact in arranging his arguments. He soon was given office. He made his maiden speech, seconding the address in Jan. 1810; later in the year he became undersecretary for war and the colonies.

His first real opportunity in politics came in 1812 when he was transferred by Lord Liverpool to the more important but difficult post of secretary for Ireland. There he was engaged until 1818 in maintaining English ascendancy over a country heaving with discontent, teeming with conspiracy and on the verge of rebellion. "I believe an honest, despotic government would be by far the fittest government for Ireland," Peel remarked. Very systematically he set out to apply this policy, relying both upon coercion and patronage. He suppressed Irish opposition newspapers, resolutely opposed Catholic emancipation, instituted a regular Irish constabulary and on the more positive side tried to promote joint education as a means of reconciling religious differences. In applying this policy, which gave him his first real experience of administration, he had to face the opposition both of English advocates of Catholic emancipation, such as George Canning, and Irish politicians, such as Daniel O'Connell. In general, his despotic policy was not successful and did not prevent a combination of agrarian and political unrest. When in 1817 he was elected member of parliament for the University of Oxford, he expressed a desire to resign his Irish responsibilities, and just before he did so a year later, he wrote, "a fortnight hence, I shall be as free as air." Although he remained out of office until 1821, he had established himself. despite the failure of his policy, as one of the most promising young Tory politicians. His support of the union and the claims of the Irish Protestant Church weakened him in Ireland but strengthened him at Westminster. He won the Oxford seat against the opposition of Canning and with the support of die-hard Tories such as Lord Eldon. He remained on good terms with the official leaders of his party and, although he had opponents who considered him stiff and punctilious, his views always had to be taken seriously.

In 1819 he was made chairman of a secret committee of the Bank of England to consider the resumption of cash payments. This again was an important but difficult task, for currency problems at this time provoked sharp differences of opinion and conflicts of interest. Along with "corn and Catholics." they were the crucial political issues of the times. In 1797 Pitt had authorized the bank to refuse cash payment for sums over £1, and an era of finance by paper money had begun. After 1815 influential economists, led by David Ricardo. pressed for a return to gold. although many supporters of the landed interest and opponents of the fundholders were bitterly opposed to what they felt would be a deflationary or an inequitable measure. Peel threw his weight behind the orthodox economists, thereby clashing with his father, and on May 24, 1819, moved and carried in the house of commons four resolutions embodying the recommendations of his committee in favour of a return to cash payments. He admitted that he had changed his mind on the question. This was the first of several occasions during his life when he showed that he had an open mind and a readiness to listen to the opinion of "experts." The return to gold, which became effective in 1821, caused great hardship to debtors, of whom the landowners were the most important and influential group. They reproached Peel with having sacrificed the landed to the funded interest: the first time that this charge, which was frequently to be repeated, was made against him. Other critics of the bill were the Birmingham industrialists, who wished to

maintain a mild inflation, and William Cobbett, who hated paper money but felt that there should be no return to gold without considerable reduction of the national debt. As a result of the bill, the nation was insisting that debts which had been contracted in depreciated paper had to be paid in gold. Peel was thus attacked from many sides, although he was supported not only by economists but by the cotton interest, international trading houses and the City of London.

In 1822 Peel rejoined Liverpool's ministry as home secretary, and in this office he was less open to criticism. Although he had once more to concern himself with Irish discontent and to struggle hard against the supporters of Catholic emancipation, he was favoured by an improvement in the English domestic situation. The period of radical agitation after 1815. which was met by severe governmental repression, was giving way to a more liberal phase. Peel himself contributed to one aspect of the liberal movement by reforming and humanizing the criminal law, especially those parts of it which related to offenses against property and offenses punishable by death. Peel was a borrower rather than an initiator, and his reforms reflected the views of other reformers, such as Sir Samuel Romilly and Sir James Mackintosh. He gained much praise, however, especially from the Whigs, and he could rightly claim that all his legislation had sought "some mitigation of the severity of the criminal law, some prevention of abuse in the exercise of it, or some security for its impartial administration." The most important of his measures was the establishment of the metropolitan police force, a reform which for many years provoked sharp controversy. He knew how far to go in his reforms. Although, for instance, he believed that "the country has outgrown its police institutions." he realized that "the difficulty in this, as in ten thousand cases, is to devise any general rule which shall apply to a society so varying in its subdivisions as ours is." In governing England, Peel saw far more clearly than in governing Ireland that problems of administration were inextricably bound up with problems of economy and society, and that coercion was never enough.

It was Ireland and not England, however, which was to cause the next crisis in his career. In 1827 the Liverpool ministry, which had carried the country through war and peace, was broken up by the fatal illness of the prime minister, and under the new premier, Canning, with whom Peel had often disagreed, both Peel and the duke of Wellington refused to serve. The rivalry between Peel and Canning was both political and personal. Canning, the political diarist Mrs. Arbuthnot had written a few months earlier, "is excessively jealous of Mr. Peel and always objects to anything that is to strengthen Mr. Peel's party, which he considers as distinct from his own." The divisions within the Tory ranks continued after Canning's death (Aug. 1827) and even in Jan. 1828, when the duke of Wellington became prime minister and Peel home secretary again. They multiplied when Peel, faced with a political crisis in Ireland, found it necessary to change his views and for reasons of expediency to adopt the same Irish policy which Canning had supported earlier for reasons of principle. After a defeat in the house of commons, Peel had to acquiesce in the repeal of the Test and Corporation acts, which imposed civil disabilities on those persons who were not members of the Church of England. Immediately afterward the general question of Catholic emancipation was brought to a head by the election of O'Connell, Peel's old enemy. as "repeal" member of parliament for the county of Clare. O'Connell was supported by the militant and well-organized Catholic association, and Peel, with his fear of widespread disorder, saw at once that a change in Irish policy was necessary. The impression that the government meant to yield became prevalent in England, and stirred up Protestant opposition to Peel, who had been a Protestant hero until that moment. Peel was naturally anxious to commit the new policy to other hands. In Jan. 1829, however, because of the continued strength of Tory and royal opposition, Wellington told Peel that unless he stayed in office, there was no chance of carrying emancipation, which both of them now felt to be necessary. Subject to pressure, Peel consented to stay in office, although the cry of "traitor" was raised against him. The consent of the king, which could scarcely have been obtained except by Wellington and Peel, was extorted, withdrawn (the ministers being out for a few hours) and again extorted; and on March 5, 1829. Peel proposed Catholic emancipation in a speech of more than four hours. Protestant newspapers talked of a betrayal of the constitution and appeared with black borders, while Protestant Oxford rejected Peel and returned the ultra-Protestant Sir Robert Inglis in his place. Peel took refuge in the close borough of Westbury, from which he afterward moved to Tamworth. Staffordshire, in 1830. He continued to sit for Tamworth until his death.

Catholic emancipation broke up the party, which had already lost much of its cohesion by the time that Liverpool died. The Whig Reform bill, which was introduced by Lord Grey, Wellington's successor, in March 1831, helped to draw them together again. Some Tories opposed the bill intemperately, but Peel, as always, spoke with restraint and moderation. He maintained that the extension of the franchise and the redistribution of seats would destroy the existing balance of the constitution, create a division in the legislature between rural and industrial interests and prepare the way for a further chain of reforms and an eventual assault on property. "I was unwilling to open a door," he remarked, "which I saw no prospect of being able to close." He refused to join the duke of Wellington in trying to form a Tory government at the height of the parliamentary and popular storm in the spring of 1832, and when the Grey ministry had gone out after the king had refused to promise them to create new peers. Although by this time he was convinced that parliamentary reform was inevitable, he could not afford to risk his future by provoking a new charge of apostasy. After the Reform bill became law in June 1832 he accepted it as irrevocable, and when the general election of Dec. 1832 left him with barely 150 followers in the house of commons, he set out to weld them into a compact body, committed to cooperation inside the new political framework. His views were clearly stated in the so-called Tamworth manifesto to his constituents in 1834. The Reform bill, he explained, was "a final and irrevocable settlement of a great constitutional question." If willingness to adopt the spirit of the bill, he went on, merely implied a review of existing institutions and redress of abuses and grievances without infringing on established rights, he was prepared to subscribe to those principles. In this manifesto Peel showed that although he had served his political apprenticeship in the age of Lord Eldon and Lord Sidmouth, he had now learned to adapt his ideas and policies to the mood of the age. He showed too that the party which he led was not incapable of appealing to the new middle class electorate, brought into existence by the Whigs in 1832.

Peel drew up the manifesto after the Whigs had demonstrated that their own control of government remained precarious despite their triumphs between 1830 and 1832. In 1834 the Melbourne ministry, the successor to that of Grey, proved so weak that the king dismissed it, leaping at a half-proffered resignation. Peel took up power before he expected or desired it. He hurried from Rome, where he was on holiday, at the request of the duke of Wellington, and became prime minister for the first time, holding the two offices of first lord of the treasury and chancellor of the exchequer. When parliament was dissolved and he appealed to the electorate — the Tamworth manifesto was his own contribution — he gained considerably in strength but not enough to secure a majority. He was outvoted on the election of a speaker at the opening of the session, and after struggling on for six weeks longer, resigned on the question of appropriating part of the revenues of the church in Ireland to national education. His time had not yet come, but the capacity and resource he displayed in this short-lived minority government raised him immensely in the estimation of the house, his party and the country. The controversies of the past seemed dead and the cry of treachery to have been forgotten.

Between 1835 and 1839 he built up a parliamentary party with a tighter discipline than any party had possessed before. He used whips to control his supporters in parliament, and encouraged his supporters outside parliament to register for the franchise. He turned the Carlton club, which had been founded in 1831, into a party headquarters. From the general election of 1835 onaard, the Carlton club provided the initiative for scrutinizing local elec-

toral rolls, although contact between centre and constituencies was not so systematic as it became later in the century. The new discipline chafed some of his supporters, who complained that an attempt was being made "to convert a body of high-minded noblemen and gentlemen into a regiment of partisans," but for the time being it was effective. "Never had the leader of a party a more complete ascendancy over that party," wrote a commentator in 1836, "than has this Tory Coryphaeus over the Conservatives in the House of Commons." The trouble was that he did not win the hearts of his followers. He was sensitive and secretive, trying to educate his party into his own way of thinking, and while he carried most of them with him in supporting such reforms as the Municipal Corporations act of 1835, he often made them restless. The landed interest frequently advocated policies with which he was out of sympathy and a popular but prejudiced local Toryism in the north of England contrasted violently with his own sober version of Conservatism. There were some of his followers who felt also that his refusal to take part in what he called factious opposition was a surrender to liberal Whiggery.

In 1839 the weak Whig government resigned when a proposal to suspend the constitution of Jamaica, where the assembly had refused to perform its functions as a protest against interference from the home government, was carried by only five votes, and Peel was called upon to form a government. After he had submitted names for a cabinet, he resigned the commission because of the young Queen Victoria's persistent refusal to dispense with any of the Whig ladies of her bedchamber. Had it not been for this crisis in the relations between Peel and the queen, his policy of patient and thoughtful party building would have ensured a relatively early return to office, which he much preferred to opposition. As it was, he had to wait until the general election of 1841, when the Whigs were in a minority of 91. They resigned. and Peel became prime minister for the second time, with a sizable majority.

The situation demanded a master hand. The national finances were in disorder. For several years there had been a growing budget deficit, estimated for 1842 at more than £2,000,000, and attempts to remedy this by additions to assessed taxes and customs duties had failed. More serious still, there was a profound social problem, reflected in bitter class relations, unemployment and starvation among the poor and slack trade among the manufacturers. The Chartists were clamouring for the six points of their formula *(see* CHARTISM), and the Anti-Corn-La league (*q.v.*) was attacking the landlords as the enemies of society. Between 1841 and 1846 Peel did much not only to reorganize the national fiscal system but also to prevent revolution and restore confidence in government. His ministry laid the foundations of Victorian England. and Peel himself was conversant with all the great issues which confronted his ministers. Unfortunately he was less conversant with the doubts and grievances of his rank-and-file supporters, and administrative triumph was eventually accompanied by political disaster. Peel saved his country only by breaking up his party. Although in retrospect he could claim that he was "much more surprised that the union was so long maintained than that it was ultimately severed," he was shocked by the violence of the disintegration and the cries of "traitor" which were once more hurled at him by his former supporters.

Peel met the immediate fiscal crisis by introducing income tax on all incomes of more than £150 a year. To encourage trade he either removed or drastically reduced duties on a vast number of articles of import, especially raw materials and foodstuffs. Increased consumption, as he anticipated, countervailed the reduction in duty. The depression lifted, the deficits were turned into surpluses, and in 1844 he was able to convert £250,000,000 of debt from 33% to 3%. In 1845, while renewing the income tax for another three years, he repealed all duties on 450 imports and all the remaining duties on exports. He had sketched the outlines of a free-trade policy not on doctrinaire grounds but for reasons of sound administration. Among the other important measures he introduced was the Bank Charter act of 1844, which rigidly separated the banking and issue departments of the Bank of England and limited its rights of issue.

There was little conflict about such proposals, but as soon as Peel turned his attention to the Corn laws, social and political difficulties loomed large. The duties on the imports of foreign corn were considered as a necessary economic and social prop by the landed interest; by the Anti-Corn-La league they were felt to be a barrier to all economic progress. In 1842 Peel lowered the duties of the sliding scale, which had been introduced in 1828 as a modification of the 1815 Corn law. Many Tories already regarded this reform as a step toward free trade. and the ***Edinburgh Review*** commented that he had "prepared the way with great adroitness, but with much caution, for the final abandonment of protection." The leaguers. led by Richard Cobden (*q.v.*), felt that the change did not go far enough, and in 1843 Cobden declared that Peel was individually responsible for the distress in the country. Peel himself admitted to W. E. Gladstone in 1843 that he could no longer stand on agricultural protection as a principle, but such a private admission diverged sharply from the opinions of many of his followers. His decision to enact total repeal was taken only when the approach of the Irish potato famine lent urgency to the repealers' case. In Nov. 1845 he faced sharp opposition from inside his own cabinet, and in early Dec. he resigned. After Lord John Russell (*q.v.*) had failed to form a Whig government, Peel returned to office on Dec. 20. Supported by all his former colleagues, except Lord Stanley, he introduced his Corn law and Customs bill in the commons in Jan. 1846, in which he proposed total repeal, although the ports were not to be completely opened until 1849. In the long and fierce debates which followed, he was attacked with the most virulent invective. His party split, 231 Tories voting against him and only 112 for him in the crucial division on the second reading on Feb. 27. He was accused both of panic and betrayal, particularly by the rising young politician Benjamin Disraeli, and although he carried repeal with the help of his political opponents, he was defeated on June 25 by a coalition of protectionists and Whigs, who opposed his new Irish Coercion bill. He immediately resigned. Once again the impact of Ireland on English politics had directly influenced his prospects. In the course of the final debates. he paid a generous tribute to Cobden, but he refused to take Cobden's advice and appeal to the country on the issue of free trade. He was sensitive to middle-class needs, but unlike Cobden he refused to contemplate a new middle-class system of government. He certainly did not wish to undermine agriculture. Basically he was still a Conservative, who. in his own words, wished "to terminate a conflict which, according to our belief, would soon place in hostile collision great and powerful classes." He counted the interests of party for little in his long-term reckoning.

After the general election of 1847, in which the Whigs secured a majority, Peel gave them considerable outside support. He joined them, for example, in carrying the repeal of the navigation laws. In 1849 he returned to the problems of Ireland, which had concerned him for so long. In 1845 he had alienated many of his Tory supporters by granting an increased subsidy to the Roman Catholic priests' seminary at Maynooth. In 1849, in a speech on the Irish poor laws. he first suggested, and in the next year succeeded in establishing. a commission to facilitate the sale of estates in a hopeless state of encumbrance. The Encumbered Estates act was designed to transfer the land from ruined landlords to solvent owners capable of maintaining and improving their property. On June 28, 1850, he made his last great speech criticizing Lord Palmerston's foreign policy; it was in line with the cautious and peaceful approach he had always advocated in foreign affairs. The speech was thought to show that, if necessary or feasible, he would return to office. On the following day he mas thrown from his horse on Constitution hill, and died on July 2. He was still in the prime of life and his prestige was high. All the tributes which respect and gratitude could pay were made to him by the queen and Prince Albert, whose sympathy and friendship he had won between 1839 and his death, by parliament, by public men of all parties, by the press, and above all by the citizens of the great industrial areas, to whom he had given "bread unleavened with injustice."

Peel, who married Julia, daughter of Gen. Sir John Floyd, in 1820, had five sons and two daughters. His domestic life was as

happy as his public life was conscientious. No statesman was more impelled by an overriding sense of public duty, and there was no greater public contribution than his to the march of improvement in 19th-century England. *See* also CONSERVATIVE PARTY, BRITISH; CORN LAWS.

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(A. BRI.)

PEEL, a seaport and seaside town on the west coast of the Isle of Man, 10 mi. N.W. of Douglas by road and on the Isle of Man railway. Pop. (1951) 2,582; area .3 sq.mi. It lies on Peel bay at the mouth of the river Neb, which forms the harbour. The old town consists of narrow streets and lanes, but a modern residential quarter has grown up to the east. On the west side of the river mouth St. Patrick's Isle, connected with the mainland by a causeway, is occupied almost wholly by the ruins of Peel castle. St. Patrick is said to have founded there the first church in Man, and a small chapel, dedicated to him, appears to date from the 8th or 10th century. There is a round tower, also of early date.

The ruined cathedral of St. German has a transitional Norman choir, with an early crypt beneath, and a nave with an early English triplet at the west end. There are remains of the bishops' palace, of the palace of the lords of Man, of the keep and guard-room above the entrance to the castle, and of the Moare or great tower, while the whole is surrounded by battlements. In 1397 Richard II condemned the earl of Warwick to imprisonment in Peel castle, and in 1444 Eleanor, duchess of Gloucester, received a like sentence. Peel has a long-established fishing industry. It was called Holen ("island"; *i.e.,* St. Patrick's Isle) by the Northmen; the existing name is Celtic, meaning "fort."

BEELE, GEORGE (1556–1596), English dramatist, predecessor of Shakespeare, who experimented in many forms of theatrical art: pastoral, history, melodrama, tragedy, folk play and pageant. His *The Arraignmenf of Paris* is one of the earliest mythological pastorals, and his *Device of the Pageant Borne Before Woolstone Dixi* is the earliest surviving complete lord mayor's show, the annual pageant produced for the inaugural ceremonies of the lord mayor of London.

Peele was born in London, the eldest son of a middle-class urban family. His father. James, was an accountant and teacher who himself wrote pageants, as well as two treatises explaining double-entry bookkeeping. Shortly after George's birth James was appointed head bookkeeper of Christ's hospital, at that time a home and school for London orphans. There the dramatist lived and studied until he went to Oxford in 1572.

What is known of Peele's career at Broadgates hall (later Pembroke college) and Christ Church, Oxford, indicates that he began his varied literary career by translating into English one of the plays of Euripides. William Gager, the celebrated Latin dramatist, wrote two commendatory poems to the young student, praising him for his literary skill; and Anthony à Wood records that Peele was "esteemed a most noted Poet in the University."

In 1579 Peele made two trips to London. His second visit was cut short at the request of the hospital governors, who seem to have felt that the added burden of a student able to shift for himself was too distracting for the now-ailing father. Peele returned to Christ Church, where he married Anne Cooke and settled down in the university community. During this period he probably wrote the first of his surviving works, a 485-line verse epitome of the *Iliad,* titled *The Tale of Troy* (published 1589).

In 1581 he moved to London but during the next two years returned to Oxford many times to cope with litigation over property his wife had inherited. Pleasanter business necessitated his return in 1583, when Christ Church presented two spectacular plays by Gager, and Peele was hired as one of the technical directors.

About this time Peele had joined a group of Oxonians living just outside the London city wall and had begun to experiment with poetry in various metres. From this association with the so-called "university wits" comes a blank verse commendatory poem to the poet Thomas Watson and two mythological pastorals: *The Arraignment of Paris* (1584) and *The Hunting of Cupid.* This sort of gentleman's writing probably brought Peele less money than praise, for shortly afterward he produced *The Device of the Pageant Borne Before Woolstone Dixi* (1585). It was followed by other pageants for the city, of which anly *Descensus Astraeae* (1591) survives.

The Arraignment of Paris was produced for the courtiers, but the rest of Peele's life was devoted to writing for the popular stage. Of the many playhouse dramas he must have had a hand in, only four can be certainly ascribed to him: *The Battle of Alcazar* (1594), *The Old Wives Tale* (1595; ed. by R. L. Blair, 1936), *Edward I* (1593) and *The Love of King David and Fair Bethsabe* (1599). To supplement a meagre income, Peele turned out poems commemorative of noteworthy events: *A Farewell* (1589), to John Norris and Francis Drake on their departure with a counterarmada to fight the Spanish; *An Eglogue Gratulatorie* (1589), to the earl of Essex on his return home from this expedition; *Polyhymnia* (1590), celebrating an important tilting match; *The Honour of the Garter* (1593), commemorating the earl of Northumberland's installation as knight of the Garter; and *Anglorum Feriae* (1595), another memorial of a noteworthy tilt. The only other work which can with any certainty be ascribed to Peele is a poem, "The Praise of Chastity," which appeared in *The Phoenix Nest* (1593), an anthology of Oxford poets.

It used to be customary to describe Peele as dissipated, depraved and desperate, but the evidence on which such an estimate of his character was largely based—an anonymous jestbook that made free use of his name—is valueless in this respect. He lived and died a varied life fraught with the perils of poverty; shortly before his death he sent his eldest daughter to Lord Burghley with a request for money, describing himself as enfeebled by long sickness. His contemporaries praised him highly. Modern critics accord him a place, along with Robert Greene, Thomas Kyd and Thomas Nashe, as an important early playwright with considerable technical skill.

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(*D. H.* H.)

PEEPUL (PIPUL): *see* BO TREE.

PEERAGE. Although in England the terms peerage (Fr. *pairage;* Med. Lat. *paragium;* M E. *pere;* O.Fr. *per, peer,* later *pair;* Lat, *paris,* "equal"), nobility, House of Lords are commonly regarded as synonymous, in reality each expresses a different meaning. A man may be a peer and yet not be a member of the House of Lords, a member of the House of Lords and yet not strictly a peer, though all peers are members of the House of Lords. either *in esse* or *in posse.*

In the United Kingdom the rights, duties and privileges of peerage are centred in an individual, while to the old monarchical notions of the Continent, nobility conveyed the idea of family, as opposed to personal, privilege.

The Origin of Peerage.—Etymologically, peers are equals *(pares),* and in Anglo-Norman days the word was invariably so understood. The feudal tenants-in-chief of the Crown were all the peers of one another; so, too, a bishop had his ecclesiastical peer in a brother bishop, and the tenants of a manor their peers in their fellow-tenants. That even so late as the reign of John the word was still used in this general sense is clear from Magna Carta, for the term *judicium parium* therein must be understood to mean that every man had a right to be tried by his equals. This right was asserted by the barons as a body in 1233 on behalf of Richard, earl marshal, who had been declared a traitor by the king's command. The English barons undoubtedly were using the word in the sense it held in Magna Carta. The change in England was gradual and probably gathered force as the gulf between the greater barons and the lesser widened, until in course of time, for judicial purposes, there came to be only two classes, the greater barons and the rest of the people. Ecclesiastics had special privileges for most purposes, being triable only by the Church. The first use of the word peers, as denoting

those members of the baronage who were accustomed to receive regularly a personal writ of summons to parliament, is found in the record of the proceedings against the Despensers in 1321. (Stubbs, *Const. Hist.* ii. 347.)

Anglo-Norman Baronage.—Properly to understand the growth and attributzs of the peerage it is necessary to trace the changes which occurred in the position of the Anglo-Norman baronage, first through the gradual strengthening of royal supremacy, with the consequent decay of baronial power locally, and subsequently by the consolidation of parliamentary institutions during the reigns of the first three Edwards In place of the individual absolute ownership of Saxon days, the Conqueror became practically the sole owner of the soil. The change, though not immediately complete, followed rapidly as the country settled down and the power of the Crown extended to its outlying frontiers. The new owners became direct tenants of the king. All tenants-in-chief were termed generally barons (*see* BARON).

The King's Court.—The king's tenants owed as a duty the service of attending the King's Court (*curia regis*), and out of this custom grew the parliaments of later days. In theory all the king's tenants-in-chief, great and small, had a right to be present as incident to their tenure. The King's Court was held regularly at the three great festivals of the Church and at such other times as deemed advisable The assembly for several generations neither possessed nor pretended to any legislative powers. Legislative power was a product of later years, and grew out of the custom of the Estates granting supplies only on condition that their grievances were first redressed. The great bulk of the tenants were present for the purpose of assenting to special taxation above and beyond their ordinary feudal dues. When necessary a general summons to attend was sent through the sheriff of every county, who controlled a system of local government which enabled him to reach every tenant. In course of time to a certain number of barons and high ecclesiastics it became customary to issue a personal writ of summons, thus distinguishing them from the general mass summoned through the sheriff.

Magna Carta and Personal Summons to the **Majores** Barones.—The sequel is found in Magna Carta, wherein it is provided that the archbishops, bishops, abbots, earls and greater barons are to be called up to the council by writ directed to each severally; and all who hold of the king in chief, below the rank of greater barons, are to be summoned by a general writ addressed to the sheriff of their shire: Magna Carta thus indicates two definite sections of the king's tenants, a division which had evidently persisted for some time. The "greater barons" are the parents of the peers of later days. As for the rest of the tenants-in-chief, poorer in estate and therefore of less consequence, it is sufficient here to note that they fell back into the general mass of manorial owners; and that their representatives, the knights of the shire, after some hesitation, at length joined forces with the city and burgher representatives to form the House of Commons. From 1254 to 1295 in varying numbers there were summoned to the King's Councils representatives of the counties, boroughs and cities. The assembly of 1295, called the Model Parliament, is regarded legally as the first of our freely-elected properly representative assemblies, but recent research now ascribes this character to a Parliament summoned as early as 1275.

To every spiritual and temporal baron accustomed to receive an individual writ, one was issued. Every county elected its knights, and every city or borough of any importance was instructed by the sheriff to elect and to return its allotted number of representatives. It may be taken for granted, however, that any assembly held since 1295, which did not conform substantially to the model of that year, cannot be regarded constitutionally as a full parliament. The point is even of modern importance, as in order to establish the existence of a barony by writ it must be proved that the claimant's ancestor was summoned by individual writ to a full parliament, and that either he himself or one of the heirs of his body was present in a full parliament.

Grades of Peerage.—An examination of the early writs issued to individuals shows that the baronage consisted of archbishops, bishops, abbots, priors, earls and barons. While the archbishops and bishops received their writs with regularity, the summonses to heads of ecclesiastical houses and greater barons were intermittent. The prelate held an office which lived on regardless of the fate of its temporary holder, and if by reason of death, deprivation or translation the office became vacant, a writ still issued to the "Guardian of the Spiritualities." The prior or the abbot, on the other hand, often outside the jurisdiction of the English Church, and sometimes even owing allegiance to a foreign order, was but the personal representative of a land-holding community. The conclusion, then, may be drawn that in theory the issue of a writ was at the pleasure of the Crown, and that in practice the moving factor in the case of the prelates was office and personal importance, and in the case of priors, abbots, earls and barons, probably, in the main, extent of possession.

Hereditary Principle.—The next point for consideration is when did the peerage, as the baronage subsequently came to be called, develop into a body definitely hereditary? Here again growth was gradual and somewhat obscure. Throughout the reigns of the first three Edwards summonses were not al ays issued to the same individual for successive parliaments; and it, is quite certain the king never considered that the issue of one writ to an individual bound the Crown to its repetition for the rest of his life, much less to his heirs in perpetuity. Again we must look to tenure for an explanation The custom of primogeniture tended to secure estates in strict family succession, and if extent of possession had originally extracted the acknowledgment of a personal summons from the Crown it is more than probable that as successive heirs came into their inheritance they, too, would similarly be acknowledged. In early days the summons mas a burden to be suffered of necessity, an unpleasant incident of tenure, in itself undesirable, and probably so regarded by the majority of recipients during at least the two centuries following the Conquest. Gradually the free and indiscriminate choice of the Crown became fettered by the principle that, once a summons had been issued to an individual to sit in parliament and he had obeyed that summons, he thereby acquired a right of summons for the rest of his lifetime; and in later years, when the doctrine of nobility of blood became established, his heirs were held to have acquired the same privilege by hereditary right.

The earl's position in the baronage needs some explanation. Modern historical opinion inclines to the view that while originally an earldom may have been something of an office, it rapidly became little more than an added name of dignity conferred on one already a leading member of the baronage. Earls received individual summonses to parliament by the name of Earl (*q.v.*); but there is reason to believe that in early clays at any rate they sat by tenure as members of the baronage.

If we review the political situation at the beginning of the 14th century a great change is evident. The line between those members of the baronage in parliament and the rest of the people is firmly and clearly drawn. Tenure as the sole qualification for presence in the national assembly has disappeared, and in its place there appears for the baronage a system of royal selection and for the rest of the people one of representation.

Peerage a Personal Dignity.—Primogeniture, a custom somewhat uncertain in early Anglo-Norman days, had rapidly developed into a definite rule of law. As feudal dignities were, in their origin, inseparable from the tenure of land, it is not surprising that they, too, followed a similar course of descent, although as the idea of a dignity being exclusively personal gradually emerged, some necessary deviations from the rules of law relating to the descent of land inevitably resulted. In the 11th year of his reign Richard II. created by letters patent John Beauchamp "Lord de Beauchamp and baron of Kyddermynster, to hold to him and the heirs of his body." These letters patent were not founded on any right by tenure of land possessed by Beauchamp, for the king makes him "for his good services and in respect of the place which he has holden at the coronation (*i.e.*, steward of the household) and might in future hold in the king's councils and parliaments, and for his noble descent, and his abilities and discretion, one of the peers and barons of the kingdom of England; willing that the said John and the heirs-male of

his body issuing, should have the state of baron and should be called by the name of "Lord de Beauchamp and baron of Kyddermynster." The grant rested wholly on the grace and favour of the Crown, and was a personal reward for services rendered. Here, then, is an hereditary barony entirely a personal dignity and quite unconnected with land. From Richard's reign to the present day, baronies (and, indeed, all other peerage honours) have ccntinued to be conferred by patent. The custom of summons by writ was not in any way interfered with, the patent operating merely to declare the dignity and to define its devolution. Summons alone still continued side by side for many generations with summons founded on patent; but after the reign of Henry VIII. the former method fell into disuse, and during the last 250 years there have been no new creations by writ of summons alone. So, from the reign of Richard II., barons were of two classes, the older, and more ancient in lineage summoned by writ alone, the honours descending to heirs-general, and the newer created by letters patent, the terms of which governed the issue of the summons and prescribed the devolution of the peerage in a line usually of the direct male descendants of the person first ennobled.

Peerages by Tenure. — It was long believed that, originally, there existed peerages by tenure alone and that such could devolve by right of tenure independent of descent. The Berkeley case of 1858–61 (better reported 8 H.C.L. 21) is essential for the student who wishes to examine the question carefully; and may be regarded as finally putting an end to any idea of bare tenure as an existing means of establishing a peerage right. (*See* also Cruise on Dignities, 2nd ed., pp. 60 et seq.)

The main attribute of a peerage is that hereditary and inalienable quality which ennobles the blood of the holder and his heirs, or, as a great judge put it in 1625, in the earldom of Oxford case, "he cannot alien or give away this inheritance because it is a personal dignity annexed to the posterity and fixed in the blood" (Dodridge, J., at p 123, Sir W. Jones's Reports).

Dukes. — Until the reign of Edward III. the peerage consisted only of high ecclesiastics, earls and barons. The earls were barons with their special name of dignity added, and their names always appear on the rolls before those of the barons. In 1337 King Edward III. created his son, the Black Prince, duke of Cornwall, giving him precedence over the rest of the peerage. Subsequently several members of the royal family were created dukes, but no subject received such an honour until 50 years later, when Richard II. created his favourite, Robert de Vere, earl of Oxford, duke of Ireland (for life). The original intention may have been to confine the dignity to the blood royal, since, with the exception of de Vere, it was some years before a dukedom was again conferred on a subject.

Marquesses. — In 1385 Richard II. had created Robert de Vere marquess of Dublin, thus importing an entirely new and unknown title into the peerage. The grant was, however, only for life, and was, in fact, resumed by the Crown in 1387, when its recipient was created duke of Ireland.

Viscounts. — Under the name of viscount (*q.v.*) Henry VI. added yet another order, and the last in point of time, to the peerage, creating in 1440, John, Baron Beaumont, Viscount Beaumont and giving him precedence next above the barons. The name of this dignity was borrowed from the Continent, having been in use for some time as a title of honour in the king's French possessions. None of the new titles above mentioned ever carried with them any official position; they were conferred as additional honours on men who were already members of the peerage.

Spiritual Peers. — The application of the hereditary principle to temporal peerages early differentiated their holders from the spiritual peers. Both spiritual and temporal peers were equally lords of parliament, but hereditary pretensions on the one side and ecclesiastical exclusiveness on the other soon drew a sharp line of division between the two orders. Gradually the temporal peers, strong in their doctrine of "ennobled" blood, came to consider that theirs was an order above and beyond all other lords of parliament, and before long, arrogated to themselves the exclusive right to be called peers, and as such the only persons entitled to the privileges of peerage.

The pretensions of the lay peers were not admitted without a struggle on the part of the prelates, who made the mistake of aiming at the establishment of a privileged position for their own order while endeavouring to retain every right possessed by their lay brethren. They fell between two stools, lost their position as peers and were beaten back in their fight for ecclesiastical privilege. For themselves Churchmen never claimed the privilege of trial by peers, and when arraigned, alleged to be altogether beyond secular authority. The Standing Orders of the House of Lords for 1625 contain the statement that "Bishops are only Lords of Parliament and not Peers" (*Lords Journals*, iii. 349). In 1640 the "Lords Spiritual" were altogether excluded from the House of Lords by act of parliament, and were not brought back until the second year of the Restoration.

Henry VIII. and the Peerage. — The reign of Henry VIII. brought about far-reaching changes in the position of the peerage. When that king ascended the throne the hereditary element was in a decided minority, but the balance was rapidly redressed until a bare hereditary majority was secured and the dissolution of the monasteries made possible. The peers, many now grown fat on abbey lands, at once began to consolidate their position; precedents were eagerly sought for, and the doctrine of ennobled blood began to find definite and vigorous expression So long, the peers declared, as there is any ennobled blood, a peerage must exist; and it can be extinguished only by act of parliament, failure of heirs or upon corruption of blood by attainder.

Surrender of Peerages. — From the doctrine of nobility of blood is derived the rule of law that no peerage (a Scots peerage is under Scots Law, which admits surrender) can be surrendered, extinguished or in any way got rid of unless the blood be corrupted. The rule is well illustrated by the earldom of Norfolk case (*Law Reports* [1907], A C. 10), in which its development was traced, and the principle authoritatively confirmed. Historically, there is little to support such a decision, and, indeed, this rigid application of the law is of comparatively recent date. Without doubt king, nobles and lawyers alike were all agreed, right down to Tudor days, that such surrenders were entirely valid. Many certainly were made, but, according to the decision of 1906, any living heirs of line of those nobles who thus got rid of their peerage honours can, if their pedigrees be provable and no attainders bar the way, come to the House of Lords with a fair chance of reviving the ancient honours.

Attainder and Corruption sf Blood. — The application of the doctrine of corruption of blood to peerages arises out of their close connection with the tenure of land, peerage dignities never having been regarded as personal until well on into the 14th century. Conviction for any kind of felony — and treason originally was a form of felony — was always followed by attainder. This resulted in the immediate corruption of the blood of the offender, and its capacity for inheritance was lost for ever. Such corruption, with all its consequences, could be set aside only by act of parliament This stringent rule of forfeiture was to some extent mitigated by the passing, in 1285, of the statute De Donis Conditionalibus (see ENTAIL), making possible the creation of estates tail, and when a tenant-in-tail was attainted forfeiture extended only to his life interest. The statute De Donis was soon applied by the judges to such dignities as were entailed (*e.g.*, dignities conferred by patent with limitations in tail), but it never affected baronies by writ, which were not estates in tail but in the nature of estates in fee simple descendible to heirs-general. In the reign of Henry VIII. an act was passed (1534) which brought estates tail within the law of forfeiture, but for high treason only The position then became that peerages of any kind were forfeitable by attainder following on high treason, while baronies by writ remained, as before, forfeitable for attainder following on felony In 1708, just after the union with Scotland, an act was passed by which, on the death of the Pretender and three years after Queen Anne's death, the effects of corruption of blood consequent on attainder for high treason were to be abolished, and the actual offender only punishable (stat. 7 Anne, c. 21, sec. 10). Owing to the 1745 rising, the operation of this act was postponed until the decease

of the Pretender and all his sons (stat. 17 Geo II. c. 39, sec. 3). In 1814, forfeiture for every crime other than high and petty treason and murder, mas restricted to the lifetime of the person attainted (stat. 54 Geo. III. c 145) Finally, in 1870, forfeiture, except upon outlawry, mas altogether abolished, and it was provided that "no judgment of or for any treason or felony should cause any attainder or corruption of blood, or any forfeiture or escheat."

In many cases there have been passed special parliamentary acts of attainder and forfeiture, and these. of course, operate apart from the general law. In any event, attainder and forfeiture of a dignity, whether resulting from the rules of the common law or from special or general acts of parliament can only be reversed by act of parliament

Growth of the Lords.—The numbers of the House of Lords grew steadily throughout the Tudor period, and during the reign of the first two Stuarts underwent a still greater increase. In the Great Rebellion the majority of the peers were the king's stoutest supporters, and thus inevitably involved themselves in the ruin of the royal cause Under Cromwell they disappeared as a legislative body and did not return to their ancient place until the restoration of Charles II.

From the reign of William of Orange the peerage has been freshened by a steady stream of men who, as a rule, have served their country as statesmen, judges, sailors and soldiers By the Act of Union with Scotland (1707) the Scottish parliament was abolished; but the Scottish peerage was given the privilege of electing, for each parliament of Great Britain, 16 of their number to represent them in the House of Lords. Further creations in the Scottish peerage were no longer to be made. The effect of this act was to leave the great majority of the Scottish peers outside the House of Lords, since only 16 of their number were to become lords of parliament. Close upon 100 years later Ireland was united with Great Britain, the Irish parliament being merged in the parliament of the United Kingdom of Great Britain and Ireland Twenty-eight Irish peers were to be elected for life by their order to represent it in the House of Lords. One archbishop and three bishops were also chosen in turn to represent the Irish Church in the House of Lords, but when that Church was disestablished in 1867 the spiritual lords lost their seats The merger of the three kingdoms had an important effect on their peerages Every peer, in his own country, had been a lord of parliament by hereditary right. The English peer (and, as the Acts of Union were passed, the peer of Great Britain and the peer of the United Kingdom) continued by hereditary right a lord of parliament. Although the Scottish and Irish peers lost this right by the two Acts of Union, they retained every other privilege of peerage. Henceforth they were to be lords of parliament only when their fellow peers elected them

The erection of southern Ireland into a self-governing dominion of the Crown has indirectly but definitely affected the status of the Irish peerage. This peerage belonged to the old united Ireland; and cannot to-day arbitrarily be divided between its two halves The Irish Free State Constitution Act, 1922, together with the machinery acts dependent thereon, has destroyed the procedure whereby Irish representative peers are elected; whether intentionally or by accident is not known Existing representative peers, having been elected for life, remain in the House of Lords, but no vacancies can henceforth be filled The Irish peerage will thus slowly diminish in numbers as existing peerages die out.

The modern meaning of the term peerage can now be rnore clearly defined. It will be noted that there have always been separate peerages of England, Ireland and Scotland. After the union of England with Scotland new creations became of the peerage of Great Britain, and after the union of Great Britain with Ireland: of the United Kingdom of Great Britain and Ireland; and now, since the advent of the Irish Free State, probably we must speak of the "United Kingdom of Great Britain and Northern Ireland" Many members of the House of Lords hold peerages in several of these groups

Several attempts have been made to limit the absolute rights of peers to a writ of summons, but this is a question which belongs rather to the history of the House of Lords as a legislative chamber. It will suffice here to note that in 1856 an attempt was made to create one of the judges a life peer, but the House, after long debate, rejected the writ, and a patent of customary form had to be followed. In 1876 legislation was passed creating two lords of appeal (with power to appoint two more) with a right to sit and vote during the holding of office. In 1887 further legislation conferred on all lords of appeal and ex-lords of appeal life peerages.

The Scottish Peerage.—The Scottish peerage, like that of England, owes its origin to feudalism. When the Scottish earls and barons came to parliament, they did not withdraw themselves from the rest of the people, it being the custom for the estates of Scotland to deliberate together, and this custom persisted until the abolition of their parliament by the Act of Union in 1707. The territorial spirit of the nobles inevitably led them to regard the honour as belonging to, and inseparable from, their land, and until comparatively late in Scottish history there is nowhere any record of the conferment of a personal dignity unattached to land such as that conferred in England on Beauchamp by Richard II. This explains the frequent surrenders and altered grants which are so common in Scottish peerage history, and which, in sharp distinction to the English rule of law, are there regarded as perfectly legal. To-day there exists no Scottish dukedom (except the royal dukedom of Rothesay), marquessate or viscounty created before the reign of James VI. of Scotland (and I. of England). Of the existing Scottish peerages 63 were created in the period between James's accession to the English throne and the Act of Union. There are now only 87 in all.

The Irish Peerage.—The Anglo-Norman conquerors of Ireland carried with them the laws and the system of tenure to which they were accustomed in England, and consequently the growth of the baronage and the establishment of parliamentary government in Ireland proceeded on parallel lines with the changes which occurred in England. Until the reign of Henry VIII the Irish were without representation in parliament, but gradually the Irish were admitted, and by the creation of new parliamentary counties and boroughs were enabled to elect representatives. In 1613 the whole country shared in representation (Ball's *Legislative Systems* of *Ireland).* Just as James I. had added many members to the Scottish peerage, so he increased the number of Irish peers.

On the death of a representative peer of Scotland a vacancy occurs and a new election takes place, but in accordance with modern practice promotion to a United Kingdom peerage does not vacate the holder's representative position (May's *Parliamentary Practice,* p 11 n.). Scottish and Irish peers, if representative, possess all the privileges of peerage and parliament enjoyed by peers of the United Kingdom; if non-representative all privileges of peerage, except the right to a writ of summons to attend parliament and to be present at and vote in the trial of peers.

Though many peers possess more than one peerage, and frequently of more than one country, only that title is publicly used which is first in point of precedence. Every peerage descends according to the limitations prescribed in its patent of creation or its charter, and where these are non-existent (as in the case of baronies by writ) to heirs-general.

In dealing with English dignities it is essential to realize the difference between a mere title of honour and a peerage. The Crown, as the fountain of honour, is capable of conferring upon a subject not only any existing title of honour, but may even invent one for the purpose So James I. instituted an order of hereditary knights which he styled baronets, and Edward VII. created the duchess of Fife "Princess Royal"—a life dignity. The dignities of prince of Wales, earl marshal and lord great chamberlain have been for centuries hereditary, and though of high court and social precedence, of themselves confer no right to a seat in the House of Lords—they are not peerages.

There is no limitation on the power of the Crown as to the number of United Kingdom peerages which may be created. As

to Scotland, the Act of Union with that country operates to prevent any increase in the number of Scottish peerages. and consequently there have been no creations since 1707, with the result that the Scottish peerage, as a separate order, is gradually approaching extinction. The Irish peerage is supposed always to consist of 100 exclusively Irish peers, and the Crown (before the erection of the Irish Free State) had power to grant Irish peerages up to the limit. When the limit was reached no more peerages might be granted until existing ones had become extinct or their holders succeeded to United Kingdom peerages. Only seven lords of appeal in ordinary may hold office at any one time. The number of archbishops and bishops capable of sitting in the House of Lords is fixed by various statutes at 26.

Since party government became the rule, the new peerages have usually been created on the recommendation of the prime minister of the day, though the Crown, especially in considering the claims of royal blood, is believed in some instances to take its own course; and, constitutionally. such action is entirely legal. By far the greater number of peerage honours granted during the last two centuries have been rewards for political services. The roll of the lords spiritual and temporal for the session of parliament assembling Feb. 1928 numbered 740.

Privileges of Peerage.—As centuries have gone by and customs changed, many privileges once keenly asserted have either dropped out of use or been forgotten. The most important now in being are a seat in the House of Lords and the right to trial by peers on any charge of treason or felony. Whatever the origin of this latter right, and some date it back to Saxon times (Trial of Lord Morley, 1678, *State Trials,* vii, 145), Magna Carta has always been ,regarded as its confirmatory authority.

The peers have always strongly insisted on this privilege of trial by their own order, and several times the heirs of those wrongly condemned recovered their rights and heritage on the ground that there had been no proper trial by peers (R.D.P., v. 24). In 1442 the privilege received parliamentary confirmation (stat. 20 Henry VI. c. 9). If parliament is sitting the trial takes place before the House of Lords in full session; *i.e.,* the court of our lord the king in parliament; if not, then before the court of the lord high steward. The office of lord high steward was formerly hereditary, but has not been so for centuries and is now only granted *pro hac vice.* When necessity arises, the Crown issues a special commission naming some peer (usually the lord chancellor) lord high steward *pro hac vice* (Blackstone's *Comm.,* iv, 258). When a trial takes place in full parliament a lord high steward is also appointed. but his powers there are confined to the presidency of the court, all the peers sitting as judges of law as well as of fact. Should the lord high steward be sitting as a court out of parliament, he summons a number of peers to attend as a jury, but rules alone on all points of law and practice, the peers present being judges of fact only. Whichever kind of trial is in progress, it is the invariable practice to summon all the judges to attend and advise on points of law. The distinction between the two tribunals was fully discussed and recognized in 1760 (Trial of Earl Ferrers, Foster's *Criminal Cases,* 139). The most recent trial was that of Earl Russell for bigamy (reported 1901, A.C. 446).

Peeresses and nonrepresentative peers of Ireland and Scotland have, with the exception of the right to sit in the House of Lords and its attendant privileges, every peerage privilege. In 1922 Sibyl Viscountess Rhondda presented a petition claiming the right to a writ of summons. The claim was heard and reheard before the Committee for Privileges and eventually rejected. This decision has disposed of the claims of peeresses in their own right, under the existing law, to sit in the House of Lords. A widowed peeress retains her privilege of peerage while unmarried, but loses it if she marries a commoner (Co. Litt. 166; *Cowley* v. *Cowley* [1901] A.C. 450).

The children of peers are commoners. The eldest son of a peer of the rank of earl (and above) is usually known socially by the name of his father's next peerage, but the courtesy nature of such title is clearly indicated in every public or legal document, the phraseology employed being "John Smith, Esq., commonly known as Viscount Blackacre." Several cases are on record in which peers' eldest sons have actually borne courtesy titles not possessed as peerage honours by their fathers. but inasmuch as such are only accorded by courtesy. no question of peerage privilege arises. The younger sons of dukes and marquesses by custom use the prefix "lord" before one of their Christian names, and all the daughters of earls as well as of dukes and marquesses are entitled similarly to style themselves "lady." on the principle that all the daughters are equal in rank and in precedence. The younger sons of earls and all of the children of viscounts and barons, including lords of appeal, use the prefix "honourable" before one of their Christian names, but this style is one of written address and reference only. Usually, when the direct heir of a peer dies, his children are given, by the Crown, on the death of the peer, the courtesy titles and precedence they would have enjoyed had their father actually succeeded to the peerage.

An alien may be created a peer, hut while remaining an alien cannot sit in the House of Lords, nor. if a Scottish or Irish peer, can he vote at elections for representative peers.

Claims to peerages are of two kinds: (1) of right; (2) of grace. In theory the Crown, as the fountain of honour, might settle any claim without reference to the House of Lords, and issue a writ of summons to its petitioner. This would not in any way prevent the House of Lords from examining the patent and writ of summons when the favoured petitioner or any heir claiming through him came to take his seat. If of opinion that the patent was illegal the House might refuse admittance. as it did in the Wensleydale case. In the case of a petitioner who has persuaded the Crown to terminate in his favour as a coheir the abeyance of an ancient barony and who has received his writ of summons, the matter is more difficult. The House cannot refuse to admit any person properly summoned by the Crown, as the prerogative is unlimited in point of numbers; but it can take into account the precedence of the newcomer. The Crown, therefore, unless there can be no question as to origin and pedigree, seldom terminates an abeyance without referring the matter to the House of Lords, and invariably so refers all claims which are disputed or which involve any question of law.

The Committee for Privileges, which for peerage claims is usually constituted of the lam lords and one or two other lords interested in peerage history! sits as an ordinary court of justice and follows all the rules of law and evidence. The attorney general attends as adviser to the committee and to watch the interests of the Crown. According to the nature of the case the committee reports to the House, and the House to the Crown, that the petitioner (if successful): (1) has made out his claim and is entitled to a writ of summons; or (a) has proved his coheirship to an existing peerage, and has also proved the descent of all coheirs that can reasonably he traced. In the first case the writ of summons is issued forthwith. but the second. being one of abeyance, is a matter for the pleasure of the Crown, which need not be exercised at all, but, if exercised, may terminate the abeyance in favour of any one of the coheirs.

During the parliamentary session of 1926 the House of Lords appointed a select committee to examine the history of abeysnt peerages and to report on the advisability of limiting future claims. After debate on the report. the House resolved that these claims ought not to be considered where long abeyance has existed and where the claimants possess only a small fraction of the original heirship. The resolution of the House was duly reported to the Crown. The recommendation of the House does not, and, in law, cannot affect the prerogative of the Crown to terminate any abeyance, but there can be little doubt that the representations made will have due weight with the advisers of the Crown in the consideration of all future claims. The report of and evidence taken by the committee is printed as a House of Lords paper (1927). (G. EL.)

See Sir W. R. Anson, *Law and Custom of the Constitution,* vol. i, "Parliament" (1911); F. B. Palmer, *Peerage Law in England* (1907); L. W. Vernon Harcourt, *His Grace the Steward and Trial of Peers* (1907); L. O. **Pike,** *Constitutional History of the House of Lovds.*

PEERLKAMP, PETRUS HOFMAN (1786–1836), Dutch classical scholar and critic, expounded the subjective method of textual criticism. which consisted in rejecting in a classical author whatever failed to come up to the standard of what that author, in the critic's opinion, ought to have written.

Descended from a family of French refugees named Perlechamp, Peerlkamp was born at Groningen, Neth.. on Feb. 2, 1786. He was professor of ancient literature and universal history at Leyden from 1822 to 1849, when he resigned from that post and retired to Hilversum near Utrecht. He died there on March 27, 1865.

His method of textual criticism was chiefly exercised on the *Odes* of Horace, the greater part of which he declared spurious, and the *Aeneid* of Virgil.

Peerlkamp also edited the *Ars poetica* and *Satires* of Horace, the *Agrzcola* of Tacitus and the romance of Xenophon of Ephesus, and he was the author of a history of the Latin poets of the Netherlands *(De vita, doctrina, et facultate Nederlandorum quz carmina latzna composuerunt,* 1838).

See L. Muller, *Geschichte der klassischen Philologie in den Niederlanden (1869);* J. E. Sandys, *History of Classical Scholarship,* vol. iii, p. 276 (1908).

PEERS, EDGAR ALLISON (1891–1952), English Hispanic scholar, was born at Leighton Buzzard. Beds., on May 7. 1891. He was educated at Dartford grammar school and at Christ's college, Cambridge. After working as modern languages master at Mill Hill and Felsted schools and Wellington college, he was appointed to the Gilmour chair of Spanish at the University of Liverpool in 1920. Attracted to the romantic aspects of English and French literature, he soon came under the spell of Spanish mysticism. He published his first Spanish study in 1923 (*Rivas and Romanticism in Spain)* and a stream of scholarly works quickly followed, establishing his reputation as an authority on Spanish thought.

Peers' studies of Spanish Romanticism culminated in the *History of the Romantic Movement in Spain,* 2 vol. (1940). His work on Hispanic mysticism, including *Spanish Mysticism* (1925) and *Studies of the Spanish Mystzcs,* 2 vol. (1927–30; vol. 1, rev. ed., 1951), as well as penetrating studies of such great Spanish mystics as *Ramon Lull* (1929), *St. John of the Cross* (1932) and *St. Teresa of Jesus* (1945) opened a rich field of poetry and devotion to English readers. He also translated St. John's *Complete Works* (3 vol., 1934–3j), St. Teresa's *Complete Works* (3 vol., 1946), Ramón Lull's *Art of Contemplation* (192j), *Blanquerna* (1926), *Tree of Love* (1926) and *Book of the Lover and the Beloved* (1923; rev. ed. 1946), and part of Bernardino de Laredo's *Ascent of Mount Sion* (1952).

He published numerous books on Spanish politics *(The Spanish Tragedy, 1930–1936,* 1936; *The Spanish Dilemma,* 1940), some travel books on Spain and was a contributor to the *Encyclopædia Britannica.* Under the pseudonym of Bruce Truscot. Peers wrote several books pleading for a recognition of the potentialities of the modern ("red-brick") universities.

Peers died at Liverpool on Dec. 21, 1952.

PEEWEE, the name (from their cry) of two North American birds of the genus *Myiochanes* (fam. Tyrannidae). The wood peewee (M. *virens*) is a little bird about six inches long, dark olive above, with a whitish throat and yellowish belly. The name closely represents its musical call. It breeds in North America and migrates in winter through eastern Mexico to South America. West of longitude 100° it is replaced by M. *richardsonii,* the western wood peewee, which has no olive tinge above and has the wings and tail slightly longer. It also winters in South America

PEEWIT, an alternative name for the lapwing (*Vanellus vanellus*), from its cry. *See* LAPWING

PEFFER, WILLIAM ALFRED (1831–1912), U.S. senator and journalist, was born in Cumberland county. Pa.. on Sept 10, 1831. He became a teacher at the age of 15 and during the summers helped his father, a farmer.

He was married to Sarah Jane Barber, who was also a teacher, in 1852, and in the following year they went to Indiana, where he engaged in farming. He later moved to Missouri and in 1862 settled in Illinois.

Peffer studied law while he was serving with the Union army from 1862 to 1865, and after his discharge as a lieutenant was admitted to the Tennessee bar. After practising law at Clarksville, Tenn., he went to Kansas, where he was editor of the *Fredonia Journal* and later editor of the *Coffeyville Journal.* In 1881 he became editor of the *Kansas Farmer,* a leading farm journal.

He was elected to the state senate of Kansas in 1874 and became a member of the U.S. senate as a representative of the People's party in 1891. He was not renominated in 1896.

Peffer's published works include *Peffer's Tariff Manual* (1888); *Americanism and the Philippines* (1900); and *Rise and Fall of Populism in the United States* (1900).

PEGASUS, a winged horse said to have sprung from the trunk of the Gorgon Medusa when her head was cut off by Perseus. After his service to Bellerophon (*q.v.*) and the latter's fall. Pegasus served Zeus (Hesiod. *Theog.,* 281).

Later authors identify him with the constellation Pegasus or Equus. The spring Hippocrene or Hippucrene (Horsewell) on Mt. Helicon is said to have sprung up from a blow of his hoof; for the connection between horses, or horse-shaped *daimones,* and water. *see* POSEIDON. Hence the erroneous derivation of *Pegasos* from *Pege* (the name is derived from the Greek *Pegos,* compact, strong, not from *Pege,* a spring). Hence also the fancy of modern poets (first in Boiardo, *Orlando inamorato)* that he is the horse of the Muses and hence a symbol of poetry.

PEGMATITE, a name originally given by French mineralogist René Haüy (1743–1822) to masses of graphic granite, comprising coarse crystals of alkali feldspars with regular intergrowths of quartz. Later usage of the term has been much broadened to include almost any wholly crystalline igneous or metamorphic rock that is at least in part very coarse grained, whose major constituents include minerals typically found in ordinary igneous rocks. and in which extreme textural variations, especially in grain size, are characteristic. Giant crystals, with dimensions measured in feet or yards, occur in some pegmatites. but the average grain size of all such rocks is only three or four inches.

Pegmatites are little different from the common igneous rocks in major elements of bulk composition, and they range from acid to basic. Granitic and syenitic types are most abundant. Quartz and alkali feldspars are the essential constituents; the most common varietal and accessory minerals are muscovite. biotite, apatite, garnet and tourmaline. Many granitic pegmatites contain various minerals that bespeak unusual concentrations of the less abundant elements, *e.g.,* beryllium in beryl, chrysoberyl, phenacite; boron in tourmaline, axinite; fluorine in apatite, micas, topaz, tourmaline; lithium in lepidolite, spodumene, several phosphate minerals; rare alkalies in pollucite, beryl, feldspars, micas; tin in cassiterite; tungsten in wolframite; zirconium in zircon; and tantalum, niobium, uranium, thorium and rare earths in many oxide and phosphate minerals *(see* GEOCHEMISTRY: *Residual Melts and Solutions).*

Most bodies of pegmatite are tabular, podlike or irregular in form, and range in size from single crystals of feldspar to dikes hundreds of feet thick and nearly a mile long Many are intimately associated with masses of fine-grained aplite (*q.v.*). They are found in terranes of igneous and metamorphic rocks in all parts of the world. and are most abundant in rocks of relatively great geologic age. Some are segregations within much larger bodies of intrusive igneous rocks. others are distributed satellitically in the rocks that surround such bodies, and still others are not recognizably associated with igneous rocks.

Granitic and syenitic pegmatite deposits are the chief source of commercial feldspar, sheet mica and beryllium, tantalum-niobium, and lithium minerals. They also yield significant quantities of cassiterite, gem minerals, scrap mica, molybdenite, tungsten minerals, rare-earth minerals, zircon and certain types of kaolin. either directly or as the sources of placer deposits. Economic lode concentrations generally occur in zoned pegmatite bodies, *i.e* , those within which two or more different rock types are systematically disposed

Three contrasting mechanisms together account for the origin of most pegmatites: (1) replacement of pre-existing non-pegma-

titic rocks through the action of various fluids; (2) crystallization of silicate melts derived by partial fusion of pre-existing rocks; and (3) crystallization of residual fluids developed during late stages in the consolidation of intrusive magmas. The first process is essentially metamorphic, the others mainly igneous. The presence of water and other volatile substances seems necessary, and probably is common to all three processes; such constituents depress the temperature range of crystallization, participate directly in the formation of many minerals and lower the viscosity of igneous melts, thereby promoting formation of large crystals. Experimental evidence indicates that the presence of a separate vapour phase is necessary for development of the giant crystals found in pegmatites.

Features indicating replacement of one mineral by another are widespread within many bodies of pegmatite. Most are attributable to attack of earlier-formed minerals either by residual liquid, by vapour separated from the liquid or by liquid condensed from such vapour. The end stages of some pegmatite crystallization are marked by development of well-faced transparent crystals, commonly as linings and partial fillings of cavities. Such occurrences have yielded handsome mineral specimens, as well as apatite. beryl, chrysoberyl, corundum, feldspars, garnets, phenacite, quartz, scapolite, spinels, spodumene, topaz, tourmaline and zircon of gem quality.

Ore minerals, chiefly sulfides and oxides, are widespread in pegmatites, but rarely are abundant. The origin and behaviour of ore-forming fluids derived from magmas (*see* ORE DEPOSITS) probably are intimately related to the processes responsible for development of pegmatites. For discussion of replacement and other mechanisms referred to above see METASOMATISM; MINERALOGY; PETROLOGY. (R. H. J.)

PEGOLOTTI, FRANCESCO BALDUCCI (*fl.* 1315–40), Florentine merchant and writer, was a factor in the service of the mercantile house of the Bardi, and in this capacity he was at Antwerp from 1315 (or earlier) to 1317; in London in 1317 and apparently for some time after; in Cyprus from 1324 to 1327, and also in 1335, when he obtained from the king of Little Armenia (*i.e.,* mediaeval Cilicia, etc.) a grant of privileges for Florentine trade. Between 1335 and 1343, he compiled his *Libro di divisamenti di paesi e di misuri di mercatanzie e d'altre cose bisognevoli di sapere d' mercatanti,* commonly known as the *Pratica della mercatura* (the name given it by Pagnini). Beginning with a sort of glossary of foreign terms then in use for all kinds of taxes or payments on merchandise as well as for "every kind of place where goods might be bought or sold in cities," the *Pratica* next describes some of the chief trade routes of the 14th century, and many of the principal markets then known to Italian merchants; the imports and exports of important commercial regions; the business customs prevalent in those regions; and the comparative value of the leading moneys, weights and measures.

There is only one ms. of the *Pratica,* viz., No. 2,441 in the Riccardian Library at Florence (241 fols. occupying the whole volume), written in 1471; and one edition of the text, in vol. iii. of Gian Francesco Pagnini's *Della Decima e delle altre gravezze imposte dal commune di Firenze* (Lisbon and Lucca—really Florence—1766); Sir Henry Yule. *Cathay,* ii. 279–308, translated into English the most interesting sections of Pegolotti, with valuable commentary (London, Hakluyt society, 1866) *See* also W. Heyd, *Commerce du Levant,* ii. (Leipzig, 1886); H Kiepert, in *Sitzungsberichte der philos.-hist. Cl. der berliner Akad.* (Berlin, 1881); C. R. Beazley, *Dawn* of *Modern Geography,* iii. (Oxford, 1906).

PEGU, a town and former capital of Lower Burma, giving its name to a district and a division. The town is situated on a river of the same name, 47 m. N.E. of Rangoon by rail; pop. (1953) 47,378: It is still surrounded by traces of the old walls, about 40 ft. wide, on which have been built the residences of the British officials. The most conspicuous object is the Shwe-maw-daw pagoda, 324 ft high, considerably larger and even more holy than the Shwe-dagon pagoda at Rangoon. Pegu is said to have been founded in 573, as the first capital ot the Talaings; but it was as the capital of the Toungoo dynasty that it became known to Europeans in the 16th century. About the middle of the 18th century it was destroyed by Alompra; but it rose again, and was important enough to be the scene of fighting in both the first and second Burmese Wars. It gave its name to the province (including Rangoon) which was annexed by the British in 1852.

The district, which was formed in 1883, consists of a portion of the forested Pegu Yomas and an alluvial tract between the Pegu Yoma range and the Sittang river: area, 4,124 sq.mi.; pop. (1941) 582,959, showing an increase of 92,990 in the decade. Christians numbered 11,038 in 1931, mostly Karens. Almost the only crop grown is rice, which is exported in large quantities to Rangoon. The district is traversed by the railway, and also crossed by the Pegu-Sittang canal, navigable for 85 mi., with locks.

The division of Pegu comprises the districts of Rangoon town, Hanthawaddy, Insein, Tharrawaddy, Pegu and Prome, lying east of the Irrawaddy: area 13,799 sq.mi.; pop. (1941) 2,961,249.

PEGUY, CHARLES (1873–1914), French author and poet. born at Orleans in 1873, came of a family which had been vine-growers for generations, and was proud of his peasant origin. He was educated at the *École Normale* and at the Sorbonne. The object of his life is perfectly indicated in the dedication of his first book, *Jeanne d'Arc* (1897), "à toutes celles et à tous ceux qui auront vécu . . . pour l'établissement de la République socialiste universelle." His works from that time until his death in Sept. 1914 are devoted to the glory of France. He was a determined republican; at the same time he was a devout Catholic. A mystical lover of France, and yet a strong socialist, he puzzled anti-clerical socialists and Catholic nationalists equally. His *Notre Patrie,* in which his views of what was necessary for the regeneration of the republic were set out, was written in 1905, but his most important prose works and the majority of his poems were written between 1910 and 1914. *Les Cahiers de la Quinzaine,* founded by him in 1900, were devoted to the expression of truth without regard to party, and in them Péguy's development, and the development of the "new France" he did so much to inspire, may be traced for over a decade. They were primarily imbued with his spirit, though in their pages many now well-known writers first came into public notice. For him truth was not to be found in compromise, and his extreme views were pronounced even at the risk of a subsequent *volte-face.* At the *École Normale* he came under the influence of Bergson, to whom he has done homage in his *Note sur* M. *Bergson* (1914). He kept his own little shop in the shadow of the Sorbonne, where he was continually amending his works. There he sold the *Cahiers.* He lived in the country, walked into Paris every morning, and brought with him something of the *province.* When war came in 1914 he refused a captaincy, because he wished to go on foot with his men. He fell leading a company on the first day of the battle of the Marne. The first volumes of his collected works were published in 1916.

See R. Johannet, *Pe'guy et ses Cahiers* (1914); J. E. Roberty, *Charles Pe'guy* (1916); A. Suarès, *Pe'guy* (1916); *D.* Halévy, *Charles Ptguy et les Cahiers* (1918); *M.* Péguy, *La Vocation de C. Ptguy* (1926).

PEINE, a town in the Land of Lower Saxony, Germany, 16 mi. W.N.W. of Brunswick, on the railway to Hanover and Hamburg. Pop. (1950) 27,404. Peine was at one time a strongly fortified place, and until 1803 belonged to the bishopric of Hildesheim. Its industries include iron and steel works, breweries and brickyards, and the manufacture of soap, sugar, malt, machinery and boots. There are also large cattle markets held here.

PEINE FORTE ET DURE, the term for a barbarous torture inflicted on those who, arraigned of felony, refused to plead and stood silent, or challenged more than 20 jurors, which was deemed a contumacy equivalent to a refusal to plead. Before he could be tried, a prisoner must plead "guilty" or "not guilty." By the Statute of Westminster, 1275, the penalty was "strong and hard imprisonment," but in 1406 pressing to death by heavy weights was substituted. This was abolished in 1772; "standing mute" being then made equivalent to conviction. By an act of 1827 a plea of "not guilty" was to be entered against any prisoner refusing to plead, and that is the rule to-day. An alternative to the *peine* was the tying of the thumbs tightly together with whipcord until pain forced the prisoner to speak. This was said to be a common practice at the Old Bailey up to the 19th century.

The last recorded instance of the infliction of the *peine* was

in 1741 at Cambridge assizes, when a prisoner was so put to death; the penalty of thumb-tying having first been tried. The only known American instance was in 1692 at Salem, Massachusetts, when Giles Corey, accused of witchcraft, was pressed to death.

PEIPING: *see* PEKING.

PEIPUS, a lake lying between north-west Russia and Estonia, also known as PEIPSI or CHUDSKOYE OZERO. The boundary between the two countries passes northwards for 60 m. through the centre of the lake, leaving the east bank in Russia and the west in Estonia, but turns east towards the north, thus including the whole northern shore and the outlet of the Narova river, in Estonia. Including its southern extension, sometimes known as Lake Pskov or Pihkwa, it has an area of 1,390 sq.m. Its shores are flat and sandy, and in part wooded; its waters are deep, and they afford valuable fishing. The lake is fed by the Velikaya, which enters it at its southern extremity, and by the Embach or Ema, along which timber is brought to Tartu, and which flows in half way up the western shore of the lake. It drains into the Gulf of Finland by the Narova, which issues at its north-east corner.

PEIRAEEUS or **PIRAEUS** (Gr. Πειραιεύς), the port of Athens, with which its story is inseparably connected. About 5 m. S.W. of Athens, the sandy bay of Phaleron is closed westward by a rocky promontory which falls abruptly also landwards into the plain. Its highest point, called Munychia, is at the north-east end; the lower plateau, Acté, stretches seaward to south-west, beyond the saddle which connects two small coves, Munychia and Zea, on the south-east coast, with the completely landlocked basin of Peiraeeus, with its inner port, Cantharus, running northward between Munychia hill and the detached ridge, Eëtioneia, which dominates the north side of the entrance. In early days Athenians used only the sandy Phaleron for sea traffic. It was Themistocles who persuaded the Athenians to fortify and utilize Peiraeeus, about 493 B.C., for their new fleet. The "long walls" from the base of Munychia hill to Athens were built soon after 460 B.C., and the town of Peiraeeus itself was laid out on a rectangular plan by the architect, Hippodamus of Miletus, probably at the suggestion of Pericles. The fortress of Eëtioneia was added during the Peloponnesian war. Traces remain of the ship-houses surrounding Zea and Munychia; the town-plan is followed by the modern streets; and the tomb of Themistocles, on the Act, and the great gate of Fort Eëtioneia are conspicuous. Peiraeeus was subjected during World War II to the bombing which Athens was spared. Axis troops occupied the port in April 1941.

PEIRCE, BENJAMIN (1809–1880), American astronomer and mathematician, son of a Harvard university librarian and historian, was born at Salem, Mass., on April 4, 1809. He graduated from Harvard in 1825 and, returning there as a tutor in mathematics in 1831, continued to teach in the university till his death nearly 50 years later. Tributes concur in the estimate that he was a wonderfully inspiring teacher. In the United States he was the leading mathematician of his time. In Europe he was elected an associate of the Royal Astronomical Society, a foreign member of the Royal Society of London, a correspondent of the British Association for the Advancement of Science, an honorary fellow of the Royal Society of Edinburgh, and a correspondent of the Gesellschaft der Wissenschaften in Göttingen. About one-quarter of Peirce's publications deal with topics in pure mathematics and three-quarters with topics mainly in the fields of astronomy, geodesy and mechanics. Of his 11 works, in 12 volumes, six were elementary texts some of which went through several editions. Among his other works were the notable *Analytic Mechanics* (1855), and the remarkably original *Linear Associative Algebra* (lithographed edition of 100 copies, 1870; new ed. by his son C. S. Peirce in *American Journal of Mathematics*, vol. IV., 1881, reprinted 1882), anticipating important work of Study and Scheffers. There are many references in scientific literature to Peirce's criterion for the rejection of doubtful observations, and it was only shown in later years (*Popular Astronomy*, 1920) that this was fallacious. The computation of the general perturbations of Uranus and Neptune, and the resulting controversy with Leverrier, was the first work to extend Peirce's reputation. He died on Oct. 6, 1880.

See R. C. Archibald, *Benjamin Peirce 1809–1880, Biographical Sketch and Bibliography* (1925). (R. C. A.)

PEIRCE, CHARLES (SANTIAGO) SANDERS (1839–1914), U.S. philosopher and logician, was born at Cambridge, Mass., on Sept. 10, 1839. He was the son of Benjamin Peirce, the Harvard mathematician. He graduated at Harvard in 1859, and at the Lawrence scientific school in 1863. Soon thereafter he joined the staff of the U.S. coast survey, where his work on the problems of geodesy and his researches on the pendulum received wide recognition.

In 1877 Peirce was the first American representative to the International Geodesic congress. In 1880–81 he gave a series of lectures on philosophical logic at Johns Hopkins university; in the spring of 1903 a series on pragmatism at Harvard and another in 1903–04 on logic at the Lowell institute, Boston. He introduced the principle of pragmatism into philosophy, defining his theory in the *Popular Science Monthly* for January 1878. Though he did not there call it *pragmatism*, he is known to have originated the word as well as the idea. It is said to have first appeared in print in his article in Baldwin's *Dictionary of Philosophy*, 1901. To avoid confusion with the theories of his contemporaries, he later changed the name to pragmaticism. He died at Milford, Pa., on April 14, 1914.

In addition to his contributions in mathematical logic, meteorology, psychophysics, philology, and other subjects, his published works include: five papers on logic in *Proc. of Amer. Acad. Arts and Sciences*, vol. 7 (1867); *Photometric Researches* (1878); *Studies in Logic* (1883); "The Architecture of Theories," *Monist*, vol. i. (1890); "What Pragmatism is," *Monist*, vol. xv. (1905); *Collected Papers of Charles Sanders Peirce*, ed. by C. Hartshorne and P. Weiss, 6 vol. (1931–35).

PEIRESC, NICHOLAS CLAUDE FABRI DE (1580–1637), French archaeologist, naturalist, scholar and promoter of learning, was born on Dec. 1, 1580, at Beaugensier, Provence. Intended by his father for the law he early showed a preference for the study of antiquities, and from 1599 to 1602 traveled in Italy visiting the museums and galleries, meeting and debating with the learned men of the universities—among them Galileo—and studying for his legal degree, which he took at Aix in 1604.

In the following year he succeeded his uncle as senator for Provence, and shortly after visited England, having interviews with King James I, Camden, Selden, William Harvey and John Barclay (*qq.v.*).

Apart from his very voluminous private correspondence no writings of Peiresc's are known; but, owing both to his great erudition and his liberality in lending scholars books and in allowing them access to his collections of coins, medals and other antiquities, his influence on the humanism and learning of the early 17th century was very great.

It was largely due to Peiresc that Barclay's *Argenis* (*see* BARCLAY, JOHN) was published in Paris (1621) shortly after its author's death: he assisted in editing Duchesne's *Historiae Normannorum scriptores antiqui* (1619), and was mainly responsible for the publication of Nicholas Bergier's *L'Histoire des grands chemins de l'Empire Romain* (1622).

The astronomers pierre Gassendi, Grotius, Thomas Campanella, Maria Mersenne and William Camden, were all indebted in various ways to him.

Peiresc was made abbé of the monastery of Guistres in 1618, and as senator was a judge of the parlement of Aix, the highest court for Provence. He was one of the earliest scholars to realize the importance of numismatics to historical research, and as evidence of his wide interests it may be mentioned that he seems to have introduced the Angora cat to Europe, and eider-down quilts and many exotic plants—including tulips—into France, and was the first to verify by experiment Harvey's discovery of the circulation of the blood.

He died at Aix on June 24, 1637.

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1909) and his general correspondence by Ph. Tamizey de Larroque (7 vol.: *Collection* de *Documents inédits sur l'histoire de France,* 2e série, 1888–98).

See also Ph. Tamizey de Larroque and *A.* Moultet, *Autour* de *Peiresc* (1898); *L. V.* Delisle, *Un grand amateur français* (1889); and C. T. Hagberg Wright, *Nicholas Fabri de Peiresc* (Roxburghe club, 1926, bibl.).

PEISANDER, of Camirus in Rhodes, Greek epic poet, supposed to have flourished about 640 B.C. He was the author of a *Heracleia,* in which he introduced a new conception of the hero, the lion's skin and club taking the place of the older Homeric equipment. He is also said to have fixed the number of the "labours of Hercules" at twelve. The Alexandrians admitted it to the epic canon—(but see Clement of Alexandria, *Stromata,* vi. 2).

See fragments in *G.* Kinkel, *Epicorum graecorum fragmenta* (1878); also F. G. Welcker, *Kleine Schriften,* vol. i. (1844).

PEISISTRATUS (605?–527 B.C.), Athenian statesman, was the son of Hippocrates and second cousin to Solon, whose friendship he retained in spite of their political opposition. About 570 he became well known and popular as commander in the war with Megara which resulted in the recovery of Salamis. He next appears in politics as leader of the third party, the men of the hill-country (Diacrii), who were still discontented in spite of Solon's reforms, which had given them freedom, but not land. Peisistratus' family estates at Marathon were in this district. His eloquence and personal charm soon made him a popular favourite; Solon (frag. 8, Diehl) warned Athens of the danger, but was unheeded. The other two parties were the Shore (Parali), led by the Alcmaeonidae, at the moment represented by Megacles, and the Plain (Pedieis) under Miltiades.

The chronology of Peisistratus' rise to power is disputed, though the sequence of events is known. By feigning an attack on his life, Peisistratus got a guard assigned to him, armed with staves, with whose assistance he seized the Acropolis and established a tyranny in 561–560. Almost at once a coalition between the Plain and the Shore drove him out, but in 560–559 Megacles had fallen out with his allies and recalled Peisistratus. Peisistratus married Coesyra, daughter of Megacles, and apparently refused to have children by her, the Alcmaeonidae being under a curse. The coalition was renewed, and in 556 Peisistratus was again driven out. He settled at Rhaecelus, where he founded a city and established friendly relations with Macedon, and then obtained command of the silver-mines of Mt. Pangaeus. This enabled him to raise a mercenary army, and he strengthened his position by intriguing with Thebes and Argos. Then he moved to Eretria as a base for operations against Athens, and in 541 landed near Marathon, among his own party, defeated the Government forces and established himself as tyrant for good. The Alcmaeonidae fled; Lygdamis, Peisistratus' assistant in the business, he made tyrant of Naxos. He ruled Athens peaceably till his death in 527.

There is no doubt that the rule of Peisistratus was generally beneficial to Athens. His foreign policy was remarkably adroit. His own interest demanded that the neighbouring States should not be alienated, or they would have harboured the plots of his exiled opponents. So he contrived to keep peace with Sparta, Argos, Thessaly, Aegina and Thebes all at the same time. Further afield he was more ambitious. The silver of Pangaeus and Laureium he already controlled. Its effect is seen in the increasing value of the Athenian tetradrachm, which reacted favourably on Athenian commerce, Of his other exploits the most important are in the northern Aegean. By recapturing Sigeium and encouraging Miltiades' venture in the Thracian Chersonese he controlled the vital corn route to the Pontus. Of his domestic policy it is admitted that it was just and beneficent, and preserved the fcrm of the Solonian constitution, while keeping the magistracies in the hands of himself and his family. It may be added that he completed Solon's work by giving land (confiscated from his enemies) to those to whom Solon had only given freedom. He put a tax of one-tenth (or one-twentieth) on the produce of the land, and used it partly to advance money to the new proprietors, to the advantage of agriculture, partly on the fortification of the city. Thus Athens was free of wars and internecine struggle, and for the first time for years knew settled financial prosperity.

The money which he accumulated he put to good use in the construction of roads and public buildings. Like Cleisthenes of Sicyon and Periander of Corinth, he realized that one great source of strength to the nobles had been their presidency over the local cults. This he diminished by increasing the splendour of the Panathenaic festival every fourth year and the Dionysiac rites, and so created a national rather than a local religion. With the same idea he built the temple of the Pythian Apollo and began, though he did not finish, the temple of Zeus. To him are ascribed also the original Parthenon on the Acropolis, afterwards burned by the Persians, and replaced by the Parthenon of Pericles. It is said that he gave a great impetus to the dramatic representations which belonged to the Dionysiac cult, and that it was under his encouragement that Thespis of Icaria, by impersonating character, laid the foundation of the great Greek drama of the 5th and 4th centuries. Lastly, Peisistratus carried out the purification of Delos, the sacred island of Apollo of the Ionians; all the tombs were removed from the neighbourhood of the shrine, the abode of the god of light and joy.

He gave equal encouragement to poetry; Onomacritus, the chief of the Orphic succession, and collector of the oracles of Musaeus, was a member of his household. As to the library of Peisistratus, we have no good evidence; it may perhaps be a fiction of an Alexandrian writer. There is a strong tradition that he first collected the Homeric poems, and had them sung at the Panathenaea.

It appears that Peisistratus was benevolent to the last, and, like Julius Caesar, showed no resentment against enemies and calumniators. What Solon said of him in his youth was true throughout, "there is no better disposed man in Athens, save for his ambition." He was succeeded by his sons Hippias and Hipparchus, by whom the tyranny was in various ways brought into disrepute. (*See* also GREECE: *History;* ATHENS.)

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PEKALONGAN, a residency of the province of central Java, Indonesia, area 2,176 sq.mi. It is in the north central part of the island, bounded on the west by Cheribon, on the east by Semarang, on the south by Banyumas, and on the north by the Java sea. Mountain groups flank all of its southern border—the Dieng, Slamat and Kumbang groups, the spurs of Slamat projecting into its centre, and from which flow its two rivers, the Chomal and Pomali. Along the valleys of these two rivers and the coast, for a considerable distance inland, the land is flat and fertile, and the Chomal and Pomali have built for themselves alluvial promontories at their mouths. The chief product of Pekalongan is sugar, and the manufacture of this is its chief industry, although it is noted also for its batik industry, and it is a coffee-, cocoa- and kapok-growing district. Rice is the chief food crop. The population of Pekalongan is 3.210,751, mostly Javanese, but including about 5.000 Europeans and more than 30,000 Chinese and other foreign Asiatics.

The capital, Pekalongan, on the coast, in the eastern part of the residency, population (1957 est.) 94.904. the seat of the resident, exports sugar and is on the stream tramway line from Cheribon to Semarang. Tegal, population (1956 est.) 85,602, is another port and is also on the tramway line. likewise Brebes, pop. (1957 est.) 23,263, and Pemalang, (1957 est.) 42.484. The railway from Cheribon to Surabaya passes through Pekalongan. There is a coast road and one by the Pomali to Purnakerta in Banyumas.

Pekalongan was granted to the Dutch by the Susuhanan in 1746 and occupied by the Japanese from 1942 to the end of World War II. In 1946 it became part of the Republic of Indonesia.

PEKIN, the seat of Tazewell county, Illinois, U.S., is an important port on the Illinois river, 10 mi. below Peoria in the central part of the state. A shipping centre for grain, cattle and coal, Pekin is served by several railroads and is on the Lakes-

to-Gulf Waterway. Its manufactures include corn products, alcohol, liquor, malt, steel tanks, barrels, burial vaults, and copper, brass, iron and aluminum castings. Ice cutting was once an important business.

The first settler was Jacob Tharp in 1824; the town was laid out in 1829 and in 1830 was named Pekin, the "new Celestial City," by Mrs. Nathan Cromwell, wife of a founder. The dragon and other Chinese symbols are still used. An outpost for Indian warfare, its first schoolhouse (Snell school) was fortified during the Black Hawk War as Fort Doolittle. Incorporated as a city in 1849, Pekin for many years'remained a rough river port, characterized by much violence. Abraham Lincoln argued cases in its old courthouse. Early settlers were Anglo-Americans from Virginia, Kentucky and Tennessee and also from the northeast. German immigration began in the 1840s and grew after the Civil War; until World War I the German language was used in schools, churches and in business. Italians and Irish also settled there.

Good hunting and fishing in the vicinity make Pekin a favourite spot for sportsmen. Its large Mineral Springs park has excellent swimming and other recreation facilities. Pekin's older streets are named Ann Eliza, Cynthiana, Henrietta, Matilda, etc., for friends of Mrs. Cromwell. For comparative population figures see table in ILLINOIS: *Population.* (M. Ws.)

PEKING (PEIPING), the capital of China, situated in Hopeh province. The name Peiping, which means "northern peace," was used in the Nationalist period, 1928–1949, while the nation's capital was at Nanking ("southern capital"). The name Peking (Pei-ching) meaning "northern capital," was used while the city was the capital of China, from 1421 to 1928, and again under the Communist regime after 1949. Peking is situated in lat. 39° 54′ N. and long. 116° 28′ E. at the northern apex of the alluvial north China plain. Its area is the point of convergence of routes from Manchuria via Shan-hai-kuan (the "gate between mountains and the sea"), and the easiest routes from the Mongolian plateau via the valley of the Yung-ting Ho and Nankow pass.

Only 35 mi. northwest of the city at its nearest point, the Great Wall of China, following the crests of the scarpland belt at an elevation of 4.000 ft., marks the historic frontier defence of the agricultural plain against the pastoral nomads of the interior plateaus. The narrow apex of the plain is thus the crucial region in the relations of China, Mongolia and hlanchuria, and is historically the border zone between two strongly contrasted types of social organization.

History.— The earliest city of which there is authentic record was that of Ch'i the capital of Ten, the most northerly of the feudal states which acknowledged the authority of the Chou dynasty in the twelfth century B.C. Thus early was the site of Peking within the Chinese culture area, but Yen was clearly a buffer state, intended to keep back the Tatar hordes, and is significantly mentioned in records of the 6th century B.C. as possessing great numbers of horses. Ch'ien Lung, the famous scholar-emperor of the Manchu dynasty, made extensive researches into the exact site of Ch'i and located it slightly to the north of the present city.

The city was destroyed by Shih Huang Ti, the "First Emperor" and founder of the Ch'in dynasty (221 B.C.), who unified China and completed the frontier defenses of the Great Wall. Yen was one of the districts which made up his empire. Cnder the Han dynasty a new city arose close to the site of Ch'i and was known first as Yen and later as Yu-chow. It remained a definitely Chinese city until the end of the Han dynasty, but in the ensuing period of anarchy and disintegration was for two centuries under Tatar control. The T'ang dynasty (7th to 10th centuries), like the Han, maintained the frontier defenses of the empire intact, and Yu-chow was the headquarters of a military governor. But early in the 10th century it came into the hands of the K'itans, one of the most famous of the Tatar groups prior to the rise of the Mongols, who successfully resisted the attempts of the Sung emperors to recover it for China. The K'itans under the Liao dynasty (sometimes called the Iron dynasty) rechristened the city Nan-ching, signifying southern capital and later (986) rebuilt it on imperial lines with walls said to have been 13 miles in length and 30 feet high.

From early in the 11th century it was known as Yenching but the K'itans of the Iron dynasty continued to hold it until 1122 when it was captured by the chief of the Tatars of the Golden Horde from the northern steppes of Manchuria, who greatly enlarged and beautified it and made it one of the three capitals of his large empire, that of the Kin or Chin (Gold) dynasty. The other two capitals were Pien-ching (now Kai-feng) in Honan and Shen-yang (Mukden) in the north, so the future Peking mas known at this period as Chung-tu or the "middle capital." This phase lasted until early in the 13th century when the greatest of all the steppeland powers arose, the Mongol empire.

The City *Under Kublai Khan.*—Kublai Khan took the decisive step of making it the metropolitan city of the immense Mongol empire. which now stretched from the Pacific to beyond the Black sea. But although this was the technical status of the city after Kublai had moved his headquarters there from Rarakorum in 1267, it was as the new capital of China that the choice was of the greatest ultimate significance. Kublai was indeed the "Great Khan who ruled in China" but his descendants were primarily emperors of China.

Under Kublai the city was once again rebuilt and on a more magnificent scale than ever before. It was named Khanbaliq, "city of the Khan," but the Chinese knew it as Ta-tu. "great capital." Through the reports of Marco Polo, who visited China at that time. Khanbaliq became known in medieval Europe as Cambaluc. This was often, as by Longfellow, inaccurately spelled Cambalu. Marco Polo described the magnificence of the capital in glowing terms. Cambaluc was laid out on a rectangular plan and had a circuit of 24 mi. Its walls, 50 ft. high and on top 15 ft. thick, were each pierced by three gates, the roadways connecting them running straight across the city.

Marco Polo was followed by the Pope's envoy, Giovanni di Monte Corvino, who was well received by Kublai and made archbishop of Khanbaliq in 1307.

The Ming and *Manchu Dynasties.*—Later under the Ming and early Manchu dynasties the Jesuits were in favour at the capital, and were encouraged to practise western mathematics and astronomy. The communications of Khanbaliq with the rest of China were actively developed by the construction of radial roads on which well-organized courier services were maintained, and by extending the Grand Canal from the Yellow river to Tientsin and connecting it by the Pai Ho and a small canal, the capital was brought into direct water-communication with the lower Yangtze valley.

Khanbaliq continued to be the capital of China throughout the Yuan dynasty but the city temporarily lost its imperial status when in 1368 Chu Yuan-chang (Hung Wu) headed the successful revolt against the Mongols and established the native ?*ling dynasty. After being under the control of foreign steppeland powers for about 450 years the region was once again under direct Chinese rule and Khanbaliq, now known as Peiping, served, as in the days of the Han and T'ang dynasties, the function of a border garrison town, subordinate to the capital city of Nanking. This phase lasted until 1421, when the third Ming emperor, Yung Lo, transferred his court to the north and Peiping was given the name of Peking.

The reason for this decisive step was undoubtedly strategic, for the Mongols were still troublesome and the hlanchurian tribes were becoming increasingly strong and restless. Peking was the only frontier capital which could guard both the vulnerable flanks. The menace from the north. increased by internal revolts, culminated in the Manchu conquest of 1644 and China once again came under Tatar domination. The new Manchu (or Ch'ing) dynasty transferred their court from Mukden to Peking and administered their newly won empire from a capital which, while it lay within the Chinese culture area, was in close contact with their own recruiting ground.

The Modern Period.—Two and a half centuries later the rule of the decadent Manchus was ended by the revolution of 1911 and the imperial office was abolished. Peking continued to function as the capital of the new republic. But the disintegrating effects of the civil war and the rise of the nationalist movement, focused in the south, meant that the rule of the Peking government was

increasingly ineffective and nominal. The final northward advance of the nationalist armies in the spring of 1928 was quickly followed by the proclamation of Nanking as the capital of the new China and by autumn 1928 the northern city had lost its metropolitan status and was known once more as Peiping, the name which it bore under the early Ming emperors. So, too, the province, in the centre of which it lies, reverted to the ancient name of Hopeh ("north of the river," *i.e.,* the Yellow river) in place of Chihli ("direct rule").

After the Tangku truce of 1933 which ended the Manchurian invasion, the Japanese endeavoured to separate Peiping and north China from the rest of China. The Chinese government was forced to approve the establishment in Peiping of a Hopeh-Chahar political council under the chairmanship of Gen. Sung Chih-yuan, commander of the 29th army. By the Ho-Umetsu agreement of 1935 all Chinese troops and Kuomintang organizations were excluded from north China. In spite of strong Japanese pressure, Sung remained loyal to the Chinese government. On July 7, 1937, the Japanese during maneuvers attacked the Marco Polo bridge (Lukou-ch'iao) across the Yung-ting Ho southwest of Peiping to sever the last railroad link with the rest of China. The Chinese garrison resisted and thus began the war with Japan which merged in 1941 with World War II. The city was taken by the Japanese in July 1937 and remained occupied until the end of World War II in 1945, when it reverted to Nationalist control. In 1949, Peiping fell to the Chinese Communists, who made it once more the capital of China under its historic name of Peking. (See also CHINA: History.)

Description. — Peking consists essentially of two walled cities, the northern Inner city and the southern Outer city. The Inner city, also known as the Tatar city, lies approximately on the site of Khanbaliq of the Mongol dynasty. It is in the form of a square with walls nearly 15 mi. in length.

The Outer city, also known as the Chinese city, was added during the reign of the emperor Chia Ching (1522–66) of the Ming dynasty. It is in the form of an oblong adjoining the Inner city, with walls 14 mi. in length, including 4 mi. of the southern wall of the Inner city.

BLACK STAR

WU MEN, PAINTED WOODEN IMPERIAL PAILOU OR GATEWAY ENTRANCE TO THE FORBIDDEN CITY IN PEKING. THE CHINESE CHARACTERS ON IT READ: "MAY BLESSINGS BE GENEROUSLY SHOWERED UPON THE PEOPLE OF THE CELESTIAL EMPIRE"

Within the Inner city was the Imperial city, also in the form of a square and with red-plastered walls six and one-half miles in length, of which only the southern wall and a part of the western wall remain. And within the Imperial city was the moated Forbidden city, with walls two and one-quarter miles long, plastered with a violet-coloured mortar, whence comes the popular name of the Purple city. The Forbidden city contained the Imperial palaces, which have been converted into a museum. The palaces, symmetrically arranged, consist of outer throne halls, an inner court, and the palace buildings.

The entrance to the Forbidden city is through the Wu Men (Meridian gate). Ancient works of art are found in T'ai-ho-tien (Hall of Supreme Harmony) and Pao-ho-tien (Hall of Preserving Harmony), two of the outer throne halls. Works of art of different dynasties ranging from the Shang (1600–1100 B.C.) to the Ming, are found in halls on the east side of the inner court. In halls on the west side of the inner court are works of art of the Manchu dynasty.

In side halls on both sides of the courtyard in front of the Wu Men is the historical museum, exhibiting historical objects from primitive times, through the Hsia (2100–1600 B.C., Shang and Chou dynasties to the Sui (A.D. 581–618) and T'ang dynasties. In the main hall above the Wu Men are objects of China's modern history after the Opium war of 1840.

South of the Palace museum, the former imperial roadway separates two parks that have been converted into public recreation areas under the Communist regime. On the west side is Sun Yat-sen park, surrounding the former Altar of Land and Grain, and on the east side is the Working People's Palace of Culture, which was the Imperial Ancestral temple, in which tablets of emperors were displayed and worshiped.

Adjoining the parks on the south is part of the remaining southern wall of the former Imperial city. The wall is pierced by T'ien-an Men (Gate of Heavenly Peace), on which China's Communist leaders gather on ceremonial occasions to review military and civilian parades in the square adjoining the gate.

Adjoining the Forbidden city on the east, in the southeast quadrant of the Inner city, is the old legation quarter, where foreign representatives had their residences. The legation quarter contains many hotels, department stores, theatres and cinemas.

In the northeast quadrant of the Inner city stand some of the most historic buildings of China, including the Lama temple and the simple but beautiful Temple of Confucius. Nearby is the Bell tower, where the curfew was sounded nightly in imperial times.

Extending in an irregular chain from the north wall of the Inner city are six artificial lakes supplied from a moat outside the nalls of the city. The shores of Pei Hai (North lake), just northwest of the Palace museum, have been converted into a park. The National library stands on the southwest shore. Grouped around Chung Hai (Middle lake) and Nan Hai (South lake), just west of the Palace museum, are the government buildings of the Chinese Communist regime.

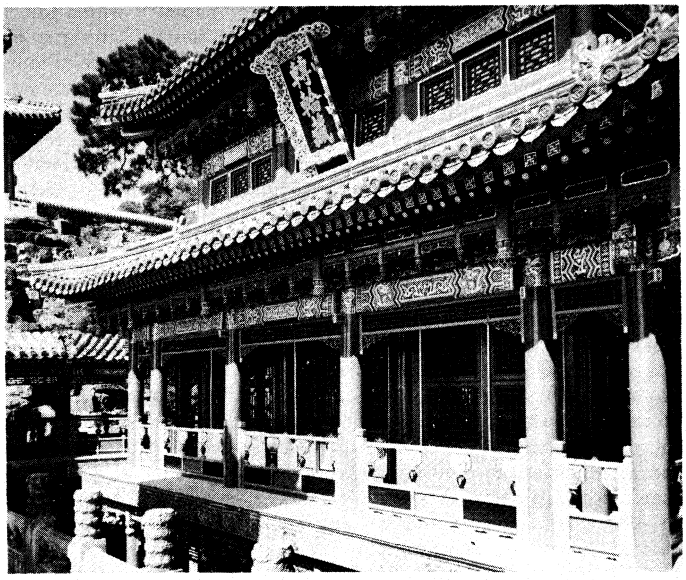
The northern part of the Outer city is a busy commercial and shopping area adjoining the city's main railroad terminal at the Ch'ien Men, the main gate connecting the Inner city and the Outer city. In the southern portion are the grounds of the Temple of Heaven and of the Temple of Agriculture.

In modern times, and especially after 1949, Peking has expanded far beyond the two walled cities that constitute its core. Residential suburbs and educational centres have risen to the west and northwest. Extending along a road going northwest to the former Summer palace and its lakes and parks are many of China's important universities: Peking (former Yenching university, Tsinghua university, People's university and many specialized institutions of higher learning, such as the Central Institute of Nationalities, and schools in the fields of iron and steel, geology, aeronautics and other engineering disciplines. Outside the northwestern gate, Hsi-chih Men, are the city's zoo and permanent exhibition grounds.

Industry.—While the city's educational and cultural institutions are being expanded largely in the western and northwestern suburbs, Peking's growing industries are concentrated east of the city. In connection with the city's growth as China's political and cultural centre under the Communist regime, attention was also given to the expansion of industry.

Manufacturing was traditionally restricted to light industry (flour mills, textiles, garments). After 1949, several heavy industrial enterprises were added, including a machine-tool plant, a printing machinery factory and a synthetic fibres mill. An auto

parts factory was expanded into a small automobile plant, and a farm-machine factory was converted into a tractor plant. Other industrial suburbs, southwest of the city, include Feng-t'ai. aith railroad marshalling yards, bridge-construction, concrete railroad ties and asbestos-pipe factories, and Ch'ang-hsin-tien, with loco-



EASTFOTO

CHUAN-LUN-TSANG. ONE OF THE BUILDINGS IN THE MANCHU EMPERORS' SUMMER PALACE PEKING

motive and rolling-stock shops.

The iron and steel plant of Shih-ching-shan is situated on the Yung-ting Ho. 14 mi. west of the city centre. This plant, first opened in 1920, was completed in 1937 and produced 80,000 tons of pig iron at its peak under Japanese rule. The plant was greatly expanded by the Communists, and annual production increased to more than five times its previous capacity. Beyond Shih-ching-shan, at the end of a rail spur, 20 mi. west of the city centre, are the coal mines of Men-t'ou-kou.

Peking is a transportation hub with rail connections to Hankow, Canton, Kalgan, Pao-t'ou, Tientsin, Mukden, Tungchow and Ch'eng Te. It is also linked to the Soviet Union via Manchuria and via Outer Mongolia.

Administration.— Under the Nationalist regime, Peking's municipal area covered more than 300 sq.mi. Under the Communists, the city limits were greatly expanded. As a result of annexations in 1953, the municipal district was extended to the Great Wall, 35 mi. from the city centre.

Within this expanded area of 1,750 sq.mi., the 1953 census reported a population of 2,768,149, of whom about 830,000 lived in the walled Inner city, 220,000 in the Outer city, and 1,700,000 in suburbs outside the walls. By the late 1950s, the population of Peking was estimated to be more than 4,000,000 as a result of the in-migration of people attracted by the city's growing importance as the nation's political, educational and economic centre. In March 1958, a second expansion of the municipal area took place, nearly doubling its territory from' 1,750 sq.mi. to 3,386 sq.mi. This time Peking absorbed the towns of T'ung-chou (Tungchon) and Shun-yi on the east, Ta-hsing on the southeast, and Fang-shan and Liang-hsiang on the southwest. The new municipal area had an estimated population of 5,420,000, of whom about 2,000,000 were rural farmers.

Peking is administered directly by the central government, and is outside the jurisdiction of Hopeh province. The municipal district itself is divided into five suburban districts (*hsien*) and eight boroughs (*ch'u*). The latter are Hsi-ch'eng and Tung-ch'eng in the Inner city; Ch'ung-men and Hsuan-wu in the Outer city; and the suburban *ch'u* of Hai-tien, with the city's educational institutions; Men-t'ou-kou, with the coal mines; Feng-t'ai and Ch'ao-yang.

The ***hsien*** consist of Ch'ang-p'ing with the Ming tombs north of the city, Fang-shan where the remains of Peking Man were found southwest of the city; Ta-hsing, T'ung and Shun-yi.

(T. SD.)

PELAGIA, SAINT (? c. 311), a 15-year-old Christian girl of Antioch who. nrobablv during Diocletian's nersecution. threw herself from a housetop to avoid outrage, and died on the spot. Her feast day is June 9.

The memory of this historical Pelagia helped to give rise to two legends of fictitious Pelagias: namely, Pelagia the Penitent (also called Margarito), a prostitute of Antioch who experienced sudden conversion and lived the rest of her days in a cave at Jerusalem. disguised as a man; and Pelagia of Tarsus. nho refused to marry the emperor Diocletian and was punished by being roasted to death. Both are named in some calendars.

The origin of the first of these two legends was the repentance of a notorious Xntiochene woman, of whom John Chrysostom speaks without mentioning her name.

Both legends are connected with that of St. Margaret (*q.v.*).

See H. Delehaye, ***The*** Legends of ***the*** Saints ***(1907).*** (D. XR.)

PELAGIUS, the name of two popes.

PELAGIUS I, (d. 561), pope from 556 to 561, was a noble born at Rome, date unknonn. Under Popes Agapetus I, Silverius and Vigilius his ecclesiastical roles were highly important. He was elected to succeed Vigilius in 555 and consecrated on April 16, 556. At first opposed to Vigilius' condemnation of the "Three Chapters" (554; ***see*** PAPACY) Pelagius upheld it as pope, winning thereby hostility in the west, especially in northern Italy, where long schism developed.

He died on March 4, 561.

PELAGIUS II (d. 590), pope from 5i9 to 590, was born at Rome date unknonn, of Gothic descent. During his pontificate, which began on Sov. 26, 579, Lombard barbarians pressed more deeply into Italy. Schism arising out of the "Three Chapters" controversy resisted his conciliatory efforts in northern Italy. Pelagius protested when the bishop of Constantinople assumed the title "ecumenical patriarch." He died on Feb. 7, 590.

(JN. F. B.)

PELAGIUS (*c.* 360–c. 420), early British theologian. Of the origin of Pelagius almost nothing is known. He seems to have been one of the earliest, if not the very earliest, of that remarkable series of men nho issued from the monasteries of Scotland and Ireland, and carried back to the Continent in a purified form the religion they had received from it. Coming to Rome in the beginning of the 5th century (his earliest known writing is of date 405), he found a scandalously low tone of morality prevalent. But his remonstrances were met by the plea of human weakness. To remove this plea by exhibiting the actual powers of human nature became his first object.

It seemed to Pelagius that the Augustinian doctrine of total depravity and of the consequent bondage of the will both cut the sinew of all human effort and threw upon God the blame which really belonged to man. His favourite maxim was, "If I ought. I can."

Judging from the general style of his writings. his religious development had been equable and peaceful. not marked by the prolonged mental conflict. or the abrupt transitions. which characterized the experience of his great opponent. With no great penetration he saw very clearly the thing before him. and many of his practical counsels are marked by sagacity, and are expressed with the succinctness of a proverb ("corpus non frangendum, sed regendurn est").

The peculiar tenets of Pelagius, though indicated in the commentaries nhich he published at Rome previous to 409, might not so speedily have attracted attention had they not been adopted by Coelestius, a much younger and bolder man than his teacher. Coelestius. probably an Italian, had been trained as a lawyer, but abandoned his profession for an ascetic life. When Rome was sacked by the Goths (410) the two friends crossed to Africa. There Pelagius once or twice met with Augustine, but very shortly sailed for Palestine, where he justly expected that his opinions would be more cordially received. Coelestius remained in Car-

thage with the view of receiving ordination. But Aurelius, bishop of Carthage, being warned against him, summoned a synod, at which Paulinus, a deacon of Milan, charged Coelestius with holding the following six errors: (1) that Adam would have died even if he had not sinned; (a) that the sin of Adam injured himself alone, not the human race; (3) that new-born children are in the same condition in which Adam was before the fall; (4) that the whole human race does not die because of Adam's death or sin, nor will the race rise again because of the resurrection of Christ; (j) that the law gives entrance to heaven as well as the gospel; (6) that even before the coming of Christ there were men who were entirely without sin. To these propositions a seventh is sometimes added, "that infants, though unbaptized, have eternal life," a corollary from the third. Coelestius did not deny that he held these opinions, but he maintained that they were open questions, on which the Church had never pronounced. The synod condemned and excommunicated him. Coelestius, after a futile appeal to Rome, went to Ephesus, and there received ordination.

In Palestine Pelagius lived unmolested and revered, until in 415 Orosius, a Spanish priest, came from Augustine to warn Jerome against him. The result was that in June of that year Pelagius was cited by Jerome before John, bishop of Jerusalem, and charged with holding that man may be without sin, if only he desires it. This prosecution broke down, and in December of the same year Pelagius was summoned before a synod of fourteen bishops at Diospolis (Lydda). The proceedings, being conducted in various languages and by means of interpreters, lacked certainty, and justified Jerome's application to the synod of the epithet "miserable." But there is no doubt that Pelagius repudiated the assertion of Coelestius, that the divine grace and help consists only in free will, and in the giving of the law and instruction; at the same time he affirmed that a man is able, if he likes, to live without sin and keep the commandments of God, inasmuch as God gives him this ability. The synod was satisfied with these statements, and pronounced Pelagius to be in agreement with Catholic teaching. Pelagius naturally plumed himself on his acquittal, and provoked Augustine to give a detailed account of the synod, in which he shows that the language used by Pelagius was ambiguous, but that, being interpreted by his previous written statements, it involved a denial of what the Church understood by grace and by man's dependence on it. The North African Church as a whole resented the decisions of Diospolis, and in 418 Zosimus, bishop of Rome, was prompted to draw up a circular inviting the bishops of Christendom to subscribe to a condemnation of Pelagian opinions. Nineteen Italian bishops refused, among them Julian of Eclanum in Apulia, a man of good birth, approved sanctity and great capacity, who now became the recognized leader of the movement. But not even his acuteness and zeal could redeem a cause which was rendered hopeless when the Eastern Church (Ephesus, 431) confirmed the decision of the West. Pelagius himself disappears after 420; Coelestius was at Constantinople seeking the aid of Nestorius in 428.

The first principle of Pelagianism is a theory which affirms the freedom of the will, in the sense that in each volition and at each moment of life, no matter what the previous career of the individual has been, the will is in equipoise, able to choose good or evil. We are born characterless (non pleni), and with no bias towards good or evil (ut sine virtute, ita et sine vitio). It follows that we are uninjured by the sin of Adam, save in so far as the evil example of our predecessors misleads and influences us (non propagine sed exemplo). There is, in fact, no such thing as original sin, sin being a thing of will and not of nature; for if it could be of nature our sin would be chargeable on God the creator. This will, capable of good as of evil, being the natural endowment of man, is found in the heathen as well as in the Christian, and the heathen may therefore perfectly keep such law as they know. But, if all men have this natural ability to do and to be all that is required for perfect righteousness, what becomes of grace, of the aid of the Holy Spirit, and, in a word, of Christianity? Pelagius appears to have confused the denial of original sin (in the sense of inherited *guilt*) with the denial of inherited nature or disposition of any kind. Hence he vacillates considerably in his use of the word "grace." In his most careful statements he appears to allow to grace everything but the initial determining movement towards salvation. He ascribed to the unassisted human will power to accept and use the proffered salvation of Christ. It was at this point his departure from the Catholic creed could be made apparent. Pelagius maintains, expressly and by implication, that it is the human will which takes the initiative, and is the ,determining factor in the salvation of the individual; while the Church maintains that it is the divine will that takes the initiative by renewing and enabling the human will to accept and use the aid or grace offered. This was tha position most strongly contested by Augustine (*q.v.*). The result was the rise of Semipelagianism, which was an attempt to hold a middle course between the harshness of Augustinianism and the obvious errors of Pelagianism. It appeared simultaneously in North Africa and in southern Gaul. In the former Church, which naturally desired to adhere to the views of its own great theologian, the monks of Adrumetum found themselves either sunk to the verge of despair or provoked to licentiousness by his predestinarian teaching. When this was reported to Augustine he wrote two elaborate treatises to show that when God ordains the end He also ordains the means, and if any man is ordained to life eternal he is thereby ordained to holiness and zealous effort. But meanwhile some of the monks themselves had struck out a via media which ascribed to God sovereign grace and yet left intact man's responsibility. A similar scheme was adopted by Cassian of Marseilles (hence Semipelagians are often spoken of as *Massilians*), and was afterwards ably advocated by Vincent of Lerins and Faustus of Rhegium. The differentia of Semipelagianism is the tenet that in regeneration and all that results from it, the divine and the human will are co-operating (synergistic) coefficient factors. Pelagius was familiar with the Greek language and theology, and frequented Rufinus, upholder of Greek theology.

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(M. D.; S. H. M.)

PELARGONIUM, a genus of plants belonging to the geranium family (Geraniaceae, *q.v.*) and including most of the cultivated ornamentals known as "geraniums." There are hundreds of species, chiefly South African. (See GERANIUM.)

PELASGIANS. Various traditions were current among the Greeks with regard to the pre-Greek inhabitants of their country. They were inclined to call all these by the general name of Pelasgians, although they recognized Carians and Leleges as distinct. The Dorians claimed that the Ionians were Pelasgian or at least mainly so, and that they themselves were true Greeks. The inhabitants of Attica, who were regarded as Ionian, boasted that they were autochthonous, the original inhabitants of the land.

In the' Homeric poems Pelasgians appear as allies of Troy. They appear to be settled in south-eastern Thrace close to the Hellespont in a district called Larissa (*Il.,* ii. 840–843, x. 429). Some suppose that the Larissa here mentioned is the town of that name in Thessaly, but the catalogue of ships, in which the passage occurs, appears to follow a definite geographical order. Larissa stands between the Hellespont and Thrace. The Iliad also refers to the district of Argos near Mt. Othrys in Thessaly as Pelasgic, and also uses the same epithet in a famous passage of the Zeus of Dodona (*Il.,* ii. 681–684, xvi. 233-235). In the Odyssey Pelasgians appear in Crete (Od. xvii. 175–177). Hesiod refers to Dodona as "seat of Pelasgians," while Hecataeus refers to Pelasgus as king of Thessaly. To Aeschylus and Sophocles Argos in the Peloponnese is the Pelasgian land. Herodotus knows of actual Pelasgians at Placie and Scylace on the Asiatic coast of the Hellespont as well as near Creston on the Strymon. The islands of Lemnos and Imbros had also, he informs us, a Pelasgian population, conquered by Athens at the close of the 6th century. Apart from these actual instances of Pelasgians, both Herodotus

and Thucydides appear to regard any survival from pre-Greek times as Pelasgic. A well-known example of this is the prehistoric wall of the Athenian acropolis, anciently regarded and still commonly referred to as Pelasgian, and the epithet spread to all similar prehistoric masonry, especially that built of large blocks, in any part of Greece.

It has been held that the common Greek tradition arose from a misunderstanding, particularly perhaps by Hesiod and Hecataeus, of the two passages in the Iliad in which the Zeus of Dodona and the Thessalian Argos are referred to as Pelasgic. Where Homer used a general epithet meaning "remotely ancient," later writers have wrongly concluded that he referred specifically to actual Pelasgians as inhabitants of these places. If this is so, the problem is merely thrown farther back, for an explanation is needed of how the epithet Pelasgic had attained the general meaning of "ancient" by the time of the composition of the Homeric poems To certain people at a certain period "Pelasgic" must have been a specific epithet. The Pelasgians must have been regarded either as very ancient people or as former inhabitants of the land. Much turns upon the meaning of the epithet Pelasgic as applied in the Iliad to the Zeus of Dodona. Zeus is the last one would expect to be referred to as Pelasgic, for of all the gods' names his is most certainly Greek. The simplest explanation is perhaps that there existed at Dodona a very ancient pre-Greek or pre-Achaean shrine occupied by Greeks who attached to the deity the name of their own god Zeus.

All instances of actual Pelasgians from Homer to Herodotus point to their being a northern people. Thrace, Epirus and Thessaly are their homes. It is certain that there were pre-Achaean inhabitants of Greece. The simplest view now held is that Greek-speaking peoples broke down into Greece from the north in three successive waves, Ionian, Achaean and Dorian, subduing a previous "Helladic" population and setting up, after the second invasion (*i.e.*, of Achaeans), the Mycenean civilization in the Peloponnese. If this is the simplest view, it does not solve all problems and it does not as yet rest upon a certain foundation of fact An early stratum of population in Greece was in close touch with Xnatolia. A large number of Greek place-names point to the conclusion that Greece was colonized from Anatolia. By whom we do not know, and we are also ignorant of what language these early people spoke. It is also possible that the Achaeans themselves were in Asia Minor before they were in Greece and that they brought thither the Anatolian place-names. It is no more than tradition that connects such early people with the Pelasgians.

The name Pelasgi which almost certainly stands for Pelak-skoi or Pelag-Skoi has been connected with πέλαγος, "the sea," and the people consequently regarded as sea-faring. The connection is not very convincing. It has also been related to the name of the semi-Illyrian Pelagones of Macedonia, and it is possible, though unproven, that the names do represent the same stem. Possibly the Pelasgians were no more than Vlachs, or Wallachian shepherds, who in classical as in modern times have been in the habit of wandering in large numbers down into Greece. The name is perhaps no more than Velak-ski. If this were so, it would account for their being dotted over various regions in Thrace and the north and also, if their habits were the same at the dawn of history as afterwards, of their being an ancient and integral part of Greek tradition and life. G. Sergi describes as "Pelasgian" one branch of the Mediterranean or Eur-African race.

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PELECYPODA, a name, now replaced by Lamellibranchia, for the bivalve Mollusca (*q.v.*).

PELEUS, in Greek legend. king of the Myrmidones of Phthia in Thessaly, son of Aeacus, king of Aegina, and usually brother of Telamon. The two, having killed Telamon's third son Phocus, were banished. Peleus took refuge in Phthia with his uncle Eurytion. who purified him from the guilt of murder and gave him his daughter Antigone to wife and a third of the kingdom as her dowry. Having accidentally killed his father-in-law at the Calydonian boar-hunt. Peleus was again obliged to flee, this time to Iolcus, where he was purified by Acastus (*q.v.*). The most famous event in the life of Peleus was his marriage with the sea-goddess Thetis (*q.v.*).

Peleus survived both his son Achilles and his grandson Neoptolemus, and was carried away by Thetis to dwell forever among the Nereids.

See Apollodorus, iii, 12, 13; Ovid, *Metam.,* xi; Pindar, *Isthmia,* viii, 70; *Nemea,* iv, 101; Catullus, lxiv; schol. Apoll. Rhod. iv, 816; Euripides, *Andronzache,* 1242–60.

PELHAM, the name of an English family, derived from Pelham in Hertfordshire, which was owned by a certain Walter de Pelham under Edward I., and is alleged to have been in the possession of the same family before the Norman conquest The family dignities included the barony of Pelham of Laughton (1706–1768), the earldom of Clare (1714–1768), the dukedom of Newcastle (1715–1768), the barony of Pelham of Stanmer from 1762, the earldom of Chichester from 1801 and the earldom of Yarborough from 1837.

In the reign of Queen Elizabeth SIR WILLIAM PELHAM (c. 1530–1587), third son of Sir William Pelham (d. 1538) of Laughton, Sussex, became lord justice of Ireland. After much service abroad he was sent to Ireland in 1579, when he was knighted by Sir William Drury, the lord justice. Drury died in October, and Pelham was provisionally made his successor, an appointment subsequently confirmed by Elizabeth. Elizabeth protested strongly against Pelham's action in proclaiming Gerald Fitzgerald, 15th earl of Desmond, a traitor, though his action was soon justified by the sack of Toughal by Desmond. Thomas Butler, 10th earl of Ormonde, was entrusted with the campaign in Munster, but Pelham joined him in February 1580. The English generals laid waste northern Kerry, and proceeded to besiege Carrigafoyle Castle, which they stormed, giving no quarter to man, woman or child. Other strongholds submitted on learning the fate of Carrigafoyle. Pelhamvainly sought for help from the gentry of the county, who sympathized with Desmond, and were only brought to submission by a series of "drives." After the arrival of the new deputy, Lord Grey of Wilton, Pelham returned to England. Leicester desired his services in the Netherlands, but it was only after much persuasion that Elizabeth set him free to join the army by accepting a mortgage on his estates as security for his liabilities. Pelham was wounded at Doesburg in 1586, and accompanied Leicester to England in 1587. He died at Flushing on Nov. 24, 1587.

From Sir William are descended the Pelhams of Brocklesby, Lincolnshire, earls of Yarborough (cr. 1837). From Sir Nicholas Pelham, elder brother of William, were descended the DUKES OF NEWCASTLE (*q.v.*). Among the other distinguished members of this family were THOMAS PELHAM, earl of Chichester (1728–1805), who held many offices under George III.; HENRY PELHAM (*q.v.*), GEORGE PELHAM (1766–1827), bishop successively of Bristol, Exeter and Lincoln; Thomas Pelham, 2nd earl of Chichester (1756–1826), who held office under Pitt and Addington.

See Lower, *Pelham Family* (1873).

PELHAM, HENRY (1696–1754), prime minister of England, younger brother of Thomas Holles Pelham, duke of Newcastle, was born in 1696. He was a younger son of Thomas, 1st Baron Pelham of Laughton (1650–1712; cr. 1706) and of Lady Grace Holles, daughter of the 3rd earl of Clare. He was educated by a private tutor and at Christ Church, Oxford, which he entered in July 1710. In 1717 he entered parliament for Seaford, Sussex. Through strong family influence and the recommendation of Walpole he was chosen in 1721 a lord of the treasury. The following year he was returned for Sussex county. In 1724 he became secretary for war, exchanging this office in 1730 for the more lucrative one of paymaster of the forces. He supported Walpole on the question of the excise, and in 1743 a union of parties resulted in the formation of an administration in which Pelham was prime minister, with the office of chan-

cellor of the exchequer; his brother, the duke of Newcastle, was very powerful in the cabinet, and there were occasional disputes between them. Being strongly in favour of peace, Pelham carried on the war with indifferent success. The king, thwarted in his favourite schemes, made overtures in 1746 to Lord Bath, but his purpose was upset by the resignation of the two Pelhams (Henry and Newcastle), who, however, at the king's request, resumed office. Pelham remained prime minister till his death on March 6, 1754, when his brother succeeded him. His very defects were among the chief elements of Pelham's success, for one with a strong personality, moderate self-respect, or high conceptions of statesmanship could not have restrained the discordant elements of the cabinet for any length of time.

See W. Coxe, *Memoirs of the Life of Henry Pelham (2* vols., *1829).*

PELHAM, HENRY FRANCIS (1846–1907), English scholar and historian, was born at Bergh Apton, Norfolk, on Sept. 19, 1846, son of John Thomas Pelham (1811–1894), bishop of Norwich, third son of the 2nd earl of Chichester. He was educated at Harrow, under Butler and Westcott, and at Trinity college, Oxford, where he took a first class in *litterae humaniores* in 1869. He was a tutor of Exeter college from 1869 to 1890, taking over the teaching of ancient history from C. W. Boase. In 1887 he became university reader in ancient history and, two years later, Camden professor. He became curator of the Bodleian library in 1892, and in 1897 president of Trinity college. He was also an honorary fellow of Exeter, a fellow of the British Academy and of other learned societies, and a governor of Harrow school. His chief contribution to ancient history was his article on Roman history in the 9th edition of the *Encyclopedia Britannica* (1886), which was republished with additions as the *Outlines of Roman History* (1890). His university lectures were full of original research and learning. He married, in 1873, Laura Priscilla, daughter of Sir Edward North Buxton. He died on Feb. 13, 1907.

Apart from the *Outlines* he published only *The Imperial Domains and the Colonate* (1890), *The Roman Frontier System (1895)* and articles in periodicals of which the most important was an article in the *Quarterly Review* on the early Caesars (April 1905). Many of these articles were published in collected form after his death by Professor F. Haverfield *(Essays on Roman History,* 1911).

PELICAN, a large fish-eating water-fowl, remarkable for the big extensible skin-pouch between the flexible rami of the lower jaw of its long, weak bill. The common pelican *(Pelecanus onocrotalus)* inhabits south-east Europe, south-west Asia and north-east Africa. It haunts the margins of large lakes and rivers, where fish are plentiful; and companies may be seen in a shallow bay, stretched out in a long line, fishing. The nest is on the ground among the reeds; the two white eggs, with chalky shells, hatch into greyish-brown plumaged young. The adult, except for the black primaries, is white, tinged with pink and, on the head, yellow. A larger eastern species, P. *crispus,* has a crest of curled feathers. Two humeri of pelicans have been found in the English fens and probably belong to this species. There are two American forms, whose methods of feeding and plumage are quite different, P. *occidentalis,* the brown pelican, individually seeking its prey from the air, is marine; P. *erythrorhynchos,* the white pelican, often combining in companies to drive fish into the shallows. In summer it haunts fresh-water. Remarkable ceremonies of courtship and relieving guard at the nest occur. *(See* F. Chapman, *Camps and Cruises of an Ornithologist.)* Allied species occur in south Asia and in Africa. It may be mentioned that the legend of the pelican feeding (and revivifying) its young with the blood from its own breast is entirely unfounded.

AUSTRALIAN BLACK-BACKED PELICAN (PELECANUS CONSTRICILLATUS), FOUND IN AUSTRALIA, TASMANIA AND NEW GUINEA

PELION, a mountain in Thessaly in the district of Magnesia, between Volo and the east coast (mod. Plessidi, 5,075 ft.). In Greek mythology, the giants piled it on Ossa to scale Olympus, the abode of the gods. It was the home of the centaurs, especially of Chiron, who in a cave near its summit educated many youthful heroes. On its summit at an altar of Zeus Actaeus, a festival was held in the dog-days, by worshippers clad in skins.

PELISSIER, AIMABLE JEAN JACQUES (1794–1864), duke of Malakoff, marshal of France, was born on Nov. 6, 1794, at Maromme (Seine Inférieure). His early service was mainly in Algeria. The severity of his conduct in suffocating a whole Arab tribe in the Dahra or Dahna caves, near Mustaganem, where they had taken refuge (June 18, 1845), awakened such indignation in Europe that Marshal Soult, the minister of war, publicly expressed his regret; but Marshal Bugeaud, the governor-general of Algeria, gave it his approval, and secured for Pélissier the rank of general of brigade, which he held till 1850, when he was promoted general of division. On May 16, 1855, he succeeded Canrobert as commander-in-chief of the French forces before Sevastopol. *(See* CRIMEAN WAR.) His perseverance was crowned with success in the storming of the Malakoff on Sept. 8. On the 12th he was promoted marshal. On his return to Paris he was named senator, created duke of Malakoff (July 22, 1856), and rewarded with a grant of 100,000 francs per annum. From March 1858 to May 1859 he was French ambassador in London, being recalled to take command of the army of observation on the Rhine. In the same year he became grand chancellor of the Legion of Honour. In 1860 he was appointed governor-general of Algeria, and he died there on May 22, 1864.

See Marbaud, *Le Mare'chal Pélissier (1863);* Castille, *Portraits historiques,* 2nd series (1859).

PELL, JOHN (1610–1685), English mathematician, was born on March 1, 1610, at Southwick in Sussex, where his father was minister. He was educated at Steyning, and entered Trinity College, Cambridge, at the age of thirteen. Pell was professor of mathematics at Amsterdam (1643–46) and at Breda (1646–52). He was Cromwell's agent in Switzerland for some years. After the Restoration he took orders and held a living in Essex. He studied mainly algebra and Diophantine analysis. He introduced the sign ÷ into England; and the indeterminate equation $ax^2+1=y^2$ bears his name although his connection with it consists simply of the publication of solutions of it in his edition of *Brounker's Translation of Rhonius's Algebra* (1668). He died on Dec. 12, 1685, in London in great poverty.

PELLA, the capital of ancient Macedonia, about 32 m. N.W. of Salonika, at the village Neochori (Turkish Yeni-keui). The seat of government was transferred hither from Edessa by Philip II., and his son Alexander was born here. Under Hadrian it was still of some importance. Scanty remains are visible and neighbouring springs are known as the "baths of Pel."

PELLAGRA AND RELATED DISORDERS. Pellagra is a dietary deficiency disease, noncontagious and occurring in persons of any age, of either sex, of any race and in any stratum of society. Until rather recently it was considered by many to be merely a disease of the skin, the Italian term *pelle agra* meaning "rough skin." For more than 200 years it was associated especially with corn-eating areas of the world.

Some of the early symptoms are weakness, apathy, loss of appetite, indigestion and neurasthenia. In the late stages of the disease appear the classical four D's: dermatitis, diarrhoea, dementia and death. The symptoms vary greatly in each case. If dermatitis is present it begins as an erythema resembling sunburn that becomes reddish brown, roughened and scaly. Lesions may appear on any portion of the body, but the commonest sites are the hands, wrists, elbows, under the breasts, knees, feet and perineal regions. A sharp line of demarcation separates the lesion from the healthy skin. Glossitis and stomatitis are common symtoms. The tongue becomes red and thickened and the mucous membrane is reddened. Severe watery diarrhoea often is present in the acute stage. Nervousness, insomnia, headache and dizziness may be present, and pellagrins are subject to periods of depression and apprehension. Unless early and adequate treatment is adminis-

tered, confusion, hallucinations and complete disorientation as to time. place and person develop. Death inevitably occurs unless the afflicted person receives prompt and intensive treatment.

The pellagrin is relieved of his disease when niacin (a member of the B group of vitamins) and substances that act similarly are given in adequate amounts. The diet of the pellagrin is deficient not only in niacin but also in thiamine (vitamin B_1), riboflavin (vitamin B_2) and folic acid (folacinj, as well as many other essential nutrients. *(See* VITAMINS.) Physicians treat all those deficiency diseases at the same time and call the tablets or capsules they use "mixed vitamin therapy." Persons who develop symptoms of pellagra, beriberi, riboflavin deficiency or folic acid deficiency not only should receive mixed vitamin therapy but they should have a diet rich in lean meat. eggs, milk. fruit and vegetables. Dried brewers' yeast powder and crude liver extracts contain these vitamins and many other useful nutrients. It is preferable to prevent deficiency diseases by means of a proper diet of the type indicated above. rather than to let the diseases develop until medical treatment is required. (T. D. Ss.)

PELLICANUS, CONRAD (1478–1556), German humanist, whose original name was Kürsner, was born at Ruffach, Alsace, on Jan. 8, 1478. He studied at Heidelberg and at Tubingen, where he became a favourite pupil of the guardian of the Minorite convent there, Paulus Scriptoris, and began the study of Hebrew. He had no teacher and no grammar; but Paulus Scriptoris brought him a huge codex of the prophets borne on his own shoulders all the way from Mainz. He learned the letters from the transcription of a few verses in the *Star of the Messiah* of Petrus Niger, and, with a subsequent hint or two from Reuchlin, who also lent him the grammar of Moses Kimḥī, made his way through the Bible for himself with the help of Jerome's Latin. In 1501 he composed the first Hebrew grammar in the European tongue. It was printed in 1503, and afterwards included in Reysch's *Margarita philosophica.* The chief fruit of his Hebrew studies is the vast commentary on the Bible (Zurich, 7 vols., 1532–39).

Pellicanus was ordained priest in 1501, and continued to serve his order at Ruffach, Pforzheim and Basel till 1526. At Basel he did much laborious work for Froben's editions. He abandoned his habit on receiving through Zwingli a call to Zurich as professor of Greek and Hebrew. He died on April 6, 1jj6.

Pellicanus's Latin autobiography *(Chronicon* C.F.R. ed. Riggenbach, 1877) is one of the most interesting documents of the period. *See* also Emil Silberstein, *Conrad Pellicanus; ein Beitrag zur Geschickte des Studiums der hebr. Sprache* (1900).

PELLICO, SILVIO (1788–1854), Italian dramatist, was born at Saluzzo, Piedmont, on June 24, 1788. At the age of ten he composed a tragedy under the inspiration of Caesarotti's translation of Ossian. His tragedy *Francesca da Rimini,* was brought out with success by Carlotta Marchionni at hlilan in 1818 (Eng. trs. 1915). The representation of his next tragedy *Eufemio da Messina,* was forbidden. Pellico attempted to weaken the hold of the Austrian despotism by indirect educational means. He acted as secretary to the powerful literary executive which gathered about Counts Porro and Confalonieri, the management of the *Conciliatore,* which appeared in 1818–19 as the organ of the association, resting largely upon him. In 1820 Pellico was arrested on the charge of carbonarism and after his removal to the Piombi at Venice in 1821, he composed several *Cantiche* and the tragedies *Ester d'Engaddi* (Eng. trs. 1836) and *Iginia d'Asti.* The sentence of death pronounced on him in Feb. 1822 was commuted to fifteen years *carcere duro,* and in the following April he was placed in the Spielberg at Briinn. Here he composed the tragedy *Leoniero* da *Dertona,* for the preservation of which he was compelled to rely on his memory. After his release in 1830 *Ester* was played at Turin in 1831, but immediately suppressed. In 1832 appeared his *Tre nuovi tragedie,* and the famous *Le Mie prigioni* (Eng. trs. 1915), an account of his sufferings in prison. In 1834 the hlarchesa di Barolo, the reformer of the Turin prisons, bestowed on him a yearly pension of 1200 francs and in 1838 gave him a home in her palace. His tragedy *Tommaso Moro* appeared in 1833 and his *Opere* in 1837. He died on Jan. 31, 1854. The simple and naïve egotism of *Le Mie prigioni* established his fame.

See Piero Maroncelli, *Addizioni alle mie prigioni (1834);* G. Briano *Della Vita* e *delle Operc di S. Pellico (1854);* P. Giuria: *S. Pellico e il suo tempo* (1854) and A. Gustarelli: *La Vita,* "Le *Mie Prigioni" e di Pellico. Saggio Biografico-critico* (Florence 1917).

PELLISSON, PAUL (1624–1693), French author, was born at Béziers on Oct. 30, 1624. In 1653 he published a *Relation contenant l'histoire de l'académie française.* He was rewarded by a promise of the next vacant place and by permission to attend their meetings. In 1657 Pellisson became secretary to the minister of finance, Nicolas Fouquet, and when in 1661 the minister was arrested, his secretary was imprisoned in the Bastille. Pellisson stood by Fouquet, in whose defence he issued in 1661, *Discours au roi, par zm de ses fidèles sujets sur le procès de M. de Fouquet,* and *Seconde défense de M. Fouquet.* I'ellisson was released in 1666. He became historiographer to the king, and wrote a fragmentary *Histoire de Louis XIV.,* covering the years 1660 to 1670. In 1670 he was converted to Catholicism and obtained rich ecclesiastical preferment. He died on Feb. 7, 1693. He was very intimate with hlle. de Scudéry, in whose novels he figures as Herminius and Acante.

See Sainte-Beuve, *Causeries du lundi,* vol. xiv.; and F. L. Marcon, *Étude sur* la *vie et les œuvres de Pellisson* (1859).

PELLITORY, a small hairy perennial herb which grows on old walls, hedgebanks and similar localities in the British Isles and is known botanically as *Parietaria officinalis.* It has a short woody rootstock from which spring erect or spreading stems 1 to 2 ft. long, bearing slender leafy branches, and axillary clusters of small green flowers. It belongs to the nettle family *(Urticaceae),* and is nearly allied to the nettle, *Urtica,* but its hairs do not sting. A similar species, P. *pennsylvanica,* is widely distributed in North America.

PELLOUX, LUIGI (1839–1924), Italian general and politician, was born on March 1, 1839, at Laroche (Haute-Savoie) of Italian parents. Entering the army as lieutenant of artillery in 1857, he fought at Custozza (1866) and at the siege of Rome (1870). He was minister of war in the Rudini and Giolitti cabinets of 1891–1893, and in the Rudini cabinet of 1896, and was appointed senator. In May 1897 he secured the adoption of the Army Reform Bill, fixing Italian military expenditure at a maximum of £9,560,000 a year, but in December of that year he was defeated in the Chamber on the question of the promotion of officers. Resigning office, he was in May 1898 sent as royal commissioner to Bari, where, without recourse to martial law, he restored public order. General Pelloux succeeded Rudini as prime minister in 1896, resigned in 1899, but again took office to repress the revolutionary elements in southern Italy. His new cabinet was military and conservative, and Pelloux was forced to resign office after the general election in June. In 1901 he was appointed to the command of the Turin army. He died on Oct. 26, 1924.

PELOPIDAS (d. 364 B.C.), Theban statesman and general. In 38j B.C. he served in a Theban contingent sent to the support of the Spartans at Mantineia, where he was saved, when dangerously wounded. by Epaminondas (*q.v.*). Upon the seizure of the Theban citadel by the Spartans (383 or 382) he fled to Athens, and took the lead in a conspiracy to liberate Thebes. In 379 his party surprised and killed their chief political opponents. and roused the people against the Spartan garrison, which surrendered to an army gathered by Pelopidas. In this and subsequent years he was elected *boeotarch,* and about 375 he routed a much larger Spartan force at Tegyra (near Orchomenus). This victory he owed mainly to the valour of the Sacred Band, a picked body of 300 infantry. At the battle of Leuctra (371) he contributed greatly to the success of Epaminondas's new tactics by the rapidity with which he made the Sacred Band close with the Spartans. In 370 he accompanied his friend Epaminondas as *boeotarch* into Peloponnesus. On their return both generals were unsuccessfully accused of having retained their command beyond the legal term. In 369, in response to a petition of the Thessalians, Pelopidas was sent with an army against Alexander, tyrant of Pherae After driving Alexander out, he passed into Macedonia and arbitrated between two claimants to the throne. In order to secure the influence of Thebes, he brought home hostages, includ-

ing the king's brother, afterwards Philip II., the conqueror of Greece. Next year Pelopidas was again called upon to interfere in Macedonia, but, being deserted by his mercenaries, was compelled to make an agreement with Ptolemaeus of Alorus. On his return through Thessaly he was seized by Alexander of Pherae, and two expeditions from Thebes were needed to secure his release. In 367 Pelopidas went on an embassy to the Persian king and induced him to prescribe a settlement of Greece according to the wishes of the Thebans. In 364 he received another appeal from the Thessalian towns against Alexander of Pherae. Though an eclipse of the sun prevented his bringing with him more than a handful of troops, he overthrew the tyrant's far superior force on the ridge of Cynoscephalae; but wishing to slay Alexander with his own hand, he was cut down by the tyrant's guards.

Plutarch and Nepos, *Pelopidas;* Diodorus xv. 62–81; Xenophon, *Hellenica,* vii. 1. *See* also THEBES.

PELOPONNESIAN WAR, THE, was the great war waged towards the end of the 5th century B.C. by Sparta and the other members of the Peloponnesian Confederacy upon Athens and the Athenian empire. The cities of the Boeotian Confederacy under Theban leadership were Sparta's allies from the first. Syracuse and other Sicilian cities gave active help in the last part of the war. Argos, her hands tied by a treaty with Sparta, remained neutral during the first ten years, but, as a democracy, was benevolently inclined towards Athens. Persia at first held aloof, waiting her opportunity to reassert her dominion over the Greek cities of the Asiatic seaboard which Athens had liberated and added to her own empire. Athens, indubitably unpopular with many members of her empire, found small sympathy beyond its limits. Her maritime supremacy however held the malcontents firmly in check. As the war progressed, the whole Greek world became divided practically into two hostile groups, and both sides resented neutrality bitterly, as the cruel fate of Melos in 416 B.C. showed. The war began on April 4, 431 B.C., by a Theban attempt to surprise Plataea, Athens' ally and outpost on the northern base of Cithaeron. It ended on April 25, 404 B.C., when Athens capitulated. Thus it lasted 27 years, and Thucydides, writing its history after its close, definitely regards it as a single war, though a peace concluded between Athens and Sparta on April 11, 421 B.C., lasted technically some seven years. During these years there was heavy fighting in the Peloponnese in which Spartan and Athenian troops were engaged on opposite sides, and Thucydides' view is so far justified The war divides into three main sections: (1) The "First" or "Archidamian" War, 431–421 B.C.; (2) The "Sicilian" War, 421–413 B.C.; (3) The "Later" or "Ionian" or "Decelean" War, 412–404 B.C.

CAUSE OF THE WAR

The true cause of the war was Sparta's fear of the growth of the power of Athens. This is Thucydides' own final judgment. The whole history of the rise and power of the Athenian empire in the 50 preceding years justifies this view, though the immediate occasions of the war concerned Corinth, Sparta's chief naval ally, rather than Sparta. Since the peace of 445 B.C. Pericles had consolidated Athenian resources, made Athens' navy incomparable, concluded, in 433 B.C., a defensive alliance with the strong naval power Corcyra (Corinth's most bitter enemy), and renewed alliances with Rhegium and Leontini in the West. The very food supply of the Peloponnese from Sicily was endangered. In the Aegean, Athens could always enforce a monopoly of seaborne trade. To this extent the Peloponnesian War was a "Trade War," and on this ground chiefly Corinth appealed to Sparta to take up arms. The appeal was backed by Megara, well-nigh ruined by Pericles' economic boycott (he hoping thereby to compel her once more to join Athens), and by Aegina, reluctant member of the Athenian empire, heavily taxed, and claiming as a right established by treaty that Home Rule which Athens refused her. But had not Sparta herself been eager for war, peace would have lasted. She was but waiting the opportunity, which came when Athens was temporarily embarrassed by the revolt of her subject-ally Potidaea in Chalcidice in the spring of 432 B.C. The rebel city held out until the winter of 430 B.C. and its blockade meant a constant drain upon Athenian military and naval resources. Sparta seized the chance. Confident of speedy victory, she refused the offer of arbitration upon all disputed questions made her by Pericles, though the peace of 445 B.C. bound her to accept it. The ultimatum despatched to Athens was tantamount to the destruction of the prestige if not of the actual existence of the Athenian empire. At Pericles' urging the Athenian people stood firm and Sparta declared war. She had a bad conscience but a good war-cry, liberation of the Hellenes from Athenian despotism.

THE FIRST YEARS, 431–427 B.C.

In a war between the chief military and the chief naval power in Greece a decisive issue was unlikely to come speedily. Sparta relied on the old traditional strategy of Greek warfare. She hoped by invading Attica and devastating the crops to induce such war-weariness in the Athenians as to make them sue for peace, unless they could be provoked first to fight the one pitched battle which must end the war. In the numbers, as in the discipline and efficiency of the troops, Athens was markedly inferior to the Peloponnesian-Boeotian levy. The flaw in this strategy was that Athens, unlike other Greek cities, could not be starved intc submission. For her food supply she was independent of the produce of Attic soil. The old king of Sparta, Archidamus, realized this, and warned his folk that the war would be bequeathed to their children. But the Spartans were confident of speedy victory.

Upon this confidence Pericles based his own strategy. He was fighting for the *status quo ante bellum,* for the survival, not for the aggrandisement, of the empire. To the enemy's "Strategy of Annihilation" he opposed his own "Strategy of Exhaustion" which should give the foe no opportunity of any success in battle. Upon invasion by the enemy the country-folk took refuge within the walls of the "linked-fortress" Athens-Peiraeus. So Athens became "an island," impregnable to attack. The great fleet should secure the empire against disaffection within and attack without, and, offensively, was to raid the Peloponnesian coast. Meanwhile every spring and autumn the Athenian land army should waste the Megarid when the Peloponnesians were busy with their own crops at home, and compel Megara to renew her former alliance with Athens. All access from the Peloponnese by land into Attica would then be denied the enemy, and the dangerous Boeotian army on the north, invaluable allies to a Spartan force in Attica, would not dare cross the Cithaeron-Parnes range unsupported. So the baffled enemy should offer acceptable terms of peace.

This Periclean strategy also had elements of grave weakness, quickly revealed, mainly psychological. The Athenian temper proved unequal to the strain. The Spartans, though disappointed of their hopes, stuck doggedly to the war. Then chance struck Athens a heavy blow. In June 430 B.C. plague, imported by merchant vessels from Egypt or Libya, seized on the city, and the crowding of the refugees within the walls in the glaring summer heat spread the infection horribly. No adequate provision of housing or sanitation had been made. Reinforcements sent to the army blockading Potidaea carried the pestilence on the troop-ships, and here too the mortality was great. No other Greek city of any importance suffered. The devastation of the fields and the ravages of the plague overcame Athens' will to endure, despite all Pericles' noble oratory. There were as yet no compensatory successes. Megara, though starving, refused to submit. The naval raids round Peloponnese, one conducted on a great scale by Pericles himself, were futile pinpricks. Sparta cared nothing for them. It was Athens which first became "exhausted," thanks to the Periclean strategy. Even her great financial superiority at the beginning of the war began rapidly to vanish. Pericles, in fact, in framing his strategy, had been too fearful of the "casualty-list," always a matter of grave peril to any statesman in a Greek democracy. And, himself an admiral of repute, he had been curiously blind to the opportunities afforded an army, even admittedly inferior, by co-operation with a powerful fleet to harass and distract the enemy. A strong expeditionary force based on Cythera, which should have been seized at once (actually the island was taken first—and uselessly—in June 424 B.C.) would at least have kept Peloponnesian armies out of Attica, and have

encouraged Athenian hopes. Pericles flung away the strategical chance offered him in the proper use of naval predominance.

As early as August 430 B.C. Athens sent a peace embassy to Sparta. It was fruitless, and the war continued. In the following winter Potidaea capitulated, and next year two remarkable naval victories at Chalcis and Naupactus at the mouth of the Corinthian Gulf, won by Phormio, the Nelson of Athens, further cheered the Athenians. In September 429 B.C. Pericles died, and when in the June following, Mitylene, chief city of Lesbos, revolted, the very truth of the dead statesman's main contention, that Athens' maritime empire was unassailable, seemed questionable. It was however soon triumphantly vindicated. The Spartan admiral Alcidas, sent a year later to redeem a promise of help to the rebels, was a coward and fled back home after a hurried raid on Ionia at a mere glimpse of two Athenian warships. Mitylene surrendered at discretion in July 427 B.C. The city was cruelly punished, though more mercy was shown than pleased an Athenian politician then coming into prominence, Cleon "the tanner," *bête noire* of the playwright Aristophanes. In August 427 B.C. Plataea at last surrendered, when its tiny garrison was on the brink of perishing of hunger. At the insistence of their Theban enemies the Plataeans were slaughtered in cold blood and their city was utterly destroyed. Corcyra was finally secured for Athens by its democratic faction amid scenes of unspeakable barbarity, consummated in 426 B.C. by a ferocious massacre. But the whole war languished and drew near to stalemate.

ATHENS' "SECOND STRATEGY," 426–421 B.C.

At last, in 426 B.C., Athens bestirred herself, under direction of Cleon and of Demosthenes, the latter her best tactician in the war. The new leaders, though always hampered by the wealthy and influential Nicias, trusted chief and representative of the *bourgeoisie,* initiated a strategy of offence far more vigorous than the Periclean. Sicily, Boeotia, the Peloponnese itself, were all to be spheres of Athenian activity. To meet the cost, Cleon in 425 B.C. largely increased the tribute imposed on all members of the empire, in many cases up to or even beyond 50%. In June 426 B.C. Demosthenes with a handful of Athenian troops proceeded to Acarnania, ostensibly to consolidate Athenian influence in the district at the expense of Ambracia, Sparta's chief ally there. His real hopes were centred upon an invasion of Boeotia by way of Phocis in co-operation with the main Athenian army which, under Nicias, was to invade by way of Tanagra on the south-east and threaten Thebes directly. The plan was a dismal failure. Demosthenes with his large army of local levies without any real stiffening by Athenian hoplites was trapped in the heart of the forests of Aetolia at Aegitium at the very outset of his enterprise, and his whole force was cut to pieces by the natives. He himself barely escaped with his life to the Athenian base at Naupactus, whence he did not dare to return to Athens to become the scapegoat of the people's indignation. Nicias won an insignificant victory at Tanagra and then withdrew. Sparta entered on vigorous reprisals. A large army under Eurylochus marched from Delphi, threatened Naupactus (which Demosthenes secured just in time), and laid siege eventually to Amphilochian Argos, Athens' ally on the Ambraciot gulf. Then Demosthenes redeemed his reputation. Two brilliant victories, those of Olpae and Idomene, won by tactical devices novel in the humdrum warfare of the time, finally destroyed all Peloponnesian and Ambraciot influence in the entire district and shattered Spartan honour. Though Acarnanians and Ambraciots henceforward observed the war from a distance, the way was henceforth clear for Athenian ships to Sicily, and Demosthenes returned in triumph to Athens.

Next year, 425 B.C., Athens, thanks to Demosthenes and Cleon, achieved the "crowning mercy" of Sphacteria. A fleet *en route* for Sicily put in to Navarino bay and Demosthenes built and himself garrisoned a rude fort here on Pylos promontory. The angry Spartans came down upon him by land and sea.. He beat off the assault on the fort, and the Athenian fleet returning on his summons from its slow voyage to the north penned up the Spartan navy in the bay and cut off a Spartan force landed on the island of Sphacteria from all hope of rescue. **A** temporary armistice secured to Athens the peaceful surrender of the hostile fleet, which she refused to return when negotiations were broken off. So Sparta for a dozen years ceased to have a fleet in being. The blockade of the island was protracted, and the approach of winter seemed likely to secure the escape of the garrison. Cleon, appointed general upon Nicias' pusillanimous, even malignant, resignation, brought Demosthenes needful reinforcements, and the latter, landing at last in overwhelming numbers on Sphacteria, overcame the Spartans' heroic resistance and brought the remnant of survivors, 292 in all, alive as prisoners to Athens. The moral effect of their surrender was prodigious throughout the Greek world. Not until the victory of Mantinea seven years later did Sparta wipe out the disgrace. Strategically the effect was to safeguard Attica from all invasion, so long as Spartan prisoners were in Athens' dungeons. Sparta now in her turn sued for peace, which Cleon refused.

Then came the black year, 424 B.C. All the Athenians' main offensive schemes miscarried. In the spring a congress held at Gela, persuaded by the Syracusan statesman Hermocrates, decided to adopt the "Monroe doctrine" of Sicily for the Sicilians, and the Athenian admirals had no choice but to return home, where they were heavily punished for a quite unavoidable failure. In the summer the renewed plan of a converging attack on Boeotia, this time from three sides, resulted in November in a crushing defeat of the main Athenian army at Delium, inflicted by the resolution and tactical ability of the Theban Pagondas. His device of a deepened wing and his skilful use of cavalry for shock tactics anticipated the coming renown of the Theban army under Epaminondas. Meanwhile an attempt to capture Megara by treachery had been frustrated when on the very pint of success by the sudden dash to the city's rescue by Sparta's greatest soldier Brasidas, and only Megara's port Nisaea remained in Athenian hands. Then Brasidas completed the discomfiture of the Athenian "Second Offensive." hlarching at top speed through Boeotia and Thessaly he appeared in the early winter in Chalcidice, the Achilles-heel of the Athenian empire, offering liberty and protection to cities revolting against the tyrant Athens. Amphipolis quickly surrendered herself, and the historian Thucydides, then in naval command in the north Aegean, arrived in hot haste from Thasos only in time to save Eion at the Strymon's mouth. Cleon's vengeance punished him unjustly with 20 years' exile. Athens sought to check Brasidas' triumphant progress by concluding a truce, the "Truce of Laches," in April 423 B.C., with Sparta, whose only anxiety was to recover the prisoners of Sphacteria. Brasidas paid no heed, taking Scione and Mende defiantly. The indignant Athenians hurried reinforcements to what was now the only scene of active war. Nicias recovered Mende this year, and in 422 B.C. Cleon hoped to end the matter. To carelessness in a reconnaissance outside Amphipolis he added cowardice. Brasidas sallie'd from the city, routed the enemy, and Cleon himself was slain. But the Spartan, like Wolfe, fell in the moment of victory. So the two great advocates of bitter war unexpectedly perished, and Nicias was able, on April 11, 421 B.C., to conclude with Sparta that peace, called after his own name, which he hoped would end the Peloponnesian War for all time.

PEACE AND WAR, 421–417 B.C.

There followed a period of uneasy peace between the Greek cities; of alliances projected, spoilt, effected; of recriminations and of diplomatic *finesse,* much of it wasted, all of it suspicious. Corinth and Boeotia refused stoutly to be parties to the Peace of Nicias. Neither Sparta nor Athens fulfilled its conditions, though the latter did surrender her Spartan prisoners in good faith. But she retained Pylos and Nisaea when Sparta professed her inability to render up Amphipolis. And when, in July 420 B.C., a new Quadruple Alliance of Athens, Argos, Mantinea and Elis confronted a Spartan-Roeotian Alliance, the already moribund peace was doomed. This new democratic League was the work of one man at Athens, Nicias' political rival Alcibiades. Like Disraeli entering on a public career about the age of 30, like him a man of brilliant talents and unbounded ambition he too in-

curred the undying distrust, even hatred, of the "respectable" majority of his fellow-citizens. Though henceforward to the end of the war Alcibiades' personality dominates Athenian life and politics, his unquestioned oratorical and military abilities could not surmount finally this handicap, and the party-animosity which he provoked was the final cause of Athens' downfall. This is Thucydides' own certain judgment.

Athens' "Third Offensive Strategy" was in idea her best. Thanks to her new Peloponnesian allies she now threatened Sparta at home and made her rival stake her very existence upon the fortunes of a single fight. Then, to her salvation, Sparta discovered in her King Agis the second of her great soldiers, one remarkable alike for strategical and for tactical ability. Taking the initiative, Agis assembled a powerful army at Phlius by a masterly piece of night-marching and descended from the north upon Argos. His Boeotian contingent failed him at the critical moment, and, forced to extricate the remainder from peril as best he could, he concluded a much misunderstood treaty with the enemy. A few months later Argos, at Alcibiades' insistence, denounced the treaty, and the allies, though including only a miserably inadequate Athenian contingent and weakened further by the selfish absence of the Eleans, threatened Tegea. Agis hastened to the rescue, and the resulting battle of Mantinea in August 418 B.C. was so striking a Spartan victory that by this, the greatest land battle of the war, Sparta redeemed her lost reputation. Argos henceforward ceased to count. That the Third Athenian Strategy was so disastrous a failure was largely due to the blind folly of Alcibiades' political enemies, through whom he himself was not elected general in this the decisive year of its trial

THE EXPEDITION AGAINST SYRACUSE, 416–413 B.C.

One hope only of bold offence now remained for Athens. In 416 B.C., on an appeal for help made by Egesta, Alcibiades advocated vigorous intervention again in Sicily. To conquer Syracuse, subdue the whole island, crush Carthage, and then return with triumphant prestige and added forces to finish the war at home was a strategy which might seem to promise a great, even if a temporary success, and did in fact come within an ace of succeeding at Syracuse itself. The expedition to Sicily was no error of judgment, and the glamour of the west which cast its spell over the vigorous youth of Athens was no false gleam. In vain Nicias urged the dreary alternative of continued operations in Chalcidice. Expedition after expedition had been sent there in 419–417 B.C. and all had been dolefully futile. Only in the west could Athens win the war. The expedition was voted with enthusiasm. On May 22, 415 B.C., the Hermae busts in Athens' streets were mysteriously mutilated. Despite the omen the great armada sailed in June, under three generals of equal authority, Alcibiades the author, Kicias the resolute opponent of the plan, and Lamachus, a straightforward soldier. Hardly had it reached western waters when Alcibiades was recalled to stand his trial at Athens for sacrilege. He had in vain demanded a trial before he sailed. In his absence his enemies played upon the religious credulity of the pious and upon the general dread of oligarchic plots. Alcibiades' own adherents were with him on shipboard. At Athens a death sentence awaited him. He eluded his escort and fled, furious, to Sparta.

Some progress at first was made in Sicily. A preliminary landing at Dascon in Syracuse Great Harbour in November 415 B.C. resulted in a useless Athenian victory. But in April 414 B.C. the whole fleet and army moved from Catana on Syracuse, and the Athenians began to encompass the city with a wall on the landward side while the fleet blocked the harbour approaches. But presently everything went wrong. Lamachus was killed, the fleet was heavily defeated, supplies ran short, a Spartan commander-in-chief, Gylippus, sent at Alcibiades' prompting, arrived to stiffen the Syracusan defence, and the circumvallation was stopped by a cross-wall. In response to Nicias' pitiful despatches Athens sent out Demosthenes with a second armada of 73 vessels. On his arrival, in July 413 B.C., he led an attack by night on the cross-wall. It was ruinously defeated. Nicias still dallied and refused Demosthenes' urgent entreaty to leave Syracuse. At last he had consented, after criminal delay, when, on August 27, an eclipse of the moon worked on the men's superstitious fears and Nicias bowed to the soothsayers' mandate to remain. The Syracusans under Hermocrates and Gylippus seized the unexpected chance. The Athenian fleet was penned up in the Great Harbour by a boom across its mouth, and, in a final desperate engagement, was heavily worsted. The Athenians, abandoning the ships, struck inland for the hills, then, their road here blocked by the enemy, turned south again in two divisions. The rear, under Demosthenes, was surrounded on Sept. 14 in the olive-yard of Polyzelus and surrendered. The van, under Nicias, struggled on for two more days until, cut off on the banks of the river Assinarus, the survivors of a bloody massacre surrendered also. The two captured generals were put to death, against Hermocrates' pleading, in cold blood. Many prisoners perished in the horrors of the quarries at Syracuse. Scarcely a man returned to Athens. The great armada was annihilated. Thucydides' story of this disaster remains the masterpiece of Greek historical writing. In its stark simplicity, sombre majesty, and tragic intensity, his narrative has never been surpassed.

ATHENS' RECOVERY, 412–408 B.C.

The whole Greek world now expected Athens' immediate downfall. Sparta, who had resumed war officially in August 414 B.C., had the disposal of a fleet of equal or superior strength, with naval reinforcements added from the west. Athens' own best mariners were dead. Her treasury was practically empty. In March 413 B.C. King Agis at Alcibiades' suggestion had occupied Decelea and kept her in a state of semi-blockade. and 20.000 of her slaves deserted to the king. The cities of her empire fell away from her in a series of revolts in 412–411 B.C. Persia now for the first time intervened actively in the war, and Sparta seemed able to count on the support of Tissaphernes, satrap of Sardis. Finally there was a successful conspiracy in Athens herself against the utterly discredited democracy, and the oligarchic extremists, Antiphon, Peisander and Phrynichus, seizing the power in June 411 B.C., opened secret and treasonable negotiations with the enemy. Two men saved Athens in this extremity. At home the "Moderate" leader Theramenes frustrated and crushed the extremists and established the "Constitution of the Five Thousand," which guarded the city and maintained the struggle. Alcibiades meanwhile had fled from Sparta to Sardis and by his charm so prevailed upon Tissaphernes that the satrap's aid to Sparta in gold was niggardly and in ships was nil. The Athenian navy, strongly democratic in sympathy, recalled Alcibiades to command at Samos, its base, and at Theramenes' urging the people in the city confirmed the election. Athens once more had a powerful fleet in being, but it was her last, and could not with safety be divided, however strenuously reinforced. The last stages of the war are purely naval.

Presently operations shifted to the Hellespont, where a victory won by the Athenian commanders Thrasybulus and Thrasylus over the Spartan Mindarus at Cynossema in Sept. 411 B.C., if far from decisive, at least restored Athenian confidence, though all hopes of Persian support had by this time been proved fallacious. At this point Thucydides' narrative breaks off short, and Xenophon, an inferior and dull, though an honest and trustworthy writer, takes up the tale. But in March 410 B.C. Alcibiades and his colleagues won so crushing a victory over the hostile navy and its supporting Persian army on land at Cyzicus in the Sea of Marmora that the Athenians were once again indisputable masters of the sea and Sparta actually suggested peace. The newly restored democracy under the demagogue Cleophon's guidance let slip the opportunity. Next year Alcibiades recaptured rebel Byzantium, cleared the Bosporus, secured Athens' corn supply, and so on June 16, 408 B.C., was able to make a triumphal entry into Athens after seven years' absence. He received a rapturous welcome, though there were many who cherished bitter ill-will against him secretly; was appointed general with autocratic powers; and so left to rejoin the fleet, now once again at Samos. He never saw his city again.

ATHENS' DOWNFALL, 407404 B.C.

Sparta at last discovered a great admiral in Lysander. Coming to his naval base at Ephesus in the autumn of 408 B.C. he built up a large well-equipped fleet, assisted by the new satrap, Prince Cyrus, second son of the Persian king, who co-operated enthusiastically with the Spartan, placing Persia's illimitable resources and bis own private purse at the latter's command. Persian vacillation thus ended, the only flaw in Sparta's naval organization was the rule forbidding the same man to hold the admiral's office in two consecutive years. In 407 B.C. Lysander resisted steadily all Alcibiades' efforts to entice him out to battle. Then that weakness, shortage of supplies, which hampered all Athenian operations in the "Ionian War," compelled Alcibiades to divide his fleet. He himself sailed north to plunder enemy coast towns, leaving in observation at Notium a squadron under one Antiochus, a good seaman and an old friend from boyhood, with strict orders not to offer battle. During his superior's absence at hostile Cyme Antiochus challenged Lysander insultingly to combat. The latter sallied out of harbour and routed him. Alcibiades returned and renewed the blockade of the foe, but the mischief was done. His personal enemies at Athens persuaded the people to dismiss him from his command. He withdrew quietly to a castle on the Hellespont, and a new board of generals next year replaced him.

Lysander, too, was superseded by Callicratidas, a brave and energetic officer. The latter, overcoming all hindrances placed in his way by Lysander and Cyrus, blockaded the Athenian Conon in Mitylene harbour. A large Athenian fleet, raised with desperate energy, sailed from Peiraeus to this general's succour. At the resulting battle of Arginusae in August 406 B.C. the fleets engaged were the largest hitherto seen on both sides in the war, but the tactics were nearly as clumsy as in the days before Phormio. Callicratidas was defeated heavily and he himself was drowned. Again Sparta offered peace. Again Cleophon, in drunken madness, secured its rejection. The very victory was marred by a failure, due in part only to heavy weather, to rescue many hundred drowning Athenian sailors from sinking or waterlogged ships. The generals were recalled to Athens. Six who obeyed were put on trial and, illegally condemned en bloc, were executed, Theramenes, whom they had tried to make their scapegoat, being largely responsible for their doom. By their removal he may have hoped to achieve Alcibiades' recall even at the eleventh hour. In this he failed. The new generals of 405 B.C. were, with one exception, Alcibiades' political opponents.

These proceeding to Ionia, moved the entire fleet up to the open roadstead of Aegospotami in the Hellespont. Lysander lay opposite in security at Abydos. In vain Alcibiades rode down to warn his compatriots of their perilous position. Insults rewarded this, the last of his many efforts to save his city. By a clever ruse de guerre Lysander in Sept. 405 B.C. captured the whole of the opposing fleet without a blow and "in one single hour brought the longest of wars to an end." Only Conon and some 20 Athenian ships escaped. So Athens lost her fleet and, with it, the war, thanks to incompetence and political partisanship combined. With slow deliberation Lysander sailed upon the city and blockaded Peiraeus. King Pausanias lay with his army outside the walls. After six terrible months of slow starvation Theramenes secured terms from Sparta tolerable compared with the utter destruction of the city demanded by Corinth and Thebes. On April 25, 404 B.C., Athens capitulated, and the Spartans marched in. Her long walls were pulled down to the merry sound of flutes. Her empire was dissolved. Samos, alone defiant, was taken. The oligarchy of the "Thirty Tyrants" was established at Athens, and Critias, its chief, presently secured the judicial murder of Theramenes in the city and the assassination of Alcibiades at Phrygian Melissa. "Liberty returned to Hellas." The Peloponnesian War was ended.

With the war the greatest, if not the happiest days of Athens' history are ended. Her political pre-eminence passes away. Interest centres rather on Thebes and Macedon in the 4th, on Achaea and Sparta in the 3rd century. Hence it is that the Peloponnesian War enjoys such importance in world-history. Apart from this, it is the genius of Thucydides which has raised to the rank of a world-epic, almost of a world-tragedy, a struggle which has seemed to some little better than a petty quarrel of ancient days.

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PELOPONNESUS ("Island of Pelops"), the ancient (and modern Greek official) name for the part of Greece south of the Isthmus of Corinth. In mediaeval times it was called the Morea, from its resemblance to a mulberry-leaf in shape.

PELOPS, in Greek legend, the grandson of Zeus, son of Tantalus and Dione, and brother of Niobe. His father's home was on Mt. Sipylus in Asia Minor. Tantalus one day served up to the gods his own son Pelops, boiled and cut in pieces. The gods detected the crime, and none of them would touch the food except Demeter, who, distracted by the loss of her daughter Persephone, ate of the shoulder. The gods restored Pelops to life, and the shoulder consumed by Demeter was replaced by one of ivory. Poseidon carried Pelops off to Olympus, where he dwelt with the gods, till, from his father's sins, he was cast out from heaven. Then. taking much wealth with him, he went to Pisa in Elis and won Hippodamia by the treachery of Myrtilus (*cf* OENOMAUS). When Myrtilus claimed his promised reward. Pelops flung him into the sea near Geraestus in Euboea, and from his dying curse sprang the woes of the house of Pelops.

Among the sons of Pelops by Hippodamia uere Atreus and Thyestes. Pelops is closely connected with Olympia. A mound there was supposed (falsely) to be his tomb; his sacrifice was an important part of the festival; he is said to have celebrated the Games "more notably than any man before him" (Paus. v., 8. 2). It is likely that his family is of the eastern branch of the Achaeans known from Hittite records to have existed in Asia Minor in early times.

PELOTA, a Spanish word meaning ball. In the Basque provinces of Spain and France the word is used to denote the popular game known as "jai-alai" or "pelota vasca," a sport played regularly or occasionally in many places, *e.g.,* Madrid, Barcelona, Buenos Aires, Havana, Miami. Fla , etc In Cuba, pelota sometimes means baseball; as in the U.S., it is the favourite sport.

PELOTAS, a city of the state of Rio Grande do Sul. Brazil, on the left bank of the São Gonçalo river near its entrance into the Lagoa dos Platos, 30 mi. N.W. of the city of Rio Grande. Pop. (1950) 78,014.

Railways connect the city with Rio Grande, and with São Paulo to the north, and with Argentina and Uruguay. The São Gonçalo river is the outlet of Lagoa Mirim, and Pelotas is therefore connected with the inland water routes. The city is built on an open, grassy plain (*campo*), a little above the level of the lake (28 ft. above sea level). Pelotas is the centre of the xarque (jerked beef) industry of Rio Grande do Sul. In its outskirts and the surrounding country are a number of xnrqueadas (slaughter-houses).

There are many factories or packing houses where the by-products are prepared for market. Shoe and furniture factories also exist.

Pelotas became a *vila* in 1830 and a city in 1835. (R. D'E.)

PELTASTS, properly, ancient Greek soldiers, carrying a light shield (πέλτη) instead of the heavier shield (ὅπλον), carried by the Hoplites. They were light infantry and were

recruited originally from Thracian mercenaries. After Iphicrates made them an efficient fighting force the term "peltasts" was applied to all light infantry (cf. Xen.. *Hell.*, iv, 4. 16 and 5, 12).

PELTIER, JEAN CHARLES ATHANASE (1785–1845), French physicist. whose discovery (1834) that an electric current produces, according to direction, either heat or cold at the junction of two dissimilar metals in a circuit completed the discovery of T. J. Seebeck. He was born at Ham (Somme), Fr., on Feb. 22. 1785, and became a clockmaker. He died in Paris on Oct. 27, 1845. (D. McK.)

PELUSIUM, an ancient city and port of Egypt, now represented by two large mounds close to the coast and the edge of the desert. 20 mi. E. of Port Said.

It lay in the marshes at the mouth of the most easterly (Pelusiac) branch of the Nile, which has long since been silted up, and was the key of the land toward Syria and a strong fortress, which, from the Persian invasion at least. played a great part in all wars between Egypt and the east.

PEMBA, an island in the Indian ocean off the east coast of Africa, forming part of the sultanate of Zanzibar. Pemba lies 25 mi. N.E. of Zanzibar in 5° S. latitude. It is 42 mi. long by about 14 mi. broad (maximum measurements). and has an area of 380 sq.mi. It is of coral origin. The average rainfall is 76.47 in. a year: the mean maximum temperature is 86.4' F. and the mean minimum 76.2° F. The population in 1948 was 114,587. Three-quarters of the inhabitants are Africans of Bantu stock (including the aboriginal Wapemba) and most of the remainder are Arabs; there are also about 2.000 Indians. mainly shopkeepers. The greater part of the plantations on Pemba were devoted to coconut cultivation until 1872, when a hurricane destroyed most of the clove trees on the island of Zanzibar. Thereupon, to benefit from the great rise in price of cloves. the Pemba planters cut down their palms and planted cloves, the cultivation of which became the major industry. The principal imports are rice and cotton piece goods. A telephone system connects the principal centres on Pemba, and a radio station keeps the island in communication with Zanzibar. There are about 70 mi. of roads suitable for motor traffic. An air service to and from Zanzibar and the mainland was inaugurated in 1954. Chake Chake, the capital (pop., 1948, 3,010), is centrally situated at the head of a shallow tidal creek partly blocked by dense growths of mangroves. Mkoani is on the southwest coast. Wete on the northwest coast; at the last-named port there is a deep and well-sheltered harbour. (*See* also ZANZIBAR.)

PEMBRQKE, EARLS OF. The title of earl of Pemhroke has been held successively by several English families, the jurisdiction and dignity of a palatine earldom being originally attached to it. The first creation dates from 1138, when the earldom of Pemhroke was conferred by King Stephen on GILBERT DE CLARE (d. 1148), son of Gilbert Fitz-Richard, who possessed the lordship of Strigul (Estrighoiel, in *Domesday* Book), the modern Chepstow, and who, after the battle of Lincoln (1141), in which he took part, joined the party of the empress Matilda and married Henry I's mistress, Isabel, daughter of Robert de Beaumont, earl of Leicester.

For his son RICHARD, and earl. and for WILLIAM MARSHAL, who succeeded to the title through his marriage with Isabel, Richard's daughter and heiress. *see* separate articles.

Marshal's eldest son, WILLIAM MARSHAL (d. 1231), 2nd earl of Pembroke of this line, passed several years in warfare in Wales and in Ireland. where he was justiciar from 1224 to 1226; he also served Henry III in France. His second wife was the king's sister, Eleanor. .afterward the wife of Simon de Blontfort. but he left no children. His brother RICHARD MARSHAL (d. 1234), 3rd earl, came to the front as the leader of the baronial party and the chief antagonist of the foreign friends of Henry III. Fearing treachery he refused to visit the king at Gloucester in Aug. 1233, and Henry declared him a traitor. He crossed to Ireland. where Peter des Roches had instigated his enemies to attack him, and in April 1234 he was overpowered and wounded; he died a prisoner. His brother GILBERT (d. 1241), who became the 4th earl, was a friend and ally of Richard, earl of Cornwall. He was succeeded in turn by two brothers. On the death of ANSELM, the 6th earl (Dec. 1245), the male descendants of the great earl marshal became extinct. The extensive family possessions were now divided among Anselm's five sisters and their descendants, the earldom of Pembroke reverting to the crown.

The next holder of the lands of the earldom of Pembroke was WILLIAM DE VALENCE (d. 1296), a younger son of Hugh de Lusignan. count of La Marche. by his marriage with Isabel of Angoulême (d. 1246), widow of the English king John; he was born at Valence, near Lusignan. In 1247 William and his brothers, Guy and Aymer, crossed over to England at the invitation of their half-brother, Henry III. who arranged a marriage between William and Joan de Munchensi (d. 1307), a granddaughter of William Marshal. 1st earl of Pembroke. He was hated as one of the most prominent of the rapacious foreigners. He quarrelled with Simon de Montfort, refused to comply with the provisions of Oxford, and took refuge in Wolvesey castle at Winchester, where he was besieged and compelled to surrender and leave the country. In 1259 he and Simon de Montfort were formally reconciled in Paris, and in 1261 he was again in England. He fought for Henry at the battle of Lewes, and then, after a stay in France, he landed in Pembrokeshire and took part in 1265 in the siege of Gloucester and the battle of Evesham. After the royalist victory he was restored to his estates and accompanied Prince Edward. afterward Edward I, to Palestine. He died in England before May 18, 1296, and was buried in Westminster abbey.

William mas never created earl of Pembroke but toward the end of his life he began to be so styled; and the title was tacitly conceded to his eldest surviving son, AYMER (*c.* 1270–1324). He was one of the lords ordainers, but later joined the king and fought at Bannockburn. In 1317, when returning to England from Rome, he was taken prisoner and was kept in France until a large ransom was paid by the king. In 1318 he again took a conspicuous part in making peace between Edward and his nobles. and in 1322 assisted at the formal condemnation of Thomas, earl of Lancaster, and received some of his lands. His second wife, Mary de Chatillon, was the founder of Pembroke college, Cambridge.

In 1339 LAURENCE. LORD HASTINGS (1320–48), a great-grandson of William de Valence, having inherited through the female line a portion of the estates of the Valence earls of Pembroke, was created, or recognized as, earl of Pembroke. His son JOHN (1347–7j) married Margaret Plantagenet, daughter of King Edward III, and on the death without issue of his son in 1389 the earldom of Pembroke reverted again to the crown.

In 1414 HUMPHREY PLANTAGENET, fourth son of King Henry IV, was created duke of Gloucester and earl of Pembroke for life, these titles being subsequently made hereditary, with a reversion as regards the earldom of Pembroke, in default of heirs to Humphrey, to WILLIAM DE LA POLE. earl of Suffolk. Accordingly. on the death of Humphrey. without issue, in 1447 this nobleman became earl of Pernbroke. He was beheaded in 1450 and his titles were forfeited. About Nov. 1452 the title was given to SIR JASPER TUDOR, second son of Owen Tudor and half-brother of King Henry VI. Sir Jasper being a Lancastrian, his title was forfeited during the predominance of the house of York, but was restored on the accession of Henry VII. On his death without heirs in 1495, his title became extinct.

During his attainder Sir Jasper was taken prisoner by SIR WILLIAM HERBERT (d. 1469), a Yorkist, who had been raised to the peerage as Baron Herbert by Edward IV, and for this service Lord Herbert was created earl of Pembroke in 1468. His son William (d. 1491) received the earldom of Huntingdon in lieu of that of Pembroke, which he surrendered to Edward IV, who thereupon conferred it (1479) on his son EDWARD, PRINCE OF WALES; and when this prince succeeded to the throne as Edward V, the earldom of Pembroke merged in the crown.

ANNE BOLEYN was created marchioness of Pembroke in 1532, a few months previous to her marriage witn Henry VIII.

The title of earl of Pembroke was next revived in favour of SIR WILLIAM HERBERT (*c.* 1506–70), whose father, Richard, was an illegitimate son of the 1st earl of Pembroke of the house of Herbert. He had married Anne Parr, whose sister later became

Henry VIII's sixth wife, and was created earl in 1551. The title has since been held by his descendants.

His elder son HENRY (d. 1601), who succeeded as 2nd earl, was president of Wales from 1 j86 until his death. He married in 1 j53 Katherine, sister of Lady Jane Grey; the marriage was dissolved after the Grey family fell. His third wife, married in 1577, was Mary Sidney, the famous countess of Pembroke (1561–1621), third daughter of Sir Henry Sidney and his wife Mary Dudley. Sir Philip Sidney, her eldest brother, wrote *The Countesse of Pembroke's Arcadia* for her pleasure. The two also worked at a metrical edition of the Psalms. On his death she made herself his literary executor, correcting the unauthorized editions of the *Arcedin* and of his poems, which appeared in 1590 and 1591. Edmund Spenser dedicated his *Ruines of Time* to her, and refers to her as Urania in *Colin Clout's Come Home Againe;* in Spenser's *Astrophel* she is Clorinda. In 1599 Queen Elizabeth was her guest at Wilton, and the countess composed for the occasion a pastoral dialogue in praise of Astraea. The countess's other works include: *A Discourse of Life and Death,* translated from the French of Duplessis-Mornay, and *Antonius,* a version of a tragedy of Robert Garnier (published together, 1592).

WILLIAM HERBERT, 3rd earl of Pembroke (1580–1630), son of the 2nd earl; was a conspicuous figure in the society of his time and at the court of James I. He was lord chamberlain of the royal household (1615–26) and lord steward (1626–30). Like his brother Philip, the 4th earl, he took a lively interest in colonial enterprises in America and the West Indies. He was chancellor of the Cniversity of Oxford in 1624 when Thomas Tesdale and Richard Wightwick refounded Broadgates hall and named it Pembroke college in his honour. By some Shakespearean commentators Pembroke has been identified with the "Mr. W. H." referred to as "the onlie begetter" of Shakespeare's sonnets in the dedication by Thomas Thorpe, the owner of the published manuscript, while his mistress, Mary Fitton (*q.v.*), has been identified with the "dark lady" of the sonnets. (*See* SHAKESPEARE, WILLIAM.) He and his brother Philip are the "incomparable pair of brethren" to whom the first folio of Shakespeare is inscribed. The earl left no sons when he died in London on April 10. 1630.

His brother, PHILIP HERBERT, the 4th earl (1584–1650), was for several years the chief favourite of James I. In 160j the king created him earl of Montgomery and Baron Herbert of Shurland, and since 1630, when he succeeded to the earldom of Pembroke! the head of the Herbert family has carried the double title of earl of Pembroke and hlontgomery. Charles I made him lord chamberlain in 1626 and frequently visited him at Wilton. He worked to bring about peace between the king and the Scots in 1639 and 1640, but when in the latter year the quarrel between Charles and the English parliament was renewed he deserted the king, who in July 1641 deprived him of his office of chamberlain. Trusted by the popular party, Pembroke was made governor of the Isle of Wight, and he was one of the representatives of the parliament on several occasions, notably during the negotiations at Cxbridge in 1645 and at Newport in 1648, and when the Scots surrendered Charles in 1647. In Feb. 1649 he became a member of the Commonwealth council of state and in April, although a peer, he was elected and took his seat in the house of commons as member for Berkshire.

THOMAS, the 8th earl (*c.* 1656–1733), was a person of note during the reigns of William 111 and Anne.

His son HEKRY, the 9th earl (*c.* 1689–1750), was a soldier but was better known as the "architect earl." He was largely responsible for the erection of Westminster bridge. Later holders of the title included HENRY, 10th earl (1734–94), a soldier, who wrote the *Method of Breaking Horses* (1761); and GEORGE AUGUSTUS, 11th earl (1759–1827), a soldier and ambassador extraordinary to Vienna in 1807.

See G. T. Clark, *The Earls, Earldom and Castle of Pembroke* (Tenby, 1880); G. E. C(okayne), *Complete Peerage,* rev. ed., vol. x (London, 1945).

PEMBROKE, RICHARD DE CLARE, 2ND EARL OF (d. 1176), commonly known as "Strongbow," son of Gilbert de Clare, the first earl, succeeded to his father's estates in 1148, but had forfeited or lost them by 1168. In that year Derrnot, king of Leinster, driven out of his kingdom by Roderick, king of Connaught, came to solicit help from Henry II. He secured the services of Earl Richard, promising him the hand of his daughter Eva and the succession to Leinster. The earl crossed over in person (1170), took both Waterford and Dublin, and was married to Eva. But Henry II., jealous of this success, ordered all the troops to return by Easter 1171. In May Dermot died; this was the signal of a general rising, and Richard barely managed to keep Roderick of Connaught out of Dublin. Immediately afterwards he hurried to England to solicit help from Henry II., and surrendered to him all his lands and castles. Henry crossed over in Oct. 1172; he stayed in Ireland six months, and put his own men into nearly all the important places, Richard keeping only Kildare. In 1173 Richard went in person to France to help Henry II., and was present at Verneuil, being reinstated in Leinster as a reward. In 1174 he advanced into Connaught and was severely defeated, but fortunately Raymond le Gros reestablished his supremacy in Leinster. Early in 1176 Richard died, just as Raymond had taken Limerick for him. As he had no male issue his daughter, Isabel, became countess of Pembroke in her own right, and the title was borne by her husband, Sir William Marshal. (*See* below.) Strongbow was the statesman, as the Fitzgeralds were the soldiers, of the conquest. He was buried in the cathedral church of Dublin, where his effigy and that of his wife are still reserved.

See Giraldus Cambrensis, *Expugnatio hibernica;* and the *Song* of *Dermot,* ed *G. H.* Orpen (1892).

PEMBROKE, WILLIAM MARSHAL, 1ST EARL OF (? – 1219), English statesman, second son of John le Maréchal, by Sibylle, the sister of Patrick, earl of Salisbury, succeeded to the title through his marriage with Isabel, daughter of Richard, 2nd earl of Pembroke (*q.v.*). In 1170 he was admitted to the household of Prince Henry, the heir-apparent, and remained there until the death of his young patron (1183). He undertook a pilgrimage to the Holy Land, where he served as a crusader with distinction for two years Although he had abetted the prince in rebellion he was pardoned by Henry II. and admitted to the royal service about 1188. In 1189 he covered the flight of Henry II. from Le Mans to Chinon, and, in a skirmish, unhorsed the undutiful Richard Coeur de Lion. None the less Richard, on his accession, promoted Marshal and confirmed the old king's licence for his marriage with the heiress of Strigul and Pembroke. This match gave Marshal the rank of an earl, with great estates in Wales and Ireland, and he was included in the council of regency which the king appointed on his departure for the third crusade (1190). He took the side of Prince John when the latter expelled the justiciar, William Longchamp, from the kingdom, but in 1193 he joined with the loyalists in making war upon the prince. Richard allowed him to succeed his brother, John Marshal, in the hereditary marshalship, and on his death-bed designated him as custodian of Rouen and of the royal treasure during the interregnum.

Though he quarrelled more than once with John, Marshal was one of the few English laymen who clung to the royal side through the Barons' War He was one of John's executors, and was subsequently elected regent of the king and kingdom by the royalist barons in 1216. He prosecuted the war against Prince Louis and the rebels with remarkable energy. In the battle of Lincoln (May 1217) he charged and fought at the head of the young king's army, and he was preparing to besiege Louis in London when the war was terminated by the naval victory of Hubert de Burgh in the straits of Dover. He was criticized for the generosity of the terms he accorded to Louis and the rebels (Sept. 1217); but his desire for an expeditious settlement was dictated by sound statesmanship. Self-restraint and compromise were the key-notes of Marshal's policy. Both before and after the peace of 1217 he reissued Magna Carta. He fell ill early in the year 1219, and died on May 14, at his manor of Caversham near Reading. He was succeeded in the regency by Hubert de Burgh, in his earldom by his five sons in succession.

See the metrical French life, *Histoire de Guillaume le Maréchal*

(ed. P. Meyer, 3 vol., [1891–1901]); G. J. Turner, "Minority of Henry III" (*Trans. Royal Hist. Soc.*, new series, vol. xviii, pp. 245–295); and W. Stubbs, *Constitutional History*, ch. xii and xiv (Oxford, 1896–97).

PEMBROKE, a town of Ontario. Canada, capital of Renfrem county, 74 mi. W.N.W. of Ottawa by rail on the south shore of Allumette lake, an expansion of the Ottawa river, and on the Canadian Pacific and Canadian National railways. Pop. (1951) 15,241.

Pembroke is the seat of a Roman Catholic bishopric, a lumber trade centre and is near Petawawa military camp.

PEMBROKE, municipal borough of Pembrokeshire, Wales. Pop. (1951) 12,296. Area 7.3 sq.mi. It is an agricultural market town on the tidal waters of the Pembroke river which flows into Milford Haven. A fortress seems to have been built there by the Norman Arnulf de Montgomery, about 1090. In the 12th and 13th centuries it was enlarged by the earls palatine of Pembroke, who made it their chief seat, and the town was surrounded with an embattled wall. The circular vaulted keep, built by William Marshall (c. 1200) is 75 ft. high and the walls are 19 ft. thick at the base. The great hall is built over the Wogan, a lofty natural cavern about 70 ft. long and 60 ft. wide having direct access to the river. As capital of the palatinate and the nearest port for Ireland, Pembroke was one of the most important fortified sites in the west. Henry VII was born in the castle in 1457. Facing the castle are remains of Monkton priory, founded by Arnulf de Montgomery in 1098.

The town was first incorporated by Henry I in 1109, and again by Richard de Clare in 1134. its privileges being later confirmed and extended. With the Act of Union (1536) the county palatine of Pembroke was abolished and in 1835 the corporation of Pembroke town was remodelled.

In 1814 a naval dockyard was built on the banks of Milford Haven, within the borough boundaries, and the tonn of Pembroke Dock grew up around this yard. The dockyard was closed in 1926 but reopened as a naval air base in 1931. The borough was made a development area under the Distribution of Industries act (1945) and has shipbuilding and repairing, light engineering and textile manufacture as its main industries. Pembroke Dock is also a garrison town.

PEMBROKESHIRE, the most westerly county of south Wales, bounded N.E. by Cardigan. E. by Carmarthen. S. by the Bristol channel, and W. and N.W. by St. Bride's bay and Cardigan bay of St. George's channel. The coast line is much indented and more than 140 mi. in length. Area 614.1 sq.mi. Pop. (1951) 90,906. In 1952 the coast became a national park.

From Haverfordwest, the county town and the main marketing centre, no fewer than ten roads radiate to ail parts of the county. Fishguard and Milford Haven have the two most westerly railway terminuses in Wales.

Pembroke, with Pembroke Dock, on the south of Milford Haven, is the only industrial area. Fishguard on the north coast is the Welsh port for steamboat service with Rosslare in Ireland. St. David's, nominally a city by possession of a cathedral, is in fact no more than a small village.

Physiography. — Much of the county consists of undulating or hilly pasture land, the highest ground being in the north. where the Prescelly hills (Mynydd Preseli) reach 1,760 ft. There are numerous streams, but the only rivers of importance are the East and West Cleddau whose estuaries merge about 4 mi. southeast of Haverfordwest and extend south to Milford Haven, thus severing direct communication between the Pembroke peninsula and the west of the county. There are magnificent cliffs along the south coast, gray Mountain Limestone alternating with Old Red Sandstone. The long, narrow inlets represent drowned valleys and there are many sandy bays. There are submerged forests in the vicinity of Amroth.

The north and south arms of St. Bride's bay are prolonged by groups of small islands of which Skokholm, Skomer and Grassholm are well-known breeding places of sea birds. The islands are protected, and the Council for the Promotion of Field Studies established a centre at Dale head, inside the northern entrance to Milford Haven.

Geology. — The region falls naturally into an upland northern section of older rocks and a lowland southern section of somewhat newer rocks. In the north the rocks range from pre-Cambrian near St. David's to the Ordovician and Silurian, forming the mass of the Prescelly hills. The general strike of the beds is southwest to northeast. From the Carmarthenshire border westward the rocks of the northern section of the county become older and oider — Silurian. Ordovician, Cambrian and finally pre-Cambrian granitic and volcanic rocks near St. David's. As the rocks get older to the west so the elevation of the hills becomes reduced and the Prescelly finger out to sea forming numerous headlands, islands and bays.

The rocks of the north and west are interspersed with igneous material such as the gabbros and diabases of Strumble head, Fishguard. Llanwnda and Prescelly; diorites northwest of St. David's, bostonites and porphyrites about Abercastle and the basaltic laccolite of Pen Caer. beside various contemporaneous acid lavas and tuffs. The Ordovician and Silurian rocks extend southward to the neighbourhood of Narberth and Haverfordwest. Silver-bearing lead has been mined at Llanfrynach. The southern plain is open to the sea and may be looked upon geologically as a continuation westward of the south Wales coalfield, with associated Lower Carboniferous. Old Red Sandstone and narrow belts of Silurian rocks, the whole having been considerably folded and faulted, producing a general northwest to southeast strike. The coal measures, highly inclined and anthracitic, stretch across from Carmarthen bay to the shore of St. Bride's bay; they are bordered on the north and southeast by the Millstone Grits, Carboniferous Limestone series and Old Red Sandstone. Because of folding, the limestone appears again farther south of Pembroke, Caldy island and St. Gowan's head, most of the remaining ground about Milford Haven being occupied by Old Red Sandstone with infolded strips of Silurian.

History. — The outstanding feature of the early history of Pembrokeshire is its importance in Megalithic times. The northwest section of the county (including the southern slopes of the Prescelly hills) is especially rich in Megalithic remains---dolmens, alignments, standing stones and stone circles. There are similar remains in the southern half of the county but they are not nearly so marked, as a group, as in the northwestern district. This wealth of Megalithic remains suggests that northwest Pembrokeshire had cultural relations with many of the northwest coastal promontories of Europe in the days when metal was beginning to be known in the west.

The interest of the stone circle culture in Pembrokeshire was increased when it was shown that the stones forming the inner circle at Stonehenge were derived from rocks in Pembrokeshire. There are the well-preserved dolmens of the Longhouse near Mathry and the Pentre Evan near Newport. The stone circle known as Parc-y-Marw near Fishguard is also well preserved.

The county does not show a wealth of Bronze Age objects though isolated discoveries fringe, as it were, the Megalithic area. The number of hilltop camps, presumably of Romano-British type and date, is important. especially guarding ways in from the coast, though actuai Roman influence in the county is slight. It is probable that the hilltop camps continued to be occupied through the post-Roman centuries as the county suffered from raiders from over the sea. In Pembrokeshire, as in Ireland, the native cultures lived on uninterrupted by Roman influences, and Pembrokeshire was apparently invaded by the Irish Deisi about A.D. 270. In the early centuries of our era the county maintained its contacts with Ireland and Brittany and became a great centre of Celtic Christianity. Memorials of this period remain in the numerous church dedications and in the beautiful Celtic crosses such as those of Carew. Penally and Nevern. Stones with Ogham inscriptions were found at Caldy Island, Bridell, St. Dogmell's (Dogmael's), Cilgerran and other places.

The route that had linked Ireland, Pembrokeshire. Cornwall, Brittany and northwest Spain in Megalithic times became the route of the Celtic saints and, in the middle ages, an important pilgrim's way to the shrine of Santiago de Compostela (northwest Spain) (see A. Hartwell Jones, Y *Cymmrodor,* 1912). In a shel-

tered valley, at a focus of roads from a number of little landing places on the northwest coast of Pembrokeshire, there grew up the great cathedral of St. David's (q v.), soon to become a centre of pilgrimage, and at the landing places were built chapels for the pilgrims. St. Non's and St. Patrick's were probably built very early.

Pembrokeshire was known to the Welsh in these early times as Dyfed. On the death of Rhodri Mawr in 877. Dyfed fell nominally under the sway of the princes of Deheubarth, or south Wales; their hold was never very secure, nor were they able to protect the coast towns from the Scandinavian pirates. This is shown by the large number of Scandinavian place names found in the coastal districts, especially near the southern coast. In 1092 Arnulf de Montgomery, son of Roger, earl of Shrewsbury, did homage to the king for the Welsh lands of Dyfed. With the building of Pembroke castle, the Normans began to spread over southern Dyfed, while about the turn of the 12th century William Fitz Martin built Nenport castle, which became the *caput* of his extensive lordship of Kemes (Cemaes) between the Teifi river and the Prescelly hills.

Flemish settlers were planted in the hundred of Rhôs, or Rhoose, in or about the years 1106, 1108 and 1111 with the approval of Henry I, and again in 1156 under Henry II. The castles of Haverfordwest and Tenby were erected to protect these aliens, and despite the fierce attacks of the Welsh princes their domain grew and their district became known as "Little England beyond Wales." In 1138 Gilbert de Clare was created earl of Pembroke with the full pouers of an earl palatine in Dyfed.

Examination of the mediaeval record shows a marked contrast between the *Englishery* of the south, with its compact villages and cultivation, and the *Welshery* of the north, with its scattered farms and tribal groups. The south was better populated than the north and maintained a closer contact with the affairs of the English plain. It was also the Norman stronghold and the south of the county has long been famous for its mediaeval castles. The finest examples are to be observed at Pembroke; Manorbier, built in the 12th century and interesting as the birthplace and home of Giraldus Cambrensis; Carew, exhibiting many interesting features of both Norman and Tudor architecture; and Picton. Other castles are the keep of Haverfordwest and the ruined fortresses at Narberth, Tenby, Newport, Wiston, Benton, Upton and Cilgerran. There are remains of monastic houses at Tenby and Pembroke, but the most important religious communities were the priory of the Augustinian friars at Haverfordwest and the abbey of the Benedictines at St. Dogmell's (Dogmael's). The latter, founded by Robert Fitz Martin in the 12th century. owned the priories of Pill and Caldy. Extensive ruins of the abbey exist near the left bank of the Teifi about one mile below Cardigan.

Of the ancient preceptory of the Knights of St. John at Slebech scarcely a trace remains, but of the college of St. Mary at St. David's founded by Bishop Houghton in 1377, the shell of the chapel survives.

Interesting examples of mediaeval domestic architecture are the ruins of the former episcopal mansions at Llawhaden, St. David's and Lamphey, the two latter of which were erected by Bishop Gower between the years 1328–47. The cathedral at St. David's is the greatest ecclesiastical monument in the county as well as in the principality. The nave dates largely from 1180–98 and the building was continued into the 13th century, added to in the 14th and 16th centuries, and restored in the 19th century.

By the Act of Union (27 Henry VIII), the king abolished all special jurisdiction in Pembrokeshire. Some parts of the county were for the king in the 17th century, though the influence of the parliament grew as the castles of Tenby and Haverfordwest fell to their arms.

Administration.— Municipal boroughs are Haverfordwest, Pembroke and Tenby. The hamlet of Bridgend and a part of St. Dogmell's (Dogmael's) parish are within the municipal limits of Cardigan. Newport (Trêfdraeth), once the chief town of the barony of Kemes, or Cemaes. was incorporated by Sir Nicholas Fitz Martin (c. 1210–1282) and mas given a nominal municipal body, the mayor being appointed by the lord of the manor. Milford Haven, Narberth, Neyland, and Fishguard and Goodwick are urban districts. Pembrokeshire lies in the south Wales circuit.

From 1918 the county returned one member to parliament. It lies in the diocese of St. David's. The national trust owned 1,487 and protected 2,397 ac. in the county in April 1953.

Occupations.— The south of the county has a warmer climate with more sunshine and less rain than any other region of Wales, although it is open to southwesterly winds, and so it is especially suited to agriculture. Milk production is particularly important. In the early 1950s there were more than 3.000 registered milk-producers, and there was a creamery at Merlins Bridge, Haverfordwest. The north of the county, particularly the area around the Prescelly hills, is devoted largely to sheeprearing.

Approximately 90,000 ac. were under tillage during the early 1950s, with about 2.000 ac. of wheat. 1,000 of potatoes and 1,000 of sugar beets. Fishing, formerly an important occupation, dwindled. Industries are relatively small and mostly connected with agriculture except at Pembroke, where some shipbuilding and repairing is carried on at Pembroke Dock.

PEMMICAN. A North American Indian (Cree) word for a meat prepared in such a way as to contain the greatest amount of nourishment in the most compact form. As made by the Indians it was composed of the lean parts of the meat, dried in the sun, and pounded or shredded and mixed into a paste with melted fat. It is flavoured with acid berries If kept dry it will keep for an indefinite time, and is thus particularly serviceable in arctic or other explorations.

PEMPHIGUS, a skin disease of unknown aetiology characterized by large blebs or bullae which rupture and form scabs. Four forms are usually distinguished; acute pemphigus. *pemphigus vulgaris, pemphigus foliaceus* and *pemphigus vegetans.* Acute pemphigus (also known as butcher's pemphigus) runs a rapid fulminating course. Its frequent occurrence after injuries has led to the suggestion that it does not belong to the pemphigus group but is a nonspecific staphylococcal infection.

The name is also applied to certain conditions in the newborn and also to certain skin lesions associated with syphilis.

(See SKIN DISEASES.) (F. L. A.)

PEN, an instrument for writing or for forming lines with an ink or other coloured fluid (Lat. *penna,* a feather, pen). The earliest writing implement was probably the stilus (Gr. γραφίς), a pointed bodkin of metal. bone or ivory, used for producing incised or engraved letters on boxwood tablets covered with wax. The calamus (Gr. κάλαμος) or arundo, the hollow tubular stalk of grasses growing in marshy lands, was the true ancient representative of the modern pen; hollow joints of bamboo were similarly employed. An early specific allusion to the quill pen occurs in the 7th century writings of St. Isidore of Seville, but there is no reason to assume that it was not in use at a still more remote date. The quills still occasionally employed among Western communities as writing instruments are obtained principally from the wings of the goose *(see* FEATHER).

In 1809 Joseph Bramah devised and patented a machine for cutting up the quill into separate nibs by dividing the barrel into three or even four parts, and cutting these transversely into "two. three, four and some into five lengths." Bramah's invention first familiarized the public with the appearance and use of the nib slipped into a holder. But a more distinct advance was effected in 1822, when J. I. Hawkins and S. Mordan patented the application of horn and tortoise shell to the formation of pen nibs. the points of which were rendered durable by small pieces of diamond, ruby or other very hard substance, or by lapping a small piece of thin sheet gold over the end of the tortoise shell.

Metal Pens.—Metallic pens. though not unknown in classical times—a bronze pen found at Pompeii is in the Naples museum—were little used until the 19th century and did not become common till near the middle of that century. It is recorded that a Birmingham split-ring manufacturer, Samuel Harrison, made a steel pen for Dr. Joseph Priestley in 1780. Steel pens made and sold in London by a certain Wise in 1803 were in the form of a tube or barrel, the edges of which met to form the slit, while the sides were cut away as in the case of an ordinary quill. Their

price was about five shillings each, and as they were hard, stiff and unsatisfactory instruments they were not in great demand. To John Mitchell probably belongs the credit of introducing machine-made pens, about 1822, and James Perry is believed to have been the first maker of steel slip pens. In 1828 Josiah Mason, who had been associated with Samuel Harrison in the manufacture of split rings, saw Perry's pens on sale in Birmingham, and after examining them saw his way both to improve and to cheapen the process of making them. He therefore put himself in communication with Perry, and the result was that he began to make barrel pens for him in 1828 and slip pens in 1829. Perry, who did much to popularize the steel pen and bring it into general use, in his patent of 1830 sought to obtain greater flexibility by forming a central hole between the points and the shoulders and by cutting one or more lateral slits on each side of the central slit; and in 1831 an improvement, which consisted in forming elongated points on the nibs of the pens, was described by Joseph Gillott.

The metal used consists of rolled sheets of cast steel of the finest quality made from Swedish charcoal iron. These sheets, after being cut into strips of suitable width, annealed in a muffle furnace and pickled in a bath of dilute sulphuric acid to free the surface from oxidized scale, are rolled between steel rollers till they are reduced to ribbons of an even thickness, about $\frac{1}{160}$ in. From these ribbons the pen blanks are next punched out, and then, after being embossed with the name of the maker or other marks, are pierced with the central perforation and the side or shoulder slits by which flexibility is obtained. After another annealing, the blanks, which up to this point are flat, are raised or rounded between dies into the familiar semicylindrical shape. The next process is to harden and temper them by heating them in iron boxes in a muffle furnace, plunging them in oil, and then heating them over a fire in a rotating cylindrical vessel till their surfaces attain the dull-blue tint characteristic of spring-steel elasticity. Subsequently they are scoured in a bath of dilute acid, and polished in a revolving cylinder. The grinding of the points with emery follows, and then the central slit is cut by the aid of two very fine-edged cutters. Finally, the pens are again polished, are coloured by being heated over a fire in a revolving cylinder, and in some cases are coated with a varnish of shellac dissolved in alcohol. An increasing quantity of pens are plated with metal alloys which give them a silverlike finish and increased resistance to acids and atmospheric conditions. Birmingham was the first home of the steel-pen industry and continued its principal centre. Manufacture on a large scale was begun in the U.S. about 1860 at Camden, N.J. Metals other than steel have been frequently suggested by inventors — gold, silver, zinc, German silver, aluminum and aluminum bronze. In 1926 pens made from stainless steel were introduced. These pens are highly resistant to the acids used in writing inks and are nontarnishing under extreme climatic conditions. *(See* also FOUNTAIN PEN.)

PENALTY: *see* DAMAGES.

PENANCE, that repentance or sorrow for sins which in the Christian revelation is a requisite for salvation: "Unless you repent, you will all perish" (Luke xiii, 5). The English word derives from the Latin *poenitentia.* In its root meaning, penance signifies regret or sorrow for a past act, though it connotes also the intention to avoid similar error in the future.

In Roman Catholic usage penance has a threefold meaning: first, interior repentance, a disposition of mind and will which includes both sorrow for past sins and a purpose of amendment for the future; secondly, the Sacrament of Penance, a religious rite in which the Christian who has sinned, after confession of sins and an act of interior penance, receives divine forgiveness through the absolution of the priest; finally, the word designates penitential works, either those imposed on the penitent by the priest in the sacramental rite, or those performed voluntarily by a repentant sinner, as a form of satisfaction to God for past sins and a manifestation of interior repentance.

PENANG, an island and state of the Federation of Malaya, situated at 5° 24' N. and 100° 21' E., about $2\frac{1}{2}$ mi, distant at its nearest point from the northwestern coast of the Malayan peninsula. It is about $15\frac{1}{2}$ mi. long by $10\frac{1}{2}$ mi. wide at its broadest point, with an area of 110 sq.mi. The mountainous centre of the island contains some jungle, coconuts grow by the shores and rice is cultivated at Balik Pulau and several other places. The population was 274,325 in 1957 and was predominantly Chinese and Tamil, although Malays were well represented.

The town, properly the "City of George Town" but generally also termed Penang, is built on the promontory nearest to the mainland and behind it Penang hill rises to a height of 2,428 ft. There is a fine hill railway, completed in 1923. George Town is the federation's chief port and is essentially a lighter harbour. The town itself, with a population of 234,855 in 1957, is distinguished by fine public buildings, tree-lined roads and the pulsating life of its Chinatown. By Penang hill is the tiered Ayer Itam (Buddhist) temple and at Sungei Kluang, 7 mi. away, is the Snake temple. In the town are St. George's church and Islamic mosques; there is also a museum. In the old cemetery is the tomb of Francis Light, the founder of the settlement. The Waterfall Botanic gardens, completely surrounded by evergreen jungle-clad hills 1,200 ft. high and containing an unusual wealth of flowers, shrubs and trees, are among the finest public gardens in the east.

Ships of many lines call at Penang and there are regular coastal sailings to ports of the Malayan peninsula, to Thailand and to Burma. The airport at Bayan Lepas, about 10 mi. S., is used by Malayan and Thai airways for local services and for connection with international airlines. Malayan railways connect by ferry to Prai in Province Wellesley (which for administrative purposes is integrated with Penang) and also run a direct service to Kuala Lumpur and to Singapore and northward via the frontier station of Padang Besar for connection with the Thai railways.

Since its foundation in 1786 Penang has been a free port and it is the chief port of northern Malaya for trans-shipment and distribution. The main exports are rubber and tin, coconut oil, copra, tapioca, betel nuts, hides, reptile skins and spices. The main imports are building materials, textiles, wheat flour and a large variety of general goods. The biggest tin-smelting company in Malaya operates in Penang; there are also four Chinese-owned coconut-oil mills and various other industries such as milling and soap factories. A large proportion of George Town's population is engaged in commerce, while the rural people live mainly from farming and fishing.

Penang was founded on July 17, 1786, the area having been ceded to the East India company by the Malay sultan of Kedah in 1785 by an agreement with Capt. Francis Light. It was then almost uninhabited and was made a penal settlement. In 1805 it was made a separate presidency and when in 1826 Singapore and Malacca were incorporated with it, Penang continued to be the seat of government. In 1837 Singapore was made the capital of the Straits Settlements and in 1867 the Straits Settlements were created a crown colony, in which Penang and Malacca were included. After 1867 Penang was under the administrative control of a resident councilor responsible to the governor of the Straits and aided by officers of the Malayan civil service. Unofficial members of the legislative council of the colony, which held its sittings in Singapore, were appointed, with the sanction of the secretary of state for the colonies, to represent Penang. Their term of office was three years. The official name of the island was Prince of Wales Island.

In Dec. 1941 Penang was bombed and occupied by the Japanese. Some of the European population was evacuated and large food and rubber stocks and shipping fell into Japanese hands. After the British return to Penang in 1945 its prewar status was restored. As a result of the Federation of Malaya agreement, 1948, steps were taken toward self-government in Malaya and there was a progressive democratization of the island's administration, culminating on Jan. 1, 1957, with the declaration of George Town as the first city of the Federation of Malaya; controlled by an elected city council. On Aug. 31, 1957, when the Federation of Malaya became an independent nation, the former settlement became a state of the federation and the post of resident commissioner lapsed. Under the new federal constitution Penang has a governor, appointed by Malaya's paramount ruler, and a chief minister nominated by the governor. (C. J. S.)

PENARTH, an urban district in the Cardiff South East parliamentary division of Glamorgan, south Wales. is situated on the south side of the estuary of the river Ely, about 5 mi. S. of Cardiff by road. Pop. (1951) 18,544; area 3.3 sq.mi. Parallel nith the river is an extensive dock built in 1860 in connection with the export of coal. South of this area and separated from it by rising ground is a modern residential area forming a dormitory for Cardiff business people and a seaside resort with pebble beaches. Penarth is well laid out with open spaces and tree-lined streets, and there are steamer trips from Penarth pier to Bristol channel ports. Turner house, presented to the town by J. P. Thompson and administered by the National museum of Wales, contains pictures by J. M. W. Turner, David Cox and J. S. Cotman.

PENATES, the household gods of the Romans and other Latin peoples, more properly di *penates.* Strictly speaking they were gods of the *penus,* "storeroom," or the penetralia, the innermost part of the house, but by extension their protection reached the entire household. They are associated with other deities of the house: Vesta (*q.v.*), the goddess of the hearth, and particularly the lares (*q.v.*), with whom they are often named interchangeably. They cannot be identical, however, for the penates, unlike the lares, are never referred to in the singular. The penates are thus all or some specific group of deities with household connections. Their number and precise identity were a puzzle even to the ancients. Thus Jupiter, Juno, Minerva, Neptune, Apollo and others (besides Vesta and the lares) are reckoned at times among their number.

The penates were worshiped privately as protectors of the individual household and also publicly as protectors of the Roman state. Each house had a shrine, however simple, with images of them that were worshiped at the family meal and on such personal occasions as birthdays and other anniversaries of special events. Offerings were of portions of the regular meal or of special cakes, wine, honey, incense and more rarely a blood sacrifice. The state as a whole worshiped them as the penates *publici,* about whom there were various opinions of nature and origin. There was a tradition connecting them with the "great gods" of the Samothracians (see CABEIRI) as well as the tradition, followed by Virgil in the Aeneid, that Aeneas brought them from Troy. A conflation of these two has the Samothracian deities introduced first at Troy and subsequently brought by Aeneas to Latium. The connection with the Cabeiri explains their further association with Castor and Pollux (*q.v.*), with whom they were popularly assumed to be identical. Indeed, their cult statue in the temple on the Velia in Rome represented them as the twins, and they are similarly represented on coins.

The worship of the penates in a state cult occupied a significant role as a focal point of Roman patriotism and nationalism. Through the republic the chief magistrates of the Roman people and commanders taking the field offered special sacrifices at their shrine at Lavinium, traditionally the original shrine in Latium founded by Aeneas. In the Augustan era much stress was placed upon the revival of the state cult as a factor in creating national unity, loyalty and support of the new regime. The personal gods of the house of Augustus (*i.e.,* the Julian gens, which had already traced its origins back to Aeneas himself) became thus associated with the gods of the Roman state.

See G. Wissowa. Religion und *Kultus* der *Römer* (1912); Pauly-Wissowa, Real-Encyclopudie der *classischen Altertumswissenschaft.*

(R. B. LD.)

PENCIL, a name originally applied to a small, fine pointed brush used in painting, and still employed to denote the finer camel's hair and sable brushes used by artists (Lat. *penicillus,* brush; literally, little tail), but now commonly signifying a solid rod of marking material used for writing and drawing, either encased in wood or enclosed in some form of holder.

It has been asserted that a manuscript of Theophilus shows signs of having been ruled with a black lead pencil; but the first distinct allusion to a pencil occurs in the treatise on fossils by Conrad Gesner of Zurich (1565) who describes an article for writing formed of wood and a piece of lead, or as he believed, an artificial composition called by some *stimmi anglicanum* (English antimony). The famous Borrowdale mine in Cumberland having been discovered about that time, it is probable that we have here the first allusion to that great find of graphite. While the supply of the Cumberland mine lasted, the material for English pencils consisted simply of the native graphite as taken from the mine.

Strenuous efforts were made, however, to render manufacturers independent of the Cumberland mine, whose supplies showed signs of exhaustion. In Niirnberg, where the great business of the family Faber (*q.v.*) was established in 1760, pencils were made from pulverized graphite cemented into solid blocks by means of gums, resins, glue. sulfur and similar adhesives, but none of these preparations yielded useful pencils. In 1795 N. J. Conté first produced pencils made of graphite which had been ground with certain clays, pressed into sticks and fired in a kiln. This method forms the basis of manufacture of all modern pencils.

Manufacture of Pencils.—Graphite (*q.v.*) and selected clays are mixed together in proportions determined by experiment and research. The materials are mixed in water and ground in heavy mills. Here is determined quality and degree; the quality by the selection of material and the intensity of grinding; the degree by the proportions of clay and graphite. After grinding, the mass is transferred to a specially prepared filter press and subjected to intense pressure, usually hydraulic, to squeeze out surplus moisture and obtain close texture. The mass so made, of a very firm consistency and just plastic, is inserted into heavy power-driven presses to be forced through an aperture of the desired diameter and shape, whence there exudes a thin, still plastic, stringlike strip which is laid on boards to dry. After drying, the leads are sealed in crucible boxes and fired in kilns to a suitable heat to vitrify the clay; the temperature varies from 600° to 1,200° C.

Cedar **for** Pencils.—Cedar wood is found in many countries, but the fine aromatic, soft, straight-grained wood most suitable for the manufacture of pencils (Juniperus *virginiana*) comes from the United States. Wood of similar class is grown in large quantities in the parallel belt of Africa, particularly in Kenya, but the Kenya wood is harder, heavier, and inferior to the American variety. Because of the steady exhaustion of cedar wood from Virginia, Californian incense cedar was introduced to the industry about 1900 and is largely used for the cheaper grades of pencils.

The slats of cedar require careful maturing to prevent warp. They are cut into various widths according to the size and growth of the log, but where possible they are produced wide enough to enable seven pencils to be manufactured simultaneously. The slats are planed and grooved in such a manner that when the two planed surfaces are brought together the grooves form either a round or other aperture which correctly embraces the lead. The surfaces are glued and the boards are clamped in piles, to be subsequently transferred to automatic shaping machines where they are reduced to single pencils, by appropriate machine tools.

The manufacture of "leads" for coloured pencils varies from the method used for the graphite pencils, the basis being kaolin blended with suitable waxes and gums, which are ground together with the necessary colour to obtain the tint required. The firing process is eliminated. "Copying" pencils used to be constructed on the same lines, with a substitution of aniline dye as the colouring matter. About 1898 improvements were made in copying pencils by blending graphite and aniline dye. (F. P. Do.)

PENCIL DRAWING. The common instrument used in pencil drawing is composed of graphite enclosed in a casing of wood (see PENCIL). The cylindrical graphite pencil, because of its usefulness in easily producing linear gray-black strokes, became the successor of the older metallic drawing stylus with which late medieval and Renaissance artists and tradesmen sketched or wrote on paper, parchment or wood.

The silverpoint (silver stylus) was the favourite instrument for metal-point drawing or writing although styluses of lead or lead alloys were frequently used. Metal points containing lead could be used on the natural surface of paper or parchment, but the metal points of silver, gold. brass and bronze required that the drawing surface be covered with an applied ground. This ground, usually made with lead white and a binding solution of glue or gum arabic, was brushed over the surface and when dry provided the

means by which the metallic tools produced strokes. The ground, either white or slightly tinted with the addition of a coloured pigment, in combination with the silverpoint provided a medium of very delicate and precise drawing. These characteristics, along with its fine linear effects, appealed to many of the great draftsmen of the late middle ages and Renaissance. Van Eyck, Durer, Raphael and Leonardo were some of the outstanding masters who used the metal point antecedents of the graphite pencil.

The metal points of lead or lead alloys, because of the metallic reflections and slightly rougher texture of their dark gray strokes, were the most apparent forerunners of the pencil. This superficial similarity in the appearance of lead-point and graphite strokes led, in England, to an erroneous and widespread identification of the graphite pencil as a "lead pencil," a mistaken identification that is still common.

Although graphite was being mined as early as the 16th century, the utilization by artists of pieces of natural graphite, inserted in a *porte-crayon* (holder), has not been established in extant drawings produced before the 17th century. At that time minor graphite details were included in sketches, notably in landscape renderings by Dutch artists such as David Teniers the Younger and Albert Cuyp. During the 17th and most of the 18th century graphite served as a means of making preliminary sketch lines for drawings to be completed in other media. Exceptions were drawings completely finished with graphite, as in the case of a few 18th-century works by Thomas Gainsborough and George Romney.

Although pencil drawings were much less commonly produced by artists of those centuries than sketches in the preferred mediums of chalks, charcoal and pen and ink, the use of graphite gradually increased among painters, miniaturists, architects and designers. By the late 18th century an ancestor of the modern pencil was constructed in the form of a rod of natural graphite fitted into a hollow cylinder of wood. However, it was not until 1795, when Nicolas Jacques Conté devised his method of producing pencil rods from mixtures of graphite and clays. that a true prototype of the modern graphite pencil was developed. Conté's technical improvement made possible the production of fine pencils whose strokes could be controlled. varying from type to type in softness and hardness, darkness and lightness. The excellent quality of these graphite pencils encouraged wider use by artists of the 19th century, and pencil drawing was to become a common method for creating studies and preliminary sketches. The fact that the graphite pencil could be used on almost any type of drawing surface helped to make it an indispensable instrument of the artist's studio.

Although graphite pencils provided a substantial range of light-dark effects and the opportunity for tonal modeling, the greatest masters of pencil drawing always retained in their creations the elements of a simple linearism or limited shading that were appropriate to drawing in this medium. This concept of pencil drawing contrasted with that sometimes employed in the 18th and 19th centuries in which extensive tonal modeling of three-dimensional forms and elaborate effects of light and shade were produced by artists and miniaturists by rubbing the soft graphite particles with a stump, a tightly rolled piece of soft paper or chamois.

The preciseness and clarity associated with the use of a moderately hard graphite pencil were developed in the highly selective draftsmanship of the French neoclassicist Jean Auguste Dominique Ingres. His figure sketches and portrait studies were the epitome of a type of pencil drawing in which lucid contours and limited shading combined to create a spirit of elegance and restraint. This manner of drawing was accepted by many artists throughout Europe, including German draftsmen such as Ludwig Richter, who exhibited a preference for the hardest of pencils and sharpest of points in order to produce wirelike delineations of figures and landscapes. Softer and darker graphite pencils offered the possibility of appropriate effects to artists whose tastes required more freedom and spontaneity of drawing. The sketches of the romanticist Eugene Delacroix, created swiftly and filled with flamboyant and undetailed strokes, possessed a visual suggestiveness of dramatic figures and compositions. Van Gogh chose a broad carpenter's pencil for powerful, blunt strokes.

One of the most sensitive of those who used the graphite pencil in the 19th century was Edgar Degas. A master pastelist and draftsman with coloured chalks and charcoal. Degas created pencil drawings possessing warmth and charm that were quite unlike the cool, classic works of Ingres or the highly animated and sometimes violent sketches of Delacroix. Degas. with high selectivity, combined graciously fluid outlines with soft, limpid tonal shadings. In creating these effects he often employed more than a single pencil in order to extend the range of softness or darkness in various parts of his figure studies.

Pencil drawing seems to have been a desirable medium for sculptors, and the sketches of Auguste Rodin, Aristide Maillol and others suggest the efficacy of the pencil for studies of contours and masses so important in sculptured figures and in the compositional grouping of sculptural forms.

Artists of the 20th century continue to use the graphite pencil as a device for sketching and for making preliminary rehearsals of conceptions later carried out in painting or sculpture. Because of the nature of much contemporary painting, there is less cause for artists to draw or preplan their paintings with the assistance of pencil studies; nevertheless, the function of drawing persists, and among many artists it is still considered an essential skill. Distinguished artists such as Henri Matisse. Amedeo Modigliani, Pablo Picasso and others, whose taste for basically linear conceptions was revealed in their graphic works, selected the graphite pencil as a device for creating lucid and simple images. *See* also DRAWING (TECHNIQUES OF); PEN DRAWING; PENCIL.

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(JS. A. W.)

PENCK, ALBRECHT (1858–1945), German geographer and geologist. Although extremely versatile, his chief interest was in geornorphology, especially its glacial aspects. Born at Reuditz, near Leipzig, on Sept. 25. 1858, he studied at the University of Leipzig and secured a Ph.D. degree at the University of Munich in 1883. He was appointed professor at the University of Vienna in 1885 and in 1906 became professor at the University of Berlin and also director of the marine museum there. Through the years he traveled to all continents of the world except the polar regions. In the course of his journeys he was Silliman lecturer at Yale university in 1908, and in 1909 Kaiser Wilhelm exchange professor at Columbia university. On virtually any topic in the field of geography and geology he had stimulating ideas to offer. Among other things he promoted the production of the 1:1,000,000-scale map of the world. For years before his death he was considered the grand old man of German geography and geology. Together with a long series of papers, two books are considered his chief works. The two-volume *Morphologie der Erdoberflache* (1894) is an account of the production and sculpture of land forms followed by a systematic, empirical classification and description of their types. However, since this approach lacked a unifying principle, it lost significance when the genetic, explanatory U.S. studies appeared. His work with E. Brückner on the Ice Age in the Alps, *Die Alpen im Eiszeitalter,* in three volumes (1901–09) is, on the other hand, an enduring, basic, comprehensive study. He had a wide range of interests and continued his activity late in life. Penck died at Prague on March 9, 1945. (O. D. v. E.)

PENDA, king of Mercia (d. 654 or 655), son of Pybba, probably came to the throne in 626. but it is doubtful whether he actually became king of Mercia until 633, the year of the defeat and death of Edwin of Korthumbria. According to the Anglo-Saxon Chronicle he was 80 years old at his death, but the energy of his administration and the evidence with regard to the ages of his children and relatives render it almost impossible. In 628 the chronicle records a battle between him and the West Saxons at Cirencester in that year. In 633 Penda and Ceadwalla overthrew Edwin at Hatfield Chase; but after the defeat of the Welsh king by Oswald at "Hefenfelth" in 634, Mercia seems to have been for a time subject to Northumbria. In 642 Penda slew

BY COURTESY OF (TOP LEFT) THE METROPOLITAN MUSEUM OF ART, N.Y., (TOP RIGHT) FOGG ART MUSEUM, (BOTTOM) THE PIERPONT MORGAN LIBRARY

GRAPHITE DRAWINGS BY AN ENGLISH AND TWO FRENCH MASTERS

Top left: "Lady Holding a Book" by George Romney (1734–1802), English. In the Metropolitan Museum of Art

Top right: "An Arab on Horseback Attacked by a Lion" by Eugène Delacroix (1798–1863), French. In the Meta and Paul J. Sachs collection of the Fogg Art museum, Harvard university

Right: "Mlle. Josephine Lacroix" by J. A. D. Ingres (1780–1867), French. In the Pierpont Morgan library

PEhTCIL DRAWING

BY COURTESY OF (TOP LEFT, BOTTOM LEFT) THE FOGG ART MUSEUM, (TOP RIGHT) RHODE ISLAND SCHOOL OF DESIGN

THREE PORTRAITS BY DRAFTSMEN OF THE LATE 19TH AND 20TH CENTURIES

Top left: "Portrait of Mme. Hertel," a study for his painting "The Lady with the Chrysanthemums" by Edgar Degas (1834–1917), French. Graphite pencil. In the Meta and Paul J. Sachs collection, the Fogg Art museum, Harvard university

Top right: "Portrait of Leopold Zborowski" by Amedeo Modigliani (1884–1920), Italian. Graphite pencil. In the collection of the Museum of Art of the Rhode Island School of Design

Left: "Portrait of Nicolas Kopeikine" by Pavel Tchelitchew (1898–1957), Russian-born. Silverpoint on a white ground with accents in graphite pencil. In the Meta and Paul J. Sachs collection, Fogg Art museum, Harvard university

Oswald at a place called Maerfeld. Me was continually raiding Northumbria and once almost succeeded in reducing Bamborough. He drove Cenwalh of Wessex, who had divorced his sister: from his throne. In 654 he attacked the East Angles and slew their king Anna. (*See* EAST ANGLIA.) In 654 or 655 he invaded Northumbria in spite of the attempts of Oswio to buy him off, and was defeated and slain on the banks of the "Winwaed." In the reign of Penda the districts corresponding to Cheshire, Shropshire and Herefordshire were probably acquired. Although a pagan, it was in his reign that Christianity was introduced into Middle Anglia by his son Peada.

PENDENTIVE, in architecture, a triangular segment of a spherical surface, filling in the upper corners of a square, rectangular or polygonal room, in order to form, at the top, a circular support for a dome. Its intersections with the walls against which it abuts are semicircles, and are usually carried by arches. The problem of supporting a dome over a square or polygonal hall was of continually growing importance to the late imperial Roman builders. This they attempted to solve, either by corbelling out the corners, projecting each course of masonry slightly over the one below, or by throwing across the corner diagonal arches or niches, which are known as squinches (*q.v.*). An early approximation of the pendentive form occurs in a domed room in one of the side buildings of the baths of Caracalla (A.D. 217). This form, however, was obtained by corbelling, whereas the true pendentive is built like a portion of a dome with radiating joints. It remained for the Byzantine architects to recognize the possibilities of the form and give it definitive development. One of the earliest examples is also one of the largest—that of the great church of Hagia Sophia at Istanbul (begun 532). Pendentives occur commonly in the domed Romanesque churches of Aquitania in France, as in S. Front at Perigueux (begun 1120). They occur spasmodically in Romanesque work in Italy. During the Renaissance the development of domed churches gave great importance to the pendentive. As a result of Byzantine influence, pendentives are frequent in Islamic architecture, often decorated with stalactite ornament or sometimes, as in Iran, with delicate ribbing. A vaulting form in which the curve of the pendentive and dome is continuous. without a break, is known as a pendentive dome.

See BYZANTINE ARCHITECTURE; DOME; ROMANESQUE ARCHITECTURE.

PENDLETON, EDMUND (1721–1803), U.S. lawyer and statesman, was born in Caroline county, Va., on Sept. 9, 1721. In 1774 he became president of the Virginia provincial convention and in 1776, as president, he drew up the instructions to the Virginia members of congress directing them to advocate the independence of the American colonies. In the same year he was chosen the first speaker of the house of delegates. With Jefferson and Chancellor George Wythe he drew up a new law code for Virginia. He was president of the court of chancery from 1777 to 1788, and was president of the Virginia court of appeals from 1779 until his death at Richmond, Va., on Oct. 23. 1803.

PENDLETON, GEORGE HUNT (1825–1889), U.S. lawyer and legislator. was born in Cincinnati. O., July 19, 1825. His early education was in his home city but in 1844 he went abroad for two years and studied at the University of Heidelberg. He was admitted to the bar in 1847 and practised law at Cincinnati. He became a Democratic member of the Ohio senate, 1854–55, was defeated for the U.S. congress in 1854, but was elected in 1856 and served from 1857 to 1865. He was a member of the ways and means and judiciary committees. He opposed coercion of the South in 1861 and became a critic of the Lincoln administration. In 1864 he was the Democratic candidate for vice-president. He was defeated for congress in 1866 but won western support for the presidential nomination as the leading advocate of the "Ohio idea," that the government should, pay the principal of the 5–20 year 6% bonds in greenbacks instead of in gold or silver. At the 1868 national Democratic convention he led on the early ballots for the presidential nomination but eastern opposition prevented his nomination.. The next year he was defeated for governor of Ohio by Rutherford B. Hayes. His interests centred on the presidency of the Kentucky Central railroad and his law practice until his election to the U.S. senate for the term 1879–85. He was acclaimed as the author of the civil service reform act of 1883, but it was a factor in his defeat for another term. Re served as minister to Germany, 1885–89, and died in Brussels, Nov. 24, 1889. His culture and aristocratic bearing gave him the nickname "Gentleman George." (E. H. Ro.)

PEND OREILLE, a large, question mark-shaped lake in northern Idaho, U.S., fed chiefly by the Clark Fork and drained by the Pend Oreille river. Noted for its rugged shore line and size (43.2 mi. long and 6.25 mi. wide), it covers 123 sq.mi. and a depth of 1,150 ft. has been recorded. Sport fishing for trout, including Kamloops, or Kootenay trout, which like steelheads are exceptionally large rainbows (up to 30 lb. or more), whitefish and landlocked salmon is popular. The name, meaning "earbob," is believed to refer either to the shape of the lake surface (a pendant hanging from an ear) or to earrings worn by the local Indians. The first trading post in Idaho, Kullyspell House, was established by David Thompson at the mouth of the Clark fork in 1809. Albeni falls dam, about 20 mi. below the lake on the Pend Oreille river, controls the water level of the lake. (M. E. Ms.)

PEN DRAWING. Pens have had the longest history and greatest popularity of all the drawing media of the artist. In part, this is the result of the variety of linear effects that can be provided by the three basic types of pens and of their adaptability to the changing styles of draftsmanship that have occurred over many centuries. These three basic types are: quill pens: cut from the wing feathers of fowls and birds; reed pens, formed and trimmed into proper shapes from stems of bamboolike grasses; and metal pens! fabricated from various metals, especially fine steel.

Pen drawing is fundamentally a linear method of image-making with the visual descriptions of the drawing being produced by a simple outline or a complex of ink strokes. In pure pen drawing where the artist wishes to supplement his outlines with tonal suggestions of three-dimensional form, this modeling must necessarily be effected by the close juxtaposition of a series of strokes forming areas of hatching or crosshatching. On the other hand, many pen studies are produced with the substitution of tonal washes laid onto the drawing with a brush, in which case the outlines or other important definitions of the figures or landscape are established by the pen lines.

Paper and Ink.—Pen drawing is usually done on papers expressly produced for this purpose. In the middle ages and the Renaissance parchment also was occasionally used. Although the pen was the instrument with which the artist distributed the delineating strokes in their desired arrangement on the paper, ink was the actual medium that made pen drawing possible. Inks used in pen studies were of various types and contributed an additional diversity to the final effects in sketches. The prime requisites of inks for drawing were great fluidity as well as strong tinting power.

Three types of ink possessed these qualities and were most frequently chosen by the great masters of drawing. One was black carbon ink. made from extremely fine particles of the soot of burnt oils or resins incorporated into a solution of either glue or gum arabic. This ink retained its original blackness over long periods of time, and old drawings produced with it reveal lines as strong as when they were initially made. The finest type of black carbon ink was known as Chinese ink and was the prototype of the modern black India ink used by artists: architects, engineers and other draftsmen. A brown ink popular with the old masters was known as bistre. It was prepared by boiling wood soot in order to obtain the liquid and transparent brown extract. Many artists chose bistre for its warm, luminous colour qualities, and it was especially effective for the illusionistic drawings of 17th- and 18th-century masters, including Rembrandt and Giovanni Battista Tiepolo. The third important ink was an iron gall or chemical ink. Its principal ingredients were iron sulfate, the extract of gall nuts and a gum arabic solution. It was, in fact, the common writing ink for centuries and was employed for most early drawings. Its colour when first applied to the paper was bluish-black, but it rapidly turned blackish and, over the course of years, became a dull brown; the effect is commonly seen in old handscript letters and documents as well as old drawings. Other inks, usually coloured inks made

from natural or synthetic dyestuffs, mere used on rare occasions. Throughout the history of drawing, however, coloured inks were less favoured, and studies in which chromatic effects were introduced are exceptional.

Pens.—The oldest of the artist's pens was the reed, although its use in antiquity and in the middle ages was for writing; it was not employed for drawings until the Renaissance, when its fibrous structure and blunt point were found attractive to some draftsmen for creating simple, heavily linear drawings, as those by Luca Cambiaso, or for large drawings, as those by Odoardo Fialetti and Marco Boschini. The outstanding master of the reed pen was Rembrandt, who used it many times in combination with the quill pen and washes to produce the richly suggestive atmospheric illusionism of his works. His usual method was to introduce very bold strokes of a broadly cut reed in order to articulate forms within shadows, while the more illuminated parts of the drawing were indicated with delicate quill lines.

The reed pen never had the widespread popularity of quill or metal pens, but for special effects it served artists admirably. Vincent van Gogh in his last years used it to produce the blunt, po erful strokes that in his drawings were counterparts of the heavy brush strokes typical of many of his Expressionist canvases. Among modern artists the reed pen occasionally has been chosen because of the simple or vigorous strokes that it easily creates; Henri Matisse and George Grosz, both distinguished practitioners of drawing, selected the reed pen for strong linear elements falling halfway between those usually associated with a fine steel pen and a wide brush.

In the history of drawing as it developed in the western world, the quill pen made from the large, hollow wing feathers of the goose, swan or raven has served with the greatest distinction of all pens, and until the time of the acceptance of the modern steel pen there were few master draftsmen who did not engage in quill-pen drawing. Before the end of the middle ages, when paper-making was introduced into Europe, providing a relatively cheap material for sketches and other types of studies, the quill pen was used in making the fine delineations of images in manuscripts. Just as it was the best pen for the precise handscript lettering of the manuscripts, so also its nibs, which could be sharpened to extreme fineness, permitted the craftsman to create small linear figures or ornamental decorations on the pages or along the borders of the parchment leaves. Whereas the fibrous reed pen gave the sensation of being dragged over the paper, the delicately cut point of the quill pen glided over the surface and needed only to be guided by the hand of the artist to create a graceful and calligraphic type of drawing. This characteristic, combined with the flexibility of the quill point, which responded to pressure for varying the widths of lines or forming accents. made it adaptable to the diverse hands and personal styles of draftsmen. Moreover, its adaptability to artistic demands enabled the quill to meet the requirements of changes in style that took place from the 15th to the end of the 19th century. Whether the requirements were for highly controlled but restless vigour as in Albrecht Dürer's linearism, graceful contour drawing similar to that of Raphael, or spontaneous and suggestive strokes as in Rembrandt's studies, the quill served artists equally well.

In most respects the metal pen became the successor of the quill. Although pens of silver, bronze, brass and gold alloy had been tried in the past, it was the development of excellent steel pens by James Perry in the 1830s, and mass production by stamping pens from steel blanks, that led to the supplanting of the quill by the metal pen. Nevertheless, artists were reluctant to adopt the steel pen, even after its ready acceptance for writing, and most drawings in pen and ink done prior to the 20th century were still produced with quills.

Although contemporary artists on occasion select reed or quill pens for the handsome and diversified effects they provide in drawing, the steel pen now is used for drawing almost exclusively. This type of metal pen has its virtues both in its easy availability and in the great variety of shapes and sizes, stiffness or flexibility. Because of the crisp, incising type of line it can produce with modern black inks, it is especially appreciated by artists and draftsmen who execute drawings to be reproduced in books and periodicals. It has become standard studio equipment of the illustrator, cartoonist and designer. Pen drawings by outstanding painters and sculptors such as Pablo Picasso, Matisse and Henry Moore suggest the assistance the steel pen provides in producing the sharpness of linear definitions generally preferred by modern masters. *See* also DRAWING (TECHNIQUES OF); ENGRAVING, LINE; INK; PEN; PENCIL DRAWING.

For bibliography *see* PENCIL DRAWING. (JS. **A.** W.)

PENELOPE, in the Odyssey, the wife of Odysseus and daughter of Icarius of Sparta and the nymph Periboea. During the course of the long absence of her husband after the fall of Troy many chieftains of Ithaca and the islands round about became her suitors. To rid herself of their importunities she bade them wait until she had woven a winding sheet for old Laertes, the father of Odysseus. But every night she undid the piece that she had woven by day. This she did for three years, until her maids revealed the secret. She was relieved by the arrival of Odysseus. In the *Telegonia,* she married Telegonus, the son of Odysseus and Circe, after he had killed his father, and dwelt with him in the Island of Aeaea or in the Islands of the Blest. Probably quite distinct from her is an Arcadian Penelope, mother of Pan. *See* HOMERIC POEMS; ODYSSEUS.

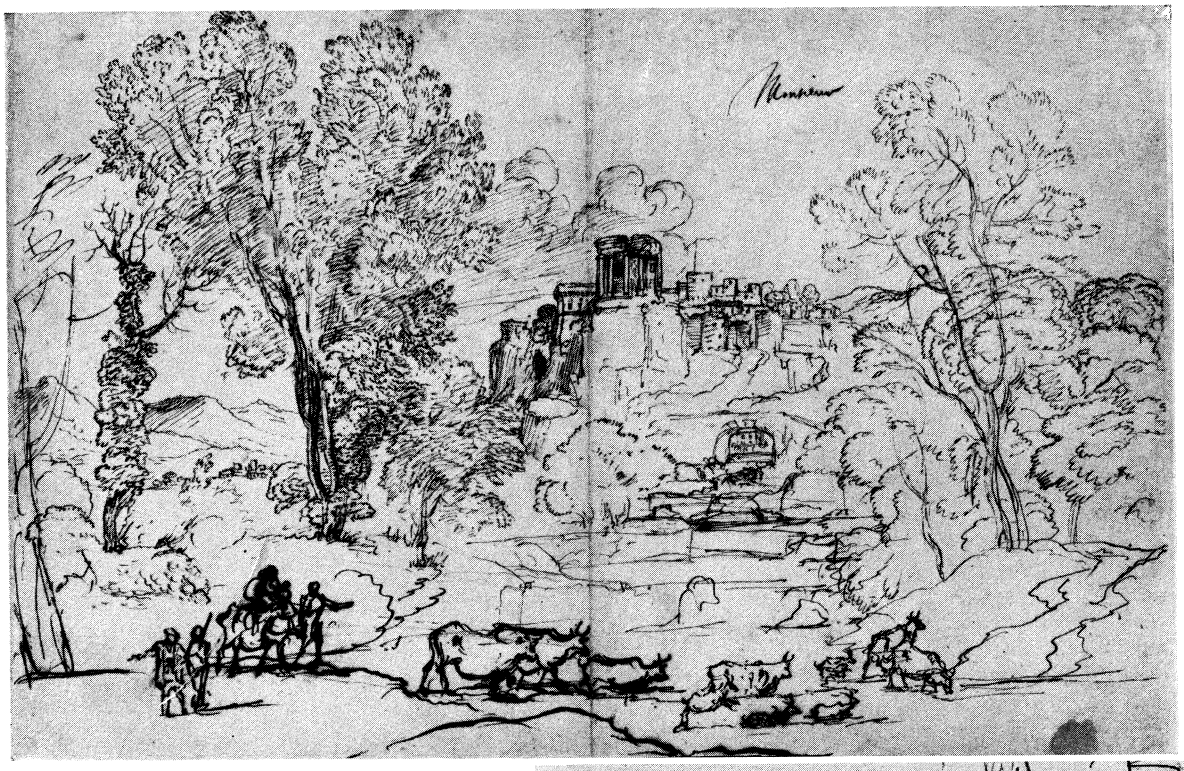
PENGE, an urban district in the Beckenham parliamentary division of Kent, Eng., about 9 mi. S.S.E. of Charing Cross, London, and part of Greater London. Pop. (1951) 25,012. Area 1.2 sq.mi. The Crystal palace, transferred from Hyde Park, London, to a site in the northwest of Penge in 1854, was burned down in 1936. Its grounds were taken over by the London County council in 1951 and within them are motor car, motorcycle and cycle racing tracks, sports grounds and a BBC television mast which can be seen for many miles round. In Penge are the Watermen's and Lightermen's almshouses (1841) and the naval asylum (1847) which houses 12 widows of naval officers. The district's chief industries are the making of plastic goods, ventilators, universal machine tools, electrical switch control gear, cycles, small electric motors and bleach preparations; printing; and pickling.

PENGUIN, the name originally given to the garefowl (*q.v.*), but now applied to the flightless sea birds forming the family Spheniscidae. The wings lack quills and are incapable of flexure, though they move freely at the shoulder joint. In the water the birds use them as paddles, and on land they are employed for fighting and, in some species, in walking. The plumage consists of small scalelike feathers and the three metatarsals are imperfectly united. Penguins feed on fish and crustacea; they have few enemies, the leopard seal or sea leopard (*q.v.*) and McCormick's skua (Megalestris *maccormickii*) being perhaps the worst, though man is even more serious as a foe when he has easy access to a rookery. The penguins belong to the southern hemisphere, none extending farther north than the Galápagos Islands, while the majority do not reach the tropics. They breed in immense rookeries, often in the most desolate parts of Antarctica. Two white eggs (one in the case of the emperor penguin) are laid in a rough nest on the ground and the young penguin is at first clad in down. The young are helpless, needing care for an unusually long time.

The largest forms are the emperor (Aptenodytes forsteri) and king (*A.* longirostris) penguins. The former breeds in the height of the antarctic winter in order that the young may be fully fledged before the next winter. The brooding instinct is so strong that birds may brood lumps of ice. The young birds are in many species cared for communally and not by their parents only. Many penguins progress on ice either by walking upright or flat on their bellies, kicking with their legs. The little Adélie penguin (Pygosceles *adeliae*) may breed several miles from the sea; it may continue to brood though completely covered with snow. It is very playful, and takes "joy rides" on pieces of floating ice. The birds have interesting mutual courtship and greeting ceremonies. The genus Eudyptes comprises the rock hoppers. About 14 species altogether are known.

PENICILLIN is a powerful antibacterial substance elaborated by certain molds of the genus *Penicillium.* It belongs to the class of antibiotics; *i.e.,* substances produced by living organisms that have a specific antagonistic effect on microorganisms. At first it was thought that there was only one penicillin, but it was later discovered that the mold could produce at least four penicillins differing slightly in their chemical structure. These have been named, in the United States, F, G, X and K, and in Great Britain 1, 2, 3 and K.

History.—Penicillin was described and named by Sir Alexander



"Classical Landscape" by Claude Lorrain (Gellée) (1600–82), French. Quill pen and iron-gall ink. In the Art Institute of Chicago

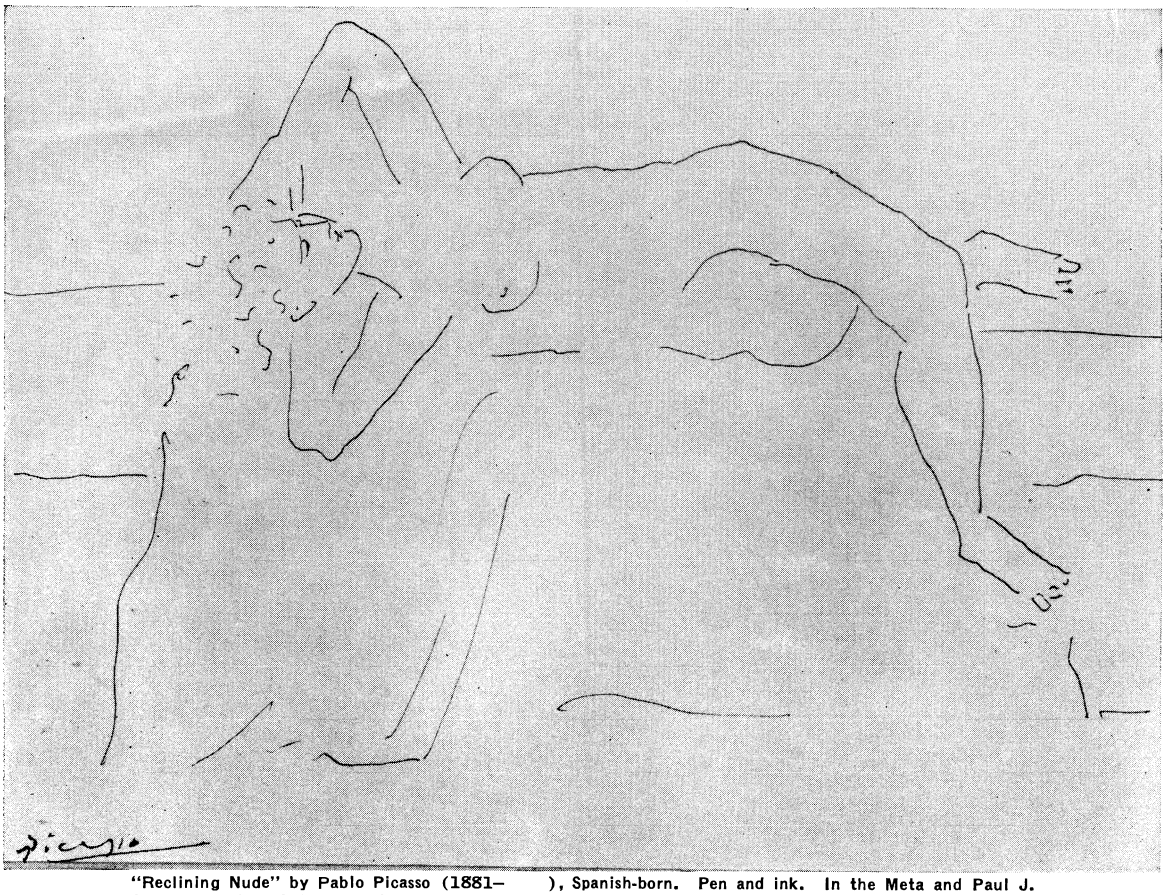
LORRAIN, REMBRANDT AND TIEPOLO

BY COURTESY OF (TOP) THE ART INSTITUTE OF CHICAGO, (CENTRE) THE METROPOLITAN MUSEUM OF ART, N.Y., (BOTTOM) THE PIERPONT MORGAN LIBRARY

"Nathan Admonishing David" by Rembrandt (1606–69), Dutch. Reed pen, quill pen brush and bister ink In the Metropolitan Museum of Art

"Group of Female Figures Seated on a Cloud" by Giovanni Battista Tiepolo (1696–1770), Italian. Quill pen, iron-gall ink, carbon ink wash and graphite. In the Pierpont Morgan library

PEN DRAWING



"Reclining Nude" by Pablo Picasso (1881–), Spanish-born. Pen and ink. In the Meta and Paul J. Sachs collection of the Fogg Art museum, Harvard university

"Peasant of the Camargue" by Vincent van Gogh (1853–90), Dutch. Reed pen. In the Fogg Art museum, Harvard university

PICASSO, VAN GOGH AND GROSZ

"The Survivor" by George Grosz (1893–1959), German. Reed and steel pens, carbon ink. In the Art Institute of Chicago

BY COURTESY OF (TOP, CENTRE) FOGG ART MUSEUM. (BOTTOM) THE ART INSTITUTE OF CHICAGO

Fleming (*q.v.*) in 1929. The work was initiated in 1928 by the unexpected contamination of a culture plate of staphylococcus by spores of *Penicillium notatum*. In the neighbourhood of the growth of the contaminating mold the colonies of staphylococcus, which had been well developed. appeared to be undergoing dissolution. The mold was isolated in pure culture and it was found to produce a substance that had a powerful destructive effect on many of the common bacteria that infect man, while it had no effect on many others. This antibacterial substance, which was christened "penicillin." was liberated into the fluid in which the mold was grown. This is the basis of all commercial penicillin production.

While penicillin had a strong antibacterial action, it was apparently without toxicity to human cells. This combination of destructive action on bacteria and absence of toxicity to human cells was unique. All the antiseptics then in common use were more toxic to human cells than they were to bacteria. Penicillin in the crude culture fluid was too weak and too impure to demonstrate its remarkable curative properties, but from 1929 onward it was used in bacteriological laboratories to facilitate the isolation of bacteria, especially members of the *Haemophilus* group.

In 1939 a team of Oxford workers. headed by Sir Howard Florey (*q.v.*), decided to investigate antibiotics. They selected penicillin as a promising one to commence with and succeeded in concentrating and purifying it. They demonstrated its curative properties first on experimental infections in mice and then on human patients suffering from staphylococcal and other infections. The next question was production on a large scale. The Oxford workers developed methods of production and extraction, and in 1941 Florey took these to the U.S. and induced the authorities there to commence production. The pharmaceutical manufacturers in England also interested themselves and there was free interchange of information. The progress was phenomenally rapid and many advances in methods of production were made: (1) the culture medium was improved by the addition of "corn steep liquor" and other substances; (2) the fermentation was carried out in large tanks instead of in thousands of bottles; (3) other strains of mold of the *Penicillium notatum-chrysogenum* group were discovered that in the fermentation tanks gave larger yields of penicillin than did the original strain isolated in 1928; (4) better methods of extraction were evolved. The penicillin molecule has been synthesized, but the synthetic method of production was found to be much less economical than production by mold fermentation. The materials used in the fermentation are cheap, so that when the initial outlay in manufacturing plant has been overcome the cost of production of penicillin is relatively small; synthesis may have no more than an academic value.

Action on Bacteria.— Penicillin is very selective in its action, having a powerful effect on some bacteria and little or none on others. (See table.)

Sensitive	Insensitive
Staph. aureus	*Enterococcus*
Staph epidermis	Nonpathogenic Gram-negative cocci found in the mouth
Streptococcus (hemolytic)	*Ps. aeruginosa*
Sir. viridans	*P. vulgaris*
Pneumococcus	*K. pneumoniae*
Gonococcus	*Baci. coli*
Meningococcus	*B. typhosus*
N. catarrhalis	*Salmonella*
B. anthracis	*Shigella*
Air-borne micrococci	*V. cholerae*
Sarcina	*Pasteurella*
Actinomyces	*Br. abortus and melitensis*
Cl. welchii	*M. tuberculosis*
Cl. oedematiens	*Haemophilus* group
Cl tetani	
Spirochetes	

The original crude culture fluid described in 1929 was bacteriostatic (capable of arresting growth) when diluted 800 times. Pure penicillin is bactericstatic even in a 1 in 80,000,000 dilution. The drog is not only bacteriostatic but it is also bactericidal (lethal to bacteria) and in some species it induces lysis (dissolution of the bacterial bodies). It acts only on bacteria when they are actively growing and dividing, and in concentrations too small to arrest growth it appears to hinder cell division, so that misshapen forms appear—giant forms or long threads instead of the normal short bacilli. The exact mode of action is unknown, but it seems likely that penicillin interferes with the enzymic action involved in the metabolism of the growing microbe.

Therapeutics.— Penicillin is used for the treatment of all infections by "sensitive" bacteria. It is very diffusible and if injected subcutaneously or intramuscularly, it rapidly appears in the blood. It is quickly excreted by the kidneys. To maintain a sufficient concentration in the blood the injections have to be repeated every two or three hours with small doses (15,000 to 50,000 units) or less often with larger doses (200,000 to 1,000,000 units). After injection penicillin circulates in the blood and reaches the infecting microbes anywhere in the body, with the notable exception of the cerebrospinal fluid. To avoid frequent injection, a suspension of procaine penicillin can be used. This is only slowly dissolved in the body, and one injection daily suffices. Solutions of penicillin also are injected into an infected area such as an abscess, the pleural cavity or the spinal canal to attack the infecting microbes locally.

The drug is also used in an ointment, cream or dusting powder for local application, or in lozenges, chewing gum or fine spray for local treatment of mouth and throat infections. Injections of penicillin are used for prophylactic purposes in operations and in war or accidental wounds where subsequent sepsis is feared. It is almost without toxicity and doses up to 2.5 g. a day have been given without harm resulting. One of the great social benefits of penicillin has been its curative action on venereal disease. After a single large dose or two or three smaller ones a gonorrheal infection disappears; in syphilis eight to ten days' active treatment suffices for the eradication of the infection in most cases.

Unit of Penicillin.—When the Oxford workers in 1940 concentrated penicillin they established a unit of potency. This corresponded with the amount that, when dissolved in 50 ml. of nutrient broth, would just inhibit the growth of their test organism, a staphylococcus. After penicillin was obtained in a pure and crystalline form an international unit was agreed on corresponding to the original Oxford unit. This international unit is equal to 0.0006 mg. of penicillin G (*2*); 1,000,000 units represents 0.6 g.

Development of Other Antibiotic Agents.— The term "antibiosis" was first used by P. Vuillemin in 1889. Louis Pasteur and Jules François Joubert in 1877 were the first to show that one microbe could prevent the growth of another, and since that time innumerable instances of bacterial antagonism have been described. Various antibiotic substances were used before penicillin for the treatment of infections, notably pyocyanase, which is produced by Bacillus pyocyaneus (*Pseudomonas* aeruginosa). This had a vogue in the early years of the 20th century, but the results were not striking and it disappeared. Long before the advent of penicillin, molds and fungi had been used in the treatment of infections, Moldy bread is an old-fashioned remedy for local septic conditions, but there are thousands of different molds that will grow on bread and only a few of them, so far as is known, will produce anything likely to be of benefit. It may be that a penicillin-producing mold sometimes was used, but it can have been only seldom. In 1939, ten years after penicillin had been described but before its remarkable curative properties had been demonstrated, René Jules Dubos described gramicidin—an antibacterial substance produced by the Bacillus *brevis*. This has a specific action on the Gram-positive bacteria, and it has been extensively used locally in superficial septic conditions. It is too toxic to be used systemically by injection into the blood stream.

The great success of penicillin stimulated an extensive search all over the world into the products of bacteria, mold, fungi and even the higher plants for other antibiotic substances. Large numbers have been found, but most of them are useless for therapeutic purposes. Many are too poisonous, some will not function in blood or body fluids. Some, however, are of great use and have greatly extended the range of antibiotic treatment. Streptomycin, for example, is effective on many Gram-negative bacilli that are insensitive to penicillin and is especially used for the treatment of tuberculosis. Chloromycetin (Chloramphenicol), aureomycin and terramycin have a very wide antibacterial spec-

trum and have had dramatic results on rickettsia1 infections such as typhus fever, in primary atypical pneumonia and in many other conditions. These antibiotics are produced by different varieties of streptomycetes, and chloromycetin was the first of the antibiotics to be synthesized commercially.

See also ANTIBIOTICS AND ANTIBIOSIS.

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(A. FL.; X.)

PENINGTON, ISAAC (1616–1679), eldest son of Sir Isaac Penington, was one of the most notable of the 17th-century Quakers. In 1661 Penington was imprisoned for refusing to take the oath of allegiance, and on several subsequent occasions he passed long periods in Reading and Aylesbury jails. He died on Oct. 8, 1679. Edward Penington (1667–1711), son of Isaac Penington, emigrated to Pennsylvania, where he founded a family. Isaac Penington's stepdaughter, Gulielma Springett, married William Penn.

PENINSULAR WAR (1808–1814). This term is applied to the operations conducted by the British, Spanish and Portuguese armies against the French in the Iberian peninsula during the years above noted. The British make the most of it: first, because they were, with one or two trifling exceptions, their only successful military operations in the whole period 1794–1814; second, because they justly raised British military reputation to the highest point; and third, because they contributed very materially to the exhaustion of France and the downfall of Napoleon.

The immediate cause of the war was Napoleon's endeavour, since he was powerless at sea, to reduce England to submission by starving its trade. With this object he had on Nov. 21, 1806, issued his Berlin decrees, ordering all continental ports to be closed to British subjects. The next thing was to enforce those decrees. The situation seemed so formidable in England that the British ministers thought seriously of abandoning all effort to trade with the old world, and of seeking new markets in Spanish America. England had but two friends in Europe: Sweden and Portugal. Napoleon left it to Russia to deal with Sweden, and resolved to take Portugal in hand himself. In Aug. 1807 he called upon it to comply with his decrees, and being answered by a protest, overawed the weak king of Spain, Charles IV, and his corrupt minister, Manuel de Godoy, into granting free passage for French troops through Spain to Portugal. Moreover, by a secret treaty, signed at Fontainebleau on Oct. 27, 1807, it was agreed that Spanish troops should assist the French, that Portugal should be divided between France and Spain and that a principality should be carved out of it for Godoy. Already on Oct. 19, 30,000 French troops under Gen. A. Junot had crossed the Spanish frontier; under orders from Napoleon, these hastened their march upon Lisbon. After long and painful vacillation between the demands of England and France the Portuguese regent fled to Brazil with the Portuguese fleet, and Junot, with an army reduced by haste and hardship to a mob of undisciplined, half-starved and half-armed stragglers, occupied Lisbon.

Next, Napoleon turned his designs against Spain itself. First he persuaded the king to send 15,000 of his best soldiers to help the French in the Baltic. Next he massed French troops upon the Spanish frontier, the treaty of Fontainebleau allowing him to send 40,000 men through Spain to the support of Junot. In Jan. 1808 he ordered from 70,000 to 80,000 men to cross the marches; in February and March the fortresses of San Sebastian, Pamplona, Figueras and Barcelona were treacherously occupied; by the middle of March there were more than 90,000 French troops in Spain, and on March 26 Murat occupied Madrid as Napoleon's vicegerent and commander in chief. The Spaniards, after a first outbreak of rage against Godoy and the king, accepted the situation in mute stupefaction. King Charles IV abdicated in favour of his son Ferdinand, who threw himself abjectly upon Napoleon's mercy; but Napoleon, setting Ferdinand aside, resolved to substitute for him his own brother Joseph. Murat intimidated his Spanish council at Madrid into requesting, on May 13, that Joseph might reign over them; but meanwhile the Spaniards had realized that they were subjected to France and on May 2 had risen in revolt.

The insurrection at Madrid was ruthlessly quelled by Murat, but the movement spread like wildfire. In province after province a junta, or committee of administration, was appointed. Troops were levied; armies were formed; about 100,000 men were collected in different parts of Spain, all alike brave and enthusiastic, but without arms, discipline, organization or commanders. Portugal likewise rose in revolt, and Junot, cut off by the Spanish insurgents from the French armies in Spain, withdrew the whole of his force into Lisbon. The Spanish province of Asturias sent emissaries to England to ask for help, and meanwhile the governor of Gibraltar, Sir Hew Dalrymple, offered such aid as could be given by British ships and by a force of 5,000 men under Gen. Brent Spencer, awaiting orders in Gibraltar harbour.

Napoleon took action against the Spaniards at once. Their most formidable force lay in Andalusia, on his front, and in Galicia on his right flank; and he judged it further most important to secure the ports on the east coast and to seize the fortress of Zaragoza, as a link of union between his forces in Catalonia and in central Spain. He accordingly detached Gen. P. Dupont with 20,000 men toward Andalusia, Moncey with 9,000 more to advance along the east coast and C. Lefebvre-Desnouettes with 4,000 more to deal with Zaragoza, while Gen. Merle with a smaller column was ordered to restore order on the northern coast. All except Merle failed. On the east coast not only Valencia but Gerona repulsed French attacks; Zaragoza defended itself with desperate tenacity; and Dupont, thanks in part to useful demonstrations made by Spencer's force on the coast, so mismanaged his operations that on July 23 he was forced at Baylen to capitulate with 18,000 men. Had not the Spanish army of Galicia, under Gen. Blake, imprudently accepted battle and been totally defeated at Medina de Rio Seco by J. B. Bessières (July 14), practically all of Napoleon's operations would have been fruitless.

The Campaign in Portugal, 1808.—Meanwhile the British government had in June decided to comply with the Spanish appeal for help. Not many troops were available, for 12,000 had been sent under Sir John Moore upon a hopeless enterprise to Sweden. However, between 10,000 and 11,000 men were embarked under Sir Arthur Wellesley. He was empowered to add Spencer's force to these, and his first objective was to be the Tagus. His information was that Junot had but 20,000 men in all, of which at least 6,000 were at a distance from Lisbon, so he landed without hesitation on Aug. 1 at the mouth of the Mondego. Thence moving south he drove back an advanced French division under Gen. Delaborde at Roliça (Aug. 17) and took up a position at Vimeiro to cover the landing of reinforcements, which were waiting off the coast to join him. Further reinforcements were on their way, including Moore's 12,000 men; but, since Moore, who was senior to Wellesley, had offended the government by returning from Sweden, two officers, Sir Harry Burrard and Sir Hew Dalrymple, had been specially appointed to keep Moore out of the chief command. Burrard appeared off the coast on Aug. 20; and on Aug. 21 Junot with 13,000 men attacked Wellesley, who had 17,000 at Vimeiro, and was hopelessly worsted. Left to himself Wellesley would have captured Junot and his whole army, but Burrard interposed, and before Burrard had held command 24 hours, Dalrymple appeared to supersede him. Though an excellent administrator, Dalrymple was inexperienced and nervous in the field. He would not follow up the beaten French, and ultimately Junot and his army were sent back to France by sea under the convention of Cintra (Aug. 31). The ministry made Dalrymple the scapegoat for the mistakes, mainly its own, which had led to the convention; but at least Lisbon had been secured as a base for future operations.

The British government decided to prosecute the advantage gained. The Spaniards had driven the French behind the line of the Ebro, and four Spanish armies, so-called, under four different commanders, each of them jealous and unskilled. with no commander in chief, were ranged along the river from Tudela to Reinosa, talking big of expelling the enemy from Spain. A space in this line was left for the English, and in September the British government resolved that it should be filled with 40.000 British

troops. Although Sir Harry Burrard had been expressly appointed to exclude Sir John Moore from the chief command, it was now determined to supersede Burrard by Moore. a decision which Burrard received not only with obedience, but in an ideal spirit of loyalty and patriotism. But meanwhile, upon the news of the disaster of Baylen, Napoleon had ordered 80.000 men to march into Spain; early in September he organized the army of Spain into six corps and a reserve, with a total strength of 200,000 men. By the end of October he had not far short of 120,000 effective men on the Ebro; on Nov. 6 he took personal command. The Spaniards likewise had been reinforced by the transport of 9,000 out of Romana's 15,000 men from the Baltic to Santander by the British fleet; but nothing. could give strength to ill-organized and half-disciplined levies. On Oct. 29 one Spanish army was dispersed at Zornosa. On Nov. 10 another was utterly routed at Gamonal, on Nov. 11 and 13 another underwent the same fate at Espinosa and Reinosa; and on Nov. 23 yet another army was signally defeated at Tudela. Briefly, the Spanish army of the left had ceased to exist, and those of the centre and right had been broken and routed. The way to Madrid was open and on Dec. 4 the capital was occupied by the French.

Sir John Moore's Campaign of 1808–09.—Meanwhile Moore, much hampered by want of transport and money, had set his troops in motion at the end of October. He had actually with him about 22,000 men, but a further body of about 18,000 more under Sir David Baird was under orders to sail from England to Corunna; Moore decided that, with the Spanish armies lying between him and the enemy, he might safely effect his junction with Baird by land. While, therefore, he himself moved northeast upon Ciudad Rodrigo and Salamanca, Baird was to strike southeastward from Corunna, and meet him at Valladolid, or even farther to the east. Owing to the lack of roads, however, Moore was obliged to send the cavalry and artillery under Sir John Hope by the valley of the Guadiana, to move eastward through Talavera to Madrid, and thence northwestward through the Escorial pass of the Guadarrama—a very considerable detour. On his march northward Moore received only disquieting news of the Spanish dispositions, and upon reaching Salamanca on Nov. 14 he heard definitely that the Spaniards had been routed at Zornosa, and that the French were advancing on Valladolid. Plainly, it was madness to think of advancing farther to effect his junction with Baird, and he therefore halted and wrote to inform the government that the plan of campaign which they had prescribed for him was visionary, that the Spaniards themselves had no definite plans, and that it was impossible for him to get any authority in Spain to take any notice of his presence.

Baird, meanwhile, had reached Corunna with his infantry on Oct. 13, but had found his arrival anything but welcome to the junta of Galicia. However, by Nov. 13 the whole of his cavalry had also joined him. and by Nov. 22 he had reached Astorga. There he received news of the rout of the Spaniards at Zornosa and Espinosa, not from any Spanish source—for the Spaniards ignored his existence—but from his own intelligence officers; and he made up his mind to retreat. On Nov. 28 Moore at Salamanca heard of the defeat of the Spanish right at Tudela, and at once decided to retire upon Portugal. He therefore sent orders to Gen. John Hope, who was already across the Guadarrama, to hasten to him with all speed, and to Baird to fall back to Corunna and join him at Lisbon by sea. Baird began his retirement at once, and Hope, by a forced march by way of Avila, Fontiveros, Peñeranda and Alba de Tormes. regained touch with Moore on Dec. 4. Urgent messages now reached Moore from J. H. Frere. the British minister at Madrid, to make an effort to save the capital, which was preparing for a desperate resistance; Moore, though distrustful, countermanded his orders to Baird, and bade him return to Astorga. On Dec. 9 he learned of the fall of Madrid, and he then resolved to make a dash upon the French communications at Burgos. On Dec. 13 he moved his headquarters from Salamanca northeastward to Alaejos, where, by great good fortune, an intercepted dispatch from L. A. Berthier, Napoleon's chief of staff, to N. J. de Dieu Soult, gave him the key to the French dispositions and showed that Soult's corps, little over 20,000 strong, lay isolated on the Carrion about 90 mi. northeast of him. Incidentally, he learned that the French in Spain now numbered 250,000, but, though fully alive to the risk, he resolved to advance and strike at Soult. Moving northward he joined hands with Baird at Mayorga on Dec. 17, his advanced parties more than once brushing against the French on the way, and marched upon Sahagun, where, on Dec. 21, his cavalry fought a brilliant little action against the French horse. On Dec. 23 he had made all his preparations for falling upon Soult on the morrow, when intelligence reached him that the French under the emperor in person were moving against him in great force. Thereupon he gave orders for immediate retreat. He had been expecting that he would have to "run for it" and now the time had come.

Napoleon had been fully convinced that the British had withdrawn into Portugal and could hardly give credence to Moore's audacity. He realized it, however. on Dec. 19, and taking 42,000 men in hand himself, and entrusting as many more to Junot and Soult, he flew to the pursuit, hoping to make an end of Moore by a great enveloping movement. Moore retired upon Corunna, but the emperor could never overtake him, and on Jan. 1, 1809, he made over the chase to Soult. The discipline of the British began to fail very early in some regiments, but Moore hustled them on, fighting many petty rearguard actions on the way, and after much hardship in crossing the mountains of Galicia, on Jan. 11, brought his army, sadly thinned indeed but safe, to Corunna. The transports having been delayed in their arrival by foul winds, he was obliged to take up a position to cover his embarkation. The ships arrived on Jan. 14, and on Jan. 16 Soult, with 20,000 men and 40 guns, attacked Moore with 15,000 men and 9 light cannon. Soult was repulsed, but Moore was mortally hurt; Baird was disabled by a severe wound, and it fell to General Hope to re-embark the troops and bring them safely to England. The result of the campaign seemed to be a failure, but Moore had dislocated the whole of Napoleon's plans and, moreover, had caused him to scatter his troops far too widely over the surface of the peninsula, with fatal consequences.

Campaign in Portugal and Spain, 1809.—Austria was preparing again to take up arms against Napoleon, and the question was whether England should act in its support. Moore had quite correctly declared the Portuguese frontier to be indefensible. Wellesley, who was now consulted, opined that, if the Portuguese army and militia were reorganized and 20,000 British were added to them, the French would need 100,000 men to conquer Portugal, and that if the Spaniards continued to resist, the French could not spare so many. The cabinet resolved to make its main effort on the Scheldt, and only with great difficulty Castlereagh persuaded them to send Wellesley out to the peninsula and to give him 26.000 men. Wellesley reached the Tagus at the end of April. He found that Soult, after his march to Corunna, had invaded Portugal and taken Oporto; that M. Ney, who had also joined in the chase of Moore, was subjugating Galicia and that C. Victor-Perrin was lying at Merida within 40 mi. of the eastern Portuguese frontier, threatening invasion by the line of the Tagus. The Spaniards had not done well during the winter. Gen. St. Cyr had beaten them badly in Catalonia, and the army of the centre had sustained defeats at Ucles (Jan. 12), Ciudad Real (Feb. 18) and Medellin (March 28). There was nothing to stop Soult except some disheartened Portuguese levies, nor to check Victor except the demoralized army of Gen. Cuesta, which had just been beaten at Medellin. However, both Soult and Victor were stationary; their headquarters were 200 mi. apart; and, although they were supposed to be acting in concert, they were not in communication with each other. Viscount Beresford and other British officers had by this time brought 15,000 Portuguese troops into a fairly efficient condition; with these and 25,000 British, Wellesley, on May 7, advanced northward against Soult. The marshal, suspecting nothing, had scattered his troops in considerable depth to south and north of Oporto, and Wellesley tried to cut off the southern detachments, but failed. He crossed the Douro just above Oporto, however, under Soult's very nose, and catching the French army by surprise drove it away as a mere disorderly mob, which would have been destroyed but for the timidity of Gen. Murray, one of Wellesley's

divisional commanders. Following Soult, Wellesley drove him north through a miserable country; and only by desperate marches and after desperate perils did the marshal finally make his way to Lugo, having lost 6,000 men and the whole of his artillery. He owed his safety mainly to the fact that Wellesley had, on the 18th, been obliged to abandon the pursuit, having received news that Victor was in motion on the Tagus.

Victor's movement proved to be nothing but a reconnaissance in force, designed to obtain intelligence of Soult; and King Joseph at Madrid, having learned, not from Soult but from Paris, of the mishaps which had befallen that marshal, recalled Victor up the Tagus to Talavera. Soult, having called upon Ney at Lugo to re-equip his army, the two commanders and their respective armies had quarrelled violently, with the result that joint operations planned between them against the Galician insurgents came quite to nought, and the French were driven out of Galicia for ever. Rather by accident than design Ney and Soult drifted southward; and by the beginning of July their corps, as also that of Mortier, some 50,000 men in all, were assembled at Astorga, Benavente and Valladolid within 50m. of the valley of the Tagus. Joseph had in and near Madrid 27,000 men, and Victor's corps numbered about 23,000; so that he was in a position at short notice to concentrate at this time 100,000 men in that valley. Such was the situation when Wellesley, having returned to Abrantes from northern Portugal, proposed that he, with 23,000 British, and Cuesta with as many Spaniards, should march on Madrid by way of the Tagus. The supreme Government of Spain eagerly accepted the suggestion, undertaking to provide everything; and, quite unconscious of the storm that was gathering before him, Wellesley marched (June 27) to join Cuesta at Plasencia. On July 17 the two armies advanced. The march was one long story of wrangling and distress. Cuesta was old, infirm, incompetent and obstinate. His army was without order or discipline; and no measures had been taken for transport and supply. Victor fell back before the allies till reinforced by Joseph to a strength of 46,000 men; then the allies fell back in turn, the Spaniatds turning their retreat into a flight. With much difficulty Wellesley stopped the panic and took up a position at Talavera (July 27). Victor attacked the key of the position on the same night and was repulsed; and renewing the onslaught in force on the next day was again repelled with a loss of 7,000 men and 17 guns. Wellesley himself had lost 5,000 men, but being reinforced by the Light Brigade on the 29th, was eager to advance. Cuesta fortunately refused, and on Aug. 1 Soult came down the pass of Baños, which Cuesta, in spite of Wellesley's urgent entreaties, had declined to defend, into the valley of the Tagus. Wellesley, awaking to his danger, abandoned his wounded, crossed the river by the bridge of Arzobispo, and led his starving army back to Portugal by way of Badajoz. Though the preoccupation of Napoleon with the Austrian war justified Wellesley in making an extraordinary effort, he had taken an unwarrantable risk. He had been warned that the Spanish troops were worthless and their supply system chaotic; and he had disregarded the warning. Having now learned his lesson, he resolved to have nothing to do with the Spaniards in the future. However, for his victories he was created Viscount Wellington.

Campaign of 1810–11.—During the winter Wellington thought matters out. The Spaniards, untaught by experience, embarked on a new winter campaign which resulted in the total defeat of Cuesta's successor, Areizaga, at Ocaña, (Nov. 19). But out of this evil came good. Soult and Joseph, from sheer cupidity, invaded Andalusia, failed from carelessness to master Cadiz and found themselves set down to the siege of a place which, without a naval force, was impregnable. Wellington gladly spared a few troops, which were made up from England to 8,000, to aid in the defence of Cadiz. The more troops squandered by the French in useless enterprises, the better for him. But the situation was serious. Napoleon had reduced Austria to submission at Wagram and would doubtless use every available soldier to master the Peninsula in 1810. Yet Wellington, so long as he had Lisbon, saw his way to thwart him. The French had three things against them. First, the sea was not open to them. Secondly, the Spanish population was to a man against them, and though the Spanish armies were valueless, the people were always cutting off stragglers and small parties, insomuch that a letter could not be sent by the French with a smaller escort than 25 men. Thirdly, the French armies always lived on the country. Wellington reasoned somewhat in this fashion: "I have to encounter 300,000 men with 40,000. I must train the Portuguese army with the help of English officers so as to make my 40,000 into 50,000." This task he committed to Beresford. "The French," he argued next, "live on the country and therefore cannot stay long in one place. I have the sea to furnish me with all that I want; and if I organize my service for feeding my army perfectly, I can go when I please and stay where I wish as long as I wish." So he set himself to organize an efficient service for transport and supply. "But," he went on, "everything depends on my base on the sea, Lisbon, and I must make Lisbon impregnable." He did so by throwing up the fortified lines of Torres Vedras, 25m. north of the city. "Now," he argued, "if I have 50,000 men the French must bring 60,000 to beat me. The removal of 60,000 men must weaken them in some part of Spain, and there the Spaniards will make trouble. If they advance against me, I shall retire before them, accepting battle if they give me a favourable opportunity, for the missile action of my lines is superior to the shock-action of their columns; but, if not, retreating steadily till I reach my fortified lines. They cannot wait long before them, because they live on the country and will exhaust it. They *must* retreat in time, through territory which they have already eaten up, and I, carrying my food with me, can pursue them and cause them heavy loss. I can go on playing this game as long as they like. I *must* win in the end. The only trouble is that, though the natural access for the French to Portugal is from the north-east, by way of Salamanca and Almeida, they can enter it also from the east by the line of the Tagus, so that I must divide my force to secure both routes. If they advance by both routes in strength, it may be awkward; but that is unlikely. The way by the Guadiana, south of the Tagus, is luckily sealed up for the present by the Spanish fortress of Badajoz. But even if driven from Portugal, I can land my army at Cadiz and play the same game there. I *must* win in the end, and the more certainly because the French generals are always quarrelling among themselves, and pay no obedience to King Joseph, their nominal commander."

And so it came about. Napoleon gave Masséna the command of 65,000 men as the army of Portugal, and Soult the command of as many as the army of Andalusia. Wellington with 18,000 British and 14,000 Portuguese awaited Masséna near Almeida, leaving Gen. Hill with about 20.000 men, mostly Portuguese, to guard the route by the Tagus. Masséna first besieged and captured Ciudad Rodrigo, which barred his way (July 10), and then pushed his advanced troops across the frontier. Gen. Craufurd with the Light Division engaged these most unnecessarily on the Coa (July 23), happily without serious mishap, though the odds against him were four to one. Then Masséna advanced, and Wellington retreated steadily before him. At Bussaco, having summoned Hill to him, Wellesley offered battle with 50,000 men in a very strong position. Masséna accepted it (Sept. 27) and was repulsed with 4,600 casualties, whereas Wellington's did not exceed 1,250. Then the retreat began again, and Wellington entered the lines of Torres Vedras (Oct. 10). Masséna lingered before them for a month, till compelled by want of subsistence to retire 30m. to Santarem. Here he waited with persistence, for it was expected that the British Ministry would fall and be supplanted by the Whigs, who would certainly withdraw the British army from the Peninsula. It was an anxious time for Wellington, for in Jan. 1811, Soult appeared with another army before Badajoz, and the Spanish army on the spot offered battle, which Wellington had begged that it would on no account do, and was, of course, beaten. Wellington detached Beresford with ten British battalions and some Portuguese to watch Soult; and at last, on March 5, Masséna began to retreat. Wellington followed him up with 44,000 men. but was obliged immediately to send 8,000 of them to Beresford, since Badajoz had (March 10) been treacherously surrendered to Soult. With the remainder he con-

tinued his pursuit; and by April 8 Masséna had recrossed the Portuguese frontier on his way to Salamanca, with his army in rags, starved and demoralized. The campaign had cost him 25,000 men killed, captured, or dead from sickness.

Campaign of 1811.—Meanwhile Sir Thomas Graham and the Spaniards had fallen upon the besiegers of Cadiz, and the British had fought a brilliant action against them at Barrosa (March 5). Thereupon Soult hurried back from Badajoz to Andalusia; and Wellington, reinforcing Beresford, set him down to beleaguer Badajoz (April 22), with the option of fighting Soult or refusing battle as soon as the marshal should march back, as he certainly would, to relieve the fortress. He then returned to his own army, which had stopped its pursuit of Masséna on the Portuguese frontier, and was now covering the blockade of Almeida. Masséna advanced from Salamanca to relieve it, and Wellington offered him battle (May 3) at Fuentes de Oñoro, just across the Spanish frontier. Masséna assailed the village on the 3rd and was repulsed with 6jo casualties, Wellington's not exceeding 250. On the 5th Masséna made a geceral attack; and then, as Wellington said, "if Boney had been there, we should have been beat." But, though Wellington's position was defective, the steadiness of his troops enabled him to hold his own. His casualties were 1,530, Masséna's 2,200; and on the 7th Masséna retreated to Salamanca, leaving Almeida to its fate. The fortress was presently abandoned and blown up by the French, the garrison, to Wellington's great vexation, escaping. Masséna was shortly afterwards recalled and replaced by Marmont; but Wellington always considered Masséna the ablest of all the French generals with whom he had to do in the Peninsula.

Meanwhile, for want of proper artillery, Beresford's siege of Badajoz had not prospered. Soult with 24,000 men and 50 guns returned from Andalusia to its relief in May, and on the 16th Beresford, with 8,000 British and 21,000 Spaniards, engaged him at Albuera. Beresford mismanaged the action and would have lost it but for one of his staff, Capt. Henry Hardinge. He was saved by the steadiness of his British troops, who suffered 4,000 casualties. The Spaniards lost 3,000 and Soult 8,000. The marshal retired, and all was safe for the present; but Wellington, with his little force, had actually fought two general actions on the two main lines of entry into Portugal—a very severe strain upon his strength.

He now (May 29) re-opened the siege of Badajoz with bad Portuguese cannon, for, living in almost daily dread of orders to evacuate the Peninsula, he had all this time kept his own siege-train on its ships in Lisbon harbour. On June 10 the prospective junction of Marmont with Soult obliged him to raise the siege and withdraw his troops, 37,000 British and 17,000 Portuguese, to the Caia, a little to west of Badajoz. Soult and Marmont having joined forces at Merida (June 17) advanced against him with nearly 60,000 men, but decided to leave him alone. The two marshals then quarrelled; and Soult returned (June 28) to Andalusia, leaving troops which raised Marmont's strength to 43,000 men. On July 13 Marmont withdrew to the valley of the Tagus. Wellington then landed his siege-train, and moved north to the blockade of Ciudad Rodrigo, leaving the bulk of his force under Graham and Hill to protect the eastern frontier. Marmont, collecting 58,000 men, marched to its relief, and Wellington, calling up troops which gave him a strength of 30,000 British and 16,000 Portuguese, raised the blockade and awaited him. On Sept. 25 hfarmont made a reconnaissance in force which brought on a lively little combat at El Bodon, but he was afraid to go farther, and on Oct. 1 retired to his cantonments on the Tagus. The campaign ended by a spring of Gen. Hill upon an isolated French detachment at Arroyo Molinos, to the north-east of blerida, when 2.000 French were killed or captured at a cost of 100 British casualties (Oct. 28).

Campaign of 1812.—Throughout the perilous year 1811, when Wellington had borne the brunt of the attack of the armies both of Portugal and Andalusia, the Spaniards had accomplished very little. But their armies had now been in large measure replaced by guerrilla-bands of irregulars, frequently under very able leaders, which made the task of holding Spain in subjection more difficult to the French than ever. To paralyse one of these chiefs, Ballesteros, in the south, Soult (Dec. 1811) directed an attack upon one of his principal bases, Tarifa, which was repelled with trifling loss to the little garrison, half Spanish, half English, but cost the French 500 casualties. And now Napoleon, intent on the invasion of Russia, decided that he would draw upon Marmont's army to subdue the eastern provinces and Andalusia thoroughly, and then turn all his strength upon Portugal. Wellington for his part had planned the capture of Ciudad Rodrigo, so as to close the north-eastern gate of Portugal; and on Jan. 8 he invested the place, battered a breach and on the 19th stormed it out of hand, with no more than 500 casualties, before Marmont could even assemble troops to save it. Marmont was left gasping with dismay. Ciudad Rodrigo, with a garrison of 5,000 raw Spaniards, had defied Marshal Ney for 25 days, and Wellington had snatched it from a French garrison in 12 days. Wellington then dispersed his trcops innocently into cantonments, as did Marmont. being unable to keep them concentrated for want of supplies. On Feh. 16 Wellington advanced to the siege of Badajoz, stationing Hill at Merida to cover the operation from the east. Ground was broken on March 17, a breach was battered, and on April j the place was taken by escalade, the storming parties having failed in their assault. The capture of Badajoz cost Wellington 5,000 casualties, and for 48 hours the troops were out of all control; but the gain was great, for he had captured the French siege-train at Ciudad Rodrigo and their pontoon-train at Badajoz. He then detached Hill to destroy the French bridge of boats over the Tagus at Almaraz (May 17), thereby reducing Soult and Marmont to the bridge of Toledo for communication between their armies; and then leaving Hill at Merida with 22,000 men to parry any movement of Soult, he advanced (June 13) with 28,000 British and 15,000 Portuguese against Marmont at Salamanca. The marshal fell back to the Douro till, being reinforced, he took the offensive (July 16) and manoeuvred against Wellington's communications. On more than one day the two armies raced each other in two parallel columns, only a few hundred yards apart, ready to wheel into line and engage at any moment. At last on July 22 Marmont made a false movement, leaving his left wing in isolation, and Wellington sprang upon him instantly and inflicted a crushing defeat. He had 50,000 men, including Spaniards, and 60 guns; Marmont had 47,000 and 78 guns The French losses were 14,000 men, 20 guns and two eagles; Wellington's casualties were 5,000. The French retreated north-east upon Burgos, and Wellington, having entered Madrid in triumph (Aug. 12) invested Burgos. The siege was most unskilfully conducted; and Wellington was obliged to raise it (Sept. 22) upon the advance of the French against him in force from all parts of Spain. With difficulty he gained time for Hill to join him as he retreated, and on Nov. 11, with 68,000 British, Portuguese and Spaniards, he offered battle to 90,000 French on the field of Salamanca. The French declined the challenge; and Wellington pursued his retirement, with some sufferingto his troops but little molestation from the enemy, to Ciudad Rodrigo, where the campaign came to an end (Nov. 19). His losses in the retreat were 9 ooo, but foreign critics count it his greatest achievement. The advance on Madrid was no doubt a mistake; but the campaign had been brilliant. It had cost him 20,000 men; but it had cost the French 40,000 and some hundreds of guns, and lastly it had cleared the French out of all Spain south of the Tagus.

Campaign of 1813.—The new year found Wellington an earl and a marquis, and Napoleon the poorer by some 400,000 men lost in the snows of Russia. The emperor was fain to draw many troops from the Peninsula, and of those that remained the unfortunate King Joseph had less control than ever. The *cortes* of Spain, on the other hand, had nominated Wellington commander-in-chief of their armies, of which a contingent. 20.000 strong, was under his immediate orders for the coming campaign. Furthermore, in 1812 the British Government had landed some 9,000 troops from the Mediterranean on the east coast of Spain —a sphere beyond the reach of Wellington—and these. with the addition of 20,000 Spanish troops in English pay, seemed likely to give trouble to the French in that quarter. Their commander,

however, Sir John Murray, the general who had failed Wellington on the Douro in 1809, was a feeble creature of whom little could be expected. He succeeded in repelling an attack by Gen. Suchet at Castalla (April 12) and with a little enterprise might have turned his success to great account. His army, though composed of five different nations, was 17,000 strong, whereas Suchet had at most 15,000; and Suchet's casualties in the action numbered 1,000 against Murray's 500. But Murray allowed the opportunity to slip; and a subsequent operation which he undertook against Tarragona was so disgracefully mismanaged that it brought Murray to a court-martial.

This, however, was only a minor incident in the Peninsular operations. In the main field Wellington marched from Portugal with a full strength of about 100,000 men, 47,000 of them British and the remainder Spanish and Portuguese. The Spanish guerrilla-leaders were so active and so formidable in Biscay and Navarre that they found full employment for no fewer than four French divisions under Gen. Clausel. Thus weakened, the French army could make no stand on the Douro, but fell back north-eastward, abandoning Burgos, to the line of the Ebro. Wellington forced it to retire by turning its northern flank; and Joseph, with Marshal Jourdan for his adviser, decided to fight a delaying action in the basin south of Vitoria, to cover his further retreat. He had only 50,000 men, for Clausel, in spite of repeated orders, had not joined him; whereas Wellington had 72,000; and had Wellington's orders been followed few of the French would have escaped. As things fell out Joseph got away with the loss of all his artillery, 150 pieces, and every scrap of baggage, but of no more than 7,000 men, Wellington's casualties being 5,000. The French retreated over the Pyrenees into France, and Wellington, having pursued them as far as Pamplona, decided to abandon the chase. It was essential to master the fortresses of Pamplona and San Sebastian before he could advance farther, and until these should fall he occupied the main western passes of the Pyrenees on a front of about 50m. south-eastward from San Sebastian. Pamplona was blockaded by the Spaniards, and the siege of San Sebastian, a tiny fortress, was entrusted to Sir Thomas Graham with one British division and one Portuguese brigade.

Meanwhile Napoleon had displaced Joseph, sending Soult to take command of all the troops that had retreated from Spain. The marshal arrived on July 13, and having received fresh artillery and restored, more or less, the organization and discipline of his 70,000 men, he on July 20 launched a great counter-attack along the three main valleys of the Pyrenees which lead to Pamplona. He met with some initial success, for Wellington's divisional generals were always rather helpless unless their commander-in-chief was at hand; but Soult's plans were not fulfilled as he had intended, and it was rather by accident than design that on July 26 he found himself at Sorauren, facing 16,000 of Wellington's troops with 30,000 of his own men. He attacked, but was repulsed with heavy loss, and Wellington then taking the offensive in his turn drove the French back after six days' fighting, as a mere demoralized mob, to their former position on the northern slopes of the Pyrenees. Soult admitted a loss of 13,000 men, whereas Wellington's did not exceed 7,000.

In the course of these operations the first assault on San Sebastian was delivered on July 25, and repulsed with a loss of 400 men. Want of ammunition then compelled the turning of the leaguer into a blockade till Aug. 22, when the siege was renewed; and on the 31st the place was successfully stormed though at great cost of life. First and last the casualties at San Sebastian were over 3,700. On the day of the storm Soult made a final effort to save the fortress, but was beaten back with a loss of 3,800, the casualties of the allies being 2,600. The brunt of the two days' fighting fell upon the Spaniards, whose losses exceeded 1,600. Soult now resolved to stand on the defensive and fortified lines of excessive extent to the south of the Bidassoa. These Wellington attacked on Oct. 7, and carried with little difficulty after three days' combat, wherein both sides lost about 1,600 men. Soult then began to fortify another position a little to the northward on the Nivelle, and Wellington, bringing his troops forward to the high ground to north of the Bidassoa, halted till the fall of Pamplona should allow him to advance farther.

He was not quite happy notwithstanding all his successes. His relations with the Spanish Government were such that he had resigned his command of the Spanish armies (Oct. g), and with the Portuguese Government they were little better. It was clear to him that, in case of a reverse, retreat into Spain would be out of the question. Moreover, though Napoleon's star was already on the wane, Wellington as yet knew only that he was standing up to his enemies in Germany; and it was always possible that he might win a great victory, come to terms with them, as his custom was, and return to launch all his forces against his foes in the Pyrenees. Moreover, on the east coast of Spain the latest British commander, Lord William Bentinck, had contrived to sustain at Ordal a reverse at the hands of Suchet (Sept. 13). However, on Oct. 25, Pamplona fell, and on Nov. 10 Wellington attacked Soult's position on the Nivelle and carried it, capturing 69 guns; the casualties, 4,300, being about the same on both sides. He was now fairly established on the plains of France, and recognized that it was vital to him to have the population on his side. He could by this time count upon the good behaviour of his own troops towards the inhabitants; but the Spaniards had suffered too much at the hands of the French and could not be kept from maltreating them. "With 40,000 Spaniards I don't know where I should stop," he wrote at this time, "but if they plunder they will ruin all." Reluctantly and regretfully he sent most of them back to Spain.

On Dec. 8 came the great news that Napoleon had been utterly overthrown at Leipzig, with orders that Wellington was to press the invasion of France. Thrown back from the Nivelle, Soult had entrenched himself on the river Nive, south of Bayonne, and here Wellington attacked him on Dec. 9. The operations lasted five days, Soult counter-attacking without success on the 10th and 11th, and were greatly complicated by the sudden rise and fall of the rivers, fed by the glaciers of the Pyrenees. Owing to the destruction of a bridge by a flood Soult was able to attack with 30,000 men and 30 guns a force of 14,000 men and 14 guns under Gen. Hill, which stood in isolation about St. Pierre (Dec. 13), but after a very severe action he was repulsed, his losses being 3,000 and the British 1,700. The casualties on the French side for the five days were 5,600 and of the allies 5,000.

Soult then withdrew to a position on the Adour; and meanwhile the European situation again gave Wellington anxiety. The allies after their victory at Leipzig had all fallen at variance with each other, and their military plans seemed to Wellington to be insane. Napoleon, moreover, was negotiating for the detachment of Spain from the side of the allies, in order to withdraw Suchet's troops thence. On this latter point Wellington's mind was soon set at ease (Jan. 9, 1814) through the rejection of Napoleon's overtures by the Spanish Government; but his misgivings as to the military projects of the allies were justified. However, after much delay through bad weather, by a series of skilful movements (Feb. 17–24, 1814) he manoeuvred Soult out of his position on the Adour, crossed the river—500 yards wide—on a bridge of most ingenious construction, and thus forced Soult into the open. Leaving Sir John Hope to invest Bayonne and the strong garrison installed there by Soult, Wellington followed the marshal in his retreat eastward, overtook him at Orthez (Feb. 27), and with 34,000 men against 37,000, drove him off with a loss of 4,000 killed, wounded and prisoners, his own casualties being just under 2,000. Soult continued his retirement eastward with Wellington in close pursuit, till days of heavy rain brought the British to a standstill, and contact was lost between the two armies (March 3). Wellington took the opportunity to occupy Bordeaux as his new base on the sea, but Soult hurried his troops as a disorderly mob towards Toulon, not halting till he reached Tarbes (March 8). Then at last he realized that his enemies were stationary some 35m. to the north-west of him, and on March 13 he moved up to Wellington's outposts as if to attack, but thought better of it and on the 16th moved away slowly to southward. He had orders from Napoleon to keep his field of action as near as possible to the Pyrenees, and endeavoured thus to fulfil them. For all that he knew the emperor would yet hold his own.

These had in fact been most critical days farther north. The Prussians had given Napoleon an opportunity, and he had struck at them a succession of telling blows. Austrians, Prussians and Russians alike were terrified, for all that they outnumbered him by three to one, and staggered back in dismay. Matters remained in doubt till March 25, when Napoleon resolved to manoeuvre against the rear and communications of the allies, and they in turn plucked up courage to ignore him and continue their march to Paris.

On March 18 Wellington, with a force raised to nearly 50,000 men by the arrival of a contingent of Spaniards, resumed his pursuit of Soult and on the 19th was constantly engaged with his rearguard. On the 20th Soult fought a useless little combat at Tarbes, which only delayed his retreat to no purpose, and compelled him to take the longer of two roads to his next point, Toulouse. Wellington followed the shorter road, and Soult, in order to anticipate him, was compelled to hurry his wretched troops on with a speed which reduced them to a rabble. Nevertheless Wellington moved on slowly and cautiously. For one thing the rain was incessant, but even more disturbing was a report which had reached him that Napoleon had fallen back to Orléans. This might mean that he intended to join Soult and raise all southern France against the British and their allies, which would be a serious matter indeed. Not till the 26th did he come up before Toulouse, unaware, of course. that on the previous day Napoleon's doom had been sealed.

The position taken up by Soult was very strong, and could not soon be approached without preparatory operations of extreme delicacy. But, having a beaten army before him, Wellington took every imaginable liberty. and finally attacked on April 10 in a most primitive and hazardous fashion. His casualties, 4,000 men, were twice as great as Soult's, and the French later were inclined to claim the fight as a victory. But Soult knew better and, evacuating Toulouse on the 12th, continued his retreat. On that day news reached Wellington of the fall of Napoleon. He at once informed Soult, but, through no fault of the marshal, the garrison of Bayonne made a sortie on the night of the 14th, which cost them 900 and the allies 800 casualties. This was the last blood shed. On the 18th an agreement for the suspension of arms was signed and the Peninsular War was over.

The heroes of the war were, whatever the British may think, the Spaniards. It is true that their provisional Government was inefficient, their improvised armies of little military value, and their most prominent commanders, such as Cuesta, Castaiios and La Romana, incompetent. Their heads were turned by their initial success at Baylen, when they had to do with a frightened man, and they were always trying to repeat Baylen with raw levies under unskilled leaders. There were, moreover, endless jealousies between rival authorities, provinces and commanders. But the spirit of the nation as a whole was beyond praise, and was quickened by a savage hatred of the French. Every French straggler's throat was cut and small bodies of men were destroyed without mercy. The French tried to quell this spirit by reprisals —burning villages and shooting villagers—but the Spaniards retorted in kind, and before the close of 1808 both sides had exhausted their powers of terror, the French by burning Spaniards alive in their houses, the Spaniards by sawing a captured French general asunder. But the losses thus inflicted upon the French were very formidable. Marbot reckoned the average number of deaths of French soldiers, from all causes, from the beginning to the end of the war as 100 daily. From the year 1812 the guerrilla-leaders took matters very much out of the hands of the regular military commanders, and proved to be much more efficient than the regular generals. These leaders were drawn from all classes—one of the best was a priest—and, as their followings swelled to three, four and even five thousand men of all three arms, they became most dangerous opponents. Their knowledge of the country in the wild mountainous districts which they preferred gave them enormous advantages over their enemies, while if closely pressed they could disperse for the time and reassemble when the peril was over. Their quality varied very greatly. Some were composed of every description of desperate adventurer, not excluding British and French deserters, and were rather wild. Others were under far stricter restraint. At least one was subjected to discipline as stern as that of Cromwell's Ironsides, and began every day with mass. Taken altogether they wrought great things for the liberation of their country, and were perhaps the best expression of the national will to victory. But the sufferings of Spain from French oppression and extortion and from the ravages of war were terrible. They were the source of many of her troubles during the 19th century, and she has not yet, perhaps, recovered from the effects of those awful years. But she has good right to be proud of her *Guerra de Independencia.*

In Portugal likewise the national spirit was admirable. There is no more frugal, patient, docile, industrious man than the Portuguese peasant, and with British officers in the higher regimental ranks to superintend his training, he made an excellent soldier. When he failed, as at one moment he did, it was owing to his Government's neglect of him; but when, in response to British protests, that fault was amended, the Portuguese soldier speedily recovered himself. The Portuguese are still proud of a phrase written by Wellington from the Pyrenees in 1813, in which he described their countrymen as "the fighting-cocks of the army." It must be added, that when once the French had been driven across the Pyrenees, the Portuguese began to manifest considerable jealousy of the British officers in their army, and that Wellington's efforts to obtain some of his old Portuguese regiments for the campaign of Waterloo failed completely. Still this was, perhaps, no more than natural. The Portuguese, like the Spaniards, suffered terribly from the war and still suffer from it. They have, however, retained two things British—their rule of the road and their bugle-calls.

The fact, nevertheless, remains that, without the little British army under the command of Wellington, Spaniards and Portuguese could hardly have worked out their deliverance. At first, as has been seen, Wellington did not realize all the difficulties of the problem set him; but after the experience of 1809 he was under no illusions, and there and then thought out the solution. His first task, however, was to train his own troops, for the army had no regular administrative services in those days and indeed was subject to three different departments—the cavalry and infantry under the commander-in-chief and War Office, the artillery and engineers under the Board of Ordnance, and supply and transport under the Treasury. The last named was that which gave him most trouble, for the Treasury's commissaries, even after 14 years of war, had little experience of the needs of an army in the field; and on landing on the Mondego in 1808 he was obliged to draw up for them a complete table for the hiring and organization of transport. Roads in Portugal hardly permitted the use of wheeled vehicles; and he was obliged later to form his transport entirely of pack-mules, which he gradually brought up to a perfect system.

As has been seen, this formed an essential part of his plan for getting the better of the French, but it was also the principal means to the great end of discipline. Soldiers regularly fed had no excuse for helping themselves, and no commander was more keenly alive than Wellington to the demoralizing effects of marauding, nor more resolute to check it. Unfortunately the House of Commons, in defiance of all military opinion, had insisted in 1805 in altering the procedure of regimental courts martial, with the result that for a long time these courts were ineffective for enforcing discipline. It was the uncertainty of punishment which allowed the men to get out of hand in the retreats from Talavera and from Burgos, and after the assaults on Ciudad Rodrigo, Badajoz and San Sebastian; and indeed it was not until Wellington in 1812 imported a lawyer to help him through the intricacies of the new procedure that discipline began to improve. The establishment of a corps of military police—the first of its kind in the British army—materially contributed towards the same object, with the result that the behaviour of the British troops in France was exemplary. Thus it came about that the French peasants sold their produce and their cattle to the English commissaries, while Soult and their own countrymen went away empty. Thus also it was that at the conclusion of the war a British division marched

almost the whole length of France without a single complaint of any French inhabitant against a British soldier.

In addition to the transport and supply service, Wellington gradually trained a staff of extreme efficiency with an intelligence department of great excellence. In other respects his staff required much training from him, but improved steadily. When the army latterly swelled to some 100,000 men of all nations it was divided, practically, into three corps of which one was under Wellington's immediate command; and the staff proved itself perfectly competent to handle it.

With the help of Sir James McGrigor, the father of British military hygiene, Wellington brought the organization and working of the medical service to a pitch of perfection till then unapproached in any European army.

In the matter of tactics, when occupying a defensive position he always hid away his troops on the reverse side of a hill. one reason for the cautiousness of the French generals, in the later stages of the war, in offensive movements against him. His habit of meeting French columns with English lines is too well known to need more than mere mention. In respect of artillery, the 12-pounders, called by Napoleon his "pretty girls" — were of greater range and calibre than any of the English field-pieces. But the English had the spherical case-shot invented by Maj. Shrapnel, which enabled the English gunners to rain grape-shot upon an enemy at long ranges.

To come last to the French, their misfortunes were due mainly to the injustice of their cause, to the fact that sea-transport was denied to them, to their dependence upon the invaded country not only for subsistence but for money, to the jealousy and cupidity of their generals, and to Napoleon's great blunder in endeavouring to control the operations from a distance instead of appointing a commander-in-chief upon the spot and insisting that he should be obeyed. No attempt was made to conciliate the Spaniards and much was done to exasperate them, with the result that the invaders were loathed beyond human bounds. The closing of the sea compelled the transport of all stores of war to be made by land, which was a great strain. Subsistence upon the country again frequently meant that the stronger men took such food as was to be obtained, while the weaker died of starvation.

Again for want of a commander-in-chief the French operations were ill-concerted and executed with ill-will. Every French general wished to be independent and many of them thought only of filling their pockets. High commanders, again, set the example of taking women into the field. From all these causes discipline suffered; the morale of the French troops deteriorated; and by 1812 every French commander was afraid to meet the British. As Napoleon drew soldiers from the Peninsula to make good his losses in Russia, the quality of Soult's force sank lower. By the end of 1813 the French army in southern France had become almost contemptible.

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PENITENTIAL, a manual used by priests of the Catholic Church for guidance in assigning the penance due to sins. Such manuals played a large rôle in the early middle ages; they were mainly composed of canons drawn from various councils and of *dicta* from writings of some of the fathers. Disciplinary regulations in Christian communities are referred to from the very borders of the apostolic age, and a system of careful oversight of those admitted to the mysteries developed steadily as the membership grew and dangers of contamination with the outside world increased. The treatment of the lapsed produced what has frequently been called the first penitential, the *libellus* in which, according to Cyprian (*Ep.* 51), the decrees of the African synods of 251 and 255 were embodied for the guidance of the clergy in dealing with their repentant and returning flocks. This manual, which has been lost, was evidently not similar to the code-like compilations of the 8th century, and it is somewhat misleading to speak of it as a penitential. Certain patristic letters had acquired almost the force of decretals; the most important were the three letters of St. Basil of Caesarea (d. 379) to Bishop Amphilochius of Iconium containing over eighty headings.

Three things tended to develop these rules into something like a system of penitential law. These were the development of auricular confession and private penance; the extension of the penitential jurisdiction among the clergy owing to the growth of a parochial priesthood; and the necessity of adapting the penance to the primitive ideas of law prevailing among the newly converted barbarians, especially the idea of compensation by the *wergild.* In Ireland in the middle of the 5th century appeared the "canons of St. Patrick." In the first half of the next century these were followed by others, notably those of St. Finian (d. 552). At the same time the Celtic British Church produced the penitentials of St. David of Menevia (d. 544) and of Gildas (d. 583) in addition to synodal legislation. These furnished the material to Columban (d. 615) for his *Liber de poenitentia* and his monastic rule, which had a great influence upon the continent of Europe. The Anglo-Saxon Church was later than the Irish, but under Theodore of Tarsus (d. 690), archbishop of Canterbury, the practice then in force was made the basis of the most important of all penitentials. The *Poenitentiale Theodori* became the authority in the Church's treatment of sinners for the next four centuries. (*See* Haddan and Stubbs's *Councils and Ecclesiastical Documents relating to Great Britain and Ireland,* iii. 173 *seq.*) A *Poenitentiale Commeani* (St. Cumian), dating apparently from the early 8th century, was the third main source of Frankish penitentials. Bishop Halitgar was commissioned (in 829) by Ebo of Reims to prepare a definitive edition; he used among his other materials, a so-called *poenitentiale romanum,* which was really of Frankish origin. The canons printed by David Wilkins in his *Concilia* (1737) as being by Ecgbert of York (d. 766) are largely a translation into Anglo-Saxon of three books of Halitgar's penitentials. In 841 Hrabanus Maurus undertook a new *Liber poenitentium* and wrote a long letter on the subject to Heribald of Auxerre about 853. Then followed the treatise of Regino of Prum in 906, and finally the collection made by Burchard, bishop of Worms, between 1012 and 1023.

BIBLIOGRAPHY.—In addition to the works mentioned above the one important work on the penitentials was L. W. H. Wasserschleben's epoch-malting study and collection of texts, *Die Bussordnungen der abendländischen Kirche nebst einer rechtsgeschichtlichen Einleitung* (Halle, 1851). *See* articles in Wetzer and Welte's *Kirchenlexikon,* Hauck's *Realencyklopädie,* and Haddan and Stubb's *Councils. See* also Seebasz in *Zeitschrift fur Kirchengeschichte,* xviii, 58. On the canons of St. Patrick *see* the *Life of St. Patrick* by *J.* B. Bury (pp. 233–275). *See* P. Oakley, *English Penitential Discipline and Anglo-Saxon Law* (New York, 1923); H. J. Schmitz, *Buss und Bussdisziplin,* 2 vols. (1883–1898).

PENN, WILLIAM (1621–1670), British admiral, son of Giles Penn, merchant and seaman of Bristol, served his apprenticeship at sea with his father. In the first Civil War he fought on the side of the parliament, and was in command of a ship in the squadron maintained against the king in the Irish seas. In 1648 he was arrested, probably on suspicion of being in correspondence with the king, and sent to London, but was soon released, and sent back as rear admiral in the "Assurance" (32). After 1650 he was employed in the Ocean, and in the Mediterranean in pursuit of the Royalists under Prince Rupert.

When the first Dutch War broke out Penn was appointed vice-admiral to Blake, and was present at the battle of Sept. 28, off the Kentish Knock. In the three days' battle off Portland, February 1653, he commanded the Blue squadron, and he also served with distinction in the final battles of the war in June and July.

He sat on the commission of admirals and generals at sea, who exercised the military command of the fleet, as well as on the board of management. In 1654 he offered to carry the fleet over to the king, but in October he commanded the expedition to the West Indies sent out by Cromwell, which conquered Jamaica. He was not responsible for the shameful repulse at San Domingo, which was due to a panic among the troops. On their return he and his military colleague Venables were sent to the Tower. When released he retired to the estate he had received in Ireland.

He continued in communication with the Royalists, and in 1660 had a rather obscure share in the Restoration. He was reappointed commissioner of the navy by the king, and in the second Dutch War served as "great captain commander" or captain of the fleet, with the duke of York (afterwards King James II.) at the battle of Lowestoft (June 3, 1665). Penn died on Sept. 16, 1670, and he was buried in the church of St. Mary Redcliffe, Bristol. His portrait by Lely is in the Painted Hall at Greenwich. By his wife Margaret Jasper, he was the father of William Penn, the founder of Pennsylvania. Penn was one of the authors of the first code of tactics provided for the navy; it was the base of the "Duke of York's Sailing and Fighting Instructions," which continued for long to supply the orthodox tactical creed of the navy.

See the *Memorials of the Professional Life and Times of Sir William Penn, by* Granville *Pena.*

PENN, WILLIAM (1644–1718), English Quaker, advocate of religious toleration, and founder of Pennsylvania, was born at Tower Hill, London, on Oct. 14, 1644, the son of Admiral Sir William Penn. He acquired the foundations of a classical education at Chigwell school, where he came under Puritan influences, and went on in 1660 to Oxford, from which he was "sent down" at the beginning of his second year for nonconformity. (He was later to denounce the English universities as "Signal Places for Idleness, Looseness, Prophaneness, Prodigality, and gross Ignorance.") After a period of travel on the continent of Europe, during which he spent nearly two years at the Protestant university of Saumur, France, he returned to England to give himself briefly to the study of law at Lincoln's Inn. This was the extent of his formal education; but, such as it was, it was to stand him in good stead in his writings and his encounters with British justice.

In 1666 his father sent him to Ireland to manage the family estates. It was there that he decided to throw in his lot with the despised sect of Quakers *(see* FRIENDS, SOCIETY OF). The instrument of his "convincement" was Thomas Loe, an itinerant Quaker preacher of Oxford. For his presence at a Quaker meeting at Cork in 1667 Penn was thrown into prison — the common fate of the Quakers under the Clarendon code. He was quickly released, but not before he had expressed in a letter to the earl of Orrery, lord president of the province of Munster, Ireland, his commitment to the principle of religious freedom. His father, outraged by his devotion to his new found faith, threatened to disinherit him, but young Penn refused to be turned aside and soon emerged as an able and outspoken defender of the religion of the Inner Light.

Truth Exalted (1668), a pamphlet attacking in turn the doctrines of the Roman Catholics, the Anglicans and the dissenting bodies, marked his entry into the theological lists. Before his literary career was over, Penn was to publish more than 100 works, ranging in length from broadsheets to lengthy books. *Truth Exalted* was followed by *The Sandy Foundation Shaken* (1668), in which he questioned the doctrine of the Trinity as commonly received. Though later, in *Innocency With Her Open Face* (1669), he qualified his heterodoxy, he was committed to the Tower of London. In the tower he wrote his most famous book, *No Cross, No Crown* (1669), in which he expounded with learning, eloquence and occasionally humour, the Quaker-Puritan morality. Perhaps the book's most characteristic dictum is: "True Godliness don't (*sic*) turn Men out of the World, but enables them to live better in it, and excites their Endeavours to mend it" — a sentence which reflects both the Puritan conception of "intramundane asceticism" and the Quaker ideal of social reform. *No Cross, No Crown* stands alongside some of the letters of St. Paul, Boethius' *Consolations of Philosophy* and Bunyan's *Pilgrim's Progress* among the world's finest examples of prison literature.

Though many of Penn's doctrinal and devotional works have lasting value, it is as a protagonist by word and act of religious toleration that he earned his prominent place in English history. In 1670 he wrote *The Great Case of Liberty of Conscience,* the most systematic and thorough exposition of the theory of toleration produced in Restoration England. Though he founded his arguments on theological and Scriptural grounds, he did not overlook rational and pragmatic considerations: he pointed out, for instance, that the contemporary prosperity of Holland was based on "her Indulgence in matters of Faith and Worship."

In that same year he had an unsought opportunity to strike another blow for freedom of conscience and for the traditional rights of Englishmen. On Aug. 14, 1670, the Quaker meeting-house in Gracechurch street. London, having been padlocked by the authorities, he preached in the street to several hundred persons. After the meetings, he and William Mead were arrested and imprisoned for riot. A full account of their trial in the Old Bailey, a vivid courtroom drama. was soon published under the title *The People's Ancient and Just Liberties Asserted* (1670). With calm courage born of his Quaker faith and with skill in pleading derived from his legal training, Penn exposed the illegality of the proceedings; the jury, under the leadership of one Edward Bushell, manfully resisted the browbeating of the mayor and recorder. For their refusal to bring in a, verdict of "Guilty," as directed by the bench, the jurymen mere fined and imprisoned; but they were vindicated, when Sir John Vaughan, lord chief justice, enunciated the principle that a judge "may try to open the eyes of the jurors, but not to lead them by the nose." "Bushell's case" stands as a landmark in English jurisprudence, establishing beyond question the independence of the jury.

Sir William Penn died in 1670, having finally become reconciled to his son's Quakerism. Young Penn inherited his father's estates in England and Ireland, and became, like his father, a frequenter of the court, where he enjoyed the friendship of Charles II and his brother James, an unusual experience for a Quaker. In 1672 he married Gulielma Springett, daughter of Mary Penington by her first husband Sir William Springett, and stepdaughter of Isaac Penington, a Quaker, like Penn, of high birth and literary attainments. Of this marriage eight children mere born, four of whom died in infancy.

During the 1670s Penn was ceaselessly busy as a polemicist and minister, producing no less than 40 controversial tracts, in which he engaged theologians of various persuasions on matters of religious doctrine and practice. These productions are probably the least interesting of his writings to the modern reader, though they were of the utmost importance to the Society of Friends, still struggling to vindicate its place among Christian bodies and fortunate to have so able and fluent a defender. Penn also undertook two preaching missions to the continent. In 1671 he traveled through Holland and into northern Germany visiting small groups of Friends and religious seekers, including the followers of the mystic Jean de Labadie (who rebuffed him) and the princess palatine Elizabeth (who welcomed him gladly). Six years later, in company with George Fox, Robert Barclay and George Keith, three of the foremost Quakers of the time, he made another missionary journey through the same region. renewing his friendship with Princess Elizabeth and established contacts which would later help him in peopling Pennsylvania with emigrants from the Low Countries.

The latter years of the decade were occupied with political activities. In the midst of the excitement generated by the "popish plot," he twice supported the candidacy of the radical republican Whig Algernon Sidney for parliament. At Guildford and later at Bramber in 1679 he campaigned vigorously but unsuccessfully for his friend, drawing down upon himself the criticism of those Quakers who considered such activity unsuitable for one of their religious profession. During these years he also wrote a number of pamphlets on behalf of the radical Whigs. *England's Great Interest in the Choice of This New Parliament,* (1679) is especially noteworthy as one of the first clear statements of party doctrine

ever laid before the English electorate.

Even before this excursion into English politics, he had become involved in American colonization as a trustee for Edward Byllynge, one of the two Quaker proprietors of West New Jersey. Though recent scholarship tends to give Byllynge the major credit for writing the "Concessions and Agreements" of West New Jersey, there is no doubt that Penn had a hand in making it the remarkable democratic and libertarian document it is. In 1681 he and 11 other Quakers bought the proprietary rights to East New Jersey from the widow of Sir John Carteret. In the same year, discouraged by the untoward turn of political events in England, where Charles II was ruling without parliament and prospects for religious freedom seemed dark, he sought and received a vast province on the west bank of the Delaware river, which was named Pennsylvania for his father (to whom Charles II had owed a large debt cancelled by this grant). A few months later the duke of York granted him the three "lower counties" (later Delaware). In Pennsylvania Penn hoped to provide a refuge for Quakers and other persecuted people and to erect an ideal Christian commonwealth. "There may be room there, though not here," he wrote to a friend in America, "for such a holy experiment."

The fundamental law of this "holy experiment" was to be the Sermon on the Mount, whose principles the Quakers construed not as counsels of perfection but as practical guides to life. As proprietor, Penn was free to create a government which should embody his Quaker-Whig ideas. In drawing up the Frame of Government he intended, he said, to leave himself and his successors "no power of doing mischief, that the will of one man may not hinder the good of a whole country." Freedom of worship was, of course, to be absolute, and all the traditional rights of Englishmen were carefully safeguarded. The actual machinery of government outlined in the Frame proved in some respects clumsy and unworkable, but he wisely included an amending clause—the first in any written constitution—so that it could be altered as necessity required.

Penn himself sailed for his province late in 1682 in the "Welcome," leaving his family behind. He found his experiment well under way. The city of Philadelphia was already laid out as a "green country town" on a gridiron pattern according to his instructions and settlers were pouring in to take up the fertile lands lying around it. Presiding over the first assembly, he saw the government of the "lower counties" united with that of Pennsylvania and the laws "agreed upon in England" incorporated in the "Great Law" of the province. In a series of treaties based on mutual trust he established good relations with the Leni-Lenape Indians. (Benjamin West's famous painting of the "Great Treaty" at Shackamaxon, however, must be regarded as an exercise of the historical imagination.) He also held an unsuccessful conference with Lord Baltimore, proprietor of the neighboring province of Maryland, to negotiate a boundary line. This boundary was to remain a bone of contention for more than half a century; in 1684, after only two years in his colony, he was obliged to go back to England to defend his interests against Baltimore.

Before his return, he published *A Letter to the Free Society of Traders* (1683), containing his fullest description of Pennsylvania and including a valuable account of the Leni-Lenape, based on firsthand observation. With the accession of his friend the duke of York as King James II, he found himself in a position of great influence at court, whereby he was able to have hundreds of Quakers, as well as political prisoners such as John Locke, released from prison. When James issued his Declaration of Indulgence in 1687, Penn welcomed it, though this attitude laid him open to criticism, since the declaration provided only for the toleration of dissent at the royal pleasure, not as a matter of fundamental right. But the Act of Toleration (1689), passed after James's abdication, finally established the principle for which Penn had laboured so long and faithfully.

His close relations with James brought him under a cloud when William and Mary came to the throne. His colony was temporarily (1693–94) taken from him, and for a time he was forced to live virtually in hiding to avoid arrest. He used this period of enforced retirement to write some of his most charming and thoughtful books. Among other works he produced *An Essay Towards the Present and Future Peace of Europe* (1693), in which he proposed an international organization to prevent wars by arbitrating disputes; *Some Fruits of Solitude* (1693), a collection of religious and practical maxims which Robert Louis Stevenson was to praise, two centuries later, as a "sweet, dignified, and wholesome book"; and *The Rise and Progress of the People Called Quakers* (1694), the earliest effort to set down the history of the Quaker movement. He also drafted (1696) the first plan for a union of the American colonies.

In 1696, his first wife having died, he married Hannah Callowhill of Bristol, by whom he had seven children, five of whom lived to adulthood. Meanwhile, affairs had been going badly in Pennsylvania. The assembly quarreled constantly with the council and with Penn's deputy governors. The "lower counties" were unhappy at being unequally yoked with the larger province. Relations with the home government were strained by the Quakers' conscientious refusal to provide military defense. And the quitrents, by which the proprietor hoped to gain an income from his province, proved almost impossible to collect. In 1699 the proprietor with his wife returned to his province and took up residence at Pennsbury, his handsome country seat on the Delaware, north of Philadelphia (now reconstructed by the commonwealth of Pennsylvania). He contrived to settle many of the outstanding difficulties and in 1701 promulgated a revised constitution, known as the charter of privileges, under which legislative power was vested in a single-chamber assembly. This democratic instrument of government was to remain in force until 1776. After less than two years his affairs at home once more demanded his presence and he left the province, never to see it again. His Pennsylvania interests he left in the capable hands of his secretary, James Logan, who upheld them loyally for the next half century.

Penn's final years were unhappy. His eldest son, William Jr., turned out a scapegrace. His own poor judgment in choosing his subordinates (save for the faithful Logan) recoiled upon him: his deputy governors proved incompetent or untrustworthy, and his steward, Philip Ford, cheated him on such a staggering scale that he was forced to spend nine months in debtors' prison. In 1712, discouraged at the outcome of his "holy experiment," he commenced negotiations to surrender Pennsylvania to the crown, saving only the precious principle of religious freedom. A paralytic stroke, which seriously impaired his memory and dulled his once-keen intellect, prevented the consummation of these negotiations. He lingered on, virtually helpless, until 1718, his wife undertaking the management of his proprietary concerns. He died July 30, 1718, and was buried at Jordans in Buckinghamshire.

Penn's collected works were published in 1726 (reprinted 1771, 1782, 1825). *The Witness of William Penn,* edited by Frederick B. Tolles and E. Gordon Alderfer in 1957, is an anthology of his writings.

BIBLIOGRAPHY.—Samuel M. Janney's *Life of William Penn* (1850) is still valuable, especially for its many excerpts from Penn's letters. Three useful modern biographies are William I. Hull's *William Penn: a Topical Biography* (1937); William Wistar Comfort's *William Penn 1644–1718: a Tercentenary Estimate* (1944); and Catherine Owens Peare's narrative *William Penn* (1957). *(F. B. T.)*

PENNANT, THOMAS (1726–1798), Welsh naturalist and traveler whose *British Zoology* (1766 *et seq.)* gave a strong impetus to zoological and particularly ornithological work in Great Britain. He was born on June 14, 1726, at Downing, Flintshire. His *Synopsis of Quadrupeds* (1771) was later enlarged into a *History of Quadrupeds* (1781). The *Arctic Zoology* was published in 1784–87. His travel books, all containing valuable information on local customs, natural history and antiquities, include the *Tour in Scotland in 1769* (1771), followed by an account of another Scottish tour (1774); *A Tour in Wales* (1778), in the second edition of which (1784) was incorporated the *Journey to Snowdon;* and *The Journey From Chester to London* (1782). His *Tour on the Continent,* describing a journey in 1765 when he met various eminent naturalists, remained in manuscript until published by the Ray society in 1948. Other works include his popular *London* (1790) and *Outlines of the Globe* (unfinished).

Pennant took no degree while at Oxford; but academic honours conferred later included membership of the Royal Society of Uppsala (1757), fellowship of the Royal society (1767) and D.C.L. of Oxford (1771). Among his many correspondents in Great Britain and abroad was Gilbert White, whose *Natural History of Selborne* is largely in the form of letters to Pennant.

(C. MN.)

PENNELL, JOSEPH (1857–1926), U.S. etcher. lithographer and writer, was born in Philadelphia, Pa., on July 4, 1857, and first studied there and in Germantown. Like his compatriot and friend, J. M. Whistler, he afterward went to Europe and made his home in London. He produced numerous books (many of them in collaboration with his wife, Elizabeth Robins Pennell), but his chief distinction is as an original etcher and lithographer, and notably as an illustrator. He contributed! indeed, more than any other artist of his period to the art of illustration. During his lifetime Pennell produced more than 900 etchings and mezzotints and more than 600 lithographs, on subjects ranging from the Panama canal and Yosemite park to the factories of England and the temples of Greece. His publications include *Pen Drawing and Pen Draughtsmen* (1889), *Lithography and Lithographers* (1898), a biography of Whistler. with Mrs. Pennell (1908), *Etchers and Etching* (1919) and *The Adventures of an Illustrator* (1925). Pennell moved back to the United States during World War I and died in Brooklyn. N.Y., on April 23, 1926.

See E. R. Pennell, *Life and Letters* of *Joseph Pennell* (1929).

PENNEY, SIR WILLIAM GEORGE (1909–), English physicist, known for his work in the field of atomic weapons, was born on June 24, 1909, and educated in the technical school. Sheerness, and the Royal college of science, London university. After holding research fellowships and exhibitions at Wisconsin university (1931–33) and at Trinity and Pembroke colleges, Cambridge, he was assistant professor of mathematics at the Imperial college of science and technology, London university (1936–45). He was elected fellow of the Royal society in 1946. During World War II, he was engaged in scientific work for the ministry of home security and the admiralty; and in 1944–45, he was principal scientific officer of the department of scientific and industrial research at the Los Alamos laboratory, N.M. In 1946–52, he was chief superintendent of armament research, ministry of supply. He was created a knight of the British empire in 1952, and was made director of atomic weapons research and development at Aldermaston, Berkshire, in 1953. Sir William Penney has published many papers in scientific journals on the theory of molecular structure. (D. McK.)

PENNINES, an extensive system of hills in the north of England formed by an upfold of Carboniferous rocks running southward from the Scottish border into Derbyshire. The name is probably derived from the Celtic *pen,* high. On the north a well-marked depression. falling below 500 ft. in height. between the low-r valleys of the Irthing and the South Tyne, from which it is known as the Tyne gap, separates the Pennines from the Cheviots. On the northwest the Eden valley falls between the Pennines and the hills of the Lake district, and the division is continued by the upper valley of the Lune. For the rest the physical boundaries consist of extensive lowlands — on the east the vale of York, on the west the coastal belt of Lancashire and the plain of Cheshire and on the south and southeast the valley of the Trent river. The Pennines thus cover parts of Cumberland, Westmorland and Northumberland, Lancashire, Yorkshire and Durham, Cheshire and Derbyshire, while the southern foothills extend into Staffordshire and Nottinghamshire.

The Pennine system is often wrongly called a chain, but it is hardly even a range. The hills are broken up into numerous short ranges by valleys cut back into them in every direction, for the Pennines iorm a north and south watershed which determines the course of all the larger rivers in the north of England. They are divided into two sections by a gap formed by the Aire river flowing east and the Ribble flowing west. To the north of this gap rise the Craven uplands and to the west Bowland forest.

The northern section of the Pennine system is broader and generally higher than the southern. Its western slope is generally short and steep, the eastern long and gradual, this distinction applying to the system at large. In the northwest a sharp escarpment overlooking the Eden valley is known as the Cross Fell Edge irom its highest point, Cross Fell (2,930 it.), to the southeast of which a height of 2.780 ft. is reached in Milburn forest and of 2,591 ft. in Mickle Fell. This range is marked off eastward by the upper valleys of the South Tyne and the Tees. In the northern section the highest points are Cross Fell, Whernside (2,419 ft.), Ingleborough (2,373 ft.) and Pen-y-Ghent (2,273 ft.), and in the southern Kinder Scout (2,088 ft.) which includes the Peak. It is seen that the higher elevations, like the steeper slopes, lie toward the west. The hills between the Lune valley on the west and the headstream of the Eden and the Ribble on the east are broken into masses by the dales of tributaries to the first-named river. The Ribble and Eden valleys afford a route for the railway between Settle and Appleby. Well-marked eastward ranges occur there between Swaledale and the Ure river, which traverses Wensleydale, and between the Ure and Wharfe. In the first the highest points are High Seat (2,328 ft.) and Great Shunner Fell (2,340 ft.); and in the second Buckden Pike (2,302 ft.) and Great Whernside (2,310 ft.). There is then a general southerly slope to the Aire gap.

In the southern section heights above 2,000 ft. are rare; the centre of the section is the well-known Peak (*q.v.*) of Derbyshire. Throughout the system the structure is of Carboniferous limestone and millstone grit with some local shales between. The drier parts of the hills are covered with heather moor while the wet peaty areas are covered mostly with cotton grass. Where the limestone has been exposed, such as in the limestone pavement of Ingleborough, the surface is bare except in the fissures where there is a luxuriant vegetation. The summits of the hills are rounded or nearly flat so that the profile of the Pennines is not striking as a rule, but much fine scenery is found in the narrow dales throughout — Wensleydale, Wharfedale and other Yorkshire dales. The population in the uplands is scanty, though some sheep are kept. There are many farms in the fertile dales and valleys. In the parts about Settle below Ingleborough, in Derbyshire and elsewhere remarkable caverns and subterranean watercourses in the limestone have been explored to great depths. In Ingleborough itself are the Ingleborough cave, near Clapham; the chasm of Gaping Gill, more than 350 ft. deep; Helln or Hellan Pot, a vast swallow hole 359 it. deep, only exceeded by Rowten Pot (365 ft.) near Whernside; and many others. Malham tarn, near the head of the Aire, is drained by a stream which quickly disappears below ground, and the Aire itself is fed by a brook gushing forth in full stream at the foot of the cliffs of Malham cove. A notable example in Derbyshire is the disappearance of the Wye into Plunge hole, after which it traverses Poole's cave, close to Buxton. There may also be noted the remarkable series of caverns near Castleton. Lakes are few and small in the Pennines but there are reservoirs for the supply of the populous manufacturing districts of Lancashire and the West Riding of Yorkshire. The Pennines have long been playgrounds for people living on either side, a fact recognized by the establishment of the Pennine way — a 250 mi. footpath route along the hills from end to end.

Prehistoric remains are numerous, the great circle at Arbor Low being one of the best known. The Romans left many traces, chief among them being Hadrian's wall which was built across the northern Pennines from Carlisle to the mouth of the Tyne and part of which stands on the Whin sill. (*See* ENGLAND; CUMBERLAND; YORKSHIRE; etc.)

PENNS GROVE, a borough of New Jersey in Salem county on the Delaware river opposite Wilmington, Del. Originally a part of Upper Penns Neck township, the settlement developed around a river boat landing. By 1830 it consisted of eight dwellings, a tavern and a store and was a daily point of call for the Wilmington-Philadelphia steamboat. In 1876 the railroad entered the town from Woodbury, and in 1894 Penns Grove became a separate borough. Its subsequent growth was stimulated by the expansion of the Du Pont industries, whose gunpowder plant was started in 1891 immediately south of Penns Grove and whose dye works were established in 1917, the year a trolley line was built from Salem. Afterward, lead-ethyl plant expansion was a further source of employment. For comparative population figures *see* table in NEW JERSEY: *Population.* (H. F. WI.)

PENNSYLVANIA, popularly known as the "Keystone state" because of its central position among the 13 original states, is one of the four states of the U.S. which are officially styled commonwealths. It is bounded north by Lake Erie and New York; east by New York and New Jersey; south by Delaware, Maryland and West Virginia; and west by the Panhandle of West Virginia and by Ohio. Thirty-third among the 50 states in size, Pennsylvania has a total area of 45,333 sq.mi., of which 288 sq.mi. are water surface. The state capital is at Harrisburg (*q.v.*). Pennsylvania's state flower is the mountain laurel, the state tree is the hemlock and the state bird is the ruffed grouse. The name. meaning "Penn's woods," was given by Charles II of England in honour of Adm. William Penn, father of William Penn, the founder of the colony.

PHYSICAL GEOGRAPHY

Physical Features. — Pennsylvania is in the form of a rec-

tangle lying between latitude 39° 43' (the Mason and Dixon line) and 42° N. and longitude 74° 43' and 80° 31' W. of Greenwich, with three exceptions: a triangular projection to latitude 42° 16' N. gives it almost 40 mi. of Lake Erie shore line; t o large bends of the Delaware river cut deeply into New York and New Jersey; and an unusual semicircular boundary separates it from Delaware.

The state has five principal physiographic divisions: the coastal plain, the older Appalachians, the newer Appalachians, the Allegheny plateau and a small part of the Lake Erie plain. The Appalachian mountain system, which curves across the state from southwest to northeast, is the most prominent feature of its topography. The state varies in height from sea level on the Delaware river to 3,213 ft. (Mt. Davis) in Somerset county. At the extreme southeast the coastal plain touches Pennsylvania in a narrow belt along the Delaware near Philadelphia (*q.v.*).

The southeast province of the older Appalachians includes the piedmont with its limestone lowlands in Chester, Lancaster and York counties and Triassic lowlands extending from Bucks county to Adams county. The northern edge of this province is a discontinuous line of uplands and hills which rise to become South mountain a few miles west of the Susquehanna river, reach an elevation of 2,100 ft. at the Maryland border and continue southward as the Blue Ridge.

A region of ridges and valleys lying beyond South mountain and its related uplands, bordered on the northwest by the high eastern edge or front of the Allegheny plateau, is known as the newer Appalachians or the central province. This province has two main subdivisions. the Great valley and the ridge and valley section, separated by the long ridge of Kittatinny or Blue mountain. The Great valley, locally called the Lehigh. Lebanon or Cumberland valley. is 12 to 20 mi. wide and 150 mi. long. The ridge and valley section, which parallels it with a width of 45 to 70 mi., is notable for ridges of considerable length and uniformity of crest lines, broken only by an occasional V-shaped wind gap, a narrow water gap or a rounded knob, and for long parallel valleys usually only a few miles wide.

In the northeast the newer Appalachians meet the Pocono plateau, a part of the Allegheny plateau which continues on to form the Catskill plateau in New York. The Allegheny plateau extends from the Allegheny front to and beyond the south, west and north borders of the state, and includes the state's highest elevations.

Nearly all of the southeast and central provinces and the northeast portion of the Allegheny plateau are drained by the Susquehanna and Delaware river systems into Chesapeake and Delaware bays. The greater part of the Allegheny plateau is drained by the Allegheny and Monongahela rivers into the Ohio. Tributaries of the Potomac drain a small part of the southeast and central provinces; the Lake Erie plain is drained by short streams into the lake; and a small section of the Allegheny plateau in northern Potter county is drained by the Genesee river into Lake Ontario.

The Susquehanna, which drains almost half of the state, is a wide, shallow stream with numerous islands. At Northumberland it forks into two major tributaries, the North branch and the West branch. both with zigzag courses. The Susquehanna and the Delaware and their principal tributaries flow for the most part transverse to the geological structure. The gorges and water gaps through which they pass in the mountain region provide some of Pennsylvania's most picturesque scenery. The gorges are also of great economic importance as passages for railways and highways. As a result of the sinking of the coastal plain the sea has entered the lower portion of the Delaware river, making a tidal estuary at the head of which the port of Philadelphia developed.

The Allegheny and Monongahela, after following southwesterly and northwesterly courses, join to form the Ohio river at Pittsburgh (q *v.*). They are of economic importance for transportation in the western Pennsylvania industrial region, and the Ohio river makes Pittsburgh the state's second port.

Climate. — Since the prevailing winds are from the west. Pennsylvania has what is called a humid continental type of climate with extremely variable weather, but with rainfall usually adequate for most crops grown in its latitude. Climatically speaking, there are two regions: one with long summers and mild winters in the southeast and in the Ohio-Monongahela valley, and one with short summers and severe winters in the Allegheny plateau and the north. The mean annual temperature is about 52° F. in the southeast, 50° in the centre, 47° in the northwest and 49° on the shore of Lake Erie. Temperatures over 100° and below zero have been recorded in the long-summer region, while the short-summer region sometimes has daytime summer temperatures over 90°, although the nights are cool. The summer maxima on the mountains are usually 8° to 10° less than in the valleys directly below them. The average annual rainfall is 42 in.

Soil. — In keeping with its topography, Pennsylvania has many types of soil. The limestone soils of the Lancaster plain, the southeastern part of the Great valley and the valleys of the ridge and valley section are the best for agriculture, although there are some good limestone soils in the southwest. The alluvial soils along the river valleys are also good. In other parts of the state where sandstone and shale predominate the soils are less fertile, varying from good to poor.

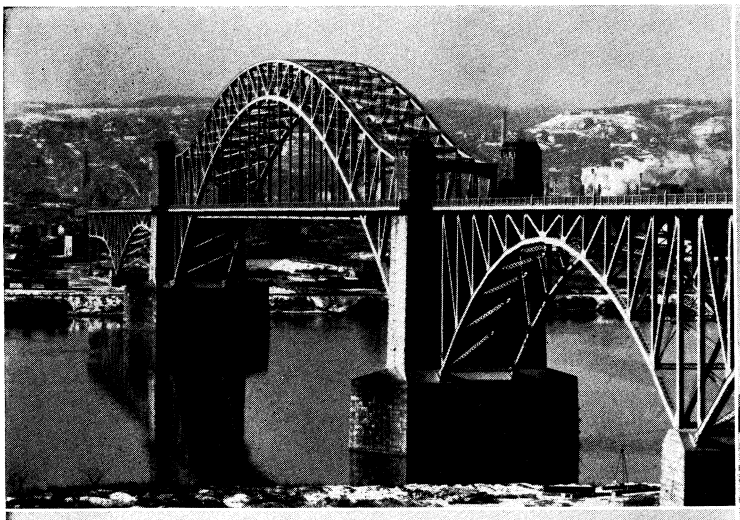
Vegetation. — Originally Pennsylvania was covered with forests, but the settlers cleared their farms, the charcoal iron furnaces used vast quantities of timber and finally great lumbering operations in the latter part of the 19th century cut down virtually the last of the original stands. In 1897 the state began the purchase of forestry reserves, and from this grew the department of forests and waters with its scientific forest conservation program. Trees were planted, seedlings provided to private land owners and forest fires fought.

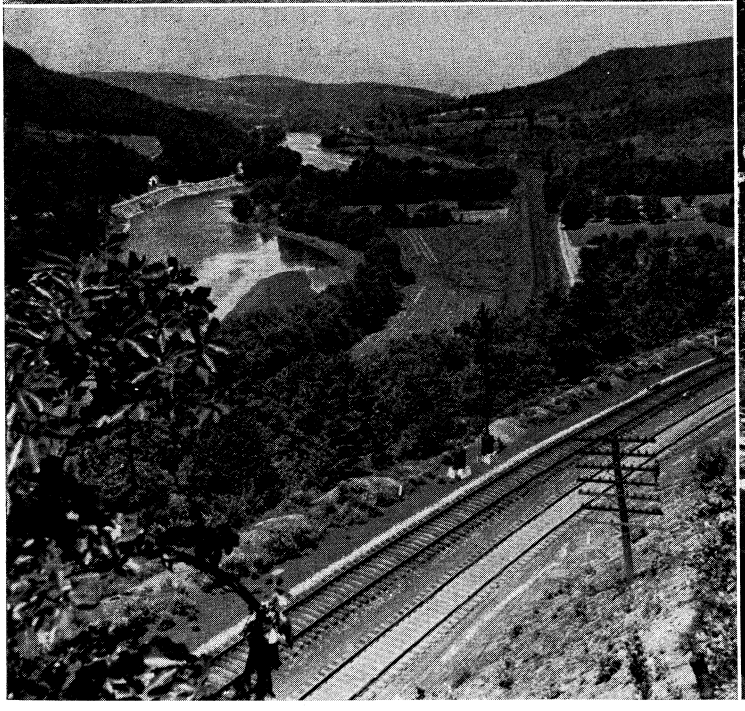
By the late 1950s the total forest area of Pennsylvania amounted to more than 15,000,000 ac. or over half the area of the state. More than 1,870,000 ac. were in state forest, 470.000 ac. in national forest, 900,000 ac. in state game land and about 11,000,000 ac. in privately owned woodland which included farm woodland. On the higher elevations the trees are mostly white pine, yellow pine and hemlock, but in the valleys oaks, hickories, maples, locusts and birches predominate. Beautiful smaller trees and shrubs include the dogwood and the mountain laurel. Among the wild flowers are hepatica, wild honeysuckle, trillium, dog's-tooth violet and anemone.

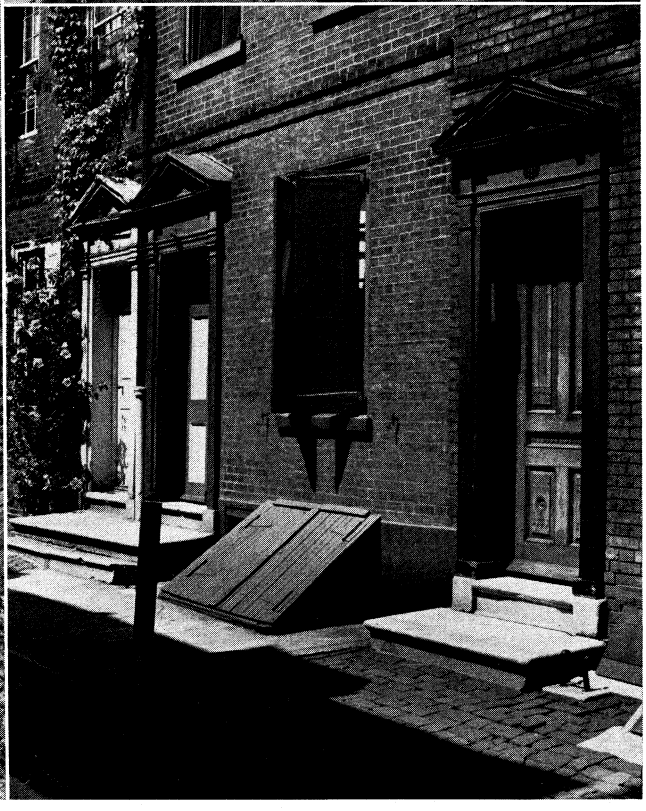
Animal Life. — The primeval forest of Pennsylvania was rich in animal and bird life. Elk, moose, deer, black bear, panthers, wildcats, wolves and passenger pigeons were abundant, but most of these subsequently became extinct. The protection and restoration of wildlife mas a part of the conservation movement in the state. The state game commission opened its first game refuge in 1905 and by the purchase of game lands, the licensing and regulation of hunting and the propagation of game birds and animals it has greatly increased the wildlife resources of the state. The black bear was saved from extinction and is now fairly common in mountain regions, the white-tailed deer was restocked and smaller animals such as raccoons, squirrels, rabbits, skunks and woodchucks are common. Wild ducks and geese, ruffed grouse. quail, pheasants and turkeys are among the game birds. The fish commission protects and propagates fish, stocking streams and regulating and licensing fishermen. Consequently, hunting and fishing have remained major sports in Pennsylvania.

State Parks and Recreation. — In keeping with the increased interest in outdoor recreation, the state has developed an elaborate system of parks and recreation areas. There are 53 parks, 52 forest picnic areas, 13 forest monuments and 12 historical parks. More than 3,000 mi. of roads and 4.000 mi. of marked trails have been constructed by the state in developing such sites as Hickory Run northeast of Hazleton, a 12,721-ac, forested tract, and Pymatuning north of Jamestomn where a 17,000-ac, lake originally designed to supply water to industry is open to boaters and fishermen. The historical parks include famous sites such as Valley Forge. where Washington's army spent the winter of 1777–78, and Bushy Run battlefield, scene of an Indian defeat during Pontiac's rising in 1763. In addition. the Pennsylvania historical and museum commission has restored and developed 21 historical properties. The Civil War battlefield at Gettysburg is a national monument.

PENNSYLVANIA







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VIEWS OF PENNSYLVANIA

Top left: Bridge over the Ohio river at McKees Rocks, an industrial suburb of Pittsburgh

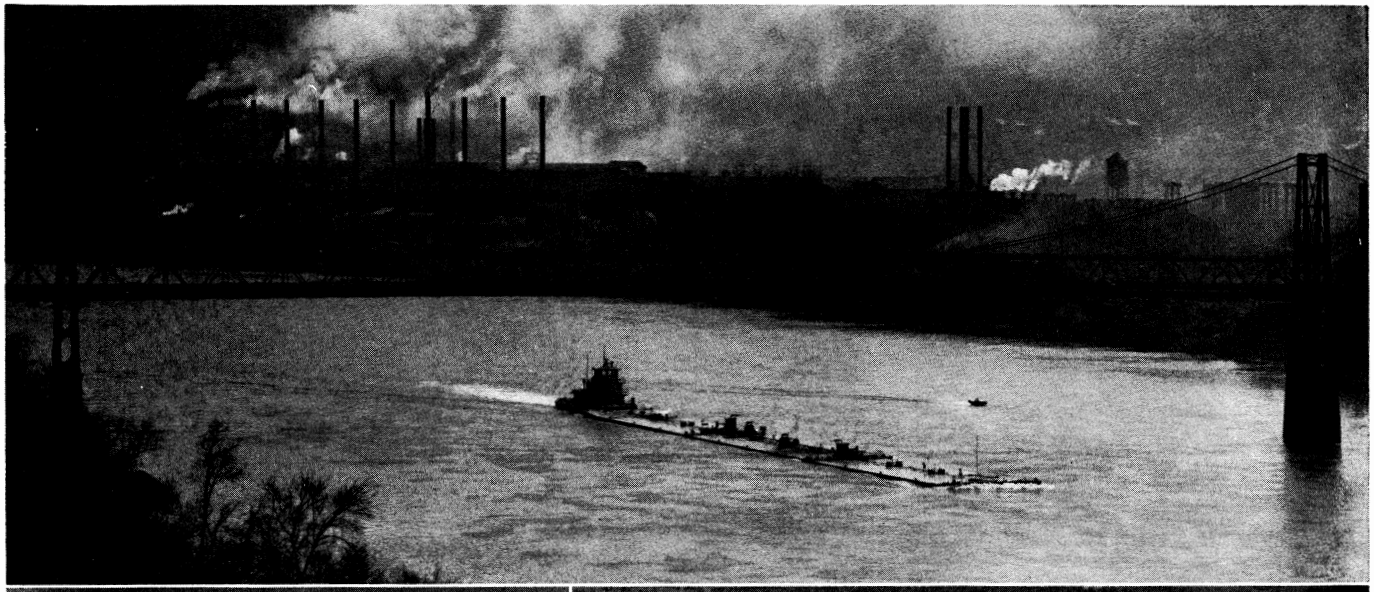
Top right: Philadelphia city hall in Penn sauare, the centre of the city. Statue of William Penn on top of the tower is by Alexander Milne Calder (1846–1923)

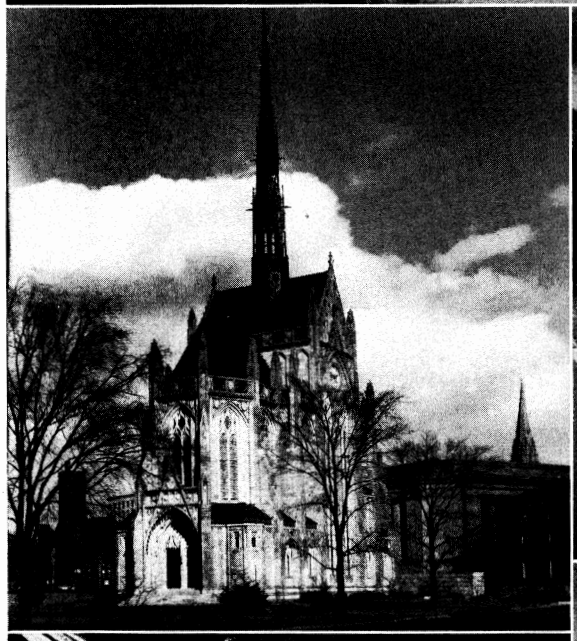
Centre left: Part of the Gettysburg battlefield showing statues of Federal generals. The standing statue is of John Buford (1826–63) who opened the battle; the eauestrian monument to the right is of John F. Reynolds (1820–63) who came to Buford's support. There are more than 2,000 statues, tablets and markers in Gettysburg National Military park

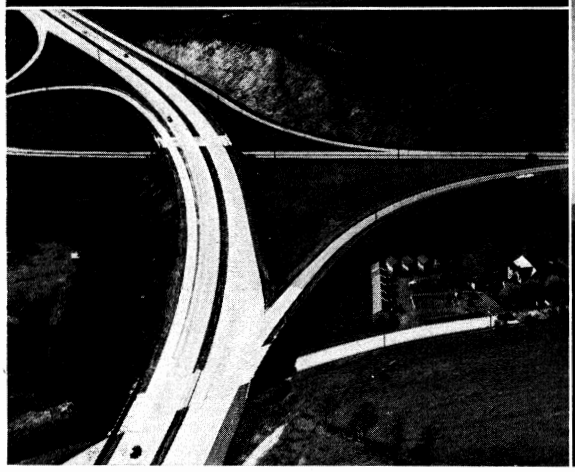
Bottom left: Susquehanna river valley near Lanesboro in the northeastern section of the state. Oats and barley are grown there

Bottom right: Elfreth's alley, Philadelphia, said to be the oldest residential street in continuous use in the U.S.

PENNSYLVANIA







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INDUSTRIAL AND HISTORIC SCENES IN PENNSYLVANIA

Top: Steel mills along the Ohio river near Pittsburgh
Centre *left:* Heinz Memorial chapel on the University of Pittsburgh campus
Centre right: Pennsbury manor along the Delaware river near Philadelphia. Built by William Penn (1644–1718) in 1683, it was restored in the 1930s and made a state park
Bottom left: Section of the Pennsylvania turnpike
Bottom right: State capitol at Harrisburg, completed in 1906. Dome is patterned after St. Peter's basilica, Rome

HISTORY

The country along the lower Delaware river was disputed by the English. Dutch and Swedes in the early days of exploration, trade and settlement. Henry Hudson, an Englishman in the service of the Dutch, entered Delaware bay in 1609. Subsequently both the Dutch and the English traded along the river and established temporary posts in what is now Pennsylvania. but the Swedes were the first to make a permanent settlement, an expansion of settlements which they had begun in Delaware in 1638. In 1643 Johan Printz, a governor of New Sweden, built a fort on Tinicum Island (at Essington) which he called New Gothenborg. Another settlement was soon established at Upland (renamed Chester by William Penn), and other small farming settlements grew up along the river. Since Finland was then under the Swedish crown, Finns made up a large proportion of the settlers. The Dutch seized the Swedish colony in 1655, but were in turn dispossessed by the English who took over their colonies in 1664 as a grant to the duke of York. The Duke's Laws were put into operation along the Delaware and a court was established at Upland. The Swedish and Finnish settlers remained as a nucleus for Penn's colony.

The Quaker Colony.—William Penn (*q.v.*) and other Quakers early became interested in a colony in America for Quakers suffering persecution in England under the so-called Clarendon code. Despite his Quaker beliefs Penn was in good standing with Charles II and his brother the duke of York; later James II, because of the services of his father, Adm. William Penn (*q.v.*). Furthermore, the younger William had inherited a substantial claim against the crown. In 1680 he petitioned for a grant of land for a colony, the duke supported his petition and on March 4, 1681. Charles II granted the charter. Penn was made proprietary of the lands, but the laws of England were to be applicable in the colony until replaced by new laws adopted with the consent of the freemen and subject to review by the crown. Penn granted several successive "frames of government" or constitutions, gradually increasing the powers of the elected assembly until the Charter of Privileges in 1701 gave it more privileges and powers than any other legislative body in the English colonies. In keeping with the purpose of his colony. provisions guaranteeing religious freedom were embodied in its first law code, the Great Law, adopted Dec. 7, 1682. All Christians holding certain amounts of property were eligible as voters and officeholders.

Penn sent commissioners to lay out, in a regular pattern, a "great town" which he named Philadelphia ("city of brotherly love"). In an advantageous location between the Delaware and Schuylkill rivers, the city grew rapidly in population and prosperity. The first assembly mas held at Chester in 1682, soon after Penn's arrival in the colony, but Philadelphia was thereafter the seat of the government. Penn maintained a friendly and peaceful policy toward the Indians, taking care to purchase their claims before surveying and settling lands. Of the many treaties which he held with them the most famous was the "Great treaty" of Shackamaxon. according to Voltaire "the only treaty not sworn to and never broken." This policy of fair dealing preserved Pennsylvania from Indian hostilities during Penn's lifetime and indeed until 1755.

In 1692, following the fall of James II and the accession of William and Mary, Penn was removed from the governorship and the colony was placed under the rule of Gov. Benjamin Fletcher of New York. Penn was reinstated, however, in 1694. Except during his two visits, in 1682–84 and 1699–1701, he and his heirs governed through deputy or lieutenant governors bound by detailed instructions and advised by a provincial council. After Penn suffered a stroke in 1712 his wife Hannah acted as proprietary, first for him until his death in 1718 and then for their children. John, Thomas and Richard. until her own death in 1727. John, who had a half interest, died in 1746, and Thomas Penn then became the chief proprietary until his death in 1775. Thomas Penn was a shrewd and somewhat narrow man who lacked his father's idealism and took an interest in the colony chiefly for the financial return it brought him. Two sons of Richard Penn mere the last lieutenant governors of the colony, John Penn in 1763–71 and 1773–76 and Richard Penn in 1771–73. John Penn continued to live in Pennsylvania until his death in 1795.

Colonial Immigration. — The liberal and tolerant principles of Pennsylvania's government attracted a constantly increasing flow of immigrants, not only from the British Isles but also from the Rhine country of Germany. Some came for refuge from intolerance, oppression and war; others came to seek a better living in a new country, lured by the enthusiastic pamphlets which Penn had circulated widely. English Quakers were the dominant element to the time of the Revolution, but Welsh Quakers came in large numbers before 1700, a large colony settling in the "Welsh barony" in Montgomery and Delaware counties. The southeastern counties became predominantly English.

German immigration began with the Mennonite Francis Daniel Pastorius (*q.v.*), who came to Pennsylvania with some Dutch Quakers in 1683 and founded Germantown (*q.v.*), the pioneer German settlement. The earlier German settlers were for the most part members of the smaller sects who came and settled as groups; they included the Mennonites. Amish, Dunkers or German Baptists, Schwenkfelders and Moravians. After 1727 the volume of German immigration greatly increased but then it consisted mainly of "church people," members of the Lutheran and Reformed churches who were thus distinguished from the smaller "sects." The Pennsylvania Dutch, as they came to be called, predominated in Northampton. Berks and Lancaster counties and adjacent areas. Their farming skills made this region a rich agricultural area and helped to increase the prosperity of the colony. By the time of the Revolution they numbered about 100,000, more than a third of the population.

The third important element in the colony's population was the Scotch-Irish who began to immigrate in numbers about 1728. A hardy, restless, pioneering people, they naturally gravitated to the frontier. pushing forward the area of settlement into the Cumberland valley and southwestern Pennsylvania. Because they differed from the Quakers and the Germans in temperament and in the problems which they faced on the frontier, they formed an opposition to the ruling Quaker element throughout the 18th century. They numbered about 70,000 by the end of the colonial period.

There was also a considerable amount of remigration from other colonies, with Marylanders settling in York county, Virginians moving into southwestern Pennsylvania and Connecticut "Yankees" settling in the beautiful Wyoming and Muncy valleys on the North branch of the Susquehanna after 1770.

This remigration reflected to some extent the serious boundary disputes with Maryland, Virginia and Connecticut. After a long period of litigation, the boundary between Maryland and Pennsylvania was surveyed in 1763–67 by Charles Mason and Jeremiah Dixon, and this Mason and Dixon line (*q.v.*) later became significant as separating the free and the slave states. Farther west, Virginia laid claim to southwestern Pennsylvania and the two colonies established rival county governments in the area in the 1770s. In 1779 a joint commission was set up. and it was decided that the Mason and Dixon line should be extended to a point five degrees west from the Delaware river: with the western boundary extending thence due north to Lake Erie. Connecticut's claim to the northern third of Pennsylvania arose out of the vague language of its sea-to-sea charter, but it was promoted by a private association called the Susquehanna company, organized in 1753. Vigorous efforts to settle the Wyoming valley gave rise to the so-called Yankee-Pennamite wars of 1769–75. During the Revolution a special court of arbitration set up by the Continental Congress decided in favour of Pennsylvania's claim in the Trenton decree, 1782. The boundary with New York. surveyed in 1786–87. caused no serious dispute. In 1792 Pennsylvania bought the Erie triangle, the small triangular strip north of the 42nd parallel. from the federal government in order to have a port on Lake Erie.

Colonial Politics. — The natural conflict between the proprietary and popular elements of the colony's government led to sharp political controversy, in which Benjamin Franklin after 1740 became the leader of the Quaker or popular party. This party. which usually controlled the assembly, contended for the right to tax proprietary iands, to issue paper money and to control expenditures; and one after another the governors went down to defeat.

These party battles, which taught Pennsylvanians the art of politics, did not interfere with the colony's rapid economic and cultural growth, however.

Pennsylvania led the colonies in the production of cereals, hay and livestock, and had a surplus for export. The lumber, textile, shipbuilding and iron industries made early beginnings. Printing and publishing began in 1686, and the first paper mill was erected by William Rittenhouse before 1693. By 1775 the colony had nine newspapers Strategically located to draw upon the resources of Pennsylvania, western New Jersey and Delaware, the merchants of Philadelphia developed an extensive foreign trade, and the city rapidly became a commercial metropolis. The cultural and intellectual life of the colony kept pace with its material prosperity. Science and invention, medicine and the arts made notable progress. Architecture flowered in such public buildings as the statehouse (later called Independence hall) and in the fine colonial mansions of the Philadelphia area. The American Philosophical society, one of the aorld's oldest learned societies, was founded in Philadelphia in 1743. and the University of Pennsylvania dates back to the same period.

The French and Indian War.—The peaceful development of the colony was interrupted by the conflict between France and Great Britain for possession of the Ohio valley, where Pennsylvania and Virginia traders had begun to trade with the Indians as early as the 1720s. The French, who considered the Ohio river an essential link between their colonies of Canada and Louisiana, became alarmed by the British penetration and especially by the formation of the Ohio Company of Virginia to exploit the lands in southwestern Pennsylvania, then claimed by Virginia. As a result, the French in 1753 began building a line of forts to secure possession of the valley, of which the first were Ft. Presque Isle (at present Erie) and Ft. Le Boeuf (at Waterford, Erie county). After sending George Washington to Ft. Le Boeuf in Dec. 1753 to warn the French against encroaching on British territory, Virginia prepared to build a fort at the forks of the Ohio where the city of Pittsburgh now stands. In April 1754 a French expedition drove away the Virginia workmen and built Ft. Duquesne on the site. An expedition led by Washington defeated a French scouting party, but was later besieged by a stronger French force at the hastily erected Ft. Necessity and compelled to surrender. The British then sent an army under Gen. Edward Braddock against Ft. Duquesne. but on July 9, 1755, at the battle of the Monongahela, Braddock's army was cut to pieces by a smaller force of French and Indians. In the same year the French built Ft. Machault at Venango (present Franklin) to strengthen their communications.

Cut off from their usual trade with the British, impressed by French successes and perhaps recalling some old grievances about sales of land, the Indians took the French side and began raiding Pennsylvania's outlying settlements. To protect the settlers the Pennsylvania government built a line of forts, and even staged a successful raid against the Indian village of Kittanning on the Allegheny (1756). In 1758 an expedition under Gen. John Forbes was successful in taking Ft. Duquesne, and in 1759 the capture of Ft. Niagara by Sir William Johnson compelled the French to evacuate their other forts on Pennsylvania soil. When Forbes took possession of the ruins of Ft. Duquesne he named the place Pittsburgh in honour of the British prime minister, and a new fort was built there and called Ft. Pitt. (See also FRENCH AND INDIAN WAR)

In 1760 the forts in northwestern Pennsylvania were rebuilt, but they were taken and destroyed by the Indians in 1763 at the outbreak of Pontiac's War, and Ft. Pitt was besieged. Col Henry Bouquet defeated the Indians in a two-day battle at Bushy Run and relieved Ft. Pitt. The next pear he led a bloodless but impressive expedition into Ohio as far as the Muskingum river and compelled the Indians to sue for peace. As a result, southwestern Pennsylvania was opened to settlement. which proceeded rapidly and made the area the first important trans-Allegheny extension of the American colonies.

Pennsylvania and the Revolution.—Pennsylvania's opposition to the Stamp act and other tax measures by which Britain sought to raise revenue from the colonies was strong but quiet in its expression. Philadelphia merchants adopted nonimportation agreements, and John Dickinson (*q.v.*) wrote the famous Letters From a Farmer in *Pennsylvania* in defense of American rights. In 1770 Philadelphia citizens refused to permit a tea ship to unload its cargo, but there was no demonstration like the Boston "tea party" and the vessel returned to England. After the so-called Coercive acts were passed to punish Boston, protest meetings were held in Pennsylvania, and an extralegal government by committees of correspondence and committees of safety gradually took shape after 1774.

Pennsylvania's attitude in the dispute with the mother country was of great importance because of its resources and central location. The opposition of many Quakers, Dunkers and Mennonites to war and revolution, the loyalty of the Church of England minority to Britain and the disinterest of the German population made Pennsylvania's position doubtful. The Scotch-Irish on the frontiers strongly favoured independence, however, and the fact that the first and second Continental Congresses met in Philadelphia (1774 and 1775–83) also helped Pennsylvania's revolutionary leaders. After the adoption of the Declaration of Independence, which Pennsylvania's delegation supported by only a narrow majority, a provincial convention met in Philadelphia, took over the government and wrote a state constitution which went into effect in Sept. 1776 without being submitted to a vote of the people. This constitution provided for an assembly of one house and for a multiple executive, the supreme executive council, which consisted of 12 members, one elected from each county and one from the city of Philadelphia. By a joint vote the two bodies annually elected a president of the council, who was titular head of the government. Existing inequalities in representation were corrected in favour of the western counties, and the suffrage was extended to all freemen who paid taxes. The Revolution in Pennsylvania was more than a break with Britain; it marked the end of Quaker dominance in the government.

Under the leadership of Joseph Reed and George Bryan the new radical government ruled with a strong hand, disfranchising the opposition by a test act and even confiscating the estates of suspected loyalists. It contributed greatly to the success of the Revolutionary War by furnishing troops and supplies. By the divesting act of 1779 the Penn heirs were deprived of the proprietary lands, although they were allowed to keep the estates or manors which had been surveyed and were further compensated by a grant of £130.000. which was paid after the end of the war. The most lasting achievement of the radicals was the passage of the gradual emancipation act of March 1, 1780. which provided that no child born in Pennsylvania after that date should be a slave. Thus slavery was ended in a generation. While the radicals ruled the state, conservatives aided the Revolutionary cause in congress and the army. Robert Morris organized congressional finances, raising money when others failed. Dickinson wrote many important documents, among them the Articles of Confederation. Anthony Wayne was the most brilliant of the generals from Pennsylvania.

Some important campaigns of the war were fought on Pennsylvania soil (see AMERICAN REVOLUTION, THE). Toward the end of the Revolution, a political reaction began which eventually brought the conservatives to power, and they confirmed their gains by repealing the test act. In spite of strong radical opposition, they secured Pennsylvania's ratification of the federal constitution on Dec. 12, 1787, and went on in 1790 to draft a second state constitution. The supreme executive council was abolished, the office of governor was restored with extensive powers and a two-house legislature was established. From 1790 to 1800 Philadelphia, then the largest and wealthiest city in the United States, was the seat of the federal government.

Pennsylvania to the Civil War.—Under Gov. Thomas Mifflin (1790–99) Pennsylvania at first supported the Federalist party, and the state aided in suppressing the Whisky rebellion in western Pennsylvania (1794) and the "Hot Water War" in eastern Pennsylvania (1799), both directed against unpopular federal taxation. The rising opposition elected Thomas McKean governor in 1799, and from then until 1860 the Democrats were the majority party, even though intraparty quarrels sometimes gave victory to

their opponents. The westward movement of population and agrarian distrust of the metropolis moved the capital from Philadelphia to Lancaster in 1799, and from Lancaster to Harrisburg in 1812.

After the Revolution settlement increased beyond the mountains in western Pennsylvania. Purchases from the Indians at Ft. Stanwix (1784). Ft. McIntosh (1785) and Ft. Harmar 11789) opened northwestern Pennsylvania to settlers, a large part of these lands being granted to veterans. The upper Susquehanna valley also had many settlers in this period. In 1800 the state's population reached 602.000. The extension of settlement led to a demand for better communications, and there was a widespread campaign for internal improvements. Roads were extended to all parts of the state. and many bridges mere built. The first important turnpike in America was the Philadelphia-Lancaster turnpike, completed in 1794. and by 1832 about 3.000 mi. of road had been built by 220 turnpike companies. The building of canals began in 1797, but the first long canal was the Union canal, completed in 1827 between Middletown on the Susquehanna river and Reading on the Schuylkill. In 1826 the state undertook to build a line of "state works" from Philadelphia to Pittsburgh, with the Allegheny portage railroad and the Columbia and Philadelphia railroad serving as links in the canal system. This was opened for traffic in 1834. Numerous branch canals were also built. The canals greatly benefited the economic development of the state, but they were ruinously expensive and created such a burden of debt that they were sold between 1843 and 1858. and later abandoned when railroads took their place. The early railroads were mainly short lines to carry coal from the mines to canals or rivers, but they eventually developed into a great transportation network.

Throughout the period there was a trend toward more popular government. A new constitution in 1838 lessened the powers of the governor. increased the number of elective officers and shortened the tenure of office. In the political controversy which led up to the Civil War, Pennsylvania generally held to a moderate course, helping to elect James Buchanan of Pennsylvania to the presidency in 1856. However. the antislavery movement found much support from the Quakers and other humanitarian groups. This and the growth of the protectionist movement drew Pennsylvania toward the newly formed Republican party. In 1860 Pennsylvania elected the Republican Andrew G. Curtin as governor and gave Lincoln a majority for the presidency.

The Civil War.—As the crisis of Southern secession developed early in 1861. the state legislature pledged support to the Union, and Governor Curtin organized the state's resources in men and money. Pennsylvania supplied 323,629 soldiers to the army. as well as 14.307 sailors and marines. Industrial development was spurred by the need for munitions and supplies. During the war Pennsylvania suffered several Confederate invasions, and the turning point of the war came on Pennsylvania soil when Gen. Robert E. Lee's march into the Cumberland valley was halted at the battle of Gettysburg (July 1–3, 1863). Nearly one-third of the Union troops in that battle were Pennsylvanians. (See also AMERICAN CIVIL WAR.)

After the Civil War.—Politically the state was dominated after the Civil War by a remarkable dynasty of "bosses." founded by Simon Cameron and continued by his son James Donald Cameron and by Matthew Stanley Quay and Boies Penrose until the latter's death in 1921. Under their astute management the Republican party generally ruled Pennsylvania, although reform movements occasionally interrupted their control, as when the Democrat Robert E. Pattison was elected governor in 1882 and 1890. During and after the Civil War there mas tremendous expansion in the iron and steel industry, in coal mining and other industries, which transformed Pennsylvania from a predominantly agricultural state to an industrial giant. The demand for labour in the growing industrial economy brought a new wave of immigration from 1865 to 1914, and Poles, Italians: Czechs, Hungarians, Russians and others supplemented the earlier population groups. As the state grew industrially a labour movement developed and gave rise to the American Federation of Labor and the Congress of Industrial Organizations, both of which began in Pennsylvania.

Progress was made in extending the services of government. Insurance and banking departments were created in 1873 and 1891 as regulatory agencies. During the administration of Gov. Samuel W. Pennypacker (1903–07) a number of new departments were created, including forestry, health and highways, and a state police force was organized. In 1915 a department of labour and industry was established. Under Gov. William C. Sproul (1919–23) the public-school system was reorganized, an extensive program of highway building was undertaken and a department of welfare was created.

After the death of Penrose, the progressives in the Republican party gained more influence; Gifford Pinchot was elected governor in 1922 and 1930. During his first term (1923–27) the administrative code was enacted to consolidate departments and centralize control. thus increasing the governor's power. This was amended and made still more complete under the intervening conservative Gov. John S. Fisher (1927–31). The division in the Republican party and the coming of the New Deal brought victory to the Democrats in 1934 for the third time since the Civil War. and they elected George H. Earle as governor and one United States senator. The Republicans regained the governorship in 1938 by electing Arthur H. James, and then elected three governors in succession, Edward Martin. James H Duff and John S. Fine. The Democratic party, box-ever. did not revert to its former weak position; it elected George M. Leader governor in 1954 and David L. Lawrence in 1958

During the depression the state undertook a program of building construction at health, penal, military and educational institutions through the General State authority, approved in 1937. The first section of the Pennsylvania turnpike from Carlisle to Pittsburgh was begun in 1938. At the close of World War II the state also undertook extensive highways and public works construction. and notable progress was made in a conservation program which involved clearing rivers of silt and pollution, reforestation and soil conservation.

GOVERNMENT

Pennsylvania is governed under its fourth state constitution, adopted in 1873 and amended frequently after 1901. Amendments must be approved by a majority of each house in two successive legislatures and then ratified by a majority of a popular vote.

Executive.— The governor, lieutenant governor, auditor general and state treasurer are elected for four years and are ineligible for a second consecutive term. The secretary of internal affairs is also elected for four years but without any limitation on succession. The governor has extensive powers, appointing, subject to the advice and consent of two-thirds of the state senate. the heads of all departments except those who are elected, the members of all independent administrative boards and commissions and—with few exceptions—the members of all departmental boards and commissions. He fills vacancies in various offices which occur when the senate is not in session. His power of veto extends to items in appropriation bills: it may be overridden by a two-thirds vote in each house. His power of pardon is exercised only on the recommendation of three members of a board of pardons consisting of the lieutenant governor, secretary of the commonwealth, attorney general and secretary of internal affairs. In the event of the governor's death, resignation, conviction on impeachment or other disability, the lieutenant governor succeeds him.

A law known as the administrative code, adopted in 1923 and amended in 1927 and later. consolidated the administrative agencies of the state into 19 departments: state, justice, auditor general. treasury, public instruction, internal affairs, military affairs, agriculture, forests and waters. labour and industry, health. highnays, public welfare. banking, insurance, mines, property and supplies, revenue and commerce. Important independent administrative commissions include game, fish, public utility, milk control and historical and museum; and similar boards include liquor control, parole and tax equalization. The governor and six department heads whom he designates constitute the executive board which standardizes employment in the various departments and approves the establishment or discontinuance of bureaus or other

divisions in the departments. Through the budget bureau, authorized in 1929, and the office of administration, established in 1955, the governor exercises control of expenditures, personnel and policies in all but the three elective departments.

Legislative. — The legislative branch of the government is officially called the general assembly. It consists of a senate of 50 members elected for four years and a house of representatives with 210 members elected for two years. The lieutenant governor presides over the senate but has no vote on the final passage of legislation. The senate has the right of confirming or rejecting appointments made by the governor and sits as a court of impeachment. The house originates appropriation bills and impeachment proceedings. The general assembly may not pass any local or special bills on a wide range of subjects but especially with regard to the affairs of counties. cities, townships, boroughs and school districts. It meets annually on the first Tuesday of January, but the sessions in even-numbered years are limited to fiscal matters. The governor may call it into special session, in which case legislation is limited to the subjects specified in his proclamation.

Judicial. — The supreme court dates from 1705, with the number of justices varying from three to five until the constitution of 1873 fixed it at seven. They are elected for terms of 21 years by the voters of the state at large; minority representation is secured by the provision that each elector shall vote for one less than the number of justices to be chosen at each election. The work of the supreme court had increased to such an extent by 1895 that the general assembly passed an act creating the superior court, consisting of seven judges elected for ten years and eligible for re-election. The supreme court handles all appealed cases involving more than $2,500 or involving felonious homicide, and is the court of last resort. The superior court handles all other appealed cases. Below the appellate courts there are courts of common pleas. courts of quarter sessions and oyer and terminer and orphans' courts which function in 59 judicial districts. usually corresponding to counties. Philadelphia has a municipal court, and Allegheny county a county court. Justices of the peace, magistrates and aldermen, elected in townships, city wards and boroughs, have jurisdiction over lesser crimes and disputes.

Local Government. — Counties, townships, cities, boroughs and other civil subdivisions in Pennsylvania derive their powers of self-government from the state, and the general assembly has enacted codes for each type of subdivision. Counties have been divided into eight classes on the basis of population, and cities into four classes. Under a constitutional amendment of 1922, the general assembly has granted cities the right to frame and adopt their own charters, as was done by Philadelphia in 1951–52.

Pennsylvania has 67 counties including Philadelphia where the functions of county government are performed by the city. The constitution provides for the election of various county officers, including a board of three county commissioners which acts as the chief administrative agency. The 51 cities are each governed by a mayor and city council, but in the third-class cities the mayor is a member of council and he and the other members direct various departments. The 938 boroughs are governed by a burgess and borough council, and there is also one town, Bloomsburg, where the president of the council performs most of the functions of the burgess. Townships are divided into two classes. The 63 first-class townships are populous suburban areas and are governed by township commissioners. The second-class townships, mainly in rural areas, are governed by township supervisors whose authority is relatively limited.

Finance. — The chief sources of state revenue are a selective sales and use tax and taxes on motor vehicles, corporations, motor fuels, alcoholic beverages, tobacco and inheritance. In 1933 the state assumed control of the sale of alcoholic beverages, setting up a system of state stores for the sale of wine and liquor. From this source it derived an income of more than $80,000,000 annually in the early 1960s. More than half the state's income was spent on education and highways. The state net debt more than trebled during the post World War II period. It was greatly increased in 1949 and 1957 as the result of state-wide elections authorizing the payment of bonuses to veterans of World War II and the Korean conflict.

POPULATION

The population of Pennsylvania in 1790 was 434,373; in 1830 it was 1,348,233; in 1870, 3,521,951; in 1910, 7,665,111; in 1950, 10,498,012; and in 1960, 11,319,366. This last figure represented an increase of 17% over 1950. The population per square mile in 1960 was 249.7, as compared with 233.1 in 1950 and with 49.7 for the U.S. in 1960.

The urban area, defined as including all incorporated places of 2,500 or more, all townships having a total population of 10,000 and a density of 1,000 or more persons per square mile, the thickly settled suburban area or "urban fringe" adjacent to cities of 50.000 or more and unincorporated places of 2,500 or more outside this fringe, had a population in 1960 of 8,102,051 or 71.6% of the state total. In 1950 the comparable figures were 7,403,036 and 70.5%. The state has 11 standard metropolitan statistical areas. These areas had a total population of 8,382,326 or 74.1% of the total population of the state in 1960.

The number of occupied dwelling units in 1950 was 2,918,672. The average population per household was 3.5 in 1950.

The population of the state was distributed by colour and nativity in 1950 as follows: 86.5% native white; 7.4% foreign-born white; and 6.1% nonwhite, practically all Negro. Of the foreign-born white population in 1950. 21% were born in Italy, 11.3% in Poland and 7.7% in Germany. There were 97.0 males per 100 females in the 1950 population, as compared with 100.0 in 1940; 8.6% of the population was 65 years old or over; and 52.1% of the population 14 years old and over was in the labour force.

Of the total number of employed males, 5.4% were engaged in agriculture. 6.9% in mining, 7.4% in construction, 36.1% in manufacturing. 6% in transportation, 16% in wholesale and retail trade and 16% in service activities of all kinds.

In spite of the great volume of immigration from southern and eastern Europe which came mainly to the industrial centres in the latter part of the 19th century, the original population pattern of the state is still noticeable in customs, architecture and speech. This is especially true in Lancaster, Berks, Lebanon, Lehigh and neighbouring counties where the Pennsylvania Germans predominate. Of these the most distinctive are the "plain people," members of the Mennonite, Amish, Dunkard and other small sects, who make up less than 10% of the Pennsylvania Germans. The "plain people" tend to retain more of the old speech, customs and dress than the other Pennsylvania Germans. The industrious diligence of the Pennsylvania Germans has kept their region as a prosperous farming country for two centuries, and they are noted for their well-kept fields and large barns, often decorated with geometric designs called "hex" signs. Authorities differ on whether these are talismans for protective purposes or merely for decoration. The Pennsylvania German love of colour and decoration is expressed in their folk art.

EDUCATION

Public-School System. — Pennsylvania's system of free public education began with the Free Public School act of 1834 which created local school districts, permitted the levy of taxes for the support of free elementary schools and provided state aid to districts accepting the act. Earlier laws had provided schooling for children 5 to 12 years old whose parents were unable to pay for it, but these were called pauper education acts and parents were reluctant to educate their children on such terms. Despite some early opposition, the public-school system gradually expanded and the state constitution of 1873 definitely provided for the education of all children above the age of six years and for a state superintendent of public instruction. High schools were established in Philadelphia and Pittsburgh in 1836 and 1849 and were authorized in every district of the state in 1895.

In 1834 the minimum school term was three months; by 1899 it had been lengthened to seven months; and it was finally extended to a minimum of 180 days of school. In 1895 the first compulsory school attendance law required all children 8 to 13 years of age to attend school 16 weeks a year, with certain exemptions pro-

*Pennsylvania: Places of 5,000 or More Population (1960 Census)**

Place	Population				
	1960	1950	1940	1920	1900
Total state	11,319,366	10,498,012	9,900,180	8,720,017	6,302,115
Abingtont	55,831	28,988	20,857	8,684	3,803
Aliquippa	26,369	26,132	27,023	2,931	620
Allentown	108,347	106,756	96,904	73,502	35,416
Altoona	69,407	77,177	80,214	60,331	38,973
Ambler	6,765	4,565	3,953	3,094	1,884
Ambridge	13,865	16,429	18,968	12,730	—
Archbald	5,471	6,304	8,296	8,603	5,396
Arnold	9,437	10,263	10,898	6,120	1,426
Ashland	5,237	6,192	7,045	6,666	6,438
Astont	10,595	5,576	3,116	2,107	2,641
Avalon	6,859	6,463	6,155	5,277	2,130
Baden	6,109	3,732	2,135	895	427
Baldwin	24,489	—	—	—	—
Bangor	5,766	6,050	5,687	5,402	4,106
Beaver	6,160	6,360	5,641	4,135	2,348
Beaver Falls	16,240	17,375	17,098	12,802	10,054
Bellefonte	6,088	5,651	5,304	3,996	4,216
Bellevue	11,412	11,604	10,488	8,189	3,416
Berwick	13,353	14,010	13,181	12,181	3,916
Bethel	23,650	11,324	5,966†	1,653†	839†
Bethlehem	75,408	66,340	58,490	50,358	7,293
Blakely	6,374	6,828	8,106	6,564	3,915
Bloomsburg	10,655	10,633	9,799	7,819	6,170
Brackenridge	5,697	6,178	6,400	4,987	—
Braddock	12,337	16,488	18,326	20,879	15,654
Bradford	15,061	17,354	17,691	15,525	15,029
Brentwood	13,706	12,535	7,552	1,695	—
Bridgeport	5,306	5,827	5,904	4,680	3,097
Bridgeville	7,112	5,650	4,459	3,092	—
Bristol	12,364	12,710	11,895	10,273	7,104
Bristol†	59,298	12,184	5,857	5,027	1,397
Brookhaven	5,280	1,042	—	—	—
Brownsville	6,055	7,643	8,015	2,502	1,552
Butler	20,975	23,482	24,477	23,778	10,853
California	5,978	2,831	2,614	2,480	2,009
Camp Hill	8,559	5,934	3,630	1,636	360
Canonsburg	11,877	12,072	12,599	10,632	2,714
Carbondale	13,595	16,296	19,371	18,640	13,536
Carlisle	16,623	16,812	13,984	10,916	9,626
Carnegie	11,887	12,105	12,663	11,516	7,330
Castle Shannon	11,836	5,459	3,970	2,353	—
Catasauqua	5,062	4,923	4,764	4,714	3,963
Centerville	5,088	5,845	6,317	4,793	260
Chambersburg	17,670	17,212	14,852	13,171	8,864
Charleroi	8,148	9,872	10,784	11,516	5,930
Cheltenham†	35,990	22,854	19,082	11,015	6,154
Chester	63,658	66,039	59,285	58,030	33,988
Clairton	18,389	19,652	16,381	6,264	—
Clearfield	9,270	9,357	9,372	8,529	5,081
Clifton Heights	8,005	7,549	4,921	3,469	2,330
Coatesville	12,971	13,826	14,006	14,515	5,721
Collingdale	10,268	8,443	8,162	3,834	603
Columbia	12,075	11,993	11,547	10,836	12,316
Connellsville	12,814	13,293	13,608	13,804	7,160
Conshohocken	10,259	10,922	10,776	8,481	5,762
Coraopolis	9,643	10,498	11,086	6,162	2,555
Corry	7,744	7,911	6,935	7,228	5,369
Crafton	8,418	8,066	7,163	5,954	1,927
Danville	6,889	6,904	7,122	6,952	8,042
Darby	14,059	13,154	10,334	7,922	3,429
Darby†	12,598	3,454	2,899	3,077	1,388
Dickson City	7,738	8,948	11,548	11,049	4,948
Donora	11,131	12,186	13,180	14,131	—
Dormont	13,098	13,405	12,974	6,455	—
Downington	5,598	4,948	4,645	4,024	2,133
Doplestown	5,917	5,262	4,976	3,837	3,034
Du Bois	10,667	11,497	12,080	13,681	9,375
Dunmore	18,917	20,305	23,086	20,250	12,583
Duquesne	15,019	17,620	20,693	19,011	9,036
Duryea	5,626	6,655	8,275	7,776	—
Easton	31,955	35,632	33,589	33,813	25,238
East Stroudsburg	7,674	7,274	6,404	4,855	2,648
Economy	5,925	—	—	—	—
Edgewood	5,124	5,292	—	—	—
Edwardsville	5,711	6,686	7,998	9,027	5,165
Elizabethtown	6,780	5,083	4,315	3,319	1,473
Ellwood City	12,413	12,945	12,329	8,958	2,243
Emmaus	10,262	7,780	6,731	4,370	1,468
Ephrata	7,688	7,027	6,199	3,735	2,451
Erie	138,440	130,803	116,955	93,372	52,733
Etna	5,519	6,750	7,223	6,341	5,384
Falls†	29,082	3,540	2,364	1,789	1,856
Farrell	13,793	13,644	13,899	15,586	—
Folcroft	7,013	1,909	1,592	—	—
Ford City	5,440	5,352	5,795	5,605	2,870
Forest Hills	8,796	6,301	5,248	—	—
Forty Fort	6,431	6,173	6,293	3,389	1,557
Fountain Hill	5,428	5,456	4,804	2,339	1,214
Frackville	5,654	6,541	8,035	5,590	2,594
Franklin	9,586	10,006	9,948	9,970	7,317
Freeland	5,068	5,909	6,593	6,666	5,254
Gettysburg	7,960	7,046	5,916	4,439	3,495
Glassport	8,418	8,707	8,748	6,959	—
Glenolden	7,249	6,450	4,825	1,944	873
Greensburg	17,383	16,923	16,743	15,033	6,508
Green Tree‡	5,226	2,818	1,880	1,043	678
Greenville	8,765	9,210	8,149	8,101	4,814
Grove City	8,368	7,411	6,296	4,944	1,599
Hanover	15,538	14,048	13,076	8,664	5,302
Harmony†	5,106	4,501	2,317	—	—
Harrisburg	79,697	89,544	83,983	75,917	50,167
Harrison†	15,710	15,116	13,161	74	650
Hatboro	7,315	4,788	2,605	1,102	823
Haverfordt	54,019	39,641	27,594	6,631	2,414
Hazleton	32,056	35,491	38,009	32,277	14,230
Hellertown	6,716	5,435	4,031	3,008	745
Hempfield†	29,704	22,463	20,687	18,598	9,256
Hershey§	6,851	6,076	—	—	—
Hollidaysburg	6,475	6,483	5,910	4,071	2,998
Homestead	7,502	10,046	19,041	20,452	12,554
Honesdale	5,569	5,662	5,687	2,756	2,864
Huntingdon	7,234	7,330	7,170	7,051	6,053
Indiana	13,005	11,743	10,050	7,043	4,142
Jeannette	16,565	16,172	16,220	10,627	5,865
Jefferson	8,280	5,534†	5,585†	5,009†	4,219†
Jenkintown	5,017	5,130	5,024	3,336	2,091
Jersey Shore	5,613	5,595	5,432	6,103	3,070
Jim Thorpe‖	5,945	—	—	—	—
Johnstown	53,949	63,232	66,668	67,327	35,936
Kane	5,380	5,706	6,133	7,283	5,296
Kingston	20,261	21,096	20,679	8,952	3,846
Kittanning	6,793	7,731	7,550	7,153	3,902
Lancaster	61,055	63,774	61,345	53,150	41,459
Lancaster†	10,020	6,859	6,151	2,647	1,782
Lansdale	12,612	9,762	9,316	4,728	2,754
Lansdowne	12,601	12,169	10,837	4,797	2,630
Lanstord	5,958	7,487	8,710	9,625	4,888
Latrobe	11,932	11,811	11,111	9,484	4,614
Lebanon	30,045	28,156	27,206	26,643	17,628
Lehighton	6,318	6,565	6,615	6,102	4,629
Lewisburg	5,523	5,268	3,571	3,204	3,457
Lewistown	12,640	13,894	13,017	9,849	4,451
Lititz	5,987	5,568	4,840	3,680	1,637
Lock Haven	11,748	11,381	10,810	8,557	7,210
Lower Burrell	11,952	—	—	—	—
Lower Merion†	59,420	48,745	39,566	23,866	13,271
Lower Southampton†	12,619	3,562	1,843	—	—
Luzerne	5,118	6,176	7,082	5,998	3,817
McKeesport	45,489	51,502	55,355	46,781	34,227
McKees Rocks	13,185	16,241	17,021	16,713	6,352
Mahanoy City	8,536	10,934	13,442	15,599	13,504
Marple†	19,722	4,779	2,170	900	812
Meadville	16,671	18,972	18,919	14,568	10,291
Mechanicsburg	8,123	6,786	5,709	4,688	3,841
Media	5,803	5,726	5,351	4,109	3,075
Middletown	11,182	9,184	7,046	5,920	5,608
Middletownt	26,894	4,987	3,136	1,365	1,383
Midland	6,425	6,491	6,373	5,452	—
Millcreek†	28,441	17,037	7,444	12,848	3,891
Millvale	6,624	7,287	7,811	8,031	6,736
Milton	7,972	8,578	8,313	8,638	6,175
Minersville	6,606	7,783	8,686	7,845	4,815
Monaca	8,394	7,415	7,061	3,838	2,008
Monessen	18,424	17,896	20,257	18,179	2,197
Monongahela	8,388	8,922	8,825	8,688	5,173
Monroeville	22,446	—	—	—	—
Montoursville	5,211	3,293	3,019	1,949	1,665
Morrisville	7,790	6,787	5,493	3,639	1,371
Mount Carmel	10,760	14,222	17,780	17,469	13,179
Mount Lebanont	35,361	26,604	19,571	2,258	—
Mount Oliver	5,980	6,646	6,981	5,575	2,295
Mount Pleasant	6,107	5,883	5,824	5,862	4,745
Munhall	17,312	16,437	13,900	6,418	—
Nanticoke	15,601	20,160	24,387	22,614	12,116
Narberth	5,109	5,407	5,217	3,704	847
Nazareth	6,209	5,830	5,721	4,288	2,304
Nether Providence†	10,380	6,173	3,793	2,344	2,033
New Brighton	8,397	9,535	9,630	9,361	6,820
New Castle	44,790	48,834	47,638	44,938	28,339
New Cumberland	9,257	6,204	4,525	1,577	1,035
New Kensington	23,485	25,146	24,055	11,987	4,665
Norristown	38,925	38,126	38,181	32,319	22,265
Northampton	8,866	9,332	9,622	9,349	—
North Braddock	13,204	14,724	15,679	14,928	6,535
North Versailles†	13,583	9,821	6,341	4,844	4,882
Norwood	6,729	5,246	3,921	2,353	1,286
Oakmont	7,504	7,264	6,260	4,512	2,323
Oil City	17,692	19,581	20,379	21,274	13,264
Old Forge	8,928	9,749	11,892	12,237	5,630
Olyphant	5,864	7,047	9,252	10,236	6,180
Palmerton	5,942	6,646	7,475	7,168	—
Palmyra	6,999	5,910	5,239	3,646	—
Penn Hills†	51,512	25,280	15,578	8,342	3,407
Philadelphia	2,002,512	2,071,605	1,931,334	1,823,779	1,293,697
Phoenixville	13,797	12,932	12,282	10,484	9,196
Pitcairn	5,383	5,857	6,310	5,738	2,601
Pittsburgh	604,332	676,806	671,659	588,343	321,616
Pittston	12,407	15,012	17,828	18,497	12,556
Pleasant Hills	8,573	3,808	—	—	—
Plum	10,241	—	—	—	—
Plymouth	10,401	13,021	15,507	16,500	13,649
Port Vue	6,635	4,756	3,601	2,538	1,803
Pottstown	26,144	22,589	20,194	17,431	13,696
Pottsville	21,659	23,640	24,530	21,876	15,710
Prospect Park	6,596	5,834	5,100	2,536	1,050
Punxsutawney	8,805	8,969	9,482	10,311	4,375
Quakertown	6,305	5,673	5,150	4,391	3,014
Radnor†	21,697	14,709	12,012	8,181	5,474
Rankin	5,164	6,941	7,470	7,301	3,775
Reading	98,177	109,320	110,568	107,784	78,961
Red Lion	5,594	5,119	4,891	3,198	1,337
Ridgway	6,387	6,244	6,253	6,037	3,515
Ridley†	35,738	17,212	8,641	5,342	1,973
Ridley Park	7,387	4,921	3,887	2,313	1,234
Rochester	5,952	7,197	7,441	6,957	4,688

*Populations are reported as constituted at date of each census. †Township population. ‡Returned until 1940 as Greentree. §Returned in 1950 as Hershey-Swatara. ‖East Mauch Chunck and Mauch Chunck consolidated to form Jim Thorpe borough.

Note: Dash indicates place did not exist during reported census, or data not available.

Pennsylvania: Places of 5,000 or More Population (1960 Census)* (continued)

Place	Population				
	1960	1950	1940	1920	1900
Rosst	25,952	15,744	10,827	4,949	2,671
St. Clair	5,159	5,856	6,809	6,495	4,638
St. Marys	8,065	7,846	7,653	6,967	4,295
Sayre	7,917	7,735	7,569	8,078	5,243
Schuylkill Haven	6,470	6,597	6,518	5,437	3,654
Scott†	19,094	8,686	6,297	4,927	3,975
Scottdale	6,244	6,249	6,493	5,768	4,261
Scranton	111,443	125,536	140,404	137,783	102,026
Sewickley	6,157	5,836	5,614	4,955	3,568
Shaler†	24,939	16,430	11,185	6,306	3,494
Shamokin	13,674	16,879	18,810	21,204	18,202
Sharon	25,267	26,454	25,622	21,747	8,916
Sharon Hill	7,123	5,464	4,467	1,780	1,058
Sharpshurg	6,096	7,296	8,202	8,921	6,842
Sharpsville	6,061	5,414	5,129	4,647	2,970
Shenandoah	11,073	15,704	19,790	24,726	20,321
Shillington	5,639	5,059	4,932	2,175	—
Shippensburg	6,138	5,722	5,244	4,372	3,228
Somerset	6,347	5,936	5,430	3,121	1,834
Souderton	5,381	4,521	4,036	3,125	1,077
South Williamsport	6,972	6,364	6,033	4,341	3,328
Springdale	5,602	4,939	4,989	2,929	2,929
Springfield† (Delaware Co.)	26,733	10,917	5,488	1,298	889
Springfield† (Montgomery Co.)	20,652	11,403	5,603	3,374	2,400
Spring Garden†	11,387	8,338	5,719	2,766	879
State College	22,409	17,227	6,226	2,405	851
Steelton	11,266	12,574	13,115	13,428	12,086
Stowe†	11,730	12,210	12,577	10,665	2,852
Stroudsburg	6,070	6,361	6,186	5,278	3,450
Sunbury	13,687	15,570	15,462	15,721	9,810
Swarthmore	5,753	4,825	4,061	2,350	903
Swissvale	15,089	16,488	15,919	10,908	1,716
Swoyersville	6,751	7,795	9,234	6,876	2,264
Tamaqua	10,173	11,508	12,486	12,363	7,267
Tarentum	8,232	9,540	9,846	8,925	5,472
Taylor	6,148	7,176	9,002	9,876	4,215
Titusville	8,356	8,923	8,126	8,432	8,244
Turtle Creek	10,607	12,363	9,805	8,138	3,262
Tyrone	7,792	8,214	8,845	9,084	5,847
Uniontown	17,942	20,471	21,819	15,692	7,344
Upper Darby†	93,158	84,951	56,883	8,956	5,385
Upper Moreland†	21,032	8,936	5,103	2,195	—
Vandergrift	8,742	9,524	10,725	9,531	2,076
Warminster†	15,994	7,127	1,977	—	—
Warren	14,505	14,849	14,891	14,272	8,043
Washington	23,545	26,280	26,166	21,480	7,670
Waynesboro	10,427	10,231	10,231	9,720	5,396
Waynesburg	5,188	5,514	4,891	3,332	2,544
West Chester	15,705	15,168	13,289	11,717	9,524
West Hazleton	6,278	6,988	7,523	5,854	2,516
West Mifflin	27,289	17,985	—	—	—
Westmont	6,573	4,410	3,741	1,976	499
West Norriton†	8,342	4,879	3,016	1,375	—
West Pittston	6,998	7,230	7,943	6,968	5,846
West View	8,079	7,581	7,215	2,797	—
West York	5,526	5,756	5,590	3,320	—
Whitehall	16,075	7,342	—	—	—
White Oak	9,047	6,159	—	—	—
Wilkes-Barre	63,551	76,826	86,236	73,833	51,721
Wilkins†	8,272	4,261	3,884	3,455	2,427
Wilkinsburg	30,066	31,418	29,853	24,403	11,886
Williamsport	41,967	45,047	44,355	36,198	28,757
Wilson	8,465	8,159	8,217	3,243	—
Windber	6,994	8,010	9,057	9,462	—
Winton	5,456	6,280	7,989	7,583	3,425
Wyomissing	5,044	4,187	3,320	2,062	—
Yeadon	11,610	11,068	8,524	1,308	689
York	54,504	59,953	56,712	47,512	33,708

*Populations are reported as constituted at date of each census. †Township population.
Note: Dash indicates place did not exist during reported census, or data not available.

vided by law. This was subsequently extended to make attendance compulsory for all children between the ages of 8 and 16 throughout the school year. About 1,750,000 children enrolled annually in the public schools and about 460,000 in private and parochial schools. Even in 1834 the state made substantial contributions to the support of the schools. In 1921 the state appropriations were made contingent on the maintenance of cerfain minimum standards as to courses and teachers' salaries and qualifications. By the second half of the 20th century the annual state appropriations amounted to almost $200,000,000.

Higher Education. — After 1854 the need for trained teachers led to the establishment of normal schools under private auspices. These schools received a gradually increasing amount of state aid, and in 1911 the state was authorized to purchase them. In'1926 they were re-organized as state teachers' colleges at Bloomsburg (originally founded in 1839), California (1852). Cheyney (1837), Clarion (1866), East Stroudsburg (1893), Edinboro (18573, Indiana (1871), Kutztown (1866), Lock Haven (1877), Mansfield (1858), Millersville (1854), Shippensburg (1871), Slippery Rock (1889). and West Chester (1869). They offer four-year courses leading to the degree of bachelor of science in education and became state colleges in 1959.

Pennsylvania State. — Pennsylvania State university at University Park, a land-grant institution. receives almost its entire financial support from public revenue. Originally chartered in 1855 as Farmers' High school, it first gave instruction on the college level in 1859. The name was changed to the Agricultural College of Pennsylvania in 1862, to Pennsylvania State college in 1874 and to Pennsylvania State university in 1953.

The university includes colleges of liberal arts, agriculture, business administration, chemistry and physics. education, engineering and architecture, home economics, physical education and athletics. and mineral industries and schools of journalism and forestry. Fourteen two-year branch campuses are located throughout the state. A department of nuclear engineering was set up in 1958. and-the Research Reactor building on the University Park campus contains an atomic reactor used in various research projects. Also in 1958 the Groth institute of crystallography and a centre for continuing liberal education were established. The university owns a student-operated FM station.

The University of Pennsylvania. — The University of Pennsylvania, Philadelphia, was founded in 1740 as a charity school. Largely through the efforts of Benjamin Franklin and other leading citizens of Philadelphia, it was transformed in 1753 into an academy, with Franklin as president of the first board of trustees. Two years later it was chartered as the College and Academy of Philadelphia. With the foundation in 1765 of the first medical school in North America the institution became in fact a university, but it was not so called until 1779 when it was, for a time. state supported. Following the passage of an act of the state legislature in 1791 it became a privately endowed and controlled institution. although it receives some state aid.

The divisions of the university include the colleges of arts and sciences! liberal arts for women and general studies. schools of education. engineering, law, dentistry, medicine, veterinary medicine. social work, allied medical professions. nursing and fine arts and the Wharton school of finance and commerce. The Wistar Institute of Anatomy, the first anatomical institute in America devoted entirely to research. was founded in 1892. Also part of the university are the Henry Phipps Institute for the Study, Treatment and Prevention of Tuberculosis, affiliated with the university in 1910; the William T. Carter foundation of Child Helping: the Institute of Local and State Government: the Albert M. Greenfield Center for Human Relations; and the Psychological Laboratory and Clinic. founded in 1887, the oldest such institution in the United States. Among its activities the university offers through the Institute for Humanistic Studies a special program for corporation executives. Teaching and research programs in radio, television and allied fields are given by the Annenberg school of communications. The university participates with Princeton in the operation of a high-energy nuclear research centre sponsored by the U.S. Atomic Energy commission.

Other Universities and Colleges. — Pennsylvania is especially rich in institutions of higher learning, many of them dating back to the 18th century. Dickinson college at Carlisle (Methodist) was founded in 1773: Franklin and Marshall college, Lancaster (United Church of Christ), the University of Pittsburgh (nonsectarian) and Washington and Jefferson college. Washington (nonsectarian), were all founded in 1787. Philadelphia. which first became a cultural centre in colonial times; is the seat of Temple university (1884; nonsectarian), Drexel Institute of Technology (1891; nonsectarian), LaSalle college (1863: Roman Catholic) and St. Joseph's college (1851; Roman Catholic). among others. Bryn Mawr college for women (1880; nonsectarian), Haverford college (1833; Society of Friends), Swarthmore college (1864; nonsectarian) and Villanova university (1842; Roman Catholic) are located nearby in municipalities of the same names. Other Pennsylvania universities' and colleges include Allegheny college, Meadville (1815; Methodist), Bucknell university, Lewisburg (1846; nonsectarian). Duquesne university (1881; Roman Catholic) and the Carnegie Institute of Technology (1900; nonsec-

tarian), both at Pittsburgh, College Misericordia, Dallas (1924; Roman Catholic), Gannon college, Erie (1944; Roman Catholic), Geneva college. Beaver Falls (1848; Reformed Presbyterian), Gettysburg college, Gettysburg (1832; Lutheran), Grove City college, Grove city (1876; Presbyterian). Lafayette college. Easton (1826; Presbyterian), Lehigh university, Bethlehem (1865; nonsectarian), the University of Scranton (1888; Roman Catholic) and Marywood college (1915; Roman Catholic). both at Scranton, Westminster college, New Wilminpton (1852; Presbyterian) and Wilkes college. Wilkes-Barre (1933; nonsectarian). (See also PHILADELPHIA.)

HEALTH AND WELFARE

Care of the needy was recognized as a public responsibility even under the duke of York and again in the Great Law of 1682. For a long period poor relief was administered by poor boards or overseers of the poor in a complex system which had no uniform pattern, and there were county homes or almshouses for institutional relief in most of the counties. In 1937 a uniform system was established. The county homes and similar institutions were placed under county institution districts and a state department of assistance was created to function through county boards of assistance in administering old-age assistance, general assistance to the unemployed, aid for dependent children and the disabled, blind pensions, unemployment counseling, school medical assistance, burial assistance and foster homes. In the late 1950s almost half the money expended for these programs came from the federal government. The department of assistance was merged with the department of welfare in 1958 to create the department of public welfare.

The department of welfare operated 18 hospitals for mental disorders, four schools for mental defectives and ten state-owned general hospitals. The management of penal and correctional institutions was transferred to the state justice department in 1953. They include four penitentiaries, an institution for defective delinquents, an industrial home for women, an industrial school and two diagnostic and classification centres. A board of parole was created in 1941 for the uniform administration of parole in the state.

THE ECONOMY

Agriculture. — Although Pennsylvania is an industrial rather than an agricultural state, it remains important for its farm production, ranking among the first 15 states in cash receipts from farm products in the second half of the 20th century. About 50% of its area was in farms and more than half of its farm acreage nas improved. The number of farms increased from 127,577 in 1850 to 224,248 in 1900 but gradually decreased thereafter as submarginal farms were abandoned and also as small farms were consolidated into larger farms. The value of all farm property in 1930 was $1,535,484,000. This decreased by about one-third during the depression and World War II years, but the earlier position had been substantially regained by the 1950s.

Farming in Pennsylvania began as general farming with emphasis on grain growing. About 1790 livestock farming began to assume greater importance. but there was also diversification into fruit growing and truck farming. About 1900 dairy farming to produce milk became the most important farm enterprise, and milk, dairy products, poultry, eggs and other livestock products came to far exceed all other agricultural products in value. Dairy farming predominates in the northern counties. where a shorter growing season favours pastures and the growing of hay, but the greatest number of cattle are in the south and west. More than 6,000,000,000 lb. of milk are produced annually. The number of sheep declined precipitously after 1900, but swine increased in both numbers and value. Chicken raising is an important source of farm income.

Usually all the rough and most of the concentrated food for stock is raised on the farms. Corn is the leading crop in value. Others include tame hay, wheat, oats, potatoes, barley, rye, buckwheat and commercial truck crops. Pennsylvania ranks high among the states in buckwheat production. Most of the buckwheat. barley and oats is grown in the northern and western counties. while corn, wheat and rye are raised more extensively in the northeast. Tobacco is raised chiefly in Lancaster county; Pennsylvania leaf is especially valued as a cigar filler and wrapper. Adams, Franklin and York counties in the south central part of the state and Erie county in the northwest are the principal fruit-growing sections. Adams county leads in the production of apples. Peaches are grown in most of the southern counties and grapes are raised mainly in the lakeshore section of Erie county.

Important farm groups have formed state associations for the study of improved methods and the advancement of their interests, beginning with the dairy farmers in 1874. A state board of agriculture was created in 1876 and this became a department in 1895. Agricultural education has been developed extensively in the schools, and the extension services of the college of agriculture of Pennsylvania State university have helped to introduce scientific methods. Soil conservation districts have been set up by many counties in co-operation with the state department of agriculture to control and prevent erosion and otherwise maintain soil resources.

Industry. — Pennsylvania consistently ranks second to New York in the value of its manufactures, which increased from about $2,800,000,000 in 1914 to more than $7,000,000,000 in 1923, declined to around $3,000,000,000 during the depression of the 1930s but rose to well over $25,000,000,000 by the'mid-1950s. During the same period and reflecting the same economic trends, the number of plants fell from around 27,500 in 1914 to about 12,000 in 1933 and then rose to more than 17.000 in the 1950s, when there were about a third more employees than in 1914. These figures reflect a trend toward larger plants.

The development of manufacturing resulted largely from abundance of fuel, the facilities for shipment through the port of Philadelphia, the availability of the ores of the Lake Superior region and the development of transportation, first by canal and later by railroad. By far the most important industry is the production of iron and steel, in which the state has always held the lead. The first ironworks in Pennsylvania was a bloomery forge, erected by Thomas Rutter in Berks county in 1716. Charcoal iron furnaces were numerous in eastern Pennsylvania after that time, and the industry continued to prosper and expand there when anthracite took the place of charcoal With the increase in the use of bituminous coal and of coke made from it, and with the development of the steel industry. western Pennsylvania became the iron and steel manufacturing centre and the Pittsburgh district in particular received a new impetus from the introduction of iron ore from the Lake Superior region. In the manufacture of pig iron Pennsylvania is easily first among the states.

Pennsylvania's industries are remarkable for their diversity and balance. Although metals are by far the most important, it is virtually impossible to mention a single manufactured product which is not made somewhere in the state. Such diversification has tended to diminish the effects of the decline in coal mining and similar but more temporary slumps in various industries. In the mid-1950s the leading manufactures were primary metal products, fabricated metal products, electrical and other machinery, petroleum and coal products, food and kindred products, textiles, apparel and related products, paper, pulp and products, printing and publishing, chemicals, stone, clay and glass products and transportation equipment.

Philadelphia is the great manufacturing centre of the state and one of the most important in the nation. It is surrounded by an area of highly diversified industry. In 1957, for example, there were within the city 4,411 factories which employed 299,552 persons and had a product valued at $5,527,693.100, or about one-quarter of the total produced in the state. Despite the development of steel mills in other parts of the state and nation, Pittsburgh remained the centre of the iron and steel industry. After Philadelphia and Pittsburgh, the more important manufacturing cities are Erie. Scranton. Reading. Allentown, Bethlehem, Chester. Wilkes-Barre, New Castle, Lancaster, Harrisburg, York, Altoona and M'illiamsport (*qq.v.*).

Mining. — Coal. — If petroleum and natural gas are included,

Pennsylvania stands second to Texas as a mineral-producing state. A large part of this output is represented by coal. With the exception of small areas in Colorado and New Mexico, Pennsylvania contains the only anthracite deposits in the United States. They are found within an area of less than 500 sq.mi. in the northeastern part of the state, chiefly in Lackawanna, Luzerne, Carbon, Schuylkill and Northumberland counties. In addition, Pennsylvania has extensive bituminous coal measures, and most of the coal obtained from these is of high quality. They form the northern extremity of the great Appalachian coal field and underlie an area of 15,000 sq.mi. or more in the west of the state. The Pittsburgh district, comprising the counties of Allegheny, Washington, Fayette and Westmoreland. is exceptionally productive. The coal in Allegheny and Washington counties is noted for its gas-producing qualities, while the famous Connellsville coking coal is obtained in Fayette and Westmoreland counties. The output of coal in Pennsylvania rose steadily from 1880, when 28,650,000 tons of anthracite and 18,425,000 tons of bituminous were mined, to World War I, when the peak figures were 99.612.000 tons of anthracite in 1917 and 178.551.000 tons of bituminous in 1918. Thirty years later, in 1948, the respective tonnages had fallen to 57,140.000 and 132,550,000, and the downward movement showed no signs of stopping. This decline reflected technological changes in industry and transportation and a shift from coal to natural gas and oil for home heating. It caused much unemployment in the coal regions, which have sought to develop new industries. The state makes loans to aid local authorities in attracting new plants to these depressed areas, and research to find new ways of utilizing coal is being conducted. Vast coal reserves remain underground. In the early 1960s it was estimated that about 13,000,000 tons of bituminous coal and 8,000.000 tons of anthracite were recoverable at the current price level and by current methods.

Petroleum.—Extending from the southwest corner of the state is the Pennsylvania section of the Appalachian oil field which, with a small section in New York, furnished nearly all of the country's supply of petroleum for several years after the discovery of its value for illuminating purposes. The first petroleum well was drilled by Edwin L. Drake near Titusville in 1859. and oil wells mere developed rapidly in the Oil creek valley and up the Allegheny river from Franklin to Tidioute. The state's output of petroleum reached its peak in 1891 with a production of 31,424,206 bbl. Thereafter the yield declined as the older wells were exhausted and few new wells were developed; in the late 1950s production was only about 6,000.000 to 8,000,000 bbl. a year. While the quantity produced has become relatively small, however, the physical and chemical characteristics of Pennsylvania oil give it special value as a base for lubricants.

Natural Gus.—Much natural gas was found and wasted in the early years of oil production. but later it was utilized as a fuel and an illuminant. The peak recorded natural gas production, 138.000.000.000 cu.ft., came in 1906 but it fell to 61,000,000,000 cu.ft. in 1932. This figure was subsequently raised by the discovery of the Leidy gas field in Clinton county.

Iron.— Deposits of various kinds of iron ore were found in the southeastern, eastern. central and some of the western counties, and from the middle of the 18th century until near the close of the 19th Pennsylvania ranked high among the states in production of iron ore. As late as 1880 it was first with 1,951,496 long tons. After the first successful experiments in making pig iron with bituminous coal, the state's iron foundries rapidly moved westward into the bituminous coal area and away from the early producing centres. The shipment of iron ore from the Lake Superior region, beginning about 1853, caused a further decline of iron mining within the state, since Lake Superior ore could be shipped to the Pittsburgh region at less cost than ore could be shipped from mines within the state. In 1932 the ore mined amounted to only 103,000 long tons, but it increased somewhat thereafter. Most of this ore comes from one mine, the famous Cornwall ore banks, worked continuously since 1740.

Miscellaneous Minerals.—Pennsylvania has extensive areas of limestone rock suitahle for making cement, and enormous quantities of it are used in this industry in Northampton and Lehigh counties. In Lehigh county the first successful portland cement plant in the United States was erected in 1870, and thereafter Pennsylvania continued to lead all states in annual cement output. Limestone and dolomites suitable for building purposes are obtained chiefly in Montgomery, Chester and Lancaster counties. Until increased facilities of transport brought more desirable stones into competition they were used extensively in Philadelphia. There are limestone quarries in nearly two-thirds of the counties and great quantities of this stone are used for flux in iron furnaces, for making quicklime, for railway ballast and in road building. Northampton, Lehigh and York counties contain the most productive slate quarries in the U.S. Northampton and Lehigh slate is the only kind in the United States used for school blackboards. There is an extensive area in the southeastern part of the state containing shale clay of a superior quality for making common brick. Kaolin abounds in Chester and Delaware counties, and fire clay in several of the western counties. The state leads all others in the value of its clay and clay products. Glass sand is abundant in both the eastern and western regions, and for many years Pennsylvania has ranked among the leading states in the manufacture of glass. In Chester county, also, is one of the most productive deposits of feldspar, second only to those of Maine.

Trade and Finance.—From colonial days when Philadelphia merchants developed a prosperous commerce with other colonies and with Europe. trade has been an important element in the state's economy. The internal improvements of the 19th century opened channels of trade with the west, and Pittsburgh grew to economic importance as the commercial gateway to the Ohio valley. In the late 1950s more than 17,000 carloads of commodities originated in the state, more than 13.000 terminated in it and more than 12,000 moved within it. There were more than 15,000 wholesale trade establishments and 120.000 retail establishments.

Pennsylvania has one port of entry on the Atlantic coast, one on the Ohio river and one on the Great Lakes. Philadelphia, the Atlantic port, exports chiefly coal, grain and flour and imports chiefly petroleum, iron ore, sugar, drugs and chemicals, manufactured iron, hemp, jute and flax. It has long ranked second among the ports of the United States in the tonnage of its foreign commerce, surpassed only by New York city. Pittsburgh has ranked high among U.S. interior ports. Erie has been an important port in the Great Lakes trade and received its first ocean-going vessel through the St. Lawrence seaway in May 1959.

The thriving commerce of colonial Philadelphia built up surplus wealth for investment and gave it an early lead as a financial centre. The first fire insurance company to be chartered in America was the Philadelphia Contributionship, founded in 1752, and the first life insurance company was formed in 1759. In 1780, 90 Philadelphians formed a bank to finance the Revolutionary army, and this bank was succeeded by the Bank of North America, chartered by congress in 1781 and by Pennsylvania in 1782, the first bank to be chartered in America. The first and second Banks of the United States were also located in Philadelphia, and many other banking institutions developed there and elsewhere in Pennsylvania. Although New York city became the leading financial centre after the Civil War, Pennsylvania remained important in this field with many insurance companies and with banks and savings and loan associations in all important centres of population. A decline in the number of banks reflected the growth of branch banking.

Transportation and Communication.— Transportation was an essential factor in Pennsylvania's development. Since the mountain ranges made east-west travel difficult, it was necessary to overcome these difficulties by roads, canals and railways. After the early roads, turnpikes and canals (see History, above), a network of railways began to develop between 1830 and 1860. The Philadelphia & Reading railway, begun in 1835, and the Lehigh Valley railroad, chartered in 1846, gradually extended' their lines to link the coal regions with New York state. The Pennsylvania railroad, chartered in 1846, opened its line from Harrisburg to Pittsburgh in 1852, using the tracks of the state's Allegheny portage railroad until its own mountain division was finished. Later, it purchased the main line of the state works and thus had a com-

plete rail line from Philadelphia to Pittsburgh, with the state's Columbia railroad. It then extended its lines rapidly to become one of the nation's most important railroads. With these and other railways the state had a virtually complete network of rail transportation by the time of the Civil War. Although some additions were made later, the basic pattern was already established. The railway mileage, *8.453* in *1890,* increased to *11,693* in *1915.* This had decreased somewhat by the early 1960s, but Pennsylvania still had the third longest track mileage in the United States.

In *1911* the state began an extensive program of highway construction which was accelerated by the introduction of the automobile. After *1918* funds were provided by bond issues) drivers' licence fees and a gasoline tax. By the late *1950s* the state highway system included more than *41.000* mi. of improved roads, while county, township. city, and borough highways totaled over *61.000* mi.. about *38,000* mi. of which were improved. In *1938* the Pennsylvania turnpike was begun as a toll road penetrating the Allegheny mountains through seven tunnels to connect eastern and western Pennsylvania. This four-lane limited-access highway was opened from Carlisle, near Harrisburg. to Pittsburgh in *1940,* and later extended from the Ohio border to the Delaware river, where it was connected with the New Jersey turnpike in *1956.* In *1957* a northeastern extension to Clark's Summit was completed, and the entire system totaled *470* mi.

The communication of ideas was also important to Pennsylvania's progress. The first newspaper was established in Philadelphia in *1719,* the fourth in the American colonies. By *1775, 9* newspapers were published in Pennsylvania and by *1810* there were *i3.* These grew to more than *400* with a total circulation of over 8,000,000. Other means of communication also developed early.

The first commercial telegraph line in the United States was opened from Philadelphia to Lancaster in *1846* and the telephone was introduced in the 1880s. The first commercial radio broadcasting station in the world was KDRA, Pittsburgh, which began a regular daily schedule on Nov. *2, 1920.* Pennsylvania has almost *100* telephone companies and more than 4,000,000 telephones are in use. There are more than *200* radio stations and more than *20* television stations.

See also references under "Pennsylvania" in the Index volume.

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PENNSYLVANIA, UNIVERSITY OF, a U.S. institution of higher learning, founded in 1740 at Philadelphia, Pa. *(see* PENNSYLVANIA: *Education).*

PENNY, a British coin (German *pfennig),* equal in value to one-twelfth of a shilling *(q.v.),* denoted after a numeral by *d.* (from Lat. *denarius).* The term is also used colloquially in the United States to denote a cent, the hundredth part of a dollar.

Whatever earlier currency the name and denomination may have had it was not until the reign of Offa *(757–796)* that English coinage was formally based on a silver penny showing the king's name on the obverse. Offa's penny weighed $22\frac{1}{2}$ gr. and *240* pennies weighed one Saxon pound (or Tower pound, as it was afterward called), hence the term pennyweight (dwt.). In *1257* Henry III struck experimentally a gold penny of the value of *20* silver pence. During the reign of his successor, Edward I, halfpence and farthings (four to a penny) became a regular part of the coinage, the penny having been cut for trade purposes into halves, quarters and perhaps even thirds. The silver penny remained the general coinage of England until the introduction of the gold florin by Edward III in *1344.* The weight and value of the silver penny declined from *1300* onward. Whereas in *1066* it weighed $22\frac{1}{2}$ gr., in *1300* it weighed *22* gr. and by *1601* it weighed only $7\frac{3}{4}$ gr.

Silver pence were struck for general circulation until the reign of George II; since then they have been coined only as part of the royal alms on Maundy Thursday. Copper halfpence were first issued by Charles II, but it was not until *1797* that copper pence were struck, weighing *1* oz. avoirdupois, together with copper twopences weighing *2* oz.: both series were found cumbersome and nere soon discontinued. In *1860* bronze was substituted for copper, the alloy containing *95* parts of copper, four of tin and one of zinc. The weight was also reduced, *1* lb. of bronze making *48* pennies, as against *24* of the earlier copper pennies. The figure of Britannia first appeared on the copper coins of Charles II.

See also NUMISMATICS: *British Coins.* (JO. M. L.)

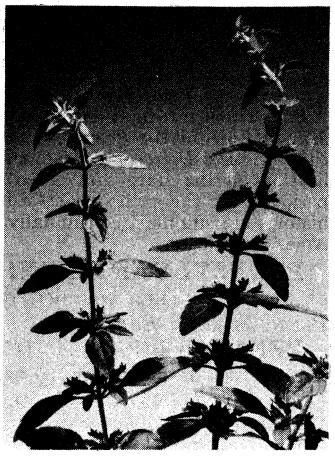
PENN YAN, a village of northwest central New York, U.S., located at the northern end of Lake Keuka. *50* mi. S.E. of Rochester; the seat of Yates county. Lake Keuka, shaped like a "Y," is one of the most beautiful of the "finger lakes" of central New York. The Keuka college for women (Baptist, founded *1892)* is at Keuka Park, *4* mi. S. of Penn Yan on the western shore of the lake. The region is a resort area but it is also known for its grapes, dairies, poultry, sheep and grain. Manufactures include buckwheat products. wines, vinegar, fruit baskets, flour, roofing paper base, baby baskets, boats, store fixtures, clothing, canned fruits, vegetables and chemical products.

The first settlers of Penn Yan were chiefly followers of Jemima Wilkinson (1753–1819), a religious enthusiast from Rhode Island, who in *1788* settled near Lake Seneca. Her followers began to desert her before *1800,* and gradually the community broke up. In 1799 the first dwelling was built on the site of Penn Yan, named as a compromise between the Pennsylvania and Yankee (New England) settlers.

It became the county seat when Yates county was created in *1823.* Penn Yan was incorporated in *1833.* For comparative population figures *see* table in NEW YORK: *Population.*

PENNYROYAL, an aromatic herb formerly much used in medicine, the name being a corruption of the old herbalist's name "Pulioll-royall," *Pulegium regium.* It is a member of the mint genus, and has been known to botanists since the time of Linnaeus as *Mentha pulegium.* It is a perennial herb with a slender branched stem. square in section, up to a foot in length and rooting at the lower nodes, small opposite stalked oval leaves about

half an inch long and dense clusters of small reddish-purple flowers in the leaf axils, forming almost globular whorls. It grows in damp gravelly places, especially near pools, on heaths and commons. It has a strong smell somewhat like that of spearmint, due to a volatile oil which is readily obtained by distillation with water, and is known in England as *Oleum pulegii.* The specific name recalls its supposed property of driving away fleas (*pulices*). Like the other mints it has carminative and stimulant properties.



ROCHE

AMERICAN PENNYROYAL (HEDEOMA PULEGIOIDES)

The similar American pennyroyal (Hedeoma *pulegioides*), also belonging to the mint family (Labiatae), occurs in dry fields from Cape Breton Island to Ontario and North Dakota, southward to Florida and Arkansas.

PENOLOGY, penal science, that part or division of criminology which concerns itself with the philosophy and practice of prison administration and the treatment of prisoners. See CRIME; CRIMINOLOGY; JUVENILE DELINQUENCY; PRISON.

PENRITH, a market town and urban district in the Penrith and the Border parliamentary division of Cumberland, Eng., 11 mi. S.S.E. of Carlisle by road. Pop. (1961) 10,931. Area 11.9 sq.mi. At Penrith are remains of a Roman military settlement known as Voreda. The parish church of St. Andrew is of Norman foundation with a 14th-century tower. and its list of vicars is complete from 1223. In the churchyard are the "Giant's grave" (ancient hogback stones and cross shafts) and the "Giant's thumb" (the remnant of a 10th-century rose cross). Fairs are held three times a year and there is a weekly market on Tuesday, all under a charter granted by Henry III in 1223.

In 1242 the manor of Penrith was handed over to Alexander II of Scotland, who held it until 1295, when Edward I seized it. In 1397 Richard II granted it to the 1st earl of Westmorland; it then passed to Warwick the Kingmaker and on his death to the crown. It later passed from the earl of Portland to the dukes of Devonshire. and the market rights were purchased by the urban council in 1878. A 14th-century grammar school was refounded by Elizabeth I in 1564, and there are two mansions dating from the same reign which have been converted into inns. The town suffered much from the incursions of the Scots, in defense against whom Ralph, earl of Westmorland, who died 1426, built Penrith castle. During the Civil War the castle was dismantled by royalist command, and the ruins are now preserved as an ancient monument. In 1597–98, 2,260 people perished by plague in the Penrith rural deanery. Hutton hall, near the parish church, was built about 1480 and incorporates an old peel tower. Though there are some small foundries. a brewery, motor repair works and sawmills, Penrith depends mainly on agriculture, particularly the breeding and sale of livestock. Small industries, such as checks, linen cloth and ginghams, and clock and watch making, carried on in houses in the 18th century, have disappeared.

Lake Ullswater is j mi. S.W. of Penrith. The village of Edenhall, east of the town, recalls the celebrated enameled goblet, known as the "Luck of Edenhall," which belonged to the Musgrave family and is now in the Bank of England. Penrith beacon (937 ft.) is a fine viewpoint for the Lake district mountains.

PENROSE, RICHARD ALEXANDER FULLERTON, JR. (1863–1931), U.S. geologist, who left a large fortune to scientific societies, was born in Philadelphia on Dec. 17, 1863. He mas graduated from Harvard university (A.B., 1884; Ph.D., 1886), where he acquired a broad view of science and a practical one of geology. After writing his thesis on phosphates, he managed mines for the Anglo-Canadian Phosphate company (1886–88) and later surveyed mineral deposits for the states of Texas (1888–89) and Arkansas (1889–92).

In 1892 he became professor of economic geography at The University of Chicago. and was full professor, 1895–1911. In 1895 Penrose was a founder of the Commonwealth Mining and Milling company at Pearce, Ariz., which produced gold; and in 1903 he founded, with his father and brother Spencer, the Utah Copper company at Bingham, Utah. The property proved to be in the largest deposit of porphyry copper in the world and became the largest single producing area in the United States.

A founder of the Society of Economic Geologists in 1920, he was its first president. He established the Penrose gold medal for economic geology and a similar medal for outstanding work in any aspect of geology, to be awarded by the Geological Society of America. He was president of that society in 1930–31 He never married and at his death on July 31. 1931, the bulk of his estate of about $10,000,000 was left to the Geological Society of America and the American Philosophical society.

PENRY, JOHN (1559–1593), Welsh Puritan, was born in Brecknockshire in 1559; tradition points to Cefn Brith, a farm near Llangammarch. as his birthplace. He was educated at Peterhouse, Cambridge, and St. Alban's hall. Oxford. He did not seek episcopal ordination, but was licensed as university preacher. The tradition of his preaching tours in Wales is slenderly supported; they could only have been made during a few months of 1586 or the autumn of 1587.

At this time ignorance and immorality abounded in Wales. In 1562 an act of parliament had made provision for translating the Bible into Welsh, and the New Testament was issued in 1567; but the number printed would barely supply a copy for each parish church. Indignant at this negligence! Penry published, early in 1587, *The Aequity of an Humble Supplication—in the behalf of the country of Wales, that some order nzay* be *taken for the preaching of tlze Gospel among those people.* Archbishop Whitgift thereupon caused him to be brought before the high commission and imprisoned for about a month.

On his release Penry married at Northampton, where he lived for several years, and set up a printing press. It was successively located at East Molesey (Surrey), Fawsley (Northampton), Coventry and other places in Warwickshire, and finally at Manchester, where it was seized in Aug. 1589. On it were printed Penry's *Exhortation to the governours and people of Wales,* and *View of . . . such publike wants and disorders us are in the service of God . . . in Wales;* as well as the celebrated *Martin Marprelate* tracts.

In Jan. 1590 his house at Northampton was searched and his papers seized, but he succeeded in escaping to Scotland. There he published several tracts, as well as a translation of a learned theological work known as *Theses Genevenses.* Returning to England in Sept. 1592, he joined the Separatist Church in London, in which he declined to take office, though after the arrest of the ministers, Francis Johnson and John Greenwood, he seems to have been the regular preacher. He was arrested in March 1593, and efforts were made to find some pretext for a capital charge. Failing this a charge of sedition was based on the rough draft of a petition to the queen that had been found among his private papers, the language of which was indeed harsh and offensive, but which had been neither presented nor published. He was convicted by the queen's bench on May 21, 1593, and hanged on the 29th.

See the ***Life,*** by John Waddington (1854).

PENRYN, a market town, port and municipal borough in the Falmouth and Camborne parliamentary division of Cornwall, Eng., 2 mi. N.W. of Falmouth and 34 mi. E.N.E. of Land's End by road. Pop. (1961) 4,448. Area 1.3 sq.mi. The town lies at the head of the estuary of the Penryn river, which opens on the west coast of Carrick Roads, into which flows the Fal. It owed its development to the bishops of Exeter, within whose demesne lands it stood. These lands appear in Domesday Book under the name of Trelivel. Glasney college was founded by Bishop Bronescombe in 1265 and became a considerable centre of learning, but appears to have been suppressed in 1547. Bishop Walter de Stapeldon secured a market on Thursdays. a fair at the feast of St. Thomas and, in 1311, a three days' fair at the feast of St. Vitalis. Mary I gave the parliamentary franchise to the burgesses in 1553. James I granted

and renewed the charter of incorporation, providing markets on Wednesdays and Saturdays and fairs on May 1. July 7 and Dec. 21. The charter having been surrendered, James II by a new charter among other things confined the parliamentary franchise to members of the corporation. This proviso. however. was soon disregarded, the franchise being freely exercised by all the inhabitants paying scot and lot. From 1553 to 1832 the borough returned two members to parliament. An attempt to deprive it of its members, because of corrupt practices?was defeated by the house of lords in 1827. The act of 1832 extended the franchise to Falmouth, in spite of the rivalry existing between the two boroughs. In 1885 the united borough was deprived of one of its members.

There is no parish church within the borough boundaries, but the church of St. Gluvias. to the north. fulfills this function. Although largely restored in 1883 it retains a 15th-century tower. Penryn's foreign trade, dating from the 14th century, is large. Granite, which is extensively quarried in the neighbourhood, is dressed and polished at Penryn, and there are also engineering works and boat repairing and lumberyards. The harbour dries at low tide, but at high tide has 13 ft. of water.

PENSACOLA, a city of Florida, U.S., located in the northwestern part of the state on the northern shore of Pensacola bay about 6 mi. (11 mi, by channel) N. of the Gulf of Mexico and 50 mi. S.E. of Mobile, Ala.; the seat of Escambia county. The city is separated from the Gulf of Mexico by Santa Rosa Island. At the western end of the island is Ft. Pickens and across the channel to the west is Ft. Barrancas. Pensacola retains much of the atmosphere of an old Spanish city, with its Plaza Ferdinand VII, Seville square. Spanish street names and religious festivals. From the ochre-yellow banks of the bay the city rises gently to heights commanding views of beautiful bayous and the Escambia river. which flows into the bay on the east. Public parks and beaches give pleasure to thousands. There are two public junior colleges: Pensacola, organized in 1948, and Washington, opened in 1949. The city has a council-manager form of government in effect since 1931.

The city's trade area includes parts of Alabama. Louisiana and Georgia. Nylon yarn, paper, wallboard. industrial chemicals, lumber, naval stores; tile, concrete, cottonseed oil and small boats predominate as manufactured products. The deep-water port of Pensacola suffers because of its proximity to Mobile.

Pensacola bay was discovered in 1516 by a ship's pilot, Diego Miruelo. In 1528 Pánfilo de Narváez with 242 followers made a water stop at Pensacola. In Jan. 1530 Diego Maldonado, commander of Hernando de Soto's fleet, entered the harbour and named it Puerto d'Achusi.

Tristán de Luna in 1559 colonized the bay, which he renamed Santa Maria de Gálvez, but the settlement was abandoned two years later.

An expedition under Juan Enriquez Barroto and Antonio Romero rediscovered Pensacola bay on Feb. 6, 1686, while searching for a colony planted by René Robert Cavelier, sieur de la Salle. Reports describing the friendly Panzacola Indians and the magnificent bay inspired an expedition, led by Adm. Andrés de Pez and Dr. Carlos de Sigiienza y Góngora, a noted Mexican mathematician, to explore Pensacola bay in 1693. It was, however, renewed French interest in the area which galvanized the Spanish into action. In 1698 expeditions under Andrés de Arriola and Capt. Juan Jordan de Reina established Ft. San Carlos at the entrance of the bay.

In the brief French-Spanish war of 1719–20 Pensacola mas seized by Jean Baptiste le Moyne, sieur de Bienville, almost immediately recaptured by Spain, seized again and burned by France and restored to Spain in the treaty of Feb. 17, 1720. A small, indolent garrison was maintained by Spain after 1720 and, except for a hurricane which destroyed the town in 1754, the post was undisturbed. At the end of the Seven Years' War the Floridas, including Pensacola, mere transferred to England. Although the Spanish inhabitants left for Mexico and Cuba, the British swiftly re-established the settlement and Pensacola was made the capital of West Florida.

During the American Revolution Pensacola was a haven for Tories. On May 9, 1781, it was captured by Bernardo de Gálvez, the Spanish governor at New Orleans. and Spanish possession was confirmed in the definitive treaty of peace of 1783.

During the War of 1812 the British made Pensacola a centre of operations despite Spanish protests, and in 1814 entered the harbour to take formal possession, but were repulsed by Gen. Andrew Jackson. In 1818 General Jackson captured the city from the Spanish, maintaining that they were encouraging the Seminole Indians in raids against the U.S., and in 1821 Florida as a whole was finally transferred to the U.S. In 1824 Pensacola was chartered as a city and mas selected as the site of a federal navy yard. During the American Civil War, on Jan. 12, 1861, the navy yard mas seized by the state qovernment but Ft. Pickens remained under federal control and on May 8, 1862, the Confederates evacuated the city.

Railroad development after the Civil War led to extensive lumbering, which in a few years devastated the pine forests of the area. In 1872 commercial shipments of fish began and by the 1880s Pensacola seafood, especially red snapper, was shipped to an ever-nidening market In 1913 the inactive navy yard was reopened as a naval air station and is now a large aviation training school.

Pop. (1960) 56,752; for comparative population figures see table in FLORIDA: *Population.* In that year, for the first time in a federal census, the population exceeded 50,000 and the Pensacola standard metropolitan statistical area (Escambia and Santa Rosa counties. pop. 203,376) was established by the census bureau.

(E. C. Jo.)

PENSHURST, a village in the Sevenoaks rural district of Kent, Eng.. at the confluence of the Eden and Medway, 5 mi. S.W. of Tonbridge. Pop. (1951) 1,554. The village has some old houses, including a timbered house of the 15th century.

Penshurst place is celebrated as the home of the Sidney family, and there Sir Philip Sidney was born in 1554. The mansion is quadrangular and has a court, chapel and hall (c. 1341) with open timber roof and a minstrels' gallery. The state rooms are open to the public during the spring and summer.

PENSIONARY, a name given to the leading functionary and legal adviser of the principal town corporations of the Netherlands, because they received a salary, or pension. At first this official was known by the name of "clerk" or "advocate." The office originated in Flanders. The earliest "pensionaries" in the Netherlands were those of Dort (1468) and of Haarlem (1478). The pensionary conducted the legal business of the town, and was the secretary of the town council and its representative and spokesman at the meetings of the provincial states. The post of pensionary was permanent and his influence was great.

In the states of the province of Holland the pensionary of the order of nobles (Ridderschap) was the foremost official of that assembly and he was named (until the death of Oldenbarneveldt in 1619) the land's advocate, or more shortly, the advocate. The importance of the advocate was much increased after the outbreak of the revolt in 1572. and still more so during the long period 1586–1619 when John van Oldenbarneveldt held the office. The advocate drew up and introduced all resolutions, concluded debates and counted the votes in the provincial assembly. When it was not in session he was a permanent member of the college of deputed councillors who carried on the administration. He was minister of justice and of finance. All correspondence passed through his hands, and he was the head and the spokesman of the deputation, who represented the province in the states-general. The conduct of foreign affairs in particular was entrusted almost entirely to him.

After the downfall of Oldenbarneveldt the office of advocate was abolished. and a new post, tenable for five years only, was erected in its place with the title of Raad-Pensionaris, or pensionary of the council, usually called by English writers grand pensionary. In the stadtholderless regime 1650–72 the grand pensionary became even more influential than Oldenbarneveldt himself, since there was no prince of Orange filling the offices of stadtholder, and of admiral and captain general of the union. From 1653 to 1672 John de Witt, re-elected twice. made the name of grand pensionary of Holland forever famous during the time of

the wars with England. The office was abolished after the conquest of Holland by the French in 1795. (G. E.)

PENSIONS. Pensions are periodic payments, usually for the natural life of a person who retires because of age or disability. Sometimes the term refers to periodic payments to wives, widows or children of a primary or deceased person or pensioner; occasionally, a pension will be conveyed solely as an honour for conspicuous service or valour. Pensions are provided by government in three guises: (1) as compensation or recompense to mar veterans and families for old age or for disability or death, usually from service causes; (2) as disability or old-age retirement benefits for civilian employees of government; (3) as social security payments for the aged, disabled or deceased citizenry based on past employment history or subject to current evidence of need. Pensions are also provided by many nongovernmental employers as a means of protecting workers retiring for age or disability and for relieving the payroll of superannuated personnel. They are sometimes provided by union-management welfare funds, associations or trusteeships. Only rarely do employees in groups, associations or unions undertake their own pension program without employer or governmental assistance.

Pensions are variously viewed in the concepts of charity, paternalism, deferred pay, depreciation or replacement charges, part of current payroll, honorarium for service rendered. the general welfare clause, aiding the velocity of money and others. Fundamental provisions of any pension plan include eligibility, conditions for the receipt of pension, pension benefit formula, death and withdrawal features, source of contributions, method of and medium for funding, equities if plan terminates (only in nongovernmental plans).

Costs are a principal concern in the pension field. This includes magnitude of costs, incidence thereof and proper accounting therefor; also the nature of the reserve—full actuarial, modified basis or pay-as-you-go (no reserve). True cost outlay can only be known in retrospect; it equals benefits paid plus expenses incurred minus interest earned on reserve funds.

UNITED STATES

U.S. pension plans for employees may be classified according to the characteristics of the employer. Examination may be made under the following headings: (1) industrial pensions; (2) public employee pensions; (3) teachers' pensions (other than [2]); (4) pensions for employees of religious bodies; and (j) pensions for other nonprofit employees. Other "pension" headings found below are (6) mothers' and widows' pensions; (7) state old-age and blind pensions; and (8) Townsend plan pensions. The main reference for (6) and (7) is under SOCIAL SECURITY. Also, military pensions are not treated below, the main reference for which is under WAR PENSIONS.

Industrial Pensions.—By the mid-1950s nearly 20,000 pension plans were in effect for about 14,000,000 employees of private industry in the United States. These were formal documental plans approved by the internal revenue service, thus clearing the employer's contributions as tax deductible and imposing no taxes on employees until distribution from the plan. In addition, many informal plans existed, either with no advance funding or with a fund represented on the books of the employer and not beyond his control..

The formally funded industrial plans had aggregate assets of the order of $21,000,000,000. They were mainly carried through either an insurance company medium or a segregated trust fund; assets were very roughly of equal magnitude for the two methods. Various insurance company contracts are used as the pension vehicle, comprising the group-annuity contract (the direct purchase of units of pension for each year of service as rendered), the deposit-administration contract (insurance company administers unallocated fund with direct purchase of individual annuities at retirement), the group-permanent contract (life insurance to retirement age with maturity then as pensions). and individual policies (various types maturing as pensions at retirement, with or without prior life insurance) held by a trustee. The trust-fund medium may be established with little or much administrative detail for the trustee (corporate or natural person or persons) and with all or none of the investment direction placed in the employer. There were various combinations of insured and trust-fund pension devices at mid-century.

Industrial plans on a formal basis were rare before the 20th century; the U.S. Steel corporation fund started in 1911, the American Telephone and Telegraph plan in 1913 (but no separate fund until 1927). Insurance companies first offered contract mediums for pensions in the early 1920s. Trust companies did not actively bid for the business until the early 1940s. The enactment of the Social Security act in 1935, instead of retarding the growth of industrial pension plans. acted as a stimulant for plans supplementing the act. The excess profits taxes of World War II and the wartime restrictions on wages and salaries also increased the incentives for the formulation of plans.

In the latter 1940s some union uelfare funds contained pension features, mainly supported by employers' contributions of so much per hour, of a set percentage of pay or of "x" cents per unit produced; e.g, per ton of coal In 1949 pensions mere ruled by the courts to be proper subjects for collective bargaining. The president's steel industry board's report and the steel union strikes of the fall of 1949 forced the implementation of the courts' dictum and pensions were won by many unions on a quasi-noncontributory basis.

Seldom is there one industrial pension plan identical to another in all respects; even in the 1949 attempts of the C.I.O. unions to set up uniform patterns in the steel and automotive industries, many variations developed in the settlements effected by collective bargaining.

By reason of union negotiations, the general desire for pension security and the incentive of tax deductions for employer contributions to pension plans, great activity in establishing these plans, or in adopting liberalizing amendments, was still under way in the 1950s. The wide coverage of these plans and the billions of dollars involved in the funds, spurred on by cases of fraud or irregularity discovered in a few union welfare plans, caused both the federal congress and the New York state legislature to commence an examination of benefit plans (including pensions) with a view to possible legislation for supervising these plans. A N.Y. state law for this purpose was passed in 1956.

Public Employee Pensions.—Under this heading fall not only employees of federal, state, county and municipal governments, and their subdivisions by department or occupational classification, but also those of certain quasi-governmental establishments, such as publicly owned corporations, municipal transit companies, the Tennessee Valley authority, the federal reserve system and others. Moreover, the employees of the international bodies such as the United Nations, the International Bank for Reconstruction and Development, the International Monetary fund, the International Labour office and others could reasonably be included as public employees for whom the U.S. furnished support, including pensions.

Public-employee plans in the United States were inaugurated before the beginning of the 20th century. The "retired-pay" measures of the armed services had already been in effect, but not as pension systems in the usual sense; they continued a certain proportion of pay, the recipients were subject to recall to duty and there was no advance funding or thought of employee contributions (see WAR PENSIONS). Agitation for a general plan for federal employees began around the turn of the century, but it was not until 1920 that enabling legislation finally brought their realization.

The federal Civil Service Retirement and Disability fund, established in 1920, as amended up to 1956, contained the following main provisions:

Voluntary retirement from age 62 to age 70 (mandatory) with 15 years of service. Certain earlier retirement privileges after 25 or 30 years of service. The pension based on length of service and on the employee's best five-year average annual salary; employee to receive 1½% of such annual salary for each year of service, or, if greater, 1% of such salary plus $2 j tor each year of service, maximum benefit 80% of such salary. Total disability pension after five years of service, determined by the better of the two formulas above. Employee to

contribute 6% of his salary and in case of death or termination of service prior to retirement, to receive a refund of his contributions with interest. If, however, at the death of an employee with five or more years of service, a qualified dependent survives (widow and/or child), one-half of the regular pension to be payable to the widow at age 50 or more, and if a child (under 18) is present, whether the mother is 50 or not, an additional one-fourth of the regular pension (with certain limits) to be payable to each child under 18; if the child alone survives, one-half pension payable. In case of termination after five years of service, employee might leave his refund and be credited with a vested deferred pension (age 62) computed on the better of the two formulas above, thus also getting credit for the government share of accrued liability; this method to be automatic if he leaves after 20 years' service. Various optional death benefit forms of pension available at retirement. Optional additional employee contributions might be made to augment the regular pension, but without direct additional government contributions. The government to meet the pensions and death benefits not provided by employee contributions from annual appropriations by congress.

Actuarial reports in the mid-1950s estimated the annual cost at about 15½% of covered payroll (including the 6% from employees) without including any amortization of "past service"; even so, it was higher than congress was appropriating. On June 30, 1955, the fund contained cash and government investments of about $6,200,000,000 which amounts to considerably less than the actuarial value of pensions already granted plus the amount of active employee contributions accumulated; hence no "employer reserve" for active employees existed in 1955.

Several special plans for certain other segments of federal employees were enacted after 1900, including one covering members of congress (retirement age, 62 or later). Aside from the civil service plan proper, and excluding military "retired-pay" systems, there were about 20 pension plans set up by, or under the aegis of, the federal government by the mid-1950s. These plans were found in the categories of District of Columbia teachers, policemen and firemen; the U.S. judiciary; certain commissioned services. such as the public health service; and quasi-federal organizations, such as the federal reserve system, permanent TVA employees and others.

The earliest state plans for public employees were those to care for superannuated teachers, starting in 1896 in New Jersey, when a noncontributory plan was adopted. The first contributory state teachers' retirement plan was provided for in 1913 in Massachusetts. (See also below, under Teachers' Pensions.) General state-employee plans began with that of Massachusetts in 1911; their growth was slow at first, then rapid; for example, there were 38 such plans in 1955 against 12 in 1940. There were at least ten plans for policemen and firemen by 1900, but plans established as large municipal-employee systems came later: in 1916 for Philadelphia, in 1920 for New York city and in 1922 for Chicago. Smaller cities followed but many of them and most towns, counties and other subdivisions among the approximately 37,000 political subdivisions of the country had no pension plans worthy of the name by 1955. (Counting all types and sizes of school districts, sanitary districts, etc.. there were perhaps 115,000 such subdivisions.) In several states progress was made on the problem by opening up the state-employee plan to participation by the local government unit and its employees. After 1950 state and local employees might elect as a group, or subgroup, to join the coverage of the federal Social Security act.

There was considerable variation in the specifications and administration of public-employee systems. While some were of the noncontributory type, most of them required employee contributions; joining the plan was mandatory in most cases; retirement age was usually quite flexible, optional, say, from age 60 to 65 and mandatory at 70; benefit formulas in relation to pay varied substantially; some vesting of benefits at termination of service was a common feature; widows' benefits existed in some plans but frequently were an elective retirement option, reducing the benefit while both husband and wife were alive; administration and funding varied, from the use of life-insurance policies to various kinds of funds, and from pay-as-you-go benefit payments to full actuarial funding. As to "international" plans, there were tendencies in the direction of larger contributions and higher degrees of vesting. The plan in effect for the old League of Nations employees probably set the pattern for the later retirement plans or "provident funds" of the International Labour office and the United Nations. Comprehensiveness and liberality of benefits and provisions were found, with costs possibly running over 20% of payroll.

Teachers' Pensions. — (See above for early state plans for public-school teachers' pensions.) Among nongovernmental educational institutions — universities, colleges and schools of various types — there were in the mid-1950s possibly 300,000 employees comprised of academic employees, nonacademic employees and employees of business enterprises owned or controlled by the institutions. Prior to 1950 these employees, except the last two, had been excluded from the Social Security act. In 1950 they became eligible to be included under the act on an elective basis by groups.

Educational groups have at their disposal all of the benefit devices and funding mediums available to industrial employers. Trust-fund plans, insured plans — individual policy, group annuity, group permanent-employer-reserve systems, and pay-as-you-go methods, formal or informal, were all possibilities for meeting the retirement problem. An additional facility established especially for this category (including many publicly administered or tax-supported educational institutions) has been freely utilized — the Teachers Insurance and Annuity Association of America (T.I.A.A.) which was incorporated in 1918 in New York state as a nonprofit legal-reserve life-insurance company. This company was founded to avoid perpetuating the adverse experience of the Carnegie Foundation for the Advancement of Teaching. To obtain a self-supporting actuarial basis, the foundation financed the formation of T.I.A.A. and met its expenses for many years. A further gift of more than $6,000,000 in 1938 permitted complete separability. A new feature was introduced by T.I.A.A. in 1952 by the formation of an affiliate, the College Retirement Equities fund (C.R.E.F.), to implement a new pension idea whereby the C.R.E.F. annuities would vary according to the variation in market value of its fund invested mainly in common stocks. Teachers could elect the respective portions of contributions going toward (1) the variable annuities of C.R.E.F. and (2) the fixed annuities of T.I.A.A., subject to at least 50% of such contributions going to the fixed annuity form. Since the establishment of C.R.E.F., the variable principle has been adopted by a few industrial pension plans and in the mid-1950s the insurance companies began looking into the principle as a possibility for issuing special annuity policies.

Pensions for Employees of Religious Bodies. — The care of their aged and disabled workers was early recognized as an obligation of the churches, even though provision for such care was not always on a satisfactory or adequate basis. The Roman Catholic Church takes care of the dependent years of its full hierarchy, which is implicit in the arrangements made and expected on all sides. The problem confronting the Protestant churches is a greater one because the wife in the rectory is so integral a part of the life and work of the pastor that widow and orphan pensions have been quite universally an important part of the ministerial pension programs of the Protestant churches. Naturally in the early days of the life of these churches in America these benefits took the form of relief grants payable on the basis of need.

The general assembly of the Presbyterian Church in the United States of America created a commission in 1904 to study the whole matter and report its findings and recommendations. As a result, a contributory annuity plan was started in 1907, partly funded on an actuarial basis and partly supported by current contributions from the churches. In the ensuing years similar plans were established in a number of the other denominational bodies.

For instance. in 1908 the Methodist Episcopal Church set up provisions for age and disability pensions for the superannuated members of the conference and also for widows' pensions and orphans' benefits. This plan was not at first set up as a contributory reserve plan, but later the Methodist Church adopted as its pension policy a church-wide contributory reserve pension plan.

In 1917 the Episcopal Church established provisions for ministerial pensions based upon service and salary. The pensions, due at retirement after 68 or prior disability, approximated half the

average salary of a minister after 40 years of membership; there was also provision for widows' pensions and orphans' allowances. The entire cost of the plan is paid for by the churches through required contributions expressed as percentages of the salaries paid to the covered members. Several other large denominations followed the lead of the Episcopal Church and set up pension programs established along similar lines but on a contributory basis.

As a result of the developments described above, the leading denominational bodies by the mid-1950s had in operation as protection to the ordained men and their families actuarial reserve systems, chiefly contributory, which in many cases were supplemented by relief grants where the regular pension or annuity payments were found inadequate. Some of these systems include widows' pensions or other death benefits. Furthermore, after the early 1950s ministers were eligible for voluntary participation in the federal Social Security coverage under the self-employment provisions thereof.

More than 20 of the leading Protestant denominations through their pension boards comprised the Church Pensions conference in the mid-1950s. Together, these denominations represented about 137,000 ministers and more than 35,000,000 church members. While in the early days all beneficiaries were relief beneficiaries, these numbered only about 5,800 while the pension beneficiaries numbered more than 38,000 (including widows and orphans). Yearly relief benefits amounted to approximately $2,000,000 whereas the pension benefits approximated $27,000,000. The reserve funds accumulated by these pension boards to meet future pension payments exceeded $345,000,000; there was also on hand more than $140,000,000 of endowment and other funds.

Denominations outside of this conference group no doubt had a smaller proportion of reserve plans and more of the relief type or none at all. Along with the development of the pension and annuity programs for the clergy, provision for the pensioning of the lay workers of the churches had also developed to a lesser extent.

Pensions for Other Nonprofit Employees.—Although many nonprofit organizations were not at the start subject to the Social Security act, many others were, and the line of demarcation was not distinct. Legislation in 1950 made it possible for all nonprofit groups to be covered by the act subject to election by the individual employer and by at least two-thirds of his employees at that time. Following this amendment to the act, a rather general election in favour of the coverage took place, with the result that by the mid-1950s most of the nonprofit employee categories were covered thereunder and had amended their own pension plans to co-ordinate with the basic federal benefit.

Many nonprofit groups adopted pension plans, often of long duration and tested provisions. In fact, this was one reason for early opposition to inclusion in the social security plan—that the latter would supersede the organization's own plan. Nonprofit groups, especially the religious, were also chary of inclusion under the Social Security act because it levied an excise tax on employers and it was feared that this would be the entering wedge for further taxation or regulation. Many of these fears were later abandoned, however, and the nonprofit group as a whole came to believe in basic advantages for their more than 1,000,000 employees (and, to a degree, for themselves as employers) of social-security inclusion.

A special nonprofit category was the charitable and welfare agencies. Large numbers of employees in federal, state and local government employ were engaged in what is rather vaguely designated as "social work." Whatever governmental employees this term might encompass, they were primarily classified as "public employees" (*see* above). But in addition to the governmental workers, there were numerous groups in this category of a nongovernmental nature, or of a quasi-governmental nature, and the pension problem had to be faced by them as it became more and more serious with the aging of their employees.

While rather homogeneous in the nature of their enterprises, these nonprofit, social-agency types of employers vary significantly in size, in geographical distribution, in the source of their funds, in their degree of likely permanence and in their employee composition by sex, age, length of service and salary levels. Taken together they comprise a relatively large group, having possibly more than 400,000 employees at mid-century. They include such organizations as hospitals, community chests, philanthropic funds and foundations, the multiplicity of charitable offices found in any city, Y.M.C.A.'s, home economics groups, local housing authorities (even though subsidized federally) and others too numerous and specialized to mention.

While many of the larger nonprofit employers had established their own plans, the smaller category continued to face difficulties. In order to make a start in solving this problem of the small nonprofit employer, the National Health and Welfare Retirement Association, Inc., acted as a vehicle for centralizing pension planning and funding. The association was formed in Jan. 1945 and incorporated under the insurance laws of New York state, with supervision of the plan by the superintendent of insurance. Benefit payments and guarantees were further protected through the association's having effected reinsurance in the form of a group-annuity contract with a well established group-writing life-insurance company.

Mothers' and Widows' Pensions.—Benefits for mothers, widows with children and elderly widows had frequently become adjuncts to U.S. employee pension plans. The former assistance which was granted needy cases under state statute later gave way to the Social Security act (*see* SOCIAL SECURITY) in which title I provided federal-state channels for assistance for needy cases in this category, and title II included benefits for widows and children of deceased covered employees as part of the old-age and survivors insurance system. While group life insurance had largely minimized the demand for widows' and orphans' benefits in industrial pension plans, and some plans with that feature had found it too costly to continue, certain labour-union demands of 1949–50 included a proposal for continuing to a dependent the pension of a deceased retired worker for a period, such as 18 months, following his death. Many pension plans had included a provision whereby an employee at or ahead of his retirement date might elect a smaller pension during his lifetime in order that it might be continued, in part at least, to a named dependent following his death. Since this option must usually be the actuarial equivalent of the full pension to the employee alone, no great or uncontemplated cost strain was imposed upon the system.

State Old-Age, Disability and Blind Pensions.—These types of assistance were mainly the problems of the individual states prior to 1935 when the Social Security act established federal-state channels for assistance to the needy aged and the blind. Later, the needy disabled were included. (*See* SOCIAL SECURITY.) The federal government also accorded special income-tax relief through added "exemptions" to the aged and the blind.

Townsend Plan Pensions and Others.—With the growth in the number and proportion of the aged in the U.S., and with the depression of the 1930s followed by the inflation of the war and postwar periods in the 1940s, a good milieu existed for the proponents of old-age benefit panaceas—greater distribution and "velocity" of money. While many proposals were forthcoming—such as "ham and eggs," "$30 every Thursday," general welfare payments, etc.—the best known was the Townsend plan, invented and nurtured with the help of many local "clubs" and emotional and political appeals, by Francis W. Townsend. This plan went through several modifications, but essentially the scheme was based on a "right" of every person over age 60 or 65 ("senior citizen") to receive a monthly income of $100 to $200, subject to the conditions that he retire and that this sum be spent by the recipient within a short time (*e.g.*, a month). The venture would be run by the federal government and the funds to pay benefits would be secured by imposing a federal "sales," "transactions" or "gross income" tax; hence, the velocity of turnover of money would in turn breed new taxes to in turn support the succeeding benefits.

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GREAT BRITAIN

Civil Service Pensions. — The pension system for British civil servants is governed by the Superannuation acts, *1834* to 1957. It is noncontributory, except for pensions for widows and children and other dependents. Only established (*i.e.*, permanent) staff are pensionable. Pension is payable after not less than ten years' service at any time on retirement for ill-health, or on retirement after the minimum retiring age (normally 60). A civil servant may resign voluntarily after 50, when payment is deferred until the retiring age, unless immediate payment is allowed on compassionate grounds.

Pension is at the rate of one-eightieth of retiring salary for each year of reckonable service. A lump sum is also paid at the rate of three-eightieths of retiring salary for each year of service. Not more than 40 years' service up to age *60* may be reckoned, but those who continue to serve after that age may count further service subject to an overriding maximum of 45 years. Pension for ill-health retirement is calculated on the years of service, except that for those retiring with between 10 and *20* years' service it is based on 20 years, or on the service the officer would have completed had he served for five years after the retiring age, if that is less. Salary and pensionable emoluments are averaged over the last three years' service in all these calculations. Temporary service after age *18* preceding establishment counts as established service if rendered after July 1949; if rendered before that date it counts as one-half. Officers who serve overseas in unhealthful places receive additional pension rights. The system provides for transfers of staff between the civil service and many other forms of public employment.

Provision for *Widows*, Children, *etc.*—The pension for a widow is one-third of the civil servant's own pension, or, if he dies while still serving, of the pension which he would have been paid if he had retired because of ill-health on the date of his death. The widow may also be paid a children's pension varying according to the number of children from one-twelfth (for one child) to one-third (for four or more children) of the officer's pension. If there are children but no widow, the children's pension is at a higher rate, varying from one-sixth to one-third of the officer's pension. About half the estimated cost of these benefits is paid by the contributions of civil servants, made either by periodical deductions of one-eightieth of salary during service, or by a deduction from the lump sum or death gratuity payable at the end of service. All married men must participate in this plan. A retiring civil servant may also, subject to his passing a medical test, surrender up to one-third of his pension to provide an actuarially equivalent pension for his wife or some other dependent. There is also a voluntary contributory plan for pensions to dependents other than widows and children.

Other Provisions. — A civil servant who is retired because of the abolition of his post, or in the interests of efficiency, may be granted immediately the pension and lump sum for which his service qualifies him. On the death of a civil servant who has served for not less than five years, a gratuity of a year's pay or the lump sum he would have received had he retired on the day he died, whichever is more, is paid to his legal personal representatives. Civil servants with less than ten years' service who retire on account of age, ill-health or abolition of post are paid a gratuity calculated on their reckonable service. A gratuity is also paid to women civil servants with not less than six years' service who resign on marriage.

Armed Forces Pensions. — Retired pay and pensions for officers and men in the navy, army and air force are governed by royal warrant or other appropriate prerogative instrument. There are difierent systems for officers and other ranks.

The basis of the officers' plan is a series of standard rates of pay related to rank; these rates are payable to officers who are retired compulsorily, either on reaching the compulsory retiring age for the rank or earlier because they have not been promoted or because no further employment is available for them. Normally, *20* years' service is necessary to qualify for retired pay; the service needed to qualify for the full standard rate ranges from *20* years in the lowest rank to *30* years in the highest. The rates take account of the relatively early retirement of many officers and are designed to provide some compensation for shortness of career. Officers permitted to retire at their own request receive reduced rates of retired pay. After 1950 officers also became eligible on retirement for a lump sum terminal grant in addition to retired pay or pension, at the rate of three times the retired pay. The rates of retired pay, pension and terminal grant are given in the command paper on Services Pay and *Pensions* (H.M.S.O., London, 1956). A major receives £625 retired pay and terminal grant of £*1,875*, a brigadier £1,150 and £4,350; and there are higher rates for senior officers. For other ranks there is a basic scale of pension for men completing *22* years' service, with additions for longer periods of service. The scale is based partly on length of service and partly on rank. The service element in pensions after Feb. 1956 was 1*s*. 6*d*. a week for each year up to 22 years with higher rates for service beyond *22* years; the rank element ranged from 8*d*. a week for each year of service as a corporal to 2*s*. 5d. for each year as a warrant officer class I; basic rates of terminal grant range from £*125* to £*330* according to the length of service. Retired pay and pensions for members of the women's services are related broadly, in the proportion of two-thirds, to those for men.

Provision is also made for pensions for widows of regular members of the forces. The plan in force in the mid-1950s dated from Dec. 1952 and was noncontributory. It covers widows of officers and other senior ranking men who had completed enough service at the time of death to qualify for service pension; also other ranks below staff sergeant, for whom there is a longer qualifying period. The rates vary with the husband's rank; a major's widow receives £140, and the rates for other ranks range from 10*s*. a week (for the corporal or private with long service) to £60 a year.

Judicial Pensions. — The lord chancellor of Great Britain receives a pension of £3,750, for which there is no qualifying period; he usually continues to sit judicially in the house of lords without salary. Judges receive pensions — in England, ranging from £2,625 to £3,000, and in Scotland, nine-sixteenths of salary — after 15 years' service or on retirement through permanent ill-health. County court judges, stipendiary magistrates and the two full-time sheriffs and the sheriffs substitute in Scotland receive pensions based on their salaries and length of service. A lump sum is also payable to all judicial pensioners on retirement or death and from it is deducted a contribution to the widows' and children's pension plan.

Local Government Pensions. — The Local Government Superannuation acts, 1937–53, provide for the superannuation of local government employees in England and Wales; the London County council, City of London, Manchester and some metropolitan boroughs operate their own programs There are about 480 local government superannuation funds, including joint funds run by local authorities in combination with one another. Bodies closely connected with local government may be admitted to local authority funds.

All full-time officers are compulsorily superannuable. Authorities may make manual workers and part-time officerssuperannuable. Benefits consist of pensions based on one-eightieth of average salary over the last three years of service for each year of contributing service (noncontributing service reckoning at half-rate), and a retirement grant of three-eightieths for each year of service. The widow's benefit is one-third of the officer's pension and is financed by a reduction in the retirement grant to one-eightieth for each year of service. There are also arrangements for death grants, injury allowance and short service grant. (These benefits are laid down under the 1953 act. People employed before they came into force on Oct. 1, 1954, could elect to retain their rights under the 1937 act; *i.e.*, an annual pension based on sixtieths without any retirement grant or widow's pension.) Pension is payable at 65 or on earlier retirement due to permanent ill-health after not less than ten years' local authority service; or at 60 after 40 years' service. Extra pension can be earned up to 70 subject to a maximum of 45 years' reckonable service. Officers contribute 6% of salary and manual workers 5%. The employing authority pays an

equivalent contribution and makes good any deficiency disclosed at each quinquennial valuation of the fund. Contributions are funded.

On termination oi employment before becoming eligible for pension the employee's contributions are returnable—in some cases with, and in others w-ithout, interest. Arrangements exist for the preservation of superannuation rights on transfer to the civil service, teaching, the national health service, public boards, colonial and commonwealth services and certain other public services. Similar provisions apply in Scotland.

National Health Service Pensions.— The ministry of health administers a program for employees of the regional hospital boards and other bodies set up under the National Health Service act, 1946, and for medical and dental practitioners giving general medical and dental services under the act. The principal benefits, pension and lump sum, are normally calculated on eightieths of the last three years' average remuneration, multiplied by the years of reckonable service, but there are exceptions where these are calculated on a percentage of total superannuable remuneration. A widow's pension is provided, the retiring lump sum benefit payable to married employees being reduced on that account. The rates of contribution are 6% for the employee and 8% ior the employer (5% and 6% for manual workers). The program is not funded. Special provisions allowed officers transferred into the new service when it began on July 5, 1948, to retain rights corresponding to those previously enjoyed. Provision was made for interchange with other superannuation plans and those leaving the national health service for other similar employment may stay in the plan in approved cases. A similar program is operated in Scotland.

`Teachers' Pensions.— England and Wales.—The teachers' superannuation plan was established in 1918 and amplified in 1925 and 1956. It applies mainly to teachers in schools aided by state grants. The main benefits are pensions and lump sums, payable at 60, or on retirement if later, based on length of service and on average salary for the last three years' service. The plan also provides for breakdown allowances (after ten years' service) and for gratuities payable on death (after five years' service). A pensioned teacher under 70 reemployed for periods totaling at least 12 months may be awarded additional benefits. Teachers contribute 6% of salary toward the cost of benefits. Employers pay equivalent contributions and are liable for payments to meet deficiencies. The program is not funded: benefits are paid from, and contributions into, the exchequer.

Scotland.— The same system applies in Scotland, but contributions are paid to, and benefits paid from, the Education (Scotland) fund, to which the exchequer contributes eleven-eightieths of net expenditure (benefits paid less contributions received) on teachers' superannuation in England and Wales.

Police and Firemen's Pensions.— Pensions for the members of all police forces in Great Britain and for their dependents are provided under the Police Pensions act, 1948. Pensions are normally calculated on average pay during the three years preceding retirement, and an ordinary service pension rises from one-half of average pay after 25 years' service to a' maximum of two-thirds of average pay after 30 years' service. A pension proportionate to length of service is awarded where a policeman retires on grounds of health after ten or more years' service. If an officer cannot continue serving as a result of injuries received on duty, an ill-health pension is payable even if he has less than ten years service; this may be supplemented if his earning capacity is affected. A widow's pension is normally payable on the death of serving policemen or police pensioners either on a scale related to the husband's average pay at the time of his death or retirement, or as a flat rate award varying according to the husband's rank; children's allowances are payable with the flat rate award. Policemen pay contributions not exceeding 6¼% of their pay toward the cost of pensions and the balance is borne in equal shares by the exchequer and the local rate funds.

Broadly similar provisions are applied to full-time operational members of local fire brigades under the Fire Services act, 1947. One-quarter of the balance of the cost of these pension benefits, not met by the men's contributions of 5% of their pay, is borne by the exchequer. If death is the result of injury on duty, the widow's pension and children's allowances are increased.

Civil List Pensions.— These are pensions granted by the sovereign upon the recommendation of the first lord of the treasury and paid (since 1837) from the Consolidated fund. By 1 and 2 Vict.C.2 they are to be granted to "such persons only as have just claims on the Royal beneficence, or who by their personal service to the Crown, by the performance of duties to the public, or by their useful discoveries in science and attainments in literature and the arts have merited the gracious consideration of their Sovereign and the gratitude of their country." A sum of £1,200 a year was allotted up to 1937, when it was increased to £2,500. In 1952 the annual allotment was increased to £5,000, in addition to the pensions already in force. A list of the pensions granted each year is presented to parliament.

Perpetual or Hereditary Pensions.— Perpetual or hereditary pensions in Great Britain were freely granted either to court favourites or as a reward for political services in the late 17th and 18th centuries. Victorious commanders such as the duke of Marlborough (£4,000), Lord Rodney (£2,000) and Lord Nelson (£5,000) were similarly rewarded. In 1887, iollowing protests by the radical politician Charles Bradlaugh, a select committee of the house inquired into the subject. As a result oi the committee's recommendations, the majority of such pensions were gradually extinguished by commutation. The Marlborough pension, for example, was redeemed in 1884 for £107,000; under the Traialgar Estates act, 1947, the Nelson pension ceased in 1951 on the death of the earl at that time. No further perpetual pensions were granted but capital sums were voted to Lord Kitchener in 1902 and to Lord Haig and other distinguished commanders after World War I. After World War II, however, neither capital sums nor perpetual pensions were granted.

Political Pensions.— The only political pensions payable are made under the Ministers of the Crown act, 1937, as amended by the Ministerial Salaries acts, 1946 and 1957. These acts entitle former prime ministers to a pension of £2,000 a year provided they are not receiving a salary of more than £750 as members of parliament, or a salary as leader of the opposition, or any other salary drawn from public funds. The House of Commons Members Fund acts, 1939, 1948 and 1957, enable periodic payments, not strictly pensions, to be paid to former members of the house of commons of at least ten years' standing or to their widows, widowers or orphans, if they are in reduced circumstances. The payments are made from funds provided solely by compulsory reductions from members' parliamentary salaries and not from the public purse.

Ecclesiastical Pensions.— Archbishops, diocesan bishops and suffragan bishops of the Church of England whose sees are in England are-entitled to receive pensions on retirement at or after the age of 70 under a contributory program governed by the Episcopal Pensions measures, 1926 and 1945, and administered by the church commissioners. All other Church of England clergy rendering ecclesiastical service or holding educational, charitable or public appointments in England are entitled to receive pensions on retirement at or after the age of 70 under a noncontributory program governed by the Clergy Pensions measures, 1948 and 1954. This program was contributory until 1954. It is administered by the Church of England Pensions board, but financial responsibility rests with the church commissioners. Under this plan there are reciprocal arrangements in respect of overseas service in many other countries. The Church of England Pensions board also administers contributory programs for pensions for widows and dependents, and for deaconesses and lay workers.

(E. E. Bs.)

PENSTEMON, a genus of perennial herbs (family Scrophulariaceae), comprising about 250 species, chiefly natives of North America, with showy open-tubular flowers. Noteworthy species are *P. laevigatus* (smooth beardtongue), P. digitalis (foxglove beardtongue) and P. *hirsutus* (hairy beardtongue) of the eastern and southern states; *P. alpinus* (alpine beardtongue), *P.* cyananthus (blue beardtongue) and *P. barbatus* (bearded penstemon) of the Rocky mountain region; and *P.* antirrhinoides (snapdragon beardtongue), *P. diffusus* (spreading beardtongue) and P. centranthifolius (scarlet bugler) of the Pacific states; these and various others are more or less cultivated. The penstemon of the florist has, however, sprung from P. hartwegi of Mexico and *P.* cobaea of southwestern United States and possibly some others.

RUTHERFORD PLATT

PENSTEMON, KNOWN ALSO **AS** BEARDTONGUE

The plants endure mild winters unharmed in favoured situations. They winter safely in cold frames, protected by mats or litter during frost, but tend to die out in a year or two, especially if grown in open sunlight. They produce seed freely, new kinds being obtained by that means.

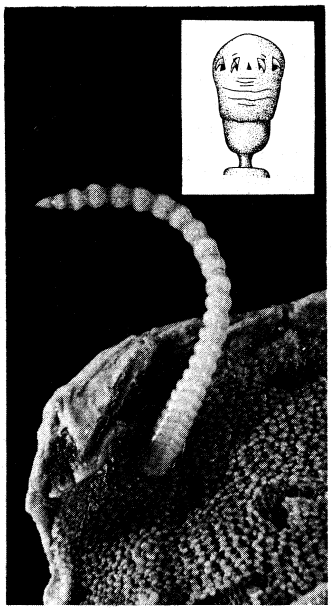
PENTAGON, a large five-sided building in Arlington county, Virginia, near Washington, D.C. It was built in 1941–42 to bring under one roof the U.S. war department offices then housed in widely scattered buildings. After World War II it became the headquarters of the department of defense, including all three services— army, navy and air force. The largest office building in the world, the pentagon covers 34 ac. (including a 5-ac. central

court), offers 3,700,000 sq.ft. of usable air-conditioned floor space and provides work space for about 30,000 persons, military and civilian. Built of structural steel and reinforced concrete, with some limestone facing, the entire structure cost $83,000,000.

The Pentagon consists of five concentric pentagons or "rings" with ten spokelike main corridors connecting the whole. (See WASHINGTON, D.C., for photograph.) With only five floors, plus a mezzanine and basement, the height of the building is short compared with its horizontal dimensions. A huge concourse larger than two American football fields provides a shopping centre for Pentagon workers. Beneath the concourse are bus and taxi terminals. Parking areas adjacent to the building can accommodate over 8,000 cars. A heliport for the Pentagon was added in 1956. (H. C. T.)

PENTASTOMIDA (LINGUATULIDA) are a small group (usually considered a class) of wormlike, bloodsucking arthropods which live as internal parasites of vertebrates. The body of an adult is externally ringed—and in many species looks like a thick string of beads—though there is no true internal segmentation. The alternate name Linguatulida or "tongue worms" is descriptive of the linguiform or tongue-shaped body of other species. Although some authorities consider the pentastomes a separate phylum, certain characteristics point to their very close arthropod relationship: (1) jointed legs in the embryo; (2) ecdysis or molting in the larval stage; and (3) the presence of breathing pores scattered over the body.

The name Pentastomida refers to the five openings arranged in a crosswise line on the head; the centrally located one is the oval, chitinous mouth, and the other two flanking pairs are the openings of pockets or sacs containing protractile hooks. The body is elongate and cylindrical in most species, a few being short and somewhat flattened. Adjoining a short head region is the long abdomen (from about ½ to 6 in. in length) marked with a variable number of superficial rings that do not represent true internal body segments and devoid of appendages. Although renroductive. nervous and digestive systems are present, there are no organs of circulation or respiration. Mouth parts are wanting and the digestive canal opens posteriorly. Sexes are separate. and the females are several times larger than the males.



PHOTOGRAPH BY COURTESY OF HOWARD R. HILL

VENTRAL VIEW DRAWING OF HEAD OF POROCEPHALUS AND PHOTOGRAPH SHOWING HEAD OF ARMILLIFER MONILIFORMIS EMBEDDED IN LUNG TISSUE OF PYTHON HOST

These bloodsuckers usually attain their adult stage within cold-blooded vertebrates, the nymphal forms occurring in warm-blooded vertebrates upon which the adult hosts feed. Adults live in the air passages of their host whereas nymphs are most frequently found encysted in the liver of their host. Development is usually combined with a change of host.

The number of known species is over 50, and they are not always restricted to a single host species. Raillietiella *furcocerca orientalis* is a common parasite of snakes in the eastern hemisphere. *Reighardia sternae* is a cosmopolitan parasite of gulls and terns. In America, *Kiricephalus coarctatus* is often found in the air passages of snakes.

Linguatula serrata, usually found in dogs, wolves and several other mammals, and Armillifer *armillatus* have been occasionally found in man. The eggs of L. serrate are scattered in sneezing, and the larvae develop in the viscera of the intermediate host—usually a rabbit, rat or sheep. After several molts the nymphal stage is attained, which may last for two or three years. Man can serve both as an intermediary and as a final host.

The adult of Armillifer armillatus is a common parasite in the lungs of large snakes in the eastern hemisphere. Pythons often become infected by devouring an infected mammal. In man, infection takes place by swallowing eggs scattered over vegetables or in water. The encysted larvae settle in various organs, and a heavy infection may lead to grave disturbances and may even result in death.

Pentastomida are divided into two orders: (1) the Cephalobaenida, with two families and four genera (Cephalobaena, *Raillietiella*, Reighardia, etc.); and (2) the Porocephalida, with two families and 14 genera (Porocephalus, Linguatula, etc.). These two orders are distinguished by the structure of their reproductive and nervous systems, the Cephalobaenida being the more primitive.

One of the best treatises is by R. Heymons, "Pentastomida," in Bronn's *Klassen und Ordnungen* (1935). *For* an extensive list of literature *see* Howard R. Hill, ['Annotated Bibliography of the Linguatulida," *Bull.* S. *Calif. Acad. Sci.,* vol. *47,* pt. *2* (1948). (H. R. HI.)

PENTATEUCH. The name Pentateuch (from the Greek pentateuchos *biblos,* "book of five volumes") designates the first five books of the Old Testament—Genesis, Exodus, Leviticus, Numbers and Deuteronomy—which embody the Law of Moses and hence are called also TORAH. The Pentateuch consists of narratives into which collections of laws are interpolated; the narratives begin with the creation of the world and conclude with the death of Moses, just before the entrance of the Israelites into the land of Canaan. They relate the primitive history of man, the stories of the patriarchs, the exodus of the Israelites from Egypt and their journey to Canaan, and the institution of the Israelite Covenant and laws at Sinai.

Development of Criticism of the Pentateuch. — Jewish and Christian tradition until the 19th century, with a few rare and uninfluential exceptions, attributed the Pentateuch to Moses. The French physician Jean Astruc suggested in 1753 that Moses compiled Genesis from two documentary sources, one of which employed the divine name Yahweh and the other the divine name Elohim. Astruc did not intend to question the authorship of Moses; but his introduction of the divine names as a criterion of documentary sources gave the impulse to the literary criticism of the Pentateuch which engaged almost every major biblical scholar of the 19th century.

The text of the Pentateuch exhibits numerous traits which indicate a complex literary origin. There are two creation accounts (Gen. i, 1–ii, 4a; ii, 4b–24). The account of the deluge (Gen. vi, 5–ix. 17) shows evidences of two accounts which have been compiled into one (the number of animals taken into the ark, the duration of the deluge, the two entrances of Noah into the ark, the blessings and Covenant pronouncements after the deluge). Ex. iv, 19 is the logical sequence of Ex. ii, 23. The expulsion of Hagar by Abraham (Gen. xvi; xxi), the call of Moses (Ex. iii; vi) and the miracles of the quail and the manna (Ex. xvi; Num. xi) are narrated twice. The wife of a patriarch is taken into the harem of a foreign ruler, or threatened with this, three times (Gen. xii; xx; xxvi). When the text is studied closely, other similar phenomena are observed. If these passages are analyzed and grouped, three strands of narrative emerge, each with distinctive characteristics of vocabulary and style, of which variation in the use of the divine names is only one.

Proceeding on these data, J. G. Eichhorn (1781) distinguished various sources in Genesis. K. D. Ilgen (1798) observed the source called Elohist could not be considered as a single source but must be divided into two. Geddes (1792), Vater (1802–05) and De Wette (1805) proposed the "theory of fragments," which assumed that there was no single document in the Pentateuch; they found in it a compilation of fragments of numerous different documents. The most important contribution of De Wette was his isolation of Deuteronomy as a distinct source. The unity of the sources, however, was too evident to be denied; and Ewald (1823) and De Wette (1840) adopted the "complementary theory," which assumed that one basic document was enlarged by the addition of fragments from other sources. This basic docu-

ment was called the Elohist. Subsequently H. Hupfeld (1853) restored Ilgen's theory of two Elohist documents. One of these (the Priestly source of later scholars) he called the First Elohist as the oldest; the Jahwist document followed, and the Second Elohist was the most recent. With the addition of Deuteronomy the lines of the four-document hypothesis were drawn.

The decisive contribution was made in 1865 by Graf, who proposed that the First Elohist was actually the most recent of the sources and was postexilic, the work of the Jerusalem priesthood. He introduced the sign "P" to designate this source. Kuenen (1869) announced that he had reached the same conclusions independently. Julius Wellhausen, in a series of works published between 1876 and 1901 and remarkable for brilliant and persuasive clarity, presented this hypothesis both to scholars and to the general public, and after 1900 it was almost universally accepted. Wellhausen's own contribution was a theory of the historical and cultural evolution of Israel and its religion, which explained the growth of Israelite belief as a rectilinear progress from the primitive polytheism of early Israel through the ethical monotheism of the prophets, the great creative thinkers of Israel, to the formal legalism and sacerdotalism of postexilic Israel. This theory of the evolution of Israel cannot now be sustained; Wellhausen worked at the beginning of the period of the great discoveries relating to the history and culture of the ancient near east, and these discoveries have rendered the theory as a whole impossible. But since in the early years of the 20th century the theory of the religious evolution of Israel was not always distinguished from the theory of the literary origins of the Pentateuch, many conservative theologians of all churches regarded Wellhausen's theory as an attack on revealed religion.

Documentary Theory.— In its classical form the documentary theory finds the Pentateuch to be a compilation of four documents: the Jahwist (German spelling; J), composed in the 9th century B.C.; the Elohist (E), composed in the 8th century B.C.; the Deuteronomist (D), composed in the 7th century B.C.; and the Priestly document (P), composed in the 5th century B.C. The Jahwist is Judahite, the Elohist Ephraimite in origin. These two versions of early Israelite tradition were fused into one document after the fall of Israel in 721 B.C. Deuteronomy was added after the exile. These were amalgamated with the Priestly source into the present Pentateuch about 400 B.C.

This hypothesis did not explain all questions of detail. Subsequent work was devoted to further analysis of the documents, to the isolation of other sources and to a more precise dating of the documents. The analysis of the documents was pushed by some scholars to the point where it issued in a new "fragment theory," and analysis based on minutiae has been proved exaggerated; the unity of the sources in some form must be explained. It is generally accepted that the documents represent strata of material rather than single unified compositions, and that the processes of redaction and expansion are too complex to permit a definitive analysis of the entire text. For the same reasons a precise date for each of the sources is scarcely possible.

Later critics, especially those of the Scandinavian school, have affirmed that the entire documentary hypothesis is false, since it does not reflect ancient methods of composition and transmission. This school asserts the primacy of oral tradition; the "documents," they say, are modern historical conceptions. While the oral traditions may be designated by the symbols J, E, etc., these actually are cycles of oral traditions not written until a relatively late date, postexilic in any case. Most contemporary critics believe that the Scandinavian school exaggerates the place of oral tradition; ancient near eastern culture offers numerous examples of the collection of traditions in writing. It is altogether probable. however, that most of the traditions of the Pentateuch were orally composed and orally transmitted in their early stages of development.

Later criticism also emphasizes the importance of literary form and of the "situation in life" in which the traditions arose. Noth, von Rad and others see in these traditions not mere popular or tribal memories, but traditions which have arisen from cultic recitals. On such great feasts as Passover the ritual included a recital of the saving deeds of Yahweh on behalf of Israel. These took variant forms in different cultic centres; the traditions of northern Israel, for instance, make Jacob prominent, while the traditions of Judah give greater prominence to Abraham. But the traditions all have in common that they are "history of salvation," a profession of the faith of Israel. Scholars agree that the study of any particular tradition must take account of its preliterary history as far as this can be traced: its local origin, its clan or tribal emphasis, its cultic significance. The compilers of the written sources were not creators; they found well-formed oral traditions which they arranged into a new literary unity.

Jahwist.—The literary composition of the Jahwist tradition probably may be placed in the reign of David or of Solomon as an expression of the new unity and prosperity of Israel under the monarchy. It began with the creation of man in Eden and contained the stories of the fall, primitive man, the deluge and the tower of Babel. The patriarchal stories of the Jahwist give the chief place to Abraham, who dwelt in the south, the later territory of Judah; it incorporates selected materials from the northern cycles of Jacob and Joseph, in particular the story of the marriages of Jacob and the births of the eponymous ancestors of the tribes. In the story of Joseph the Jahwist makes Judah the protagonist of the brothers. Analysis of the sources in Exodus and Numbers is more difficult; the Jahwist appears to have made Kadesh-barnea the focal point of his account of the wandering.

The Jahwist has been called the national epic of Israel. His are some of the best-known pieces of biblical narrative; they are concrete, vivid and moving. His conception of the deity is the most anthropomorphic of all the sources, and his human characters are portrayed with earthy realism. In spite of the childlike and primitive traits of his narrative, some of the most profound theological ideas of the Bible are expressed in such stories as those of the fall, the deluge, primitive man, the destruction of Sodom. Israel escapes from the curse, which he traces to human origins, by accepting the blessing granted to Abraham and to his seed; and the promises are obviously fulfilled in the peace and prosperity of the monarchy of David.

Elohist.—Compared to the Jahwist, the Elohist appears to be a torso; no doubt the document was edited by the Judahite compilers when it was fused with the Jahwist. The Elohist begins with Abraham and emphasizes Covenant rather than blessing. It contains at length the stories of Jacob and Joseph, the heroes of the northern tribes. The story of the exodus is centred about the Covenant of Sinai. The Elohist lacks the vividness of the Jahwist; his conception of the deity avoids grosser anthropomorphisms, and his human characters are more idealized. The literary composition of the Elohist is to be placed after the establishment of the divided kingdom; like the Jahwist, it is an expression of the traditions of the kingdom, with more emphasis upon the northern element in those traditions.

Priestly.— The Priestly source is often called a précis of history. It begins with an elaborate account of creation (Gen. i); but elsewhere it appears as brief notices, genealogies and lists, and the narrative is prolonged only when religious institutions are concerned, many of which it retrojects to earliest times. It has created an artificial chronological scheme. Its style is dry and pedestrian and easily detected. The historical sketch of the Priestly source is intended as framework for the priestly collection of law.

Law and History.— In addition to the priestly collection of laws there are other collections of laws of various date and provenance. A historical prologue usually stood at the beginning of ancient near eastern legal collections. This is in a sense the conception which governs the compilation of the Pentateuch. Israelite law arises out of the history of Israel, but not its secular history; law is incorporated into the history of the saving deeds and the revelation of Yahweh, who elects Israel as his people and lays down as terms of his Covenant the laws by which Israel should live.

In the history of Judaism the Torah, the law of Moses, as the Pentateuch was designated, was the dominant influence. The Torah was the exclusive object of study and interpretation in the

rabbinical schools, whose interpretations were collected in the Talmud. The Pentateuch is designated as law in the prologue of Sirach (written about 130 B.C.) and frequently in the New Testament. From the Pentateuch arises the characteristic Jewish conception of Israel as a people chosen by God, delivered and preserved by his saving deeds, established in a commonwealth by him and living under his revealed law. This conception of Israel as the people of God was incorporated into the teaching of primitive Christianity and applied to the church.

See BIBLE and articles on the separate books; for the special problems of DEUTERONOMY *see* that article; on the extension of the sources of the Pentateuch in subsequent books of the Old Testament *see* HEXATEUCH. *See* also references under "Pentateuch" in the Index volume.

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PENTATHLON is an athletic contest involving five distinct types of competition (from the Greek *penta,* "five," and *athlon,* "contest"). In the ancient Greek Olympics, the pentathlon included a race the length of the stadium (200 m.), the broad jump. discus throw, javelin throw and a wrestling match between the two athletes scoring highest in the previous four events.

This Greek pentathlon was adopted for modern track and field competition by setting the sprint distance at 200 m, and by substituting a 1,500-m. run for the wrestling match. The event was introduced to the Olympic games in 1912 but discontinued after 1924.

The modern or military pentathlon, which has been included in the Olympic games since 1912, demands far greater diversity of skills than its track and field counterpart. It requires each contestant to perform the tasks that might confront a mounted courier under historical battle conditions.

Entrants are required to: (1) ride a strange horse, selected by lot, over a 5.000-m. obstacle course; (2) engage each of his rivals in an épée fencing match; (3) shoot with pistol at a silhouette target; (4) swim 300 m.; (5) run 4,000 m. on an unfamiliar cross-country course. The competition takes three days.

Each nation enters three contestants and they are scored according to a point table established by the International Pentathlon union. Team prizes are awarded by adding up the three individual scores. World championships, under International Amateur Athletic federation auspices. are held in non-Olympic years. Military men have dominated the event, with Swedish officers nearly monopolizing the Olympic titles. *See* OLYMPIC GAMES. (E. J. G.)

PENTECOST (from Greek *pentekostos,* "50th"), the Jewish Feast of Weeks, or Shabuoth, celebrated on the 50th day after Passover. The name also is given to the Christian feast popularly called Whitsunday, celebrated on the 50th day after Easter to commemorate the descent of the Holy Spirit on the apostles. *See* JEWISH HOLIDAYS; WHITSUNDAY.

PENTELICUS (mod hiendeli), a mountain northeast of the Athenian plain, height 3.638 ft. Its white marble was not regularly worked until after the Persian wars; later all the chief buildings and sculptures of Athens were constructed of it.

PENTLANDITE. A sulfide of nickel and iron is the chief source of nickel. It is abundant in the nickel mines of Canada, as in the Sudbury district of Ontario where the mineral has an average nickel content of 35%. It also occurs in Norway, Sweden and South Africa; in the United States it is found in Nevada and Yakobi Island, Alaska. It was named after J. B. Pentland, who first noted the mineral. The formula is (Fe, Ni)S. It crystallizes in the cubic system but is never found in distinct crystals. It has a metallic lustre and light bronze-yellow colour. It is nearly always associated with pyrrhotite. For production and uses *see* NICKEL. (W. F. FG.; X.)

PENUMBRA (Lat. *paene,* "almost"; *umbra,* a "shadow"), in astronomy, the partial shadow of a heavenly body as cast by the sun. It is defined by the region in which the light of the sun is partially but not wholly cut off through the interception of a dark body. *See* also ECLIPSE.

PENUTIAN, a stock of North American Indian languages defined by the linguist E. Sapir as extending originally from British Columbia to Mexico. The families and languages are, from north to south: Tsimshian; Chinook (including Wishram); Sahaptian (Sahaptin, including Nez Perce, Yakima; Molala-Cayuse; Klamath); Oregon Penutian (Coastal: Alsea, Siuslaw, Coos; Kalapuya; Takelma): Californian (Wintun, Maidu, Miwok-Costanoan, Yokuts); Mexican Penutian (Zoque, Huave). It has been suggested that Penutian is part of a larger grouping (phylum), Macro-Penutian, which includes Azteco-Tanoan (Uto-Aztecan; Kiowa-Tanoan), and possibly Mayan and Totonac in Mexico. The relationships have not been worked out in detail, but may be considered reasonably valid. About 5,000 speakers of Penutian are left, and some of the languages are extinct.

Penutian languages (and Macro-Penutian as a whole) have structures that remind one of Indo-European — inflectional suffixes, internal stem-change, noun cases — with much variation. *See* also CENTRAL AND NORTH AMERICAN LANGUAGES; AMERICAN ABORIGINAL LANGUAGES; INDIAN, NORTH AMERICAN. (G. L. T.)

PENZA, an *oblast* of the Russian Soviet Federated Socialist Republic, U.S.S.R., surrounded by those of Saratov, Tambov, Ryazan, Gorki and Ulyanovsk. Area 16,680 sq.mi. Pop. (1959) 1,510,000. The *oblnst* forms part of the central Russian plateau, there reaching a height of 900 ft. It is deeply dissected by rivers, the chief being the Moksha, flowing north to the Oka, the Sura to the Volga, and the Khoper flowing south to the Don. The Moksha and Sura are navigable, and other streams are available for floating timber. Patches of forest occur in the west and also to the east of the Sura river but are insufficient for local timber needs, most of which are supplied by timber floated down the rivers from the north. Most of the land favourable for cultivation is used. and agriculture is the main occupation. Marshes exist in the Krasnoslobodsk district, and sandy stretches along the rivers, but there is much fertile black earth. Winter rye and oats are the chief crops, lentils are produced, and peas, sunflower seed, potatoes, beetroot, fruit and vegetables are grown.

Sheep, dairy and working cattle, pigs and horses are bred, the sheep providing wool for the felt and woolen industry and fat for tallow. Industries include sawmilling, paper and match manufactures, and woolen cloth, felt, glass, leather and tobacco works.

PENZA, capital of Penza *oblast,* Russian Soviet Federated Socialist Republic, U.S.S.R., at the confluence of the Penza with the navigable Sura. Pop. (1959) 254,000. The town has sawmills and paper and match factories, and is an important trading centre for corn, timber and the products of sheep and cattle raising. It dates from the 17th century and was captured by E. Pugachev in 1774. Several times fire destroyed it.

PENZANCE, a municipal borough, seaport and holiday resort, in the St. Ives parliamentary division of Cornwall, 280 mi. W.S.W. of London by road and the most westerly town in England. Pop. (1961) 19,433. Area 4.9 sq.mi. After 1934 the borough included Newlyn, Mousehole, Gulval and Heamoor. It is the only quarter sessions borough in Cornwall.

The town stands on rising ground overlooking Mounts bay, and has a remarkably equable climate, enabling many subtropical plants to flourish in the open air. Great quantities of early vegetables, flowers and fruits are raised locally and in the Isles of Scilly (*q.v.*), and are sent to London and elsewhere. Penzance is connected with the Scilly Isles by steamer and air services. Some fishing is done from Penzance harbour, but most of the fishing boats work from Newlyn harbour. From the mean sea level in Newlyn harbour — ordnance datum — is calculated the elevation of all places shown on ordnance survey maps. Newlyn is a well-known centre for artists.

Edward III granted Penzance a charter market in 1332. In 1512 Henry VIII granted a charter as to profits from all ships visiting the harbour, although the town's importance as a fishing port dates from the 14th century. The charter of incorporation was granted in 1614 and in 1663 Penzance was constituted a coinage town for tin, and so remained until 1838. The old name (Pen-

sans) is thought to have referred to a chapel of St. Anthony (patron saint of fishermen) formerly on the headland south of the harbour. The seal and coat of arms granted by the College of Heralds in 1934 to replace the old corporate seal, however, makes a very free translation of the name and depicts the head of St. John the Baptist on a charger.

PEONAGE, a form of involuntary servitude which developed in Mexico. It prevailed extensively in Yucatan and especially in the Valle Nacional, where cheap labour was required in the cultivation of tobacco. The beginning of peonage, however, has been traced as far back as the conquest of Mexico by the Spaniards. Early in the history of Mexico the conquerors worked out a scheme by which the poor, especially the Indians, could be forced to do the work of the planters and mine operators. The word *peon* became synonymous with the English word labourer, but it later was restricted in its meaning to those labourers who were compelled to serve their creditors to pay debts which by contract they had pledged themselves to pay in labour. Although the 13th amendment and legislation of the U.S. government prohibited any such involuntary servitude in that country, the former slave-holding states devised certain legislation, following emancipation, which might make labour compulsory. Under these state laws employers deceived ignorant men by inducing them to sign contracts for labour in payment of debts, and those who might pay fines imposed by the courts to sign other similar contracts. In rural districts far removed from the populous centres the chain gang system of forced labour under the pretense of farming out the services of misdemeanants or penal offenders developed into great injustices. The practice of leasing short-term prisoners, both blacks and whites, to managers of labour camps was continued in a few of the southern states. (C. G. W.)

PEONY, common name for *Paeonia,* a genus of plants remarkable for their large and showy flowers; it belongs to the buttercup family (Ranunculaceae). The peonies are native mostly to Europe and Asia; one species, *P. browni* (the western peony), is found naturally along the Pacific coastal mountains in North America.

Known from ancient times, and called *paeonia* by the Greeks, after Paeon, the god of healing, the peony was regarded with the greatest respect. As late as the 17th century its roots, flowers and seeds were used in medicine in England. In China and Japan it has been grown for ages and esteemed for its beauty and fragrance. The Mongols in Siberia were reported, in the 18th century, to have eaten the roots and seeds of the peony.

There are two distinct general groups of peonies—the herbaceous and the tree or moutan peonies. The herbaceous are strong-growing perennials from two to three feet in height; the large, glossy, much-divided leaves, decorative from spring to fall, are supported on annual stems, which arise from the fleshy root-stock. The ample flowers, which blossom in late spring and early summer, when few flowers equal them in effect, vary in form from the open single to the globular sorts of the double varieties. The Chinese *Paeonia albiflora* and the European P. *officinalis* (the common peony—an old garden favourite), along with their many horticultural varieties, are the herbaceous garden peonies which produce the large single and double flowers of white, pink, rose and deep crimson. Modern garden hybrids are quite beautiful, the flowers being in many instances delicately tinted uith more than one colour, such as buff with bronzy centre, carmine with yellowish centre, rose with orange centre, white tinted with rose, etc. Hundreds of names are given to the colour variations of both the herbaceous and tree peonies.

The moutan or tree peonies, which have sprung from the Chinese P. *suffruticosa,* are stiff-growing plants with half-woody permanent stems. They are remarkable for their subshrubby habit, forming vigorous plants sometimes attaining, a height of four to six feet, and producing in late spring magnificent flowers which vary in colour from white to lilac, magenta, violet and rose. These are produced on the young shoots and are in consequence liable, unless protected, to be cut off by spring frosts. They require to be thoroughly ripened in summer, and therefore a hot season and a dryish situation are desirable for their well-being;

ROCHE

JAPANESE DOUBLE TREE PEONY (HORTICULTURAL VARIANT OF PAEONIA SUFFRUTICOSA)

and they require rest during winter. They are increased by grafting in late summer or autumn on the roots of the herbaceous peonies.

A race of hybrids has been developed by crossing the tree peony with P. *lutea,* mostly double flowered in shades of yellow and yellow with tinges of red.

All peonies thrive in rich moist garden loam in a sunny location, planted—preferably in the spring—so that the buds or "eyes" of the fleshy roots are not more than three inches deep. They are not commonly grown from seed. After about a year they become well established and will produce blooms for years without the necessity of dividing.

An annual top-dressing of bonemeal or rotted manure is beneficial, since peonies are heavy feeders.

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PEORIA, a city of north-central Illinois, U.S., on the Illinois river where it widens to form Lake Peoria, ,roughly midway between Chicago and St. Louis, Mo., is a leading commercial centre of downstate Illinois and the seat of Peoria county.

Named for one of the five Indian tribes in the Illinois confederacy. Peoria represents one of the oldest settled locations in the state. The French under René Robert Cavelier, Sieur de La Salle (*q.v.*) first built Fort Crèvecoeur on the bluffs opposite the present city in 1680. but it was plundered and deserted later that same year. Subsequent settlements around Peoria lake by the French, Indians and Americans give an almost unbroken history to the region. After 1813 the location was known as Fort Clark and when Peoria county was established in 1825, the community reverted to the French-Indian name of Peoria and was established as the county seat. Peoria was incorporated as a town in 1835 and chartered as a city in 1845. It was there, on Oct. 16, 1854, that Abraham Lincoln publicly denounced slavery in a rebuttal to a speech by Stephen Douglas.

Peoria is situated in the heart of the corn belt, with deposits of bituminous coal, sand, gravel and gypsum nearby. It has excellent rail, road and air transport facilities including the Illinois waterway.

The city's industry is both vast and varied. Producing more than 900 different products in more than 200 manufacturing plants, Peoria is as well known for its tractors, agricultural implements and earth-moving equipment as it is for products of its numerous distilleries and breweries. The output of chemicals, food products, household goods. brick, tile and stone, radio equipment and electric power is also extensive.

The northern regional research laboratory of the G.S. department of agriculture which searches for new and improved uses for farm commodities is located there.

The city, extending for more than 10 mi. along the Illinois river, is noted for its setting amid the scenic beauty of the surrounding area. Six public parks totaling more than 2,000 ac. offer opportunities for relaxation and recreation.

Bradley university, located near the west edge of the city, was established by Lydia Bradley in 1897 and endowed by her with a gift of $2,000,000.

The population of the city was 103,162 in 1960, and of the Peoria standard metropolitan statistical area, comprising Peoria and Tazewell counties. was 288.833. (R. M. Su.)

PEPE, GUGLIELMO (1783–1855), Neapolitan general, born at Squillace in Calabria, took part in 1799 in the republican movement at Naples inspired by the French Revolution; he fought against the Bourbon troops under Cardinal Ruffo, was captured

and exiled to France. He entered Napoleon's army and served first under Joseph Bonaparte and later under Joachim Murat. After commanding a Neapolitan brigade in the Peninsular campaign, Pepe returned to Italy in 1813, with the rank of general, to help to reorganize the Neapolitan army. fhen the news of the fall of Napoleon (1814) reached Italy Pepe and other generals demanded from Murat a constitution. On Napoleon's escape from Elba (1815) Pepe served on Murat's staff in the campaign of 1815. The Neapolitan officers retained their rank under Ferdinand IV (*q.v.*) who now regained the throne of Naples. While engaged in suppressing brigandage in the Capitanata, Pepe organized the *Carbonari* (*q.v.*) into a national militia. In 1820 a military revolt broke out. Pepe was sent against the rebels, but Ferdinand promised a constitution (July 1820). The king. who had no intention of respecting the constitution, obtained the loan of an Austrian army with which to restore absolute power. Pepe now took command of the army and marched against the Austrians. He attacked them at Rieti (March 7, 1821), but his ram levies were repulsed. In 1848 Pepe returned to Naples, where a constitution had again been proclaimed. He was given command of the Neapolitan army which was to co-operate with Piedmont against the Austrians, but when he reached Bologna the king recalled him and his troops. Pepe resigned his commission in the Neapolitan service! and crossed the Po with 2,000 volunteers to take part in the campaign. On the fall of Venice, Pepe and Manin were among those excluded from the amnesty; he again went into exile and died in Turin in 1855.

PEPERINO, an Italian name applied to a brown or gray volcanic tuff (*q.v.*), formed from volcanic ash or dust and containing fragments of basalt and limestone, with disseminated crystals of augite, mica, magnetite, leucite, etc. The typical peperino occurs in the Alban hills, near Rome, and was used by the ancients, under the name *lapis albanus,* as a building stone and for the basins of fountains. Other tuffs and conglomerates in Auvergne and elsewhere are also called peperino. The name originally referred to the dark coloured inclusions, suggestive of peppercorns. See also ROME: The Ancient *City: Materials.*

PEPO, the typical fruit of the plants of the gourd family (Cucurhitaceae) consisting of a large, fleshy. berrylike structure with a tough rind and a spongy seedy interior, as in the pumpkin, squash. melon and cucumber.

PEPPER is a name applied to several unrelated plants from which pungent spices are obtained: black, white and long pepper (Piper); red, chili and cayenne peppers (*Capsicum*) and Melegueta pepper (*Aframomum melegueta*). Pepperroot (*Dentaria*) whose underground Parts and peppergrass (*Lepidium*) whose fruits have a pungent taste are members of the crucifer family. A number of plants named pepper, including the California pepper tree (*Schinus molle*), pepper vine (*Ampelopsis arborea*) and sweet pepper bush (Clethra *alnifolia*), are grown as ornamentals and are not used for spices.

The true pepper or black pepper (*Piper nigrum,* family Piperaceae) is native to northwest India, and in early historic times was widely cultivated in the tropics of southeastern Asia, where it became highly regarded as a condiment. Marco Polo in the 13th century observed great quantities of peppers being used in China and noted that their cultivation expanded as far as Java. Pepper early became an important item of overland trade between India and Europe. It became a medium of exchange, and tributes were levied in pepper in Greece and Rome. The Venetians and Genoese were two of the chief distributors, and their virtual monopoly of the trade helped instigate the search for a sea route to the far east.

The pepper plant is a woody climber that by means of aerial roots reaches heights of 30 ft. or more. The shiny green leaves are broad, ovate and alternately arranged. The inconspicuous flowers, which lack a perianth, are arranged in dense slender spikes of about 50 flowers each. The fruit, called a peppercorn, a small globose berrylike structure, $\frac{1}{5}$–$\frac{1}{4}$ in. in diameter, becomes yellowish red at maturity and bears a single seed. A number of cultivated varieties are known.

The plant requires a long rainy season, fairly high temperatures and partial shade to produce its best growth. Propagation is generally by stem cuttings, which are set out near a tree or a pole that will serve as a support. The plants are sometimes interplanted in tea or coffee plantations. Peppers start bearing in two to five years and under good conditions may produce for 40 years or more. Harvesting is done by hand just before the fruits ripen. The peppercorns are spread out to dry in the sun or occasionally over fires. In a few days the green fruits turn black and are ready for shipment. When ground, the whole peppercorn yields black pepper. For the preparation of white pepper, which has a milder flavour, the outer hull and pulp are first removed from the seed by fermentation in water. White pepper also is prepared from the whole dried peppercorns by grinding off the outer coating.

W. H. HODGE

FRUITING BRANCH OF A BLACK PEPPER TREE (PIPER NIGRUM)

Pepper owes its pungency to a resin and its flavour to a volatile oil. Piperine, an alkaloid with the same empirical formula as morphine, $C_{17}H_{19}NO_3$, also is present. It is probably the world's most widely used spice and also has a limited usage in medicine.

The pepper is rather widely cultivated in India. Thailand, the East Indies, and islands of the South seas. with Indonesia producing the bulk of the world's supply. The plant has been successfully introduced into tropical areas of Africa and of the western hemisphere. World exports have amounted to 170,000,000 lb. a year, with U.S. imports reaching 50,000,000 lb. a year.

Long pepper, whose culture and preparation is similar to that of black pepper, is prepared from Piper *retrofractum,* native to Java, and Piper *longum,* native to India. Although it was popular in Europe during the middle ages, it is little used today outside the areas where it is grown. Of the some 600 to 700 species of Piper, a few others are of economic importance. Cubebs from Piper *cubeba,* native to the East Indies and cultivated in the far east, formerly were used as a spice or condiment and now have a limited use in medicine for the treatment of catarrh. The roots of Piper *methysticum* are used throughout Oceania to produce the beverage kavakava. The leaves of the betel pepper (*Piper betle*) are chewed with the nuts of the betel palm in much of the tropics of the old world as a masticatory.

For the sweet garden peppers, cayenne, etc., see CAPSICUM; CAYENNE PEPPER.

See Howard Scott Gentry, "Introducing Black Pepper into America," Econ. *Bot.,* vol. ix, pp. 256–268 (1955); Albert F. Hill, *Economic* Botany (1952). (C. B. H.)

PEPPERGRASS, a name given, especially in the United States, to certain species of *Lepidium* (family Cruciferae), which are widely spread as needs. They are erect, mostly annual herbs with freely branching stems, about one-half to one and one-half feet high, small, toothed or deeply cut leaves, minute white or yellow flowers, followed by elongated, cylindrical clusters of small, short-stalked, flattened, nearly round, two-seeded, slightly notched pods. Examples are the wild peppergrass (L. *virginicum*), with mostly undivided leaves, found in fields from Quebec to Minnesota and southward to Mexico and the West Indies, and also naturalized in southern Europe, and the roadside peppergrass (L. ruderaie), with narrowly divided leaves, native to Europe but now naturalized from Nova Scotia to Texas, and occurring also in Australia.

PEPPERMINT, a perennial herb of the family Labiatae, and genus *Mentha* (see MINT), the species *M. piperita,* is distinguished from other species of the genus by its stalked leaves and oblong-obtuse spikelike heads of flowers. It is native to Europe and has become naturalized in North America, found near streams

and other wet sites. In several parts of the world, including Europe, Asia and North America, it is cultivated for its essential oil. Many varieties of peppermint have resulted from natural hybridization among wild species, but only two varieties, the black and white, are recognized by growers. The former has purplish and the latter green stems; the leaves are more deeply toothed in the white. Black peppermint (also known as English peppermint and mitcham mint) is the form extensively grown in the United States, probably because it is found to yield more oil. The white variety is less hardy and less productive but its oil is considered more delicate in odour and obtains a higher price.

U.S. DEPARTMENT OF AGRICULTURE

PEPPERMINT (MENTHA PIPERITA)

After about 1900 the United States became an important producer of peppermint oil. Production on a large commercial scale was first attained in southern Michigan and was later extended to northern Indiana. Shortly after World War II, the states of Washington and Oregon became important centres of peppermint culture because of climatic factors, including long summer days with abundant sunshine. which favour the production of high yields of oil. In the beginning of the second half of the 20th century, the United States was the leading peppermint-producing country, with production of over 2,000,000 lb. accounting for nearly three-fourths of the world's supply of peppermint oil. Bulgaria, Italy. the U.S.S.R., France and other countries in Europe and Asia also produce the oil. Peppermint can be grown on a wide range of soil types but does best in deep, rich soils well supplied with moisture from rainfall or irrigation. In the United States it is produced on muck soils in Michigan and Indiana and sandy-loam soils in Oregon and Washington. Peppermint is propagated commercially by planting stolons (underground shoots) taken from existing fields. It is often grown in rows the first year and then allowed to spread over the field in solid stands spoken of as meadow mint. Fields may produce satisfactory crops for two to five years or longer if weeds and diseases are controlled. Best yields of oil are obtained when peppermint is harvested by cutting at the full-bloom stage.

Oil of peppermint is a volatile oil distilled with steam from the partially dried herb. It is widely used for flavouring dental creams, mouth washes, tooth pastes, cough drops, chewing gum and confectionery, and to a lesser extent for masking the flavour and odour of numerous medicinal products. When pure, peppermint oil is nearly colourless and has an agreeable odour and a powerful aromatic taste, followed by a sensation of cold when air is drawn into the mouth. When oil of peppermint is cooled to 4° C. it sometimes deposits colourless hexagonal prisms of menthol, which are soluble in alcohol and ether, almost insoluble in water, and fusible at 92" F.; the oil consists chiefly of menthol and a ketone called menthone. Oil of peppermint is sometimes adulterated with phellandrene or other terpene compounds, water soluble glycols or synthetic menthol. Adulteration with terpenes or glycols can be detected readily by using appropriate chemical or physical tests, but no satisfactory method has been found for proving adulteration with synthetic menthol. Oil of Japanese mint (*M. arvensis* var. *piperascens*) is a rich source of menthol, very different from peppermint oil. The name Japanese peppermint is sometimes used for this plant, but it should not be confused with true peppermint.

See E. Guenther. *The Essential Oils,* vol. 3, pp. 586–640 (1949).

(L. M. Pz.)

PEPPERRELL, SIR WILLIAM (1696–1759), American soldier, was born in Kittery, Me., then a part of Massachusetts, on June 27, 1696. He studied surveying and navigation. and joined his father in his shipbuilding, fishing and general trading business, becoming one of the wealthiest and most influential men in the province and a colonel of militia. Pepperrell served in the Massachusetts general court (1726–27), and in the governor's council (1727–59), of which for 18 years he was president. Although not a lawyer, he was chief justice of the court of common pleas from 1730 until his death. In 1745 he was commander in chief of the New England force which besieged and captured the French fortress of Louisburg. Pepperrell, in Nov. 1746, was created a baronet—the only New Englander so honoured. Active in raising troops during the French and Indian War, he was made lieutenant general in Feb. 1759. He died in Kittery on July 6, 1759.

See Usher Parsons, *Life of Sir William Pepperrell, Bart.* (1855); L. Dame, "Life and Character of Sir William Pepperrell," *Essex Inst. Hist. Coll.,* vol. xxi, pp. 161–176 (1884); "The Pepperrell Papers," *Mass. Hist. Soc. Coll.,* ser. 6, vol. x (1899); Charles Henry Lincoln (ed.), *The Journal of Sir William Pepperrell Kept During the Expedition Against Louisbourg* (1910); and John Francis Sprague, sketch in *Three Men from Maine* (1924).

PEPPER TREE, a tree which has no proper connection with the true pepper (Piper). and is really a member of the family Anacardiaceae, being known botanically as *Schinus molle,* from the Peruvian name *Molle.* It is a native of tropical South America and is grown in the open air in the south of Europe. Introduced into California, it became widely popular as an ornamental tree! but later it was found to be a host plant for scale insects very destructive to orange orchards. with the result that in citrus districts the trees were cut down and further plantings discouraged. It is a small tree with unequally pinnate leaves, filled with volatile oil stored in large cells or cysts which are visible to the naked eye and appear like holes when the leaf is held up to the light. When the leaves are thrown upon the surface of water the resinous or oily fluid escapes with such force as to agitate them violently. The flowers are small, whitish, arranged in terminal clusters and polygamous or unisexual, with five sepals, as many petals, ten stamens (as large as the petals in the case of the male flower, very small in the female flower, but in both springing from a cushionlike disk surrounding the base of the three-celled ovary).

The fruit is a small, globose. pealike drupe with a bony kernel enclosing a single seed; its fleshy portion has a hot aromatic flavour from the abundance of the resin it contains. The resin is used for medicinal purposes by the Peruvians, and has properties similar to mastic. The very similar Christmasberry tree (S. terebinthifolia), native to Brazil, with stiffer, less pendulous branches, more densely clustered flowers and smaller, bright red fruit, is sparingly planted for ornament. The Japan pepper tree is Zanthoxylum *piperitum* the fruits of which have also a hot taste.

Along the Riviera the tree known as Melia *azedarach* or the "pride of India." is also incorrectly called the pepper tree.

PEPSIN is the powerful enzyme. or ferment, in gastric juice that digests proteinous foods such as meat, eggs or seeds that are introduced into the stomach. Enzymes (*q.v.*), in general, are catalysts that in small quantities speed up biochemical reactions. They are formed by living tissues, and all cells are dependent upon them to speed up the many reactions that otherwise would proceed far too slowly. No enzyme has been synthesized in the laboratory.

Pepsin was first recognized in 1836 by the German physiologist Theodor Schwann. Nearly a century later, in 1930, it was crystallized and its protein nature established by John H. Northrop of the Rockefeller Institute for Medical Research.

The tissues lining the stomach make and store pepsin in an inactive form called pepsinogen, or propepsin. When pepsinogen is secreted into the stomach and mixed with the acidic gastric juices, it is rapidly converted into pepsin. Pepsin speeds up this conversion, and since it is also a product of the conversion, the reaction once started goes faster and faster; *i.e.,* it is self-accelerating or autocatalytic. The digestive power of pepsin

changes with acidity, and, as might be expected, it is fastest at the acidity of normal gastric juice (pH 1.5–2.5).

Proteins, in general, are made up of some 20 different kinds of amino acids linked together. Only the links between certain pairs of amino acids are opened by pepsin In the digestive tract this leads to only partial degradation of proteins to smaller units called peptides. which are then either absorbed from the intestine into the blood stream or are broken down further by pancreatic enzymes. The magnitude of the digestive power of pepsin may be indicated by pointing out that one ounce of pure pepsin can coagulate (an early step in the digestion) 200,000 gal. of milk in an hour at body temperature or can digest thousands of times its weight of other proteins in a similar period. Although pepsin is a protein, it is resistant to its own digestive powers.

Like other enzymes and proteins, pepsin is a large, complex molecule. On a weight scale in which an atom of hydrogen is 1 and ordinary table salt (sodium chloride) is 58, pepsin is 35,000.

Pepsin is prepared commercially from swine stomachs, which contain on the average about one gram (one-thirtieth of an ounce) of enzyme per stomach. Crude pepsin is used in the leather industry to remove hair and residual tissue from animal hides prior to their being tanned. It is also used in the recovery of silver from discarded movie films, which it does by digesting the gelatin layer that holds the silver compound. Still another commercial use is in the preparation of peptone (partially digested protein), which is an important ingredient of growth media for bacteria and related microorganisms.

See also DIGESTION; PROTEINS.

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(R. M. **Hr.**)

PEPUSCH, JOHN CHRISTOPHER (1667–1752), English musician! of German parentage, was born in Berlin. He was for many years musical director at Lincoln's Inn Fields theatre, and arranged the tunes and composed the overture for John Gay's *Beggar's Opera,* doing the like later for its sequel, *Polly.* In 1737 he became organist of the Charterhouse. His later years were spent in study, in the composition of chamber music and some admirable motets and in teaching some favoured pupils, among these being William Boyce. Pepusch died on July 20, 1752. His *Treatise on Harmony* (anonymous 1st ed., 1730) is believed to have been an embodiment of his rules drafted by his pupil, Viscount Paisley, aftenvard earl of Abercorn.

PEPYS, SAMUEL (1633–1703), English diarist, was born on Feb. 23, 1633, in a house in Salisbury court, close to St. Bride's churchyard, where his father, John Pepys, carried on the business of a tailor. The family can be traced in Cambridgeshire as far back as the reign of Edward I. They rose by slow degrees from the class of small copyholders and yeoman farmers to the position of gentry. In 1563 they had a recognized right to use a coat of arms. The name was pronounced in the 17th century, and has always been pronounced by the family, "Peeps." John Pepys was a younger son, who, like other gentlemen in his position in that age, went into trade. He married Margaret Kight, "washmaid to my Lady Veere," whose brother William was a butcher in Whitechapel. This was regarded as a *mésalliance,* for Samuel refers to his mother's relations with a certain disrespect. In 1661 John Pepys inherited a small estate at Brampton near Huntingdon where he died in 1680, his wife having predeceased him in 1667.

Samuel was fifth child and second son of a large family, all of whom he survived. His first school was in Huntingdon, but he was afterward sent to St. Paul's in London, where he remained till 1650. On June 21 in that year he was entered at Trinity hall, Cambridge, but migrated to bfagdalene as a sizar on Oct. 1. On March 5, 1651, he went into residence, obtaining a Spendluffe scholarship a month after entering, and one on John Smith's foundation on Oct. 4, 1653. In March 1654 he proceeded to the B.A. degree, and in 1660 to that of M.A. Nothing is known of his university career except that on Oct. 21, 1653, he was publicly admonished with another undergraduate for having been "scandalously overseene in drink." At Cambridge he wrote a romance, *Love is* a *Cheat,* which he afterward destroyed.

On Dec. 1, 1655, he was married at St. Margaret's church, Westminster. to Elizabeth, daughter of Alexander Marchant, sieur de St. Michel, a French Huguenot exile from Anjou who had married an English lady named Kingsmill. Pepys had at this time no independent means and probably relied on his relatives, the Mountagus. to provide for him. On March 26, 1658, he was cut for the stone. an event which he always kept in memory by a solemn anniversary. In 1659 he went as secretary with his kinsman, Edward Mountagu, afterward earl of Sandwich, on a voyage to the sound. On his return he was engaged as a clerk under (afterward Sir) George Downing, one of the four tellers of the exchequer. In 1660 he accompanied Mountagu when he commanded the fleet which brought King Charles II back from exile. In that year, by the interest of his kinsman, he was appointed clerk of the acts in the navy office, but was compelled to buy off a competitor, one Barlow, with an annuity of £100. Though he was so ignorant of business that he did not even know the multiplication table when he first took office, he soon mastered the needful mechanical details by working early and late. He had other posts and honours, which came to him either as consequential on his clerkship or because he was a useful official.

The Official.—On July 23, 1660, he was appointed a clerk of the privy seal, but he resigned the office on Aug. 17, 1662. On Sept. 24, 1660, he was made a justice of the peace. In 1662 he was appointed a younger brother and in 1672 an elder brother of the Trinity House. In 1662 also he was named a commissioner for managing the affairs of Tangier, then occupied by an English garrison. In 1664 he became a member of the corporation of the royal fishery, and in 1665 was appointed treasurer for Tangier. In that year also he was elected a fellow of the Royal society.

During the naval war with Holland (1665–67) he proved himself an indefatigable worker. As surveyor of victualling, the whole burden of a most important department was thrown on him in addition to his regular duties. While the plague was raging in London in 1666 he remained at his post when many of his colleagues ran away, and he manfully avowed his readiness to take the risk of disease, as others of the king's servants faced the dangers of war. He had now gained the full confidence of the lord high admiral, the duke of York, afterward King James II. When, on the termination of the war, the navy office was violently attacked in parliament, he was entrusted with its defense. The speech which he delivered at the bar of the house of commons on March 5, 1668, passed for a complete vindication. The charges of mismanagement were well founded, but the fault was not in the officials of the navy office only, and Pepys, who was master of the details, had no difficulty in making out a defense.

Nobody indeed was better acquainted with the defects of the office. for in 1668 he drew up for the duke of York two papers of inquiry and rebuke, "The Duke's Reflections on the several Members of the Navy Board's Duty" and "The Duke's answer to their several excuses." (*See* Pepysian manuscript at Magdalene, no. 2242, and Harleian manuscript 8003.) In 1668 he went for a fortnight's tour in the west of England, and in 1669 he and his wife travelled in Holland and France. His success in addressing parliament gave him the ambition to become a member of the house of commons. He stood for Aldeburgh, but the death of his wife, on Nov. 10, 1669, prevented him from conducting his canvass in person, and he was not elected. In 1673 he was, however, returned for Castle Rising. The validity of his election was questioned by his opponent, Offley, and the committee of privileges decided against him, but the prorogation of the house prevented further action.

The no-popery agitation was now growing in strength. The duke of York was driven from office by the Test act, and Pepys was accused of "popery," partly on the ground that he was said to keep a crucifix and altar in his house, partly because he was accused of having converted his wife to Roman Catholicism, but the charges broke down on examination. In 1673 Pepys **was**

transferred by the king from the navy office to the secretaryship of the admiralty. In 1679 he was member for Harwich, and in the height of the "popish plot" mania he was accused, manifestly because he was a trusted servant to the duke of York, of betraying naval secrets to the French. He resigned office on May 21, 1679, and on the following day he was committed to the Tower, but he was released on bail on July 9, and in the following February the charges against him were finally dropped.

In Oct. 1680 he was with the king at Newmarket, and took down the narrative of his escape after the battle of Worcester. In 1676 Pepys had been appointed a governor of Christ's hospital and was elected master of the Trinity House, and in 1677 he became master of the Clothworkers company. A proposal to make him provost of King's college, Cambridge, in 1681 came to nothing. In 1682 he accompanied the duke of York to Scotland, and in 1683–84 he was engaged in arranging for the evacuation of Tangier. He visited the place and kept a diary of his voyage and of a subsequent tour in Spain. In 1684 he was elected president of the Royal society.

When the admiralty commission of 1679 was dissolved in 1684 Pepys was restored to the secretaryship of the admiralty, and he retained the office when James II ascended the throne. His chief work during this period was the establishment of the special commission of 1686 "for the recovery of the navy." by which its impaired efficiency was entirely restored. In 1685 he again sat in parliament as member for Harwich, and in the same year he was for a second time master of the Trinity House. The revolution of 1688 ended his official career. He was dismissed on March 9, 1689, and spent the rest of his life in retirement and, except for two brief imprisonments in 1689 and in 1690 "on suspicion of being affected to King James," in peace. He died at his friend William Hewer's house in Clapham on May 26, 1703, in the 71st year of his age.

His last years were passed in correspondence with his friends, who included Evelyn and Dryden, or in arranging his valuable library. This was left on his death to his nephew, John Jackson, son of his sister Paulina, and in 1724, by the terms of his will, was transferred to Magdalene college, Cambridge, where it is still preserved.

The Diary. — Such was the outward and visible life of Samuel Pepys, public servant, whose diligence was rewarded by success. The other Pepys, whom Sir Walter Scott called "that curious fellow," was revealed in 1825 when his secret diary was partly published. The first entry was made on Jan. 1, 1660, the last on May 31, 1669, when the increasing weakness of his eyes. which had given him trouble since 1663, compelled him to cease writing in the conditions he imposed upon himself. If there is in all the literature of the world a book which can be called "unique" with strict propriety, it is this. Confessions, diaries. journals, autobiographies abound, but such a revelation of a man's self has not been discovered. The diary is a thing apart by virtue of three qualities which are rarely found in perfection when separate and nowhere else in combination. It was secret: it was full; and it was honest. That Pepys meant it for his own eye alone is clear. He wrote it in Shelton's system of tachygraphy, published in 1641, which he complicated by using foreign languages or by varieties of his own invention whenever he had to record the passages least fit to be seen by his servants or by "all the world." Relying on this cypher, he put down whatever he saw, heard, felt or imagined, every motion of his mind, every action of his body, and he noted all this, not as he desired it to appear to others, but as it was to his seeing.

The result is "a human document" of amazing vitality. The style is as peculiar as the matter — colloquial, garrulous, racy from simplicity of language and full of the unconscious humour which is never absent from a truthful account of the workings of nature in the average man. To his credit must be put the facts that he knew the animalism and the vice of the Restoration period to be what they were; that he had a real love of music and gave help to musicians, Cesare Morelli, for instance; that though he made money out of his places he never allowed bad work to be done for the navy if he could help it; that he was a hard worker; and that he had a capacity for acts of kindness and generosity.

The diary, written in shorthand in six volumes, was included among his books at Magdalene. On the publication of Evelyn's diary in 1818, the then master of Magdalene, the Hon. and Rev. George Neville, decided to publish Pepys's. The library contained both the short and the longhand copy of Pepys's account of King Charles's adventures, but its contents were so little known by the curators that this key was overlooked. The manuscript was deciphered between 1819 and 1822 by John Smith, afterward rector of Baldock in Hertfordshire. The first and partial edition, edited by Richard Griffin Neville, 3rd Lord Braybrooke, appeared in 1825. It attracted great attention, and was reviewed by Sir Walter Scott in the *Quarterly* for Jan. 1826. A second edition followed in 1828. A third and enlarged edition appeared in 1848–49 and a fourth in 1854. A still fuller edition was published in 1875–79 by Mynors Bright. Finally, in 1893–99, H. B. Wheatley printed the whole of the diary with the exception of a few unprintable passages. Pepys's only known publication in his life was the *Memoires of the Royal Navy* (1690).

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PERACIDS. The term used in the older literature to characterize acids which contain a peroxide group **(–O–O–j** and which are more properly called peroxy acids; *e.g.*, peroxymonosulfuric acid (H_2SO_5) and peroxydisulfuric acid ($H_2S_2O_8$). *See* PEROXYACIDS. (J. B. Ps.)

PERAVIA: see TRUJILLO VALDEZ.

PERCEPTION is a living organism's awareness of external objects or situations, an awareness gained by means of its senses. In 1765 the Scottish philosopher, Thomas Reid, distinguished between sensation (*q.v.*) and perception; applying the term sensation to the immediate data that come directly from stimulation and the term perception to the larger awareness that includes the reference of these sensations to the external stimulating object. This distinction held until the third decade of the 20th century when, under the influence of Gestalt psychology *(see* PSYCHOLOGY, HISTORY OF: *Gestalt Psychology*) the concept of sensation tended to drop out of use and psychologists began to direct their attention to the larger systems of sensory stimulation, which. since objective reference is implicit in them, are properly called perceptions.

THEORIES OF PERCEPTION

A theory of perception undertakes to explain how the individual organism is aware of the external world in which it lives. Since an organism, if it is to survive and succeed, must have adequate information about its environment, one crucial question is this: how is correct perception possible?

Discrimination. — In the first place, it must be noted that discrimination provides the evidence of perception. The animal or person must react discriminatively to objects or situations if others are to know that perception is taking place. It is much easier to be assured of the occurrence of adequate perception than to know whether the perception is consciously or unconsciously mediated.

A rat can learn always to choose the brighter of two disks of equal size if the brighter of the pair consistently marks the door to a food box. The rat thus perceives a difference in brightness.

In a sense he may be said to have a conscious perception of the disks, but actually that question does not have to be raised. A man engrossed in conversation with his dinner companion finds that the little pile of nuts by his plate has disappeared and that he even has a nut in his mouth. Another man across the table saw him actually eat the nuts. So he must have perceived the nuts, for he discriminated them from other inedible objects which he did not try to ingest. Most psychologists would say that such well-habituated perception is unconscious, although an exact answer to that question depends on the definition of consciousness (see below)

This general rule holds: perception of an object by an organism is always the organism's discrimination among objects as evidenced by its specific reaction to the object.

Representation in Kind.—The Greeks believed that objects emit faint copies of themselves, copies which are transmitted by the senses to the sensorium which perceives the object by perceiving its copy. While this view was too naive to survive in the age of science, the basic principle that perception resembles its object recurs again and again in psychological theory. For instance, John Locke in 1690 distinguished between the primary and secondary qualities of perceived objects. The primary qualities are those characteristics in which the perception resembles its object, like spatial extension. The secondary qualities are the characteristics in nhich the perception does not resemble its object. like colour. This is an important distinction. In modern terms the secondary qualities are those in which there is a functional dependence between experience and stimulus without representation in kind: seen redness depends upon light of long wave lengths, but there is nothing long or undulatory about the hue red itself

About *1920* the Gestalt psychologists proposed psychophysiological isomorphism as a theory of perception. This theory lays down the principle that, in respect of spatial relations, there is a point-to-point correspondence between the experienced perception and the brain pattern nhich underlies the perception, a correspondence such that all the spatial orders of one system are preserved in the other, although shapes and magnitudes may not be preserved. In other words, the correspondence between the brain pattern and the experienced pattern is topological, but not necessarily topographical. The chief evidence for this view comes from the physiological discovery that the excitation of the visual area of the brain corresponds topologically, point for point, to the excitatory pattern on the retinas.

Thus there are four patterns, all topologically isomorphic with one another: *(1)* the projected stimulus pattern of light; *(2)* the pattern of excitation on the retinas; (3) the neurally projected pattern on the visual areas of the brain; and (4) the experienced pattern in the perception. In this way, for the visual perception of bidimensional spatial patterns, the simple theory of perceptual representation of the object in kind, a modern theory of primary qualities, is preserved.

The Gestalt psychologists carried isomorphism further. They believe that the principle holds for tridimensional visual space perception, that the visual perception of depth and solidity corresponds to a tridimensional field of excitation in the brain. They also hold that the perception of intensity, time and movement are ismorphic. In certain cases this theory requires that the characteristics of the stimulus object, which are represented functionally but not in kind in the initial phases of excitation, must be reconstituted in the brain fields that underlie the experienced perception. For instance, in the stereoscopic perception of depth, the depth is represented on the retinas, not in kind, but by disparity between the two retinal images. Isomorphism requires that this disparity operate in the action of the nervous system to reconstitute a solid excitatory field in the visual areas of the brain. The evidence was not yet conclusive in the 1950s as to how or even whether this reconstitution of the stimulus field actually occurs in the brain *(see* below).

Functional Representation.— It is quite clear that not all perceptual qualities are primary; some are secondary. Not all perceptual representation is in kind; some of it is a correspondence between dissimilars, a correspondence that is adequate because it is functionally specific. The longest visible wave lengths of light always look red if they fall, uncombined with other wave lengths, upon the retina of a man who is not colour-blind. That is *a* functional correspondence of dissimilars, the case where isomorphism in perception is certainly not the correct principle.

This view is fully as old as Johannes Müller's theory of specific nerve energies, which he first formulated in *1826* as a protest against the ancient doctrine that perceptual representation. is always in kind. Muller argued for the existence of five specific nerve "energies" or qualities. one for the nerve of each of the five senses. The sensorium perceives, he said. not the properties of the objects themselves, but the properties of the nerves which the objects affect. Thus sight and light are quite different kinds of events. The reason that a person knows there is light when he has sight is that there is, according to Muller, a "specific irritability" of the retina which makes it most easily excited by light. C. S. Sherrington later *(1906)* used the term "adequate stimulus" to designate this specificity of relation between a sense organ and its normal stimulus. Illusion occurs when an unusual stimulus is effective, in spite of its inefficiency, as when pressure on the eyeball arouses the perception of coloured patterns.

It would seem that all perception must imply functional representation of the perceived characteristics of the stimulus, both in the brain and in the experienced perception. Sometimes. but not always, this representation is "in kind" or isomorphic. Presumably there is a topological representation of the stimulus characteristics in the perception of temporal duration, stimulus intensity, visual and tactual spatial patterns in two dimensions, and visual, tactual and auditory movement.

Perceptual Context.— Thus far only the sensory core of a perception, a core which in familiar perceptions is adequate by itself for the identification of the stimulus object, has been considered. Often! however, the core alone is insufficient to constitute the complete perception that the organism wishes or needs. A context must be added to the core if identification of the perceived object is to be satisfactory. I smell a rose. What have I perceived? An odour. But if, by association, there is added to the odour a visual image of a rose, then this visual context, accruing to the olfactory core, provides greater specificity of meaning and further completes the perception. I see a face. It is strange. Then a name comes to mind, and, because of that added context, I have recognized the face.

This context theory of perception is basically an associative theory of perceptual meaning. It was first elaborated by Bishop George Berkeley in 1709, then developed by the associationists (Thomas Brown in 1820, James Mill in 1829, Wilhelm Wundt in 1874), and finally made the basis for Wundt's "mental chemistry" in which meaning is always explained by compounding, by the association of two or more conscious items. The associations that form these identifying contexts are often learned, but they may be inherited reflexes. For instance, a human infant instinctively gives the startle reflex when stimulated suddenly by a loud sound. That reflex is not learned, yet it constitutes the context which makes the sound perceived as "something to be startled by." Similarly a protozoon that turns away from the light may be said to perceive the light as something to be avoided. The light is the core; the turning, the context.

The context theory of perception'was named by E. B. Titchener in 1909. His chief contribution was to note that contexts may be conscious or unconscious, that novel perceptions generally require conscious contexts for their specification, but that the conscious context tends to drop off as the perception becomes familiar, leaving the meaning to be carried unconsciously and evidenced by the adequate discriminatory behaviour of the organism. When a person first sees the word "argali" the perception is inadequate. He does not know what the word means. When he has been told that an argali is a kind of wild sheep or has been shown a picture of one, then for a while the verbal core will arouse an identifying context, the word "sheep" or the visual image of an argali. When the word has become familiar, this context drops off. He can now comprehend the meaning of argali without the context, as is evi-

denced by the fact that later on he can demonstrate his correct comprehension of a text which contains the word. New words need contexts, but in most reading there is no time for the perceptual contexts to accrue. Thus the context theory recalls the basic fact that the evidence of perception is discrimination (see above).

The foregoing theories of perception are supplementary and not mutually exclusive. When perception occurs, the perceived characteristics must have functional representation in the brain. Sometimes this representation is in kind, is isomorphic, and there is further evidence that in some cases physiological means exist for re-establishing a topological correspondence between the stimulus field and the brain field, even when such correspondence has been lost in the initial phases of excitation.

TYPES OF PERCEPTION

The foregoing discussion of theories of perception indicates that perception may be conscious or unconscious, that the functional adequacy of a perception normally enables the organism to obtain correct information about its environment and that a perception, especially a novel one, normally receives further specification by the addition to its sensory core of a context, either a learned association or an innate reflex. It is now proper to discuss further the reconstitution of objects in perception, the perception of relations and unconscious perception.

Perceptual Reconstitution. — Stereoscopic vision furnishes one of the best examples of how the characteristics of the stimulating object are reconstituted in perception. A solid object, viewed with the two eyes, produces somewhat disparate images on the two retinas. Since the two eyes perceive only a single perceptual field, one might expect to see this disparity as a doubling of some of the lines. Instead one perceives a solid object in three dimensions, with no doubling, in spite of the fact that it would not be possible to make the two retinal images coincide in superposition.

The fact that one sees objects single in binocular vision is also an instance of this principle of reconstitution. In this case a little is known about the physiological basis for the perception: corresponding points on the two retinas are projected to the same region of the brain.

The Gestalt psychologists made a great deal of what has been called the constancy phenomenon, that is to say, the tendency to see objects as constant in size, shape, brightness and hue, even when the immediate stimulation from them varies greatly. For instance, a receding object does not lose size nearly so rapidly as the retinal image of it diminishes. Experiments have shown that in free binocular vision the perception of an illuminated disk in the dark may not diminish in size at all as the disk recedes from a distance of 20 ft. to a distance of 200 ft., although the retinal image under those conditions shrinks to $\frac{1}{10}$ of its initial linear size. Such perceived constancy depends, however, on the availability to the organism of clues to the distance, so that the perceiving mechanism can, as it were, correct the perception for the distance. When the clues to distance are reduced by eliminating the use of one eye and eliminating all sight of the intervening space, then the constancy is also reduced and the perceived size is found to diminish with the size of the retinal image.

It is obvious that perceptual constancy can be of great advantage to the organism in its struggle for survival and success. Experiments show that chickens, trained to choose the larger grains of corn and to let the smaller lie, will choose remote large grains which, because remote, have small retinal images, in preference to near small grains which, because near, have the larger retinal images. They choose always the larger object, whether its image on the retina be the larger or the smaller.

The shape of objects also tends to be reconstituted in perception when an oblique viewing of the stimulus distorts the shape of the retinal image. A circle in oblique regard continues to look like a circle, even though its retinal images may be narrow ellipses.

The apparent brightness of an object likewise tends to remain constant in spite of varying illumination. Coal, recognized as coal, looks black even in bright sunlight. Snow, recognized as snow, looks white even in shadow. Actually the snow in shadow may he darker than the coal in sunlight. If both objects are viewed through tubes, which obscure the clues to their nature as objects and reveal only small circular patches of the two surfaces, then the illuminated coal will appear a much brighter gray than the shaded snow.

A discrete displacement of the retinal image will, with the right speeds and spacings, give rise to the visual perception of continuous movement. The cinema makes use of this principle. Actually the translation of the discrete displacement into continuous movement is often a reconstitution of an original stimulus. A moving object is seen clearly only when the eyes move with the object, allowing the image momentarily to remain stationary on the retina. Thus discrete retinal displacement is the rule in the perception of continuous movement, and the perception of continuity of movement is really a reconstitution of the original continuity.

Auditory localization also illustrates the way in which the stimulus situation is reconstituted in the perception. A sound that originates in the median plane between the two ears affects both ears equally and is heard not as a double sound, one on the right and another on the left, but as a single sound localized correctly in the median plane. A sound from the right, however, coming earlier and louder to the right ear is localized at the right. Thus, in general, any sound which comes to both ears but is either earlier or louder at one ear will he localized as coming from the side of that ear.

The general rule is that perception, insofar as it is adequate, tends to reconstitute the characteristics of the stimulus object. Many of these principles were worked out by Gestalt psychology although some of the basic facts. like singleness of vision with two eyes, have been recognized since antiquity.

Perception of Relations. — For the most part perception is relativistic and not absolute. An object has no perceived size, except as is it compared with another object. Precise judgments of tonal pitch, of visual brightness and even of hue are possible only by reference to some standard. Accurate perception is always the perception of a relation.

It is well known that the perception of pitch is relative and that a melody or harmony depends on the relations between the musical notes and not on their absolute pitches. In the same way the visual perception of brightness is relative. If a man or animal learns to choose the brighter of two grays, he will take a given gray when it is combined with a darker one and reject it when it is combined with a lighter one. Men, children, apes, dogs, rats and bees all react in this relativistic manner.

Unconscious Perception. — Whether a perception is to be regarded as conscious or unconscious depends almost entirely upon the definition of consciousness (*q.v.*). It is usual, however, to regard perception as being unconscious when an accurate discrimination leaves no memory trace of its occurrence, when the perceiver cannot say minutes or even seconds afterward whether he perceived or what he perceived. Familiar, well-habituated perceptions fall in this class (see above), as do all rapid discriminations. A man can perceive a familiar designated object quickly when it lies on a table with 99 other strange objects, and he can pick out the designated object again and again from different sets of strange objects, quickly and accurately. He must indeed "see" the other objects in order to reject them and continue his rapid search for the specified object, but he cannot afterward tell much about these other objects. This hurried negative perception of wrong objects, perceived in order to reject them, is practically unconscious — for they do not stick in memory.

There have been experiments in which a discrimination has been determined or aided by clues of which the discriminator declares he was fully unaware. In the same way judgments can be passed without the judge being aware of the motives and prejudices that influence his thought.

There is also the case of contradictory perception which occurs with hypnotism (q.v.). For example, the hypnotist may suggest to the hypnotic subject that they two are alone in the room, although actually there is a third person present. The subject then becomes "blind" to the third person and acts consistently as if he were not there. Nevertheless, the subject never collides with the third person, never tries to sit where the third person is sitting. If the hypnotist suggests that the subject take the chair occupied by the "invisible" person, the subject will find excuses and reasons for not doing what is, in fact, impossible for him to do. In this case it appears that the subject "sees" the man to whom he is blind in order that he may know not to "perceive" him. From these instances it appears that unconscious perception is essentially equivalent to immediately unremembered discrimination.

Social Perception. — This term, which came into vogue in the late 1940s, is used to designate either: (1) the perceptions of social phenomena, like the perception of anger or danger; or (2) those perceptions which are understood by reference to their social determining causes.

The first class of social perceptions presents no new problems or principles. It consists of perceptions of social meanings in which the determinants and even the sensory cores may be unreportable by the perceiver and in that sense are unconscious. Thus a man may perceive anger in another man without knowing what bits of behaviour or facial expressions form the basis for his perception. Nor is this case different from the perception of the constant apparent size of a receding object when the observer does not know that he is unconsciously tdking perceived distance into account.

Of the other class of social perceptions it has been said that the perceived pattern of the external world always mirrors the pattern of the needs of the perceiver. There are many well-known subje-tive determinants of perception, and by no means do they all operate to create illusion, lor true knowledge of the real world is one of the fundamental needs of the organism. Perceptual mechanisms tend to reconstitute the perception in such a manner as to increase the accuracy with which perception represents external objects and other events. Stereoscopic perception of depth, the object constancies and the perception of continuous movement with cinematic dis-

continuity *(see* above) are all cases in point.

Organisms have, however, many other needs besides knowledge of the truth. Illusion may be created by the projection of wishes into perception. "If she be not fair to me, what care I how fair she be." The thematic apperception test samples the needs of a subject or patient by having him describe what he sees in a given picture, one that is capable of many interpretations. Sometimes children see desired objects as larger than undesired ones when all objects are of the same size, and this tendency to subjective distortion has been measured in experiments which provide a set of neutral comparison objects.

Social determinants operate like any of the other determinants of perception. They may work, for instance, in a defensive manner: as when a person, given sufficient time to perceive a rapidly exposed word, nevertheless fails to perceive it because it is an unwelcome word, one that embarrasses or shames him. This case belongs with the contradictory perceptions of the hypnotic state *(see* above), for presumably the respondent must first have perceived the word in order to be able to exclude it from his immediate memory.

See HALLUCINATION; ILLUSION; PARAPSYCHOLOGY; PSYCHOLOGY; PSYCHOLOGY, HISTORY OF; SENSATION.

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(E. G. BOR.)

PERCEVAL, the hero of a comparatively small but highly important group of romances, now forming part of the Arthurian cycle. Originally the story of Perceval was of the character of a folk tale, and that one of considerable importance and world-wide diffusion. He is represented as the son of a widow, *"la dame veuve,"* his father having been slain, in battle or tourney, either immediately before or shortly after his birth. The mother, fearful lest her son should share his father's fate, flies to the woods, either with one attendant or with a small group of faithful retainers, and there brings up her son in ignorance of his name and parentage and all knightly accomplishments. The youth grows up strong, swift-footed and of great personal beauty but, naturally, of very limited education. He spends his days chasing the beasts of the forest.

As the result of a chance meeting with a party of knights he determines to set forth into the world in search of knighthood. He comes to Arthur's court, where he creates a sensation by his personal beauty and uncouth behaviour. He succeeds, by a cast of his javelin, in slaying the Red Knight, a foe of Arthur's who has vainly challenged the knights of the Round Table, and clothing himself in his armour sets out on a series of adventures which differ in the various versions, but the outcome of which is that he becomes a skilful knight and regains the heritage of his father.

This, the Perceval story proper; has been recognized by scholars as the variant of a widespread folk-tale theme, designated by J. G. von Hahn as the Aryan expulsion and return formula, which counts among its representatives such heroes as Perseus, Cyrus and Romulus and Remus. This particular variant appears to be of British-Celtic origin, and the most faithful representative of the original tale is now very generally held to be the English *Sy Percyvelle of Galles,* a poem preserved in the Thornton manuscript of Lincoln cathedral library. Here the hero is nephew to Arthur on the mother's side, and his father, of the same name, is a valiant knight of the court. A noticeable feature of the story is the uncertainty as to the hero's parentage; the mother is always a lady of rank, a queen in her own right or a sister of kings, but the father's rank varies. He is never a king, more often simply a valiant knight, and never of equal rank with his wife.

The connection of the story with Arthur and his court brought about an important development, the precise steps of which are not yet clear. Perceval became the hero of the Grail quest, ousting Gawain to whom the adventure originally belonged, and the Perceval became merged in the Grail tradition. Of the Perceval-Grail romances the oldest, from the point of view of manuscript preservation, is the *Perceval* or *Conte del Graal* of Chrétien de Troyes, but as Chrétien had already in a previous poem (*Cligés*) referred to Perceval as *"un vassal* de *grant renon,"* and states at the commencement of the *Conte del Graal* that he is about to "rimoier" the best tale told in a royal court, it is quite clear that, contrary to the theory of Foerster and Golther, Perceval is no invention of Chrétien's but was already a popular hero. Unfortunately the *Perceval* mas left unfinished, so there is no guide (which the conclusion might have afforded) to the precise character of Chrétien's source and the three writers, Wauchier de Denain, Gerbert and Manessier, who eventually carried the story to a conclusion, differ widely from each other and were clearly familiar with divergent traditions. An interesting problem is that of the relation between Chrétien's poem and the *Parzival* of Wolfram von Eschenbach, which was long held to be a translation from the French poem in spite of the fact that Wolfram himself asserts that his source was the work of a certain Riot and that Chrétien has told the story wrong. A fragment attached to two of the Chrétien manuscripts relates the birth and parentage of the hero, the death of his father and flight of the mother (details only alluded to by Chrétien) in a manner which corresponds curiously with the German poem and which, taken in connection with the knowledge on the part of other writers of features peculiar to the *Parzival,* would indicate that Wolfram was right and that the two works are independent derivations from a common source.

There are also two prose versions of the *Perceval* story, the older, contained in two manuscripts only, is attributed to Robert de Borron and forms the final section of his trilogy, concluding with a version of the death of Arthur manifestly derived from a rhyming chronicle akin to but not identical with that of Wace. The second romance, the *Perlesvaus,* obviously knew and used this text, but it is a much longer and more complicated romance, relating the adventures of Gawain, Lancelot and Perceval (Perlesvaus) in quest of the Grail. It probably formed at one time the *Quest* section of the prose *Lancelot,* and was later displaced in favour of the Galahad version. In fact two Paris manuscripts retain its opening adventure as introductory to the Galahad *Queste,* and in the early printed editions the two are found together. It was in all probability composed toward the close of the 12th century by a Welsh monk of Glastonbury, and was designed to exploit the discovery of the tombs of Arthur and Guenevere in that abbey.

The exact position of the Welsh *Mabinogi, Peredur, Son* of *Evrawc,* is still a matter of debate. It contains incidents which are found in Chrétien, but there is much which is obviously of Welsh and folk-lore origin. The theory that it is a mere translation of the French poem must be rejected, but its exact relation, with that of other *Mabinogion,* to the parallel French versions is uncertain. (*See* also GRAIL, THE HOLY; WAGNER, WILHELM RICHARD.)

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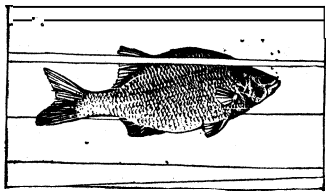
(J. L. W.)

PERCEVAL, SPENCER (1762–1812), prime minister of England from 1809 to 1812, second son of John, 2nd earl of Egmont, was born in Audley square, London, on Nov. 1. 1762. He was educated at Harrow and at Trinity college, Cambridge, and was called to the bar at Lincoln's Inn in 1786, becoming K.C. in 1796. Entering parliament for Northampton in 1796, he supported the administration of Pitt. In 1801, on the formation of the Addington administration, he was appointed solicitor general, and in 1802 he became attorney general. An ardent opponent of Catholic emancipation, he delivered in 1807 a speech on the subject which helped to destroy the Grenville administration; he then became chancellor of the exchequer under the duke of Portland, whom in 1809 he succeeded in the premiership. Perceval retained office till he was shot by a madman named Bellingham, a bankrupt with a grievance who had vainly applied to him for redress, in the lobby of the house of commons on May 11, 1812. Bellingham was certainly insane. nevertheless he was hanged.

See Spencer Walpole, *Life of Spencer Perceval* (1874); P. Treherne,

Spencer Perceval (1909).

PERCH, a fresh-water fish (Percn *fluviatilis*), generally distributed over Europe, northern Asia and North America, and a type of the Percidae, a family of spiny-rayed fishes. It inhabits rivers and lakes but thrives best in waters with a depth of more than 3 ft.; in large lakes it frequently descends to 50 fathoms and more. It occurs in Scandinavia as far north as the 69th parallel. The species exhibits many variations in shape, some specimens being high-backed, others low and long-bodied. A rich greenish brown with golden reflections covers the back and sides, which are ornamented with five or seven dark crossbands. A large black spot occupies the membrane between the last spines of the dorsal tin; and the ventral, anal and lower part of the caudal are bright vermilion. The perch is carnivorous and most voracious. Perch are good, wholesome food and. highly esteemed in inland countries. The perch is exceedingly prolific; it begins to spawn when three years old. in April or in the first half of May, depositing the ova, which are united by a viscid matter in lengthened or net-shaped bands. on water plants. The American yellow perch is almost identical with the perch of Europe. but the American white perch is more nearly related to the European bass. Other members of the Percidae are the pope and the pike-perch (*q.v.*).



BY COURTESY OF THE N.Y. ZOOLOGICAL SOCIETY

THE WHITE PERCH (MORONE AMERICANA), ONE OF 125 SPECIES

PERCHE, a region of France extending over the departments of Orne, Eure. Eure-et-Loir and Sarthe. Its boundaries are Normandy on the north arid west; Maine, southwest; Vendômois and Dunois, south; Beauce, east; and Thimerais. northeast. The greater part of the district is occupied by a semicircle of heights (from 650 to 1,000 ft.) stretching from Moulins-la-Marche to Montmirail; within the basin formed thereby lie the chief towns —Mortagne, Nogent-le-Kotrou and Bellême. Stock raising and dairy farming flourish in the Perche, which is famous for the production of a breed of large horses. Cider apples and pears are grown. In the middle ages the Perche constituted a countship of which Corbon, Mortagne and Nogent-le-Rotrou were successively the capitals. Under the *ancien régime* it formed. together with Maine, a *gouvernement* of which Mortagne was the capital.

PERCIVAL, JAMES GATES (1795–1856), U.S. poet, philologist, and geologist, was a man of many parts. Born in Kensington, Conn., on Sept. 15, 1795, after receiving B.A. and M.D. degrees from Yale, he attempted many professions, becoming a physician, a tutor, and then a lecturer in chemistry at West Point. His reputation in literature, gained by his Poems (1821), proved ephemeral. In 1827 he worked with Noah Webster on the latter's dictionary until the two men quarreled. Percival knew ten languages, was a prolific poet in his own and in foreign tongues, and studied German, Scandinavian, and Slavic cultures. He was the state geologist for Connecticut (1835–42) and for Wisconsin from 1854 until his death at Hazel Green, May 2, 1856.

His Poetical Works, with a biographical sketch by L. W. Fitch, were published in 1859.

See J. *H.* Ward, *Life and Letters of James Gates Percival* (1866).

PERCUSSION INSTRUMENTS, the name given to those musical instruments from which sound is produced principally by striking. They are divided into two main classes which sometimes overlap: idiophones, in which sound is produced by striking or clashing together hard substances — wood, metal, etc.—and memhranophones, in which sound is produced by vibrating a stretched skin. There are separate articles on all the main percussion instruments or classes of instruments in use in the modern orchestra or dance band; this article traces the development of early instruments, and also describes some unusual and interesting examples of instruments of this type used in folk music or in ancient civilizations. See also CHINESE MUSIC; JAPANESE MUSIC; INDIAN MUSIC; AFRICAN MUSIC.

The first stage in the making of music and the development of musical instruments began when primitive man stamped on the ground or slapped his own body to produce rhythmic sound The sounds produced varied in tone according to whether the heels or toes were used in stamping or whether bony or fleshy parts of the body were struck in slapping With this preinstrumental music is associated the stamped pit, a hole dug in the ground and covered at the top or midway down with a lid of bark. The earliest knonn prehistoric instrument, found always associated with the stamped pit in Paleolithic excavations, is the slung rattle, which was shaken or hung from the ankle. arm or neck of the dancer. It consisted of several shaking pieces nutshells, seeds, hooves, teeth or similar hard objects The gourd rattle (a gourd containing such hard objects) became an important instrument in ritual and to mark time for dancing. Like other primitive instruments it was believed to possess magical power. As a nursery toy, its modern equivalent soothes and amuses children. Under the name maraca (see below) it is an important instrument in the modern Latin-American dance orchestra.

Primitive Drums. — Next in chronological order are the slit drum and the membrane drum found in Neolithic excavations. In its earliest form the slit drum was a hollowed tree trunk, the fashioning of the cavity giving the drum two distinct tones, one on each side of the opening. The original instrument was stamped upon. rammed with long sticks or struck with cudgels, the tone produced being of considerable resonance and carrying power. Existing specimens measure up to 20 ft. in length and 7 ft. in width. The size of the instrument diminished as it developed. In the modern orchestra, the slit drum is found in the form of the Chinese wood block. a small percussion instrument with a clear, penetrating tone.

The drum became indispensable in primitive life. Credited with powers of magic and having numerous other functions, it was held to be the most sacred of instruments, and was therefore developed in several forms. The early membrane drum, which was struck with the bare hands, consisted of a section of hollowed tree trunk covered at one end with reptile or fish skin. Later. the end was covered with the skin of hunted game or of cattle, and sticks were used for striking the drum. which was played in an upright or slanting position, according to its length. The double-headed drum came later, and, with the advent of pottery, the clay drum, an earthenware vessel taking many shapes — goblets, cups, etc. Various methods were used for fastening the skins, some of which are still in use. The skin might be secured to the single-headed drum with pegs, nails, glue, buttoning or neck lacing with cord, while the skins of the double-headed drum were directly cord-braced (*i.e.* laced through the holes of the skin).

Each of the early civilizations furnishes evidence of the development of the drum. A vase from Bismaya (*c.* 3000 B.C.) and other objects found in Mesopotamia at this period illustrate the shallow or frame drum and small cylindrical drums being played in horizontal and vertical positions. A drum (nailed head) as tall as the two players is depicted on a Sumerian vase of the same period. Early Egyptian artifacts show a drum with the skins stretched by a network of thongs, and provide evidence of the use of clappers and concussion sticks. Struck together, the latter were used to scare birds, as a musical instrument to accompany ritual dances and to provide rhythm for work in the fields and at the stamped wine press. An ancient tomb of the Egyptian kings in the catacombs of Eleithya, near Thebes, depicts a group of performing women, one of whom holds a curved concussion stick in each hand.

The origin of the hourglass drum is obscure. A waisted drum, narrower in the middle than at the ends and little longer than it is wide. is seen on one of the Bharatat reliefs, the oldest Indian temple reliefs (2nd century B.C.). The instrument is suspended from an ape's shoulders, and is heing played with two sticks by the animal. The Indian clapper drum (*damaru*), a small drum which is similar in shape to the hourglass, has one or two cords fixed in such a manner that they strike the skins when the instrument is moved to and fro. An hourglass drum with movable pitch (*kalengo*), is still used in Nigeria. Leather thongs stretch from end to end, connecting the two membranes. The drum is held in the hand or under the arm, the player squeezing the cords or releasing the pressure to alter the pitch. The kalengo is played

with the hands or a curved flat-ended stick. It is used by the Yoruba for their Sakara dances and signaling. Skilled players are able to make the drum follow their own tonal language and to interpret it. The manufacture of an important drum involves considerable ceremony. and its use is observed with time-honoured customs. In east Africa, the drum is considered holy and the drumyard a place of refuge. The coronation drums are struck with sticks made of human tibias, and offerings such as cattle made to the royal instruments. Complex rhythms characterize the playing of African drums.

The barrel and shallow nail drum are associated with India and the far east. The wooden frame of the shallow Chinese drum is lacquered red, as a symbol of happiness. and the skins emblematically adorned with the dragon and phoenix. The drum is normally suspended on a stand, the player striking the centre with leather-knobbed sticks. named male and female. A spring is fixed inside certain types of shallow drums of Chinese origin. The spring strikes the inner side of the skins when the outer surfaces are struck. Giant drums were used in Asia in war. The drums and players (who were madmen recruited from prisons) nere secured to wagons drawn by oxen, and placed at the head of battle formation. The frenzied performers pounded their instruments unceasingly with heavy clubs and whips. The strength of the noise from the opposing sides often proved a decisive factor in the conflict. The giant drum of the Chinese called *Hiuen-Kou* is said to have been invented for use in the imperial palace in 1122 B C. This instrument was a barrel drum with nailed heads, upward of four inches in diameter and depth. It oscillated on a specially prepared stand and had a smaller drum on each side.

The wooden fish (China and Japan) is a form of slit drum expertly carved to resemble a mythical fish. The instrument is hollowed out through a ventral slit representing the creature's open mouth, lacquered red and gold and is struck with a heavy painted stick similarly coloured. It is beaten to attract the attention of the divinity, and is tolled in slow tempo by mourners at a funeral service. In modern times the wooden fish is found in many sizes in western orchestras under the name of temple block. It often replaces the coconut shells used to imitate the sound of horses' hooves, and it adds humour to numerous situations on film and radio such as the sound of a popping champagne cork.

The *tablā* player. who is a prominent musician in Indian chamber music, performs on two drums, the *bāmyā* and *tablā*. The *bāmyā* is a small kettledrum (metal shell) with skin stretched by means of leather thongs. The *tablā* has the shape of a truncated cone, is made of wood and is painted in multicoloured stripes. The skin is stretched by leather thongs which are tightened by movable wooden dowels. Circular patches of a substance resembling hard rubber are affixed to the vellum of each drum. The skins are struck with the hand, finger tips, or side of the thumb and vibrated by friction, the ingenious rhythms being enhanced by the different tones obtained from various parts of the vellums. A skilled *tablā* player ranks as a virtuoso. Nakers is the name given in medieval times to small hand-drums with bowl-shaped bodies made of metal, the precursor of the orchestral timpani. *Naqqára* is the Arabic name for similar instruments, which came to Europe as the result of the Crusades. Nakers are often mentioned in medieval literature. and depicted in the Louterell Psalter of the early 14th century, where a pair is seen suspended in front of the player by a strap round the waist, a stick being held in each hand. In Holbein's wood engraving "Dance of Death" Death is seen beating a drum with a thighbone. The instrument is similar in appearance to and positioned like the medieval naker.

Bongoes are'small Cuban drums, bucket-shaped wooden vessels with strong vellum heads which are struck with the fingers and thumb. They form part of the Latin-American orchestra and modern dance bands and consist of a pair of drums of different size and pitch, normally tuned a fifth apart. The instruments are fixed together, and held between the knees or affixed to a stand. Timbales, the French name for kettledrums, is a term loosely applied to instruments in the form of large bongoes in the Latin-American orchestra. They are a pair of drums mounted on a stand and played with sticks. Often the player also performs on a cowbell or paila (mounted on the same stand); the latter was originally an upturned bucket but was later made in the form of a metal plate. (See DRUM).

Percussion **Groups.**—Marrow bones and cleavers is the name given to the traditional music of the butchers of England and Scotland, for which the meat vendors of the old Clare market. London. were long famous. The players produced a musical effect from their implements by a skillful manipulation of their knives (cleavers), and an assortment of marrow bones. A complete octave, rendering the effect of a peal of bells, was produced from the cleavers, and rhythmic features were provided by striking the bones and also drums. Important weddings brought these players considerable remuneration both for their attendance and their abstention. On being informed that the "orchestra" intended to serenade the couple, the father of the bride would seldom refuse the gratuity in advance to escape the infliction. The marrow bones and cleavers can be observed in use in plate VI of Holbein's series "The Wedding of the Industrious Apprentice to His Master's Daughter" (1538). An early use of percussion instruments in domestic music making is seen in Bottom's remark in *A Midsummer Night's* Dream ". . . I have a reasonable good ear in music. Let's have the tongs and the bones." A domestic instrument associated with the marrow bones and cleavers was the saltbox. It mas beaten with a rolling pin in such a manner as to produce varying sounds, and was used to provide a rhythmic accompaniment to an instrumental ensemble. The verse in Bonnell Thornton's burlesque "Ode to St. Cecilia's Day" (1763). which so amused Dr. Johnson, describes the method of performance.

> In strains more exalted the salt-box shall Join,
> And clattering and battering and clapping combine;
> With a rap and a tap while the hollow side sounds,
> Up and down leaps the flap, and with rattling rebounds.

Steel Band.—This form of music originated in Trinidad; the instruments consisted at first of dustbin lids. and Iater, of oil drums. It is believed that these domestic appliances replaced various bamboo instruments, and that the authorities prohibited their use on feast days in view of their possible use as weapons during periods of unrest. Dents are skillfully fashioned in metal receptacles of varying size. and the base of the depression struck with a mallet. The pitch of the note is determined by the diameter and depth of the indentation. The steel band in commercial entertainment has a considerable musical attraction, the range of the instruments covering four chromatic octaves.

Bell Instruments.— The Turkish crescent (chapeau *chinois* or jingling johnny) is an instrument introduced into the military bands of Great Britain and elsewhere about 1800, at the time of the popularity in western Europe of Janissary music. The crescent is an upright pole surmounted by a tent-shaped construction and metal headpiece. composed of a crescent and other symbols. from which points and elsewhere on the pole, hang small bells and jingles. Plumes made from horsetails further ornament the instrument, the bells and jingles of which are shaken in rhythm.

The sistrum is an instrument of percussion of definite pitch (occasionally found in Italian scores) consisting of a series of small mushroom-shaped bells, mounted in pyramid-fashion on a handle. The compass of the instrument ranges from one to three octaves, with the bells mounted diatonically in a single row, or chromatically in two rows. (See SISTRUM; GLOCKENSPIEL; BELL.)

The tubaphone was a popular solo instrument in the military band repertoire during the early part of the 20th century. It consisted of a series of short metal tubes arranged in a frame in tuo rows. Similar in design and sound to the orchestral glockenspiel, it was played in the same manner.

The jingles are a spray of bells, or metal pieces, smaller than the normal sleigh or harness bells.

Percussion Instruments in the **Orchestra.**—"Slap-Stick" is a device used in the orchestra to produce the sound of the crack of a whip and consists of two pieces of wood, joined in a V-shape by hinging at the base, or partway up to form a handle.

The maraca or maracas is a Latin-American percussion instrument used in pairs in the rumba band. A gourd, or substitute, fixed to a handle is filled with dried seeds which rustle when the

instrument is shaken. or alternatively produce a clicking sound when the gourd is tapped with the forefinger. (*See* above), Claves are round sticks of hardwood six to eight inches in length, descendants of the primitive concussion sticks (*see* above). In the Latin-American dance orchestra rhythm is marked by the claves which the player strikes in a recurring pattern. One piece of wood, held over the upturned fingernails of one hand, is struck with the other, held lightly in the manner of a drum stick. Bones are a percussion instrument used in the 19th-century British or American Negro minstrel band. Two pieces of a rib bone of an animal, are held between the fingers and clicked together. The cabaça is a Latin-'American instrument consisting of a calabash shell surrounded with a network of beads. The handle of the cabaça is held in the right hand with the bowl of the instrument resting in the palm of the left hand. Rotation of the handle causes the resonant bowl to turn within its network of beads, producing a gentle rasping sound.

The guiro (known also as scraper or reso-reso) is a calabash gourd, or short length of bamboo stem into which is plowed a series of deep grooves in regular formation. Sound is produced by drawing over the grooves a thin strip of bamboo, or similar rigid object. Stravinsky wrote a part for the "guero" in the original score of *Le Sacre du printemps* but later deleted it. The guiro forms an integral part of the modern rumba band.

See also MUSICAL INSTRUMENTS.

See Curt Sachs, *The History of Musical Instruments* (1910); Francis W. Galpin, Old *English Instruments of Music* (1932). (J. BL.)

PERCY (FAMILY). This family, whose deeds are so prominent in English history, was founded by WILLIAM DE PERCY (*c.* 1030–96), a follower of the Conqueror, who bestowed on him a great fief in Yorkshire and Lincolnshire. The register of Whitby abbey, which he founded anew, and in later days the heralds. were responsible for the fabulous origin and pedigree of the family. By Emma, daughter of Hugh de Port, a great Hampshire baron. William was father of several sons. of whom ALAN the eldest succeeded him. His grandson WILLIAM (d. 1175) was the last of the house in the direct line. and left two daughters and coheiresses, Maud countess of Warwick, who died childless, and Agnes. Agnes de Percy had married Jocelin, brother of Queen Adelaide, second wife of Henry I, and from this marriage descended the second house of Percy (which name it assumed). till its own extinction in the male line five centuries later (1670). By it was brought into the family the great Petworth estate in Sussex, which Jocelin had obtained from his sister. His son RICHARD (*c.* 1170–1244) was one of the 25 barons appointed to enforce the observance of Magna Carta and in 1216 was an active supporter of Louis of France against King John.

HENRY DE PERCY (1273–1314) was one of Edward I's most active agents in the subjugation of Scotland until the success of Robert Bruce drove him out of Turnberry castle, and made him withdraw into England. Summoned to parliament as a baron in the time of Edward I, he later, as one of the lords ordainer, supported the baronial opposition to the personal rule of Edward II. Hitherto the family had been mainly connected with Yorkshire, but Henry gave its fortunes a new direction by his purchase of lands in Northumberland from Antony Bek, bishop of Durham, among them the great lordship of Alnwick, which became the principal seat of the family. Henceforth the Percys, now the greatest landowners in Northumberland, became the principal guardians of the northeastern border against the Scots, and successive members of the family served regularly as wardens of the marches.

Henry's son, another HENRY (c. 1299–1352), did splendid service to his sovereign by defeating and taking prisoner David II, king of Scotland. at the battle of Neville's Cross (1346).

To him succeeded his son, another HENRY PERCY (1322–1368), a feudal baron like his predecessors. who fought at Crécy during his father's lifetime and whose brother THOMAS PERCY (1333–1369) was bishop of Norwich from 1356 to 1369. Henry's son, HENRY PERCY. 1st earl of Northumberland, father of the famous Hotspur, SIR HENRY PERCY (*q.v.*), was killed at Bramham Moor in 1408, his title and estates being forfeited after his rebellion in 1405. Henry V formally restored them in 1416 to this earl's grandson, HENRY (1394–1455), then' a prisoner with the Scots, whose liberation he procured. For the later history of the family *see* NORTHUMBERLAND, EARLS AND DUKES OF. (C. D. R.)

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PERCY, SIR HENRY, called HOTSPUR (1364–1403), eldest son of Henry. 1st earl of Northumberland, was born on May 20, 1364 He saw active service when he was 14 at the siege of Berwick. His zeal in border warfare won the name of Hotspur for him from his opponents. In 1386 he was sent to Calais and raided French territory, but was shortly afterward recalled to defend England against a naval attack by France. In popular story and ballad he is known as one of the heroes of Otterburn or Chevy Chase. In the summer of 1388 the Scots invaded England by way of Carlisle, sending a small body under the earls of Douglas, Mar and Moray to invade Northumberland. The earl of Northumberland remained at Alnwick, but sent his sons Sir Henry (knighted in 1377) and Sir Ralph against the enemy. In hand-to-hand fighting before the walls of Newcastle, Douglas is said to have won Hotspur's pennon, which he swore to fix upon the walls of Dalkeith. The Scots then retreated to Otterburn where Hotspur, who was bent on recovering his pennon, attacked them on a fine August evening in 1388. Douglas was slain in the battle, though not (as is stated by Walsingham) by Hotspur's hand. Hotspur was captured by Sir John Montgomery, and his brother Ralph by Sir John Maxwell. Hotspur was released on the payment of a heavy ransom, to which Richard II contributed £3,000, and in the autumn his term as warden of Carlisle and the West March was extended to five years.

In 1399, together with his father, he joined Henry of Lancaster (afterward Henry IV), who gave the charge of the West March to Northumberland, while Hotspur received the castles of Bamburgh, Roxburgh and Berwick and the wardenship of the East March, with a salary of £3,000 in peacetime and £12.000 in war. During the first year of Henry's reign Hotspur was appointed justiciar of North Wales and constable of the castles of Chester. Flint, Conway, Denbigh and Carnarvon. Henry also gave him a grant of the island of Anglesey, with the castle of Beaumaris. William and Rees ap Tudor captured Conway castle on April 1, 1401, and Percy in company with the prince of Wales set out to recover the place, Percy providing the funds.

In May he reported to the king the pacification of Merioneth and Carnarvon, and before the end of the month Conway was surrendered to him. His demands for arrears of pay were, however, refused, and he had the same difficulty in obtaining money for his northern charge as he had experienced in Wales. Anglesey was taken from him, and he was deprived of Roxburgh castle in favour of his rival. the earl of Westmorland. The Scots again invaded England in the autumn of 1402, headed by the earl of Douglas and Murdoch Stewart, son of the duke of Albany, but were heavily defeated by Northumberland and Hotspur at Humbledon, or Homildon hill. on Sept. 14. Disputes with the king arose over the disposal of the Scottish prisoners, Percy insisting on his right to hold Douglas as his personal prisoner, and he was summoned to court to explain.

It is related that when he arrived Henry asked for Douglas, and Hotspur demanded in return that his brother-in-law, Edmund Mortimer, should be allowed to ransom himself from Owen Glendower, with whom he was a prisoner. High words followed, in the course of which Henry called Percy a traitor, struck him on the face, and drew his sword on him. Percy is said to have answered this defiance with the words, "Not here, but on the field."

In the summer of 1403 Hotspur raised the standard of rebellion in Cheshire, where Richard II had won for himself a special loyalty. Henry was accused of having broken his promises, of murdering Richard II, and of excluding from the throne Richard's legitimate heir, the young earl of Rlarch, to whom Hotspur was related

through his wife, Elizabeth Mortimer. The king's speedy action prevented Hotspur's occupying Shrewsbury and joining his Welsh ally, Glendower, and on July 21, 1403, Hotspur, accompanied by his uncle. Thomas Percy, earl of Worcester, and the earl of Douglas, with a force of Cheshire men, was forced to give battle outside Shrewsbury. Hotspur was killed, the earls of Douglas and Worcester, Sir Richard Venables of Kinderton and Sir Richard Vernon were captured, and the rebel army dispersed. Worcester, Venables and Vernon were executed the next day. Percy's body was buried at Whitchurch, but was disinterred two days later to he exhibited in Shrewsbury. The head was cut off and fixed on one of the gates of York. *See* also NORTHUMBERLAND, EARLS AND DUKES OF: PERCY (FAMILY).

BIBLIOGRAPHY. –J. H. Wylie, *England Under Henry IV*, 2 vol. (1884–98); J. H. Ramsay, *Lancaster and York* (1892); C. L. Kingsford, *English Historical Literature in the 15th Century* (1913); John Hardyng, *Chronicle*, ed. by Henry Ellis (1812); R. Holinshed, *Chronicle*, 6 vol. (1807–08).chief source of Shakespeare's account of Hotspur in *Henry IV*.

PERCY, THOMAS (1729–1811), English man of letters and bishop of Drornore, whose ballad collection *Reliques of Ancient English Poetry* (1765) stimulated research into ballad poetry and inspired the romantic movement. He was born at Bridgnorth, Shropshire, April 13, 1729. He went to Christ Church, Oxford, and held livings at Easton Maudit (1753) and Wilby (1756), both in Northamptonshire, for many years. In 1763 he edited the poems of the earl of Surrey and published *Five Pieces of Runic Poetry From the Islandic Language*. The *Reliques* were based on an old manuscript he rescued from a friend's house, where parts of it had been used to light the fire. He edited them at William Shenstone's suggestion and, although some doubted their authenticity and many scoffed at their primitive style, they became increasingly popular and profoundly influenced Scott, Wordsworth and Coleridge. The standard edition is by H. B. Wheatley (1876). In 1770 Percy published *Northern Antiquities*, a set of translations including one (from a Latin version) of the Icelandic *Edda*, which thus became available to English readers for the first time. In his preface he makes a scholarly distinction, unusual for his period, between the various branches of the Celtic and Teutonic peoples. His *Ancient Songs*, chiefly on Moorish subjects, translated from Spanish, were edited by D. Nicol Smith (1932).

Percy became domestic chaplain to the duke of Northumberland (1770) and, through his influence! dean of Carlisle in 1778 and bishop of Dromore in Ireland in 1782. He died there on Sept. 30, 1811.

See A. C. C. Gaussen, *Percy, Prelate and Poet (1908)*; *The Percy Letters*, ed. by D. Nichol Smith and C. Brooks, 5 vol. (1944–57).

PERDICCAS, the name of three kings of Macedonia, who reigned respectively *c.* 700 B.C., *c.* 454–413 B.C., and 364–359 B.C., and of one of Alexander the Great's generals, son of Orontes, a descendant of the independent princes of the province of Orestis. At Alexander's death Perdiccas was probably acting chiliarch (vizier), and supported the claim of the unborn child of Roxana to the throne. Meleager's revolt forced a compromise under which Philip Arrhidaeus and the unborn child (if a son) were to be joint kings. with Craterus as regent for Arrhidaeus and, perhaps, Perdiccas for the infant, who was duly born a son (Alexander IV.). The Lamian war called Craterus to Europe and left Perdiccas in control; it was he who divided up the satrapies. In the ensuing confusion Perdiccas may be classed among those who wished to keep the Empire a unity, though personal friendship and circumstances first grouped him with Ptolemy, a convinced separatist, against Antipater and Antigonus. Perdiccas had to abandon Alexander's Arabian schemes, but set himself to complete the conquest of Asia Minor. When Antigonus refused to help, he invaded Cappadocia in 322, established his most reliable subordinate, Eumenes. there and made progress in Pisidia and Armenia. Then he called Antigonus to account; Antigonus fled to Antipater and Craterus and convinced them that Perdiccas was aiming at the throne; Ptolemy joined them. Perdiccas marched to meet the allies, failed to force the Nile at Pelusium, and his soldiers mutinied and murdered him. *(See* MACEDONIAN EMPIRE.) (E. R. B.)

PERDIGUIER, AGRICOL (1805–1875). French worker-writer, and a leading spokesman of the French working-class movement of the 1830s and 1840s. Born on Dec. 3, 1805, at Morières near Avignon, he was largely self-educated and learned the trade of cabinetmaker working his way across the country in the *Tour de France* customary for members of a *compagnonnage; i.e.,* one of the centuries-old secret societies of journeymen-artisans that were the most effective labour organizations of the period. Going to Paris in 1829, he worked actively and wrote extensively to reform the *compagnonnages*, but his lifelong labours to unify the warring societies were in vain. The *compagnonnages* themselves were doomed by their own exclusiveness and by their failure to adjust themselves to the industrial transformations of the age.

A republican, Perdiguier was elected to the constituent assembly in 1848 and to the legislative assembly in 1849. On Louis Napoleon's *coup d'ttat* in 1851, he was exiled, although he had been neither a socialist nor a conspirator. In Belgium and Switzerland he wrote his most important book, *Mémoires d'un compagnon* (1854–55, 2nd ed., with introduction by D. Halévy, 1914), which describes his *tour* and gives a vivid picture of life, work and labour organization in Restoration France. Back from exile in 1855, Perdiguier remained a man of moderation and opposed the Paris Commune of 1871. He died in Paris on March 26, 1875.

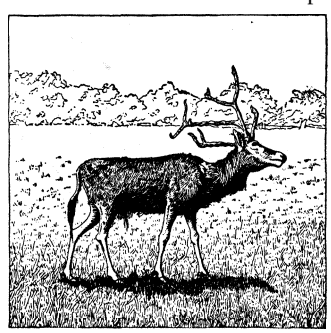
See Jean Briquet, *Agricol Perdiguier: compagnon du Tour de France et représentant du peuple, 1805–75* (1955). (V. R. L.)

PEREDA, JOSÉ MARÍA DE (1833–1906), Spanish novelist, was born at Polanco near Santander, and began his literary career by contributing articles to a local journal, *La Abeja montañesa,* in 1858. In 1864–71 appeared his powerful realistic sketches of local life and manners under the title of *Escenas montañesas,* and a second series was published under the title of *Tipos y paisajes* (1871). These were followed by *Bocetos al temple* (1876), *Tipos trashumantes* (1877), and *El Buey suelto* (1877), which was intended as a reply to the thesis of Balzac's work, *Les Petites misères de la vie conjugale*. More and more pessimistic as to the political future of his country, Pereda took occasion in *Don Gonzalo González de la Gonzalera* (1879), to ridicule the revolution as he had seen it at work, and to pour scorn upon the *nouveaux riches* who exploited liberalism for their personal ends. Two novels by his friend Pérez Galdós, *Doña Perfecta* and *Gloria,* drew from Pereda a reply, *De Tal palo tal astilla* (1880), in which he endeavours to show that tolerance in religious matters is disastrous alike to nations and to individuals. The *Esbozos y rasguños* (1881) is of lighter material, and is less attractive than *El Sabor de la Tierruca* (1882), a striking piece of landscape which won immediate appreciation. In *Pedro Sdnchez* (1883) Pereda leaves his native province to portray the disillusion of a sincere enthusiast who has plunged into the political life of the capital. Pereda's masterpiece is *Sotileza* (1884), a vigorous rendering of marine life by an artist who perceives and admires the daily heroisms of his fisher-folk. It has often been alleged against the author that he confines himself to provincial life, to lowly personages and to unrefined subjects, and no doubt an anxiety to clear himself from this absurd reproach led him to attempt a description of society at the capital in *La Montálvez* (1888), which is certainly the least interesting of his performances. In *La Puchera* (1889) he returned to the marine subjects which he knew and loved best. Again in *Peñas arriba* (1895), his love of country life is manifested in the masterly contrast between the healthy labour of the fields and the squalid life of cities.

Pereda belongs to the native realistic school of Spain, which, founded by the unknown author of *Lazarillo de Tormes,* was continued by Mateo Alemán, Cervantes, Quevedo, Castillo Solórzano and many others. With the single exception of Cervantes, however, the picaresque writers are almost entirely wanting in the spirit of generous sympathy and tenderness which constitutes a great part of Pereda's charm. His realism is purely Spanish, as remote from Zola's moroseness as from the graceful sentimentality of Pierre Loti. Few 19th-century writers possessed the virile temperament of Pereda, and, with the single exception of Tolstoy, none kept a moral end more steadily in

view. This didactic tendency unquestionably injures his effects. Moreover, his grim satire occasionally degenerates into somewhat truculent caricature, and the excessive use of dialect and technical terms which caused him to supply Sotileza with a brief vocabulary is a grave artistic blemish. But he saw, knew, understood character; he created not only types, but living personages, such as Andrés, Cleto and Muergo in Sotileza, Pedro Juan and Pilara in La *Puchera;* and he personified the tumult and calm of the sea with more power than Victor Hugo displayed in *Les Travailleurs de la mer*. His descriptive powers were of the highest order, and his style, pure of all affectations and embellishments, is of singular force and suppleness. With all his limitations, he was as original a genius as Spain produced during the 19th century. (J. F.-K.)

PÈRE DAVID'S DEER, an aberrant mule-like deer (*q.v.*), the first evidence of whose existence was made known in Europe by the Abbé (then Père) David, who in 1865 obtained the skin of a specimen from the herd in the imperial park at Pekin. The front prong of the main fork of each of the large antlers, which lack brow-tines, curves forward and divides at least once; while the hind prong is of great length, undivided, and directed backwards in a manner found in no other deer. The tail reaches the hocks, and is donkey-like in form. The head is long and narrow, with a prominent ridge for the support of the antlers, moderate-sized ears, and a narrow and pointed muzzle. A gland and tuft are present on the skin of the outer side of the upper part of the hind cannon-bone; but there is no gland on the inner side of the hock. Although new-born fawns are spotted, the adults are uniformly coloured; the general tint of the coat at all seasons being reddish tawny with a tendency to grey. The antlers are shed and replaced twice a year, a unique feature. The true home of this deer has never been ascertained, all now living being kept in confinement.



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PERE DAVID'S DEER, THE MI-LOU OF CHINA; TRUE HOME UNKNOWN

PEREGRINE FALCON: *see* FALCON.

PEREGRINUS PROTEUS (2nd cent. A.D.), Cynic philosopher, of Parium, Mysia. At an early age he was suspected of parricide, and was obliged to leave his native place. During his wanderings he reached Palestine, where he became the virtual head of the Christian community. His fanatical zeal and craving for notoriety led to his imprisonment, but the governor of Syria freed him. He resumed his wandering life, at first assisted by the Christians, but having been detected profaning the rites of the Church, he was excommunicated. During a visit to Egypt he made the acquaintance of the famous Cynic Agathobulus and joined the sect. Meeting with little encouragement, he journeyed to Rome, whence he was expelled for insulting the emperor Antoninus Pius. Crossing to Greece, he finally took up his abode at Athens. Here he obtained many pupils, including Aulus Gellius. But, having given offence by his attacks on Herodes Atticus and finding his popularity diminishing, he announced his intention of immolating himself on a funeral pyre at the celebration of the Olympian games in 165, and actually carried it out. Lucian, who was present, has given a full description of the event.

See C. M. Wieland's *Geheime Geschichte des Philosophen Peregrinus Proteus* (Eng. trans., 1796); this is an attempt to rehabilitate his character. *See* also Lucian, *De morte Peregrini;* Aulus Gellius xii. II.; Ammianus Marcellinus xxix.; Philostratus, *Vit. Soph.* ii. *1.,* 33; J. Bernays, *Lucian und die Kyniker* (1875); E. Zeller, "Alexander und Peregrinus," in his *Vorträge und Abhandlungen,* ii. (1877); and Uberweg, *Grundriss der Gesch. der Philosophie,* Bd. *1.* (1926).

PEREIRE (Pereira), GIACOBBO RODRIGUEZ (1715–1780), one of the inventors of deaf-mute language, was born at Estremadura, Spain, on April 11, 1715. He fell in love with a young girl who had been dumb from birth, and devoted himself to discovering a method of imparting speech to deaf-mutes. He devised a sign alphabet for the use of one hand. Pereire was made a member of the Royal Society of London in 1759. He died at Paris on Sept. 15, 1780.

PEREKOP, a village of the Crimean A.S.S.R., on the isthmus which connects the Crimea with the Continent. It was formerly a salt trading town, but declined rapidly after the opening of the Rharkov to Sevastopol railway. It was re-graded as a village in 1925. In ancient times the isthmus was crossed by a ditch which gave the name of Taphros to a Greek settlement. This line of defence having fallen into decay, a fort was erected and a new ditch and dike constructed in the 15th century by the Tatar khan of the Crimea, Mengli Ghirai, and by his son and successor Sahib Ghirai. The fort, known as Kapu or Or-Kapu, became the nucleus of the town. In the middle ages Perekop was known as Tuzla. In 1736 it was captured by the Russians and again in 1738 under Lassy (Lacy), who blew up the fort and destroyed a great part of the dike. In 1754 the fort was rebuilt by Krim Ghirai; but the Greek and Armenian inhabitants of Perekop formed a new settlement at Armyanskiy Bazar (Armenian Market), 3 mi. south. Captured in 1771, the town passed into Russian possession with the rest of the Crimea in 1783.

PERENNIALS, the name given to those plants whose natural term of life or life cycle continues for more than two growing periods or years in contradistinction to annuals. which exist for a single growing period, and biennials whose life term embraces only two growing periods. Perennials may be woody (*e.g.,* trees and shrubs) or herbaceous (*e.g.,* iris).

PEREYASLAVL, a town of the Ukrainian S.S.R.. in 50° 4' N., 31° 30' E, at the confluence of the Trubezh and the Alta, which reach the Dnieper 5 mi. lower down at the town's port, the village of Andrushi Pop. (1956 est.) 22,200. Though founded in 993 by Vladimir the Great of Moscow in memory of his success over the Turkish Pechenegs, Pereyaslavl has now few remains of antiquity. From 1054 Pereyaslavl was the chief town of a separate principality. As a southern outpost it often figures in the 11th, 12th and 13th centuries, and was plundered by the Mongol. in 1239. In later times it was a centre of the Cossack movement; and in 1628 the neighbourhood was the scene of the extermination of the Polish fdrces known as "Taras Night." By the Treaty of Pereyaslavl in 1654 the Cossack chieftain Bogdan Chmielnicki acknowledged the supremacy of Tsar Alexis of Russia. The town is the centre of an agricultural district and has a flour-milling industry.

PEREZ, ANTONIO (*c.* 1540–1611), for some years the favourite minister of Philip II. of Spain and afterwards the object of his unrelenting hostility, was the natural son of Gonzalo Perez, secretary both to Charles V. and to Philip II. Legitimated by an imperial diploma issued (1542) at Valladolid, Pérez became secretary of State in 1567, protonotary of Sicily, and at the death of Ruy Gomez de Silva, prince of Eboli, in 1573, head of the "despacho universal," or private bureau, from which Philip governed by correspondence the affairs of his dominions. Juan de Escovedo, another of the king's secretaries, attached after 1574 to Don John of Austria to check the latter's ambitious schemes, was sent by John to Rome to obtain the pope's consent to his plan for making himself master of England by marrying Mary Queen of Scots. Pérez was shown the pope's letter by his nuncio in Spain; he informed Philip who authorized him to arrange for the murder of Escovedo. After several unsuccessful attempts to poison Escovedo, Pérez had him assassinated in a street of Madrid on March 31, 1578. A prosecution was set on foot by the representatives of the murdered man. Philip appeared at first willing to protect his accomplice; ultimately he was the secret instigator of those who sought his ruin. Pérez was arrested on July 28, 1579. The process dragged on until 1589 when, on the eve of being condemned, Perez escaped to Aragon. An Aragonese by birth, by the ancient "fueros" of that kingdom, he could claim a public trial and so bring into requisition documentary evidence of the king's complicity-in the deed.

To avoid this, Philip ordered Pérez to be transferred from the civil prison in Saragossa to that of the Inquisition, on a charge

of heresy arising from certain blasphemous expressions used by Perez. A popular tumult broke out. Perez escaped across the Pyrenees, and Aragon was punished by losing its ancient "fueros" altogether (1591) after a crushing defeat from Philip's armies. Perez was well received at Pau by Catherine de Bourbon, passed on to the court of Henry IV of France, and both there and in England, his talents and diplomatic experience, as well as his well-grounded enmity to Philip, secured him at first much popularity. In England he became intimate with Francis Bacon, and was also much in the society of the earl of Essex. After the Peace of Vervins (1598) he lost all political importance; his efforts to obtain pardon from Philip III proved vain and he died in poverty and obscurity in Paris on Nov. 3, 1611.

See J. A. Froude, *An Unsolved Historical Mystery* in *The History of the Spanish Armada* (London, *1892*); M. Hume, *Españoles e ingleses* (1903); J. Fitzmaurice-Kelly, *Antonio Pérez* (Oxford, 1922).

PÉREZ DE AYALA, RAMÓN (1881–), Spanish novelist and poet, was born at Oviedo. Beginning with a volume of verse. *La Paz del sendero* (1904), he first attracted notice as a novelist by *A. M. D. G. (ad majorem Dei gloriam)* (1910). *La Putn de la raposa* (1912), *Belarmino y Apolonio* (1921), *Luna de miel* and its sequel *Urbano y Simona* (1922) and the short stories *El Ombligo del mundo* (1925) consolidated his literary reputation. His last full-length novels were *Tigre Juan* and *El Curandero de su honra* (1926). After serving as ambassador to Great Britain (1931–36) he went to live in Argentina.

PÉREZ DE HITA, GINES (1544?–1619), Spanish novelist and poet, served in the campaign of 1569–71 against the Moriscos. He relates his experiences in the second part of the *Guerras civiles de Granada* (1595–1604?), which purports to be a chronicle based on an Arab original. It is in reality a historical novel. The events which led to the downfall of Granada are related with uncommon brilliancy, and the sympathetic transcription of life at the Emir's court undoubtedly influenced the Hispano-Mauresque novels of Mlle. de Scudéry and others.

PÉREZ GALDOS, BENITO (1843–1920), Spanish novelist, was at first engaged in political journalism, but the reception given to his early novels, *La Fontana de oro* (1870) and *El Audaz* (1871), encouraged him to adopt novel writing as a profession. He had already determined upon the scheme of his *Episodios nacionales*, a series which might compare with the *Comédie humaine*. Old charters, old letters, old newspapers were collected by him with the minuteness of a German archivist; no novelist was ever more thoroughly equipped as regards the details of his period. *Trafalgar*, the first volume of the *Episodios nacionales*, appeared in 1873, and long before the first series ended in 1879 Perez Galdós took rank among the foremost novelists of his time. A monument of industry and exact knowledge, of realism and romantic conception, the *Episodios nacionales* were carried on into a fifth series, raising the total of volumes to 46. Parallel with his immense achievement in historical fiction, Perez Galdós published a collection of romances dealing with contemporary life, its social problems and religious difficulties. Of these the best known, and perhaps the best, are *Doña Perfecta* (1876); *Gloria* (187;) ; *La Familia de Ledn Roch* (1878); *Marianela* (1878); *Fortunata y Jacinta* (188;); and *Angel Guerra* (1891). Nor does this exhaust his prodigious activity. Besides adapting several of his novels for stage purposes, he wrote original dramas such as *La Loca de la Casa* (1893), *San Quintin* (1894), *Electra* (1900) and *Mariucha* (1903); but his diffuse, exuberant genius was scarcely accommodated to the convention of theatrical form.

PERFUMES, substances, generally of complex composition, which by reason of their fragrance gratify the sense of smell. The history of perfumes is closely associated with that of cosmetics (*q.v.*), and many of the earliest forms were made by digesting odorous vegetable substances with sesame, almond or olive oil. The principle underlying this process is still made use of although in an improved form and will be referred to later under *Maceration.*

Natural Perfumes.—These are the product of plant metabolism and their highest form is found in the scent of fresh flowers. This fragrance is due to the occurrence in the petals of minute traces of essential oil which in rose and lavender is in the free state, whereas in jasmin and tuberose it is in the form of a glucoside. Under favourable conditions this complex substance is progressively decomposed in the presence of an enzyme or ferment with the formation of a volatile oil. The occurrence of natural perfume is, however, by no means confined to the inflorescence but frequently exists in other parts of the vegetable organism. Briefly it is found in the

flowers of cassia, carnation, clove, hyacinth, heliotrope, mimosa, jasmin, jonquille, orange blossom, rose, reseda, violet and ylang ylang;
flowers and leaves of lavender, rosemary, peppermint and violet;
leaves and stems of geranium, cinnamon and patchouli;
barks of cinnamon and cassia;
woods of cedar, linaloe and santal;
roots of angelica, sassafras and vetivert;
rhizomes of calamus, ginger and orris;
fruits of bergamot, lemon, lime and orange;
seeds of bitter almonds, anise and nutmeg;
gums or *oleo-resinous exudations* from myrrh, peru balsam, storax and tolu

As mentioned above, the odoriferous constituents of the plant generally occur as a volatile oil which, after separation as described below, is a highly aromatic, mobile liquid. This usually contains several individual bodies, differing chemically, and to one or more of these the typical odour of the oil is due. Chemistry has been able in many cases to establish definitely these principal constituents, as, for instance, the odour of almond oil is attributed principally to *benzaldehyde*, of clove oil to *eugenol* and of lemon oil to *citral*. Where the oil is of complex composition, the typical odour is believed to be due to several perfectly blended constituents. For instance, in rose otto the *higher aliphatic aldehydes* in minute traces, together with the esters of the alcohols *geraniol* and *citronellol*, undoubtedly determine the distinctive rose fragrance. The separation of these natural odoriferous materials from the plant is no easy matter since a process that is suitable for one is of no use for another because the delicate perfume substance may be destroyed or decomposed or, furthermore, may be incompletely extracted. It will be best to describe briefly each process of the plant material under treatment.

Distillation. — This is effected by either boiling the vegetable organism with water in a closed apparatus when the source of heat may be an open fire or a steam-heated coil or jacket in the bottom; or by blowing live steam through the material. In each case the still is connected at the top with a condenser, through which the steam passes, carrying with it in suspension the fine particles of essential oil, the condensed steam and oil emerging from the lower orifice. On standing aside the oil floats to the top and is separated. Distillation with an open fire is the oldest process and in places far distant from modern factories this is resorted to by the peasants. It is, however, not free from danger, for if the water in the apparatus gets low the material is burned, then the odour of the resulting oil is impaired. In some parts of Bulgaria this method is used for preparing rose otto and in some parts of India for distilling palmerosa oil. When steam is used for distillation a separate boiler is erected near by and the question of damaging the oil by burning is therefore eliminated. Generally the raw material does not touch the bottom of the apparatus but is supported upon a false bottom or perforated sheet of metal and sometimes placed in an open wire basket suspended inside. In some cases the water used for distillation dissolves part of the oil or its constituents. It is sold separately, as, for instance, rose water or orange-flower water. Modern apparatus as used in Europe and America is often required to take one ton of material, such as lavender or peppermint, the capacity of the still being about 1,200 gallons. This process is applicable to the majority of the vegetable organisms mentioned above, the principal exceptions being some of the *flowers* and most of the *fruits.*

Expression.—The general name of the processes used to extract the essential oil occurring in the peels of bergamot, lemon, lime and orange fruits. The *sponge process* is used mainly for lemons and oranges cultivated in Sicily and the Calabrian belt. Girls cut the fruits either transversely or longitudinally and remove the pulp. The peel is then steeped in water to make the

cells more turgid. Men then press this drained peel on sponges which absorb the oil. The sponges are squeezed and the oil runs out into a shallow earthenware bowl placed in front of each operator. As each bowl is filled it is emptied into jars and allowed to stand until any juice has separated at the bottom. Subsequently it is filtered and packed in copper cans for export. The *Ecuelle* method consists of rolling the whole fruits about in hollow vessels covered with spikes inside. The oil cells are broken and the liquid flows into a receptacle in the handle. It is then clarified as above. Machines are now largely used to extract the oil from bergamots and lemons. In some cases the peel is broken and the oil collected, while in others the whole fruit is subjected to pressure, when the oil and juice run out together. The oil is separated in a machine something like a milk separator and comes out at the top (cream orifice). Limes are sometimes pressed by the sponge process, but the greater part of the oil is a by-product in the preparation of lime-juice.

Extraction. — The general name given to the processes used for extracting the essence from those flowers to which distillation would not be suitable because (1) the high temperature of steam would damage some of the unstable aromatic constituents and (2) the yield would be inadequate. Enfleurage has been employed in the south of France for many years and until comparatively recently was the process used for extracting all flowers. To-day it is used mainly for jasmin and tuberose and depends upon the absorption of perfume by fats. Wooden frames, called "chassis," each support a glass plate, on both sides of which is painted a specially prepared and purified mixture of beef and pork fats. The petals are spread lightly on the layers of grease and the chassis piled one upon the other. These are left for some hours until the grease has absorbed all the perfume. Fresh flowers replace the exhausted ones and the process is repeated until the fats are fully charged with perfume. These fats are known as pomades. Maceration differs from enfleurage in that the flowers are immersed in hot fats or oils at about 65°C. The heat ruptures the cells and the perfume is absorbed by the fat. Roses and all other flowers excepting jasmin and tuberose are treated this way. Volatile solvents are now largely used for extracting the essence from all flowers and many leaves and mosses. The vegetable organism is placed in a series of hermetically sealed cylinders and petroleum ether of great purity is allowed to run through them slowly. The last container is connected with a vacuum still and the solvent is distilled off and returned to the tank for use again. The perfume remains behind in the retort and is called a concrete. It contains the highly odorous essence together with natural and insoluble plant waxes. The concretes are shaken with strong and pure alcohol for 24 hours in machines called "batteuse." The perfume and some wax is dissolved and the insoluble waxes filtered out. The alcoholic extract is then placed in a freezing mixture, when the soluble waxes are separated. The solution of the pure flower essence is distilled in *vacuo*, which removes the alcohol and leaves behind the so-called absolute flower oil. This is the most expensive type of perfumery raw material and in the case of jasmin is worth from £3 to £6 an ounce according to the flower crop. The quantity of this flower used per annum for oil or other of these processes has for many years exceeded 1,300 tons while in the case of orange blossom it is even 2,000 tons.

Animal Perfumes. — These are of great importance in preparing finished perfumes and impart to them "life" and diffusiveness. The principal animal perfume is musk. This is a dried secretion from the preputial follicles of the male musk deer, which inhabits the mountainous districts of the Atlas and Himalayan ranges. The most important commercial variety is known as *Tonquin* musk, coming from Tibet and the plains of Kokonor, where the animal is found at altitudes of about 8,000 feet. The Chmese hunters capture the deer by various means and after killing it remove the gland completely. This is dried to develop the odour when it is known as a musk pod. After treatment and frequent adulteration with blood, earth, shot and hide the pods find their way to Tatsienlu in the province of Szechven. This is the principal centre for the trade and pods are then sent to dealers in Shanghai, whence they are exported. A quantity of musk is retained by the Chinese for medicinal purposes. Ambergris is a calculus formed in the intestines of the sperm whale. It is sometimes found there when the animal is killed but at others is picked up in the sea after being expelled. The calculus is the product of an intestinal disease caused probably by the insufficient digestion of cuttlefish, a food much appreciated by the sperm whale, To find a large piece of ambergris is a rare stroke of luck for sailors and one of the largest pieces ever found was stated to weigh 248 lb. and was valued at £13,200. Civet is a soft fatty substance of foetid odour imported principally from Abyssinia and packed in horns. It is a glandular secretion of both male and female civet cats. Castor is another perfume of animal origin, being the dried preputial follicles and their secretion from the Canadian and Russian beaver.

Balsams, Gums and Oleo-resins. — These are very important raw materials for perfumes because they generally have a soft and tenacious odour. Commercial samples consist of the natural exudation from the plant together with extraneous matter which is present owing to the crude methods of collection in different parts of the world. The valuable portion of the material contains a small percentage of highly odorous essential oil and a large proportion of soluble resin. The extraneous matter is eliminated by treating the crude substance with alcohol or other solvent, filtering out the insoluble matter and concentrating the filtrate by suitable methods. Some of the more important substances coming under this head are as follows: — Benzoin is obtained from trees native to Siam, Sumatra and Java. Incisions are made in the trunk and when the bark is removed the resin flo s out as a milky sap and dries in the sun. Labdanum is a secretion from the leaves of several species of a genus of the rock rose family. The modern method is to collect the leaves and extract them, as described above, by means of volatile solvents. *Storax* is a balsam obtained from trees occurring in vast forests in the south-west of Asia Minor. It is collected by the Yaruks who beat the outer bark of the tree in midsummer and this causes the balsam to exude into the inner bark. The outer bark is then removed and the inner bark stripped off with knives. It is boiled with water, whcn the balsam separates and floats to the top.

Synthetics and Isolates are substances of standard quality prepared by chemical means. An isolate exists in a natural product and is separated from it in a nearly pure state. Examples of this are geraniol, an alcohol from palmerosa oil; carvone, a ketone from caraway oil; eugenol, a phenol from clove oil; safrol, a phenolic ether from camphor oil. A synthetic is "built up" from other substances, but this does not mean that it cannot exist in nature. There are many instances where a perfumery material occurs as one of the constituents of an essential oil, but it would never pay to separate it because it can be synthesised chemically much cheaper. Examples are phenyl ethyl alcohol, occurring in rose otto but synthesised from phenyl acetic esters; benzyl acetate, occurring in jasmin oil but synthesised from benzyl alcohol; linalyl acetate, occurring in lavender and bergamot oils but synthesised from acetic anhydride and linalol. Many synthetics, however, do not, so far as is known, exist in nature but are the result of chemical research. Examples are ionone, having the odour of violets and synthesised from citral and acetone; hydroxy-citronellal, having the odour of lilies and lilac and synthesised by hydrating citronellal; phenyl acetic aldehyde, having the odour of hyacinths and synthesised from cinnamic acid; musk ketone, having an odour recalling that of animal musk and synthesised by nitrating butyl-meta-xylene; d-cresyl phenylacetate, having an odour resembling that of narcissus and synthesised from coal tar liquors. Other important synthetic aromatic chemicals are amyl salicylate — (odour of clover); anisic aldehyde — (odour of may-blossom); benzylidene acetone — (odour of sweet pea); beta naphthol ethers — (odour of orange blossom); coumarin — (odour of tonka-beans); iso-eugenol — (odour of carnation); heliotropin — (odour of heliotrope); ethyl protocatechuic aldehyde — (odour of vanilla); gamma undecalactone — (odour of peaches); methyl phenyl acetate — (odour of gardenia); terpineol — (odour of lilac).

Artificial Flower Oils. — These are very widely used in the

perfumery industry, not only as a basis for finished perfumes, but more particularly for scenting cosmetics. The misconception which exists concerning the crudeness of odour of these oils is altogether unfounded, especially when they have been prepared by an expert. It is quite true to say that no perfume offered to the public is entirely made from natural flower extracts. It is the *absolutes* skilfully blended with the synthetics, balsams and animal extracts that impart the delicious softness of odour so much appreciated. The question of price generally decides how much of the natural substance shall enter the artificial compound. For instance, a good jasmin oil made without any absolute would cost about two shillings an ounce. If about 2% of real Jasmin were added (and this proportion is necessary for the best oils) then the price would be doubled. In many cases the perfume of flowers has been analysed, not completely because so far the reactions are not known for detecting many of the mere traces of aromatics present in a flower. When a flower perfume has been analysed by present methods, however, it is a relatively simple matter to prepare an imitation from the known constituents, but there is always something lacking in the artificial odour. In order to compensate for this missing link a small quantity of the natural extract is used. In those cases where the composition of the flower perfume is not known the chemist must employ the nearest natural substance having an odour akin to that being imitated. For instance, the composition of the perfume of violets is not known, so a small percentage of cassia absolute is used to give a natural finish to the ionone employed as its base.

Finished Perfumes.—These are prepared from the artificial flower oils by solution in alcohol of about 80% strength. They are toned or blended with balsams, gums and oleo-resins, which retard the rate of evaporation, and small quantities of extracts of animal origin are added to give greater persistence and diffusiveness of odour.

In many cases further quantities of flower extracts are added to improve the delicacy of the perfume and the whole is allowed to stand for several weeks or months in glass-lined tanks to allow it to mature.

The tenacity of a scent is of the utmost importance, and the longer a perfume will remain fragrant after application to the handkerchief or garment the more popular it becomes. This is known as *fixation* and must be controlled during the whole of the process of manufacture.

Examples of fixators are (1) oils—patchouli, clary sage, sandalwood, vetivert; (2) balsams, gums and oleo-resins—benzoin, labdanum, myrrh, oakmoss, storax; (3) synthetics—benzyl cinnamate, ethyl phthalate, coumarin, musk ambrette, heliotropin, vanillin. Many perfumes are so-called bouquets of flowery odour, yet representing no particular flower. In these cases the typical odour is generally a combination of synthetics, one of which is used in sufficient quantity to create a new perfume note. (W. A. Po.)

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PERGA (mod. *Murtana*), an ancient city of Pamphylia, situated about 8 m. inland, at the junction of a small stream (Sari Su) with the Cestrus. It was a centre of native influences as contrasted with the Greek, which were predominant in Attalia, and it was a great seat of the worship of "Queen" Artemis, here represented as a human-headed cone and a purely Anatolian nature goddess.

In Perga, Paul and Barnabas began their first mission in Asia Minor (Acts ix. 13). A much frequented route into Phrygia and the Maeander valley began at Perga, and Alexander made it the starting-point of his invasion of inner Asia Minor. Long the metropolis of Pamphylia Secunda, it was superseded in Byzantine times by its port, Attalia, which became a metropolis in 1084. The extensive ruins all lie in the plain south of the Acropolis. The walls are well preserved, but of late Roman or Byzantine reconstruction. The most notable monument is the theatre outside the walls on the S.W. Modern Murtana is only a large village.

PERGAMUM or PERGAMUS (mod. *Bergama*), an ancient city of Teuthrania, a district in Mysia. It is usually named Πέργαμον by Greek writers, but Ptolemy has the form Πέργαμος.

Little but mythology is known of the city till the time of Xenophon, but it had been striking coins since 420 B.C. at latest. Its importance began under Lysimachus. In 283 B.C. Philetaerus, governor of the fortress, rebelled, and Pergamum became the capital of a little principality. Philetaerus contrived to keep on good terms with his neighbours on all sides (283–263 B.C.). His nephew Eumenes (263–241) succeeded him, increased his power, and even defeated Antiochus II. of Syria near Sardis. His successor Attalus I. (241–197) won a battle over the Gauls, and assumed the title of king. Other Greek kings in Asia Minor reduced Pergamenian power to a very low ebb about 222. On the other hand, the influence of the Romans was beginning to make itself felt in the East. Attalus prudently connected himself with them and shared in their continuous success. Pergamum thus became the political and cultural capital of a considerable territory. The splendour of Pergamum was at its height under Eumenes II. (197–159). He continued true to the Romans during their wars with Antiochus and Perseus, and his kingdom spread over the greater part of western Asia Minor, including Mysia, Lydia, and a great part of Phrygia, Ionia and Caria. He left an infant son, Attalus (III.), and a brother, Attalus II. (Philadelphus), who ruled 159–138, and was succeeded by his nephew, Attalus III. (Philometor). The latter died in 133, and bequeathed his kingdom to the Romans, who erected part of it (excluding Great Phrygia, which they gave to Mithradates of Pontus) into a province under the name of Asia. Pergamum continued to rank for two centuries as the capital, and subsequently, with Ephesus and Smyrna, as one of the three great cities of the province; and the devotion of its former kings to the Roman cause was continued by its citizens, who erected on the Acropolis a temple to Augustus. It was the seat of a *conventus*, including the cities of the Caïcus valley and some of those in the northern part of the Hermus valley. Under the Roman Empire Pergamum was one of the chief seats of the worship of Asclepius "the Saviour." Pergamum was the chief centre of the imperial cult under the early empire, and in Rev. ii. 13 is referred to as the place of "Satan's throne." It was also an early seat of Christianity, and one of the Seven Churches. The place, re-fortified by the Byzantines, and still retaining its name as Bergama, passed into Muslim hands early in the 14th century. The lower town was rebuilt, and in the 17th and 18th centuries became a chief seat of the great Dere Bey family of Kara Osman Oglu, which did not resign it to direct Ottoman control until about 1825. It is still an administrative and commercial centre of importance. Excavations in the late 19th century at the south end of the Acropolis led to the discovery of the Altar of Zeus erected by Eumenes II. in 180 B.C. to celebrate his victory over the Gauls. In very high relief and representing furious action, these altar sculptures are the finest which survive from the Pergamene school, which replaced the repose and breadth of earlier schools by excess of emphasis and detail. The summit of the Acropolis is crowded with public buildings, between the market place, which lies at the southern point, and the Royal Gardens on the north. In the interval are the Zeus altar; the great hexastyle Doric temple of Athena flanked by the palace on the east, by the theatre and its long terrace on the west, and by a library on the north; and a large Corinthian temple of Trajan. The residential part of the Greek, and practically all the Roman city lay below the Acropolis on ground now mostly occupied by modern Bergama; but west of the river Selinus, on rising ground facing the Acropolis, are the remains of a Roman theatre, an amphitheatre and a circus.

See, beside general authorities for Asia Minor, J. Dallaway, *Constan-*

tinople, etc. (1797); W. M. Ramsay, *Letters to the Seven Churches* (1904); and especially the publication by the Royal Museum of Berlin, *Alterthümer von Perganton* (188; *sqq.)*; "Operations at Pergamon 1906–1907," *Athenische Mitteil.*, xxxiii, 4 (1908); G. Leroux, "La Prétendue basilique de Pergame," *Bull. Cor. Hell.*, pp. 238 *sqq.* (1909).

PERGOLESI (or PERGOLESE), **GIOVANNI BATTISTA** (1710–1736), Italian musical composer, was born at Jesi near Ancona on Jan. 3, 1710. He was sent by a noble patron to complete his education at Naples, where he became a pupil of Greco, Durante and Feo for composition and of Domenico de Matteis for the violin.

His earliest known composition was a sacred drama, *La Conversione di S. Guglielmo d'Aquitania,* between the acts of which was given the comic intermezzo *Il Maestro di musica.* These works were performed in 1731, probably by fellow pupils, at the monastery of St. Agnello Maggiore. Pergolesi was then commissioned to write an opera for the court theatre, and in the winter of 1731 successfully produced *La Sallustia,* followed in 1732 by *Ricimero,* which was a failure. Both operas had comic intermezzi, but in neither case were they successful. After this he abandoned the theatre for a time and wrote 30 sonatas for two violins and bass for the prince of Stigliano.

In Sept. 1732 he returned to the stage with a comic opera in Neapolitan dialect, *Lo Fratè inammorato,* which was well received; and in 1733 he produced a serious opera, *Il Prigionier,* to which the celebrated *Serva padrona* furnished the intermezzi. About this time (1733–34) Pergolesi accompanied the duke of Maddaloni to Rome. The failure of *L'Olimpiade* at Rome in Jan. 1735 was followed by a conspicuous success with his comic opera *Il Flaminio* at Naples in September of the same year. In 1736 he was sent by the duke of Maddaloni to the Capuchin monastery at Pozzuoli. the air of the place being considered beneficial to cases of consumption. There he is supposed to have written the celebrated *Stabat Muter;* Paisiello, however, stated that this work was written soon after he left the *Conservatorio dei poveri di Gesù Cristo* in 1729. Of quite a different nature was the humorous, not to say improper, *Scherzo fatto ai Cappuccini di Pozzuoli.* Pergolesi died prematurely on March 17, 1736, and was buried in the cathedral of Pozzuoli.

BIBLIOGRAPHY.—The most complete life of Pergolesi is that by E. Faustini Fasini (Ricordi, 1900); G. Annibaldi, *Il Pergolesi in Pozzuoli, vita intima* (Jesi, 1890), gives some interesting additional details derived from documents at Jesi, but is cast in the form of a romantic novel. H. M. Schletterer's lecture in the *Sammlung musikalischer Vorträge,* ed. by Count P. von Waldersec, is generally inaccurate and uncritical, but gives a good account of later performances of Pergolesi's works in Italy and elsewhere. Complete lists oi his compositions are given in Eitner's *Quellen-Lexicon* and in *Grove's Dictionary* (New York, 1955).

PERI, JACOPO (1561–1633), Italian musical composer, was born at Florence on Aug. 20, 1561, of a noble family. After studying under Cristoforo Malvezzi of Lucca, he became *maestro di cappella,* first to Ferdinand, duke of Tuscany, and later to Cosmo II.

He was a member of the literary and artistic circle which frequented the house of Giovanni Bardi, conte de Vernio, where the revival of Greek tragedy with its appropriate musical declamation was a favourite subject of discussion. The poet Ottavio Rinuccini supplied a drama with the title of *Dafne,* to which Peri composed music, and this first attempt at opera was performed privately in 1597 in the Palazzo Corsi at Florence. In 1600 Rinuccini and Peri were commissioned to produce an opera on the occasion of the marriage of Henry IV of France with Maria de' Medici. This work (*L'Euridice*) attracted a great deal of attention, and the type once publicly established, the musical drama was set on the road to success by the efforts of other composers and the patronage of other courts.

Peri afterward wrote recitatives to Rinuccini's *Arianna* (1608), an opera *ddone* for Mantua (1620) and *La Precedenza delle dame* for the court of Florence (1625). He died in Florence on Aug. 12, 1633.

Peri's *Dafne* (which has entirely disappeared) and *L'Euridice* (printed at Florence. 1600; reprinted Venice, 1608, and Florence. 1863) are of the greatest, importance not only as being the earliest attempts at opera, but as representing the new monodic and declamatory style which is the basis of modern music as opposed to the contrapuntal methods of Palestrina and his contemporaries. Of his work only *L'Euridice* and the *Varie musiche a una, due a tre voci* (Florence, 1609) survive.

See R. Rolland, *Histoire de l'opéra en Europe avant Lulli et Scarlatti* (1895).

PERIANDER (625–585 B.C.), the second tyrant of Corinth. In contrast with his father Cypselus, the founder of the dynasty, he is generally represented as a cruel despot. The Greek tradition, however, is probably derived from a prejudiced source. There is no doubt that he was ruthless with the remains of the nobility. A careful sifting of the available evidence would rather tend to represent Periander as a ruler of probity and insight, and the firmness and activity of his government is beyond dispute. His home administration was so successful that he was able to dispense with direct taxation, and, combined with the farseeing colonizing activities, laid the foundations of Corinth's commercial and industrial prosperity.

Periander further appears as a patron of literature, for it was by his invitation that the poet Arion came to Corinth to organize the dithyramb. To promote and protect Corinthian commerce he established colonies at Potidaea and Apollonia in Macedonia. at Anactorium and Leucas in northwestern Greece, and he is said to have projected a canal through the isthmus. In Greece proper he conquered Epidaurus and annexed Corcyra. He cultivated friendly relations with the tyrants of Miletus and Mytilene, and maintained a connection with the kings of Lydia, of Egypt and, possibly, of Phrygia.

Periander was reckoned one of the seven sages of Greece, and was the reputed author of a collection of maxims in 2,000 verses. The letters ascribed to him are spurious.

See Herodotus iii. 48–53, v, 92; Aristotle, *Politics,* v, 6, 10–12; Heracleides Ponticus in C. Müller's *Frag. hist. graec.,* ii, 212; Nicolaus Damascenus, *ibid.*, iii, 393; Dioyenes Laertius, *De vitis clarorum philosophorum,* i, ch. 7; *Cambridge Ancient History,* vol. iii (1925).

PERIANTH, the term used in botany to denote the outer covering of the flower, composed of more or less modified but nonreproductive leaves and divided usually into an outer, often greenish whorl, the calyx of sepals; and an inner, often brightly-coloured whorl, the corolla of petals.

(See FLOWER.)

PERIBOLOS or PERIBOLUS, in architecture, a sacred enclosed space, usually containing a temple, altar or shrine, especially used of such enclosures in ancient Greece, but occasionally of the enclosed, consecrated ground around an early mediaeval church, which was the limit to which its rights of sanctuary extended.

PERICARDIUM, DISEASES OF. The serous sac (pericardium) containing the heart may become the seat of inflammation (pericarditis) just as the cardiac valves and heart muscle may during the course of such acute diseases as rheumatic fever. (For anatomy, *see* COELOM AND SEROUS MEMBRANES.) The normal shiny appearance is lost; the membrane becomes congested; and inflammatory serum exudes into the cavity. In this stage the visceral and parietal layers grate upon one another with each heart beat and give rise to a "friction rub" over the front of the chest which can be heard with the stethoscope and may be perceptible to the hand. As more inflammatory exudate collects, the surfaces are separated and friction disappears. Thereafter the course of the disease varies as the inflammation advances or recedes. The accumulation may become so extensive that it seriously impedes cardiac action; and if the pericarditis accompanies or follows pneumonia the fluid may become purulent. In either event exit must be given to the fluid surgically.

If the disease recedes the roughened pericardial surfaces again come into contact through absorption of the exuded fluid and friction reappears. Fibrous adhesions form between the pericardial layers over a greater or smaller area; sometimes they become universally adherent and the cavity is obliterated. Occasionally when the covering of the heart and the lining of its sac become firmly adherent one to another, the mechanical function of the heart is disturbed and congestive heart failure results. Calcium may be deposited in the pericardium under these circumstances,

making the diagnosis much easier by its appearance in X-rays of the chest. For this condition there are highly successful surgical procedures. Exudation of fluid into the pericardial cavity, apart from inflammation, occurs in certain diseases of the kidney; in these cases often unaccompanied by symptoms though. it is a serious omen. In rupture of the heart or in certain varieties of aneurysm the pericardial sac is suddenly filled with blood. Distress is extreme, and death from mechanical interference with the action of the heart occurs after a few seconds.

Another condition that occasionally results in accumulation of fluid in the pericardial sac is myxedema (hypothyroidism). This condition can be completely alleviated by the administration of thyroid extract. Tumours of the pericardium are very rare and are nearly always benign. They may cause mechanical difficulty in the heart's activity. *See* also HEART, DISEASES OF THE; HEART AND LUNG, SURGERY OF. (W. S. L.-B.; E. B. BY.)

PERICLES (*c.* 490–429 B.C.), Athenian statesman, was born about 490 B.C., the son of Xanthippus and Agariste. His father took a prominent part in Athenian politics, and in 479 held high command in the Greek squadron which annihilated the remnants of Xerxes' fleet at Mycale; through his mother, the niece of Cleisthenes, he was connected with the former tyrants of Sicyon and the family of the Alcmaeonidae. His early training was committed to the ablest and most advanced teachers of the day; Damon instructed him in music, Zeno the Eleatic revealed to him the powers of dialectic; the philosopher Anaxagoras, who lived in close friendship with Pericles, had great influence on his cast of thought and was commonly held responsible for that calm and undaunted attitude of mind which he preserved in the midst of the severest trials.

The first important recorded act of Pericles falls in 463, when he helped to prosecute Cimon on a charge of bribery, after the latter's Thasian campaign; but as the accusation could hardly have been meant seriously Pericles was perhaps put forward only as a lay figure.

Undue prominence has commonly been assigned to him in the attack upon the Areopagus in 462 or 461 (see AREOPAGUS; CIMON), which was mainly the work of his senior colleague Ephialtes. To Ephialtes likewise we must ascribe the renunciation of the Spartan alliance and the new league with Argos and Thessaly (461).

Not long after, however, when Ephialtes fell by the dagger, Pericles undoubtedly assumed the leading position in the state. On several later occasions, and throughout the period 443–429 B.C., he held the office of strategus (general in command), and to the end of his life he remained the most influential speaker in the ecclesia (popular assembly).

The beginning of his ascendancy is marked by an unprecedented outward expansion of Athenian power. In continuance of Cimon's policy, 200 ships were sent to support the Egyptian insurgents against Persia (*c.* 459 B.C.), while detachments operated against Cyprus and Phoenicia.

At the same time Athens embarked on several wars in Greece proper. An alliance with the Megarians, who were being hard pressed by their neighbours of Corinth, led to enmity with this latter power, and before long Epidaurus and Aegina were drawn into the struggle. On sea the Athenians, after two minor engagements, gained a decisive victory which enabled them to blockade Aegina. On land their general Myronides beat off two Corinthian attacks on Megara, which had been further secured by long walls drawn between the capital and its port Nisaea, located nearly a mile distant. In 457 the Athenians and their allies ventured to intercept a Spartan force which was returning home from central Greece. At Tanagra in Boeotia a pitched battle was fought, in which both Pericles and the partisans of Cimon distinguished themselves.

The Spartans were successful but did not pursue their advantage. and soon afterward the Athenians, seizing their opportunity, sallied forth again and obtained the submission of all Boeotia, save Thebes, and of Phocis and Locris. In 455 Tolmides secured Naupactus on the Corinthian gulf; in 454 Pericles himself made a descent upon Oeniadae at the mouth of the gulf. These years mark the zenith of Athenian greatness. Yet the drain on the country's strength was severe, and when news arrived in 453 that the Egyptian armament had been destroyed by the Persians a reaction set in, and Cimon was empowered to make peace with Sparta on the basis of the status quo. For a while the old anti-Persian policy again found favour in Athens, and Cimon led a great expedition against Cyprus; but on his death hostilities were suspended, and a lasting arrangement with Persia was brought about. It was probably in order to mark the definite conclusion of the Persian War and to obtain recognition for Athens' work in punishing the Mede that Pericles now proposed a pan-Hellenic congress at Athens to consult about the rebuilding of the ruined temples and the policing of the seas; but owing to the refusal of Sparta the project fell through.

Pericles may now have hoped to resume his aggressive policy in Greece proper, but the events of the following years completely disillusioned him. In 447 an Athenian army, which had marched into Boeotia to quell an insurrection, had to surrender in a body at Coroneia, and the price of their ransom was the evacuation of Boeotia. Upon news of this disaster Phocis, Locris, and Euboea revolted, and the Megarians massacred their Athenian garrison, while a Spartan army penetrated into Attica as far as Eleusis. In this crisis Pericles induced the Spartan leaders to retreat, apparently by means of a bribe, and hastened to reconquer Euboea; but the other land possessions could not be recovered, and in a thirty years' truce which was arranged in 445 Athens definitely renounced her predominance in Greece proper. Pericles' foreign policy henceforward underwent a Profound change—to consolidate the naval supremacy, or to extend it by a cautious advance, remained his only ambition. While scouting projects for interference in distant countries, he occasionally made a display of Athenian power abroad, as in his expedition to the Black sea (after 445 B.C.) and in the coionization of Thurii (445–443 B.C.), which marks the resumption of a western policy. The peaceful development of Athenian power was interrupted by the revolt of Samos in 440. Pericles himself led out a fleet against the seceders; he won a first engagement, but unwisely divided his armament and allowed one squadron to be routed. In a subsequent battle he reduced the town itself.

Turning to Pericles' policy towards the members of the Delian League, we find that he frankly endeavoured to turn the allies into subjects (*see* DELIAN LEAGUE). A special feature of his rule was the sending out of numerous cleruchies (*q.v.*), which served the double purpose of securing strategic points to Athens and converting the needy proletariat of the capital into owners of real property. The land was acquired either by confiscation from disaffected states or in exchange for a lowering of tribute. The chief cleruchies of Pericles are: Thracian Chersonese (*c.* 450 B.C.), Lemnos and Imbros, Andros, Naxos and Eretria (before 447); Brea in Thrace (446); Oreus (445); Amisus and Astacus in the Black sea (after 445); Aegina (431).

In his home policy Pericles carried out more fully Ephialtes' project of making the Athenian people truly self-governing. His chief innovation was the introduction of payment from the public treasury for State service. He provided a remuneration of one to two obols a day for the jurymen, and he created a "theorikon" fund which enabled poor citizens to attend the dramatic representations of the Dionysia. In connection with this system of salaries should be mentioned a somewhat reactionary law carried by Pericles in 451, by which an Athenian parentage on both sides was made an express condition of retaining the franchise and with it the right of sitting on paid juries. The measure by which the archonship was opened to the poorer citizens (457 B.C.) may also be due to Pericles (see ARCHON).

The last years of his life were troubled by a new period of storm and stress. A conflict between Corcyra and Corinth, the second and third naval powers of Greece, led to the simultaneous appearance in Athens of an embassy from either combatant (433). Pericles had, as it seems, resumed of late a plan of western expansion by renewing alliances with Rhegium and Leontini, and the favourable position of Corcyra, on the trade-route to Sicily and Italy, as well as its powerful fleet, no doubt helped to

induce him to secure an alliance with that island, and so to commit an unfriendly act towards a leading representative of the Peloponnesian League. Pericles now seemed to have made up his mind that war with Sparta, the head of that League, had become inevitable. In the following spring he fastened a quarrel upon Potidaea, a town in Chalcidice, which was attached by ancient bonds to Corinth, and in the campaign which followed Athenian and Corinthian troops came to blows. A further *casus belli* was provided by a decree forbidding the importation of Megarian goods into the Athenian empire, presumably in order to punish Megara for her alliance with Corinth (spring 432). The combined complaints of the injured parties led Sparta to summon a Peloponnesian congress which decided on war against Athens, failing a concession to Megara and Corinth (autumn 432). In this crisis Pericles persuaded the wavering assembly that compromise was useless, because Sparta was resolved to precipitate a war in any case. An embassy calling upon the Athenians to expel the accursed family of the Alcmaeonidae, clearly aimed at Pericles himself as its chief representative, was left unheeded, and early in 431 hostilities began between Athens and Sparta and their respective allies (*see* PELOPONNESIAN WAR).

At the same time Pericles was being sorely hampered by his adversaries at home. The orthodox Conservatives and some democrats who were jealous of his influence, while afraid to beard the great statesman himself, combined to assail his nearest friends. The sculptor Phidias (*q.v.*) was prosecuted on two vexatious charges (probably in 433), and before he could disprove the second he died under arrest. Anaxagoras was threatened with a law against atheists, and felt compelled to leave Athens. A scandalous charge against his mistress Aspasia, which he defeated by his personal intercession before the court, was taken very much to heart by Pericles. His position at home scarcely improved during the war. His policy of abandoning the countryside was unpopular with the land-owning section of the people, who from the walls of Athens could see their own property destroyed by the invaders. At the end of the first year of war (early in 430) Pericles made a great appeal to the pride of his countrymen in his well-known funeral speech. But in the ensuing summer, after a terrible outbreak of plague had ravaged the crowded city, the people became thoroughly demoralized. Pericles led a large squadron to harry the coasts of the Peloponnese, but met with little success. On his return the Athenians sued for peace, though without success, and a speech by Pericles had little effect on their spirits. Late in 430 they deposed him from his magistracy. In addition to this they prosecuted him on a charge of embezzlement and imposed a fine of 50 talents. A revulsion of feeling soon led to his reinstatement, apparently with extraordinary powers. But the plague, which had carried off two of his sons and a sister, had left its mark also on Pericles himself. In the autumn of 429 he died and was buried near the Academia, where Pausanias (150 A.D.) saw his tomb. A slightly idealized portrait of Pericles as *strategus* is preserved to us in the British Museum bust, No. 549, which is a good copy of the well-known bronze original by Cresilas.

If we now endeavour to give a general estimate of Pericles' character and achievements, it will be well to consider the many departments of his activity one by one. In his foreign policy his standpoint was at all times purely Athenian. We may clearly distinguish two periods in his administration of foreign affairs. At first, joining to Cimon's anti-Persian ambitions and Themistocles' schemes of western expansion a new policy of aggression on the mainland, he endeavoured to push forward Athenian power in every direction, and engaged himself alike in Greece proper, in the Levant and in Sicily. After Cimon's death he renounced the war against Persia, and the collapse of 447–445 had the effect of completing his change of attitude. Henceforward he repressed all schemes of adventure and confined himself to the gradual expansion and consolidation of the empire. It is not quite easy to see why he abandoned this successful policy in order to hasten on a war with Sparta, and neither the Corcyrean alliance nor the Megarian decree seems justified by the facts as known to us, though commercial motives may have played a part which we cannot now gauge. In his adoption of a purely defensive policy at the beginning of the Peloponnesian War he severely tried the temper of the Athenians, but in the main his policy was sound, and the disasters of the war cannot fairly be laid to his charge. In his attitude towards the members of the Delian League Pericles likewise maintained a purely Athenian point of view, and his appropriation of federal funds for Athenian purposes is difficult to justify. But he could hardly be said seriously to have oppressed the subject cities. Under Pericles Athens also attained her greatest measure of commercial prosperity, and the activity of her traders all over the Levant, the Black sea and the West, is attested not only by literary authority, but also by many Attic coins and vases.

Pericles' home policy has been much debated since ancient times. His chief enactments relate to the payment of citizens for State service. These measures have been interpreted as an appeal to the baser instincts of the mob, but this assumption is entirely out of keeping with all we know of Pericles' general attitude towards the people, over whom Thucydides says he practically ruled as a king. We must, then, admit that Pericles sincerely contemplated the good of his fellow-countrymen, and we may believe that he endeavoured to realize that ideal Athens which Thucydides sketches in the funeral speech—an Athens where free and intelligent obedience is rendered to an equitable code of laws, where merit finds its way to the front, where military efficiency is found along with a free development in other directions and strangles neither commerce nor art. In accordance with this scheme Pericles sought to educate the whole community to political wisdom by giving to all an active share in the government, and to train their aesthetic tastes by making accessible the best drama and music. It was most unfortunate that the Peloponnesian War ruined this project by diverting the large supplies of money which were essential to it.

Pericles also incurred unpopularity because of his rationalism in religious matters; yet Athens in his time was becoming ripe for the new culture, and would have done better to receive it from men of his circle—Anaxagoras, Zeno, Protagoras and Meton—than from the more irresponsible sophists. The influence of Aspasia on Athenian life, though denounced unsparingly by most critics, may indeed have been beneficial, inasmuch as it tended towards the emancipation of the Attic woman from the over-strict tutelage in which she was kept. As a patron of art and literature Pericles was a still greater force. He counted Sophocles and probably also Herodotus among his personal friends, and he left a profound impression on the mind of Thucydides. He is largely responsible for the splendour of Attic art in his time, for had he not so fully appreciated and given such free scope to the genius of Pheidias, Callicrates and Ictinus, Athens would hardly have witnessed the raising of the Parthenon and other famous structures.

Of Pericles' personal characteristics we have a peculiarly full and interesting record. He was commonly compared to Olympian Zeus, partly because of his serene and dignified bearing, partly by reason of the eloquence with which he held friend and foe spellbound. The same dignity appeared in the grave beauty of his features, though the abnormal height of his cranium afforded an opportunity for ridicule of which the comedians made full use.

ANCIENT AUTHORITIES.—Our chief source must always remain Thucydides (i. and ii. 1–65), whose insight into the character and ideals of Pericles places him far above all other authorities. The speeches which he puts into his mouth are of special value in disclosing to us Pericles' inmost thoughts and aspirations (i. 140–144; ii. 35–46; ii. 60–64). Thucydides alone shows sympathy with Pericles, but he was by no means a blind admirer. Of other 5th-century sources, Aristophanes is obviously a caricaturist, pseudo-Xenophon (*de republica Atheniensium*) a mere party pamphleteer. Plato, while admiring Pericles' intellect, accuses him of pandering to the mob; Aristotle in his *Politics* and especially in the Constitution of Athens, which is valuable in that it gives the dates of Pericles' enactments as derived from an official document, accepts the same view. Plutarch (*Pericles*) gives many interesting details as to Pericles' personal bearing, home life, and patronage of art, literature and philosophy; but he reproduces scandalous anecdotes in a quite uncritical spirit.

For Pericles' politics, *see* E. Abbott, *Pericles and the Golden Age of Athens* (1898); Ad. Schmidt, Das Perikleische *Zeitalter;* and the relevant parts of the general histories of Greece. For Pericles' buildings,

see E. A. Gardner, *Ancient Athens* (1902) and M. L. d'Ooge, *The Acropolis of Athens* (1908). *See* ATHENS: *History;* GREECE: *History;* and GREEK ART. (M. C.)

PERIDOTITE is a dark, heavy, igneous rock containing at least 10% olivine; other iron- and magnesia-rich minerals, generally pyroxenes; and not more than 10% feldspar. Most peridotites are coarse-grained and granitoid, although some are coarsely porphyritic. Peridotite occurs in four main geologic environments: (1) interlayered with iron-, lime- and magnesia-rich rocks in the lower parts of tabular-layered igneous complexes or masses; (2) as irregular masses, rich in olivine $(Mg,Fe)_2SiO_4$, with or without related gabbro, in alpine-type mountain belts; (3) in volcanic pipes (the variety known as kimberlite); and (4) as dikes and irregular masses with rocks exceptionally rich in potash and soda. The layered complexes are believed to have been formed in place by selective crystallization and crystal settling from a previously intruded fluid or magma; the remaining types seem to have ranged from fluid magmas to semisolid crystal mushes at the time of emplacement. Nearly all peridotite is more or less altered to serpentine (*q.v.*) and cut by many irregular shear surfaces.

Peridotite is the ultimate source of all chromium ore and naturally occurring diamonds, and of nearly all chrysotile asbestos. It is one of the main host rocks of talc deposits and platinum metals and formerly was a major source of magnesite. Some varieties of serpentine (verd antique) are used as building and ornamental stone, and fresh dunite (pure olivine rock) is used in parts of glass furnaces. In warm humid climates peridotite and serpentine have weathered to soils and related deposits (*see* LATERITE) which, though now worked on a relatively small scale, are enormous potential sources of iron, nickel, cobalt and chromium. (T. P. T.)

PÉRIER, CASIMIR PIERRE (1777–1832), French statesman. was born at Grenoble on Oct. 11, 1777, the son of a rich banker and manufacturer, Claude PCrier (1742–1801), who was one of the first directors of the Bank of France; of his eight sons, Augustin (1773–1833), Xntoine Scipion (1776–1821), Casimir Pierre and Camille (1781–1844), all distinguished themselves in industry and in politics. Casimir joined the army of Italy in 1798. On his father's death he left the army and with his brother Scipion founded a bank in Paris. He opposed the ruinous methods by which the duc de Richelieu sought to raise the war indemnity demanded by the allies, in a pamphlet *Réflexions sur le projet d'emprunt* (1817), followed in the same year by *Dernières réflexions* . . . in answer to an inspired article in the *Moniteur*. In the same year he entered the chamber of deputies for Paris, taking his seat in the left centre and making his first speech in defense of the freedom of the press. Re-elected for Paris in 1822 and 1824. and in 1827 for Paris and for Troyes, he sat for Troyes until his death. Under Louis Philippe, PCrier became president of the chamber of deputies, and sat for a few months in the cabinet without a portfolio.

On the fall of the ministry of Laffitte, Casimir PCrier, who had drifted more and more to the right, was summoned to power (March 13, 1831); and in a year he restored civic order in France and re-established her credit in Europe. Paris was only held in check by the premier's determination; revolts at Lyons and Grenoble were also put down. The minister refused to be dragged into armed intervention in favour of the revolutionary government of Warsaw, but he constituted France the protector of Belgium by the prompt expedition of the army of the north against the Dutch in Aug. 1831; French influence in Italy was asserted by the audacious occupation of Ancona (Feb. 23, 1832); and the refusal of compensation for injuries to French residents by the Portuguese government was followed by a naval demonstration at Lisbon. In the spring of 1832 during the cholera outbreak in Paris, PCrier visited the hospitals with the duke of Orleans. He fell ill the next day and died on May 16, 1832.

His *Opinions et discours* were edited by A. Lesieur, 2 vol. (1838); C. Nicoullaud published in *1894* the first part (*Casimir-Périer, député de l'opposition, 1817–1830*) of a study of his life and policy; and his ministry is exhaustively treated by Thureau-Dangin in vol. i and ii (1884) of his *Histoire de la monarchie de juillet.*

For the family in general *see* E. Choulet, *La Famille Casimir-Périer* (1894).

PERIGEE, in astronomy, that point of the moon's orbit or of the sun's apparent orbit at which the rnoon or sun approaches nearest to the earth (Gr. *peri,* "near." *ge,* "the earth"). The sun's perigee and the earth's perihelion (*q.v.*) are so related that they differ 180° in longitude; the first being on the line from the earth toward the sun, and the second from the sun toward the earth. The longitude of the solar perigee is now ror°, that of the earth's perihelion 281°.

PÉRIGORD, as a French province, formed part of the military government of Guienne and Gascony, and was bounded on the north by Angoumois, on the east by Limousin and Quercy, on the south by Agenais and Bazadais. and on the west by Bordelais and Saintonge. It is now represented by the *ddpartement* of Dordogne and part of Lot-et-Garonne. PCrigord was in two divisions: PCrigord Blanc (cap. PCrigueux) and PCrigord Noir (cap. Sarlat). Under the Roman empire it was included in *Aquitania secunda,* and it afterwards formed the diocese of PCrigueux. From the 8th century it had its own counts, who were feudatories at first of the dukes of Aquitaine and afterwards of the kings of England. In the 15th century the county passed to the dukes of Orléans, and in the 16th came to the family of d'Albret, becoming crown land again on the accession of Henry IV.

See the *Dictionnaire topographique du ddpartement de la Dordogne* by the Vicomte de Gourgues *(1873)*; the Bulletin of the *Société historique et archkologique du Pkrigord (1874 et seq.)*; *L'Inventaire sommaire de la "Collection de Pdrigord"* in the Bibliothèque nationale *(1874)*; J. L. Dessalles, *Histoire du Ptrigord,* 3 vol. (1883–86).

PÉRIGUEUX, a town of southwestern France, formerly capital of the old province of PCrigord Blanc, now chief town of the *département* of Dordogne, 79 mi. E.N.E. of Bordeaux, on the railway between that city and Limoges. Pop. (1954) 37.168. Vesunna was the capital of the Petrocorii, allies of Vercingetorix when Caesar invaded Gaul. The country was afterwards occupied by the Romans, who built a second city of Vesunna on the right bank of the Isle river, opposite the site of the Gallic town. The barbarian invasion brought this prosperity to a close. St. Front preached Christianity here in the 4th century and over his tomb there was raised a monastery, which became the centre of the new town called Le Puy St. Front. The *cité* was pillaged by the Saracens about 731, and in 844 the Normans devastated both quarters. The new town soon began to rival the old city in importance, and it was not until 1240 that the attempts of the counts of PCrigord and the bishops to infringe on their municipal privileges brought about a treaty of union. During the Hundred Years' War, PCrigueux was twice attacked by the English, who took the *cite'* in 1356; and the whole town was ceded to them by the treaty of Brétigny, but returned to the French crown in the reign of Charles V. The county passed by marriage into the hands of Anthony of Bourbon. father of Henry IV, and was converted by the latter into royal domain. During the Huguenot wars PCrigueux was frequently a stronghold of the Calvinists, who in 1575 did great destruction there; and it also suffered during the troubles of the Fronde.

The town, standing on a height on the right bank of the Isle, is divided into three parts. On the slope of the hill is the medieval town; to the west is the modern town; to the south of the modern town is the old Roman town or *cite'.* Three bridges connect PCrigueux with the left bank of the Isle, where stood Vesunna, the capital of the Petrocorii. Hardly a trace of this old Gallic town remains, but not far off, on the Plateau de la Boissibre, the rampart of the old Roman camp can still be traced. On the right bank of the Isle, in the Roman city, there have been discovered some baths of the 1st or 2nd century, supplied by an aqueduct 4 mi. long, which spanned the Isle. A circular building, called the "Tower of Vesunna," stands at what was formerly the centre of the city. It is believed to have been originally the cella or main part of a temple, probably dedicated to the tutelary deities of Vesunna. The amphitheatre, now in ruins, had a diameter of 1,312 ft., that of the arena being 870 ft.; it dates from the 3rd

or even the 2nd century. The counts of Périgueux used it for their château, and lived in it from the 12th to the end of the 14th century. In 1644 it was given over by the town to the Order of the Visitation, and the sisters built their nunnery with stones from it. Of the ruins of the *cite'*, the Château Barrière is an example of the fortified houses formerly common there. Two of its towers (3rd or 4th century) formed part of the fortified *enceinte;* the highest tower is of the 10th century; and the part now inhabited is of the 11th or 12th century, and was formerly used as a burial chapel. The bulk of the château is of the 12th, and some of the windows of the 16th century.

The chief medieval building in the *citd* is the (11th and 12th centuries) church of St. Etienne, once the cathedral; it has a fine carved wooden reredos of the 17th century and a tomb of a bishop of the 12th century. In the medieval town, known as Le Puy St. Front, is the cathedral of St. Front which, till its restoration in the 19th century, was of unique architectural value. Nearby are the remains of an old basilica of the 6th century, above which rises the unique Byzantine 11th-century belfry. It is composed of two massive cubes, placed the one above the other in retreat, with a circular colonnade surmounted by a dome. To the southwest of St. Front, the buildings of an old abbey (11th to 16th century) surround a 13th-century cloister. Of the fortifications of Le Puy St. Front, the chief relic is the Tour Mataguerre (14th century).

Périgueux is the seat of a bishop, prefect and court of assizes, and has tribunals of first instance and of commerce, and a board of trade arbitrators. The trade of the town is in pigs, truffles, vegetables, brandy, poultry, pies known as *pâtés de Pkrigord,* and all kinds of preserved foods. There are quarries in the adjacent vicinity.

PERIHELION, in astronomy, the point of nearest approach of a body to the sun (Gr. *peri,* "near," *helios,* "sun"). The earth is at perihelion about Jan. 3.

PERIM, an island in the Strait of Bab-el-Mandeb, 96 mi. W. of Aden, and within the British colony of Aden. Pop. about 1,700. Formed of volcanic rocks, it stands on the shallow threshold of the Red sea, 2 mi. from the Arabian shore, and is about $3\frac{1}{2}$ mi. long with an area of 5 sq.mi. Its highest point is 214 ft. It is horseshoe-shaped, and a good harbour occupies the concavity on the south side. At one time Perim was of importance as a coaling station. With cessation of commercial operations there in 1936 the cable station was closed. Perim, the Diodorus of the *Periplus,* was garrisoned briefly by the British in 1799. Reoccupied in 1857, in view of the cutting of the Suez canal, it is administered in conjunction with Aden.

PERINTHUS (Turk. ***Eski*** *Eregli,* "Old Heraclea"), an ancient town of Thrace, on the Propontis, 22 mi. W. of Selymbria, strongly situated on a small peninsula. It was a Samian colony, founded about 599 B.C. for trade with Thrace and beyond. Its original name was Mygdonia; later it was called Heraclea Thraciae or Heraclea Perinthus. In 340 B.C. it successfully resisted Philip II of Macedon and rivalled Byzantium in importance.

PERIODICAL. This term, which was once applied to all publications appearing at regular intervals, is now used by librarians and others to designate all such serials except newspapers (*q.v.*).

Early Periodicals. — The forebears of the literary periodical in the 17th century were the book notices inserted by publishers in the early newsbooks. By 1646 such notices, accompanied by short critical comments, were appearing with some regularity; about 1650 they began to be grouped together and to form a regular feature of the newsbook or paper. Of far greater importance than the book notice was the digest or abstract journal, of which the pioneer was the *Journal des sçavans* (later *Journal des savants),* first issued in Paris on Jan. 5, 1665, by Denys de Sallo and continued in a series unbroken except for a short period of suppression from 1797 to 1816. Though original material began to appear in it after the issue of the first few numbers, its primary aim was to give summaries of all important books published in Europe, together with obituaries and bibliographies of prominent writers and reports on important philosophical, literary and scientific matters. The *Journal des sçavans* was closely followed by the *Philosophical Transactions (Acta philosophica)* of the Royal society of London (March 1665), the first abstract journal in English, designed to record "the present undertakings, studies and labours of the Ingenious in many considerable parts of the world." Italy followed with the short-lived *Giornale de' letterati* (Rome, 1668–81) — another journal with the same title was published at Parma from 1668 to 1690 (with a break between 1679 and 1686) — and the *Galleria di Minerva* (Venice, 1696–1717); in Germany the *Acta eruditorum,* published in Latin, appeared in Leipzig from 1682 to 1731. Christian Thomasius' *Monatsgesprache* (1688) was the first periodical in the German language.

Meanwhile the book advertisements in the newsbooks had developed into regular catalogues — of which the *Mercurius librarius* (1668–70) or *Term Catalogues* was the most noteworthy — though these were but "dry things, scarce able to raise in men that gust and appetite for learning" that the *Weekly Memorials for the Ingenious* (1681–83) hoped to foster by means of the critical notes that it attached to each title. This periodical was the precursor of the critical review; it was shortly followed by the *Universal historical bibliothkque* (1686) which announced its intention of printing reviews of important books, and for the first time invited contributions from scholarly critics.

In 1690, Samuel Wesley, father of John and Charles, joined John Dunton in launching the *Athenian Gazette* (later the *Athenian Mercury,* ended 1697), the forerunner of *Notes and Queries* and *Answers,* which attempted a kind of information service on all literary and scientific matters about which its readers might ask. Daniel Defoe was one of the contributors. In 1692 Dunton began to issue supplements dealing with natural history and natural phenomena. Dunton's later journal, *The Compleat Library* (1692–94), virtually the successor of the *Athenian Mercury,* was the first periodical of importance to allot, in the manner now customary in learned journals, definite proportions of its space to original contributions and to book reviews.

Side by side with these attempts to popularize learning were the periodicals of amusement, of which *Mercurius Jocosus* (1654) was one of the earliest, and Donneau de Vizé's *Mercure galant* (Paris, 1672–1820) the most successful. Modeled on the latter, but more serious in content, was P. A. Motteux's *Gentleman's Journal* (1692–94), which contained essays, verses, letters and stories. Edward Ward's *London Spy* (1698–1700), with lively sketches of London manners and customs, was one of a number of short-lived journals whose contents were mainly humourous, vulgar or obscene.

GREAT BRITAIN

If the 17th century saw the establishment of the abstract journal or digest, the learned journal, the critical review and the periodical of amusement, the 18th century produced in the essay periodical its own characteristic contribution to English journalism. This form, itself one of the most important manifestations of 18th-century English literature, constituted the first attempt to create an organized popular opinion in matters of literary taste and manners in general. Richard Steele issued the *Tatler* in 1709–10; and a dozen similar publications appeared in the same year, at least half of them imitating the title as well as the form. Joseph Addison contributed to the *Tatler* and, with Steele, ran its successor the *Spectator* (1711–14) and also the *Guardian* (1713). Swift and Bolingbroke wrote political articles for the *Examiner* (1710–14); the *Spectator* and the *Guardian* replied on behalf of the Whigs, the latter finding itself in no way cramped in this respect by its early profession of freedom from political controversy.

The Stamp act of 1712 struck a hard blow at the essay periodicals — the *Spectator's* sales dropped from about 4,000 copies to 1,600 — but the very severity of the act is striking evidence of their success in forming public opinion not only in the literary but also in the political sphere.

Meanwhile a series of literary reviews — the *History of the Works of the Learned* (1699–1712), the *Memoirs of Literature* (1710–17) and others — carried on the tradition of the *Weekly Memorials for the Ingenious* and the publications of John Dunton. The first Irish review, *A Literary Journal* (Dublin, 1744–46), falls

within this period. Of importance was the *Monthly Review* (1749–1844). The first magazine or miscellany of modern type was Edward Cave's *Gentleman's Magazine* (1731–1907), modeled on Motteux's *Gentleman's Journal* of 1692; Samuel Johnson joined the staff in 1738. *The London Magazine or Gentleman's Monthly Intelligencer* (1732–85) was the most formidable of a large number of rivals to the *Gentleman's Magazine;* others were the *Scots Magazine* (1739–1826); the *North Briton,* edited by John Wilkes (1762–63); the *European Magazine and London Review* (1782–1826); and the *Monthly Magazine* (1796–1843). The most noteworthy development of the last few years of the century was the specialized periodical — Archaeologia (1770), *Curtis's Botanical Magazine* (1787), the *Philosophical Magazine* (1798) and the *Farmer's Magazine* (1800–25) being among the more important examples, and the first three the longest-lived.

The 19th Century. — To Edinburgh is due the first high-class critical journal, the *Edinburgh Review* (1802–1929), established by Sydney Smith, Henry Brougham and Francis Jeffrey and issued in the buff and blue colours of the Whig party that it supported. Among its more eminent contributors were Carlyle, William Hazlitt and Macaulay. Its brilliant Tory competitor, the *Quarterly Review* (1809), was begun by the London publisher John Murray at the instance of Sir Walter Scott, who, though at first contributing to the *Edinburgh,* soon found himself dissatisfied with it. George Canning, Robert Southey, Lord Salisbury and Gladstone were all contributors to the *Quarterly,* and Scott himself reviewed in it. The third of the famous 19th-century periodicals was *Blackwood's Magazine* (1817), with contributions from Scott, John Lockhart, John Galt and many others. The *Edinburgh* ceased publication with the end of its 250th volume; the *Quarterly* and *Blackwood's* were still current at mid-20th century.

Of other quarterlies may be noted the *Westminster Review* (1824–1914), *Mind* (1876) and a large number of denominational reviews. Among the monthlies and weeklies were the *Christian Observer* (1802–77), the *Monthly Repository* (1806–38), the *Athenaeum* (1828, later combined with *New Statesman and Nation*), the *Spectator* (1828), the *Fortnightly Review* (1865–1950, monthly from 1866), the *Contemporary Review* (1866) and the *Nineteenth Century* (1877, called *Twentieth Century* after 1950). W. T. Stead's *Review of Reviews* (1890–1936) introduced a new development in printing criticisms of work published in other reviews. The *Times* (London) began to issue its *Literary Supplement* in 1902.

The 19th century also produced a flood of popular magazines. John Limburd published the *Mirror* (1822–49) as a twopenny illustrated magazine. A decade later came *Chambers's Journal* (1832), long conducted by the John Chamberses, father and son; the *Penny Magazine* (1832–46), published by Charles Knight; and the *Saturday Magazine* (1832–44), issued by the Society for Promoting of Christian Knowledge. Charles Dickens' *Household Words* (1850–59) was followed by his *All the Year Round* (1859–95); the latter was continued by the novelist's son. Leading sixpenny monthlies were the *Cornhill Magazine* (1860–1939), initially edited by Thackeray and the first to publish serial fiction regularly; *Fraser's Magazine* (1830–82), which published much early Thackeray and some of the best of Thomas Carlyle; and *Temple Bar* (1860–1906), first edited by G. A. Sala. *Notes and Queries* (1849) has long interested the curious antiquary. Nor were the interests of women forgotten: the *Queen* (1861) and the *Lady* (1885) were destined for long lives.

The 20th Century. — The late 19th century saw the birth of the illustrated magazine proper, and the 20th saw its great development. Many magazines had already inserted full-page illustrations and woodcuts in the 1860s, but none of these approached what is now accepted as an illustrated magazine. The continually changing attitude of the public is clearly shown by Sala's statement in *Temple Bar* that, with due regard to the interests of his readers, he preferred to give them 16 extra pages of print rather than an illustration or two. The *English Illustrated Magazine* (1883–1913) may perhaps be considered the parent of illustrated monthlies.

Innumerable publishers forthwith adopted the view of Sir George Newnes that a magazine should give "wholesome and harmless entertainment to crowds of hard-working people craving for a little fun and Bmusement," by providing light literature and illustrations. The *Strand Magazine* (1891–1950) was designed to "contain stories and articles by the best British writers and special translations of the chief foreign authors." No limit was to be put to illustration. It was a bold move, and even the publishers felt that they were embarking "upon the wildest extravagance in furnishing no fewer than a hundred and ten illustrations in a single number." This was before the general adoption of process engraving, and woodcuts were still in use. The success which followed was phenomenal. In a different category must be placed the illustrated weeklies in which the illustrations counted for more than the letterpress; of these the *Illustrated London News* (1842) was the pioneer. The *Sphere* began in 1900, the *Tatler* in 1901; *Picture Post* (1938–57) was the most striking example at mid-20th century.

Besides illustrations, 20th-century magazines are notable for variety of specialization in the professions. industries, trades, religion, arts and letters, sports, etc. *Radio Times* (1923), which reached a spectacular 9,000,000 circulation by mid-century and continued to rise, was an outstanding example. There were many prosperous motion-picture periodicals, and many devoted to women's interests; the weekly *Woman* (1937) had over 3,000,000 circulation before the end of its second decade.

The outbreak of World War II wrote finis to the files of many periodicals; in 1939 death came to the literary *Criterion* (1922), Sir John Squire's *London Mercury* (1919), and the monthly *Windsor* (1895).

Shortage of paper supply continued to cripple magazine publication for some years after the end of the war.

Children's Magazines. — Another outstanding feature of the late 19th century was the development of literature for the young. Since the spread of education had inspired the production of encyclopaedias and dictionaries expressly intended for the comprehension of children, it is not surprising that periodicals for boys and girls should also have assumed an important role. The best magazines contained a mixture of fiction. science and practical suggestions to young people in a variety of crafts and hobbies. Most prominent of the 19th-century juveniles were *Chatterbox* (1866–1934), *Little Folks* (1871–81), the *Boy's Own Paper* (1879–1904) and the *Girl's Own Paper* (1880). *My Magazine* (1914–33) is a later example.

The so-called "comics" descended upon Britain in mid-20th century like the locusts upon Egypt of old.

Historical and Scientific Magazines. — Though specialized journals began to make their appearance in the late 18th century, it was not until the end of the 19th that any very great expansion of their numbers took place. Mention must be made, however, of a few outstanding earlier examples, such as the *Lancet* (medical; 1823); the *Provincial Medical and Surgical Journal* (1840–52), followed by *British Medical Journal* in 1857; the *Economist* (1843); and *Nature* (general science; 1869). After 1880 every science, art, profession and trade began to issue its own periodical or periodicals until no field of activity, however highly specialized, was unrepresented. It must be sufficient here to list only a few: the *Law Quarterly Review* (1885), the *English Historical Review* (1886), the *Library* (1889), the *Studio* (art; 1893), *Man* (anthropology; 1901), the *Hibbert Journal* (theology and philosophy; 1902).

Canada. — The first monthly in eastern Canada was the *Novia Scotia Magazine* (1789–92), and in Canada proper the *Canadian Magazine* (Montreal, 1823–25). In addition to these were the bilingual *Quebec Magazine* (1791–93), a quarterly; and several others entirely in French: *L'Abeille canadienne* (1818–19), *La Bibliothèque canadienne* (1825–30; continued as *L'Observateur* [1830–31]) and the *Magasin du Bas-Canada* (1832). The *Literary Garland* had a longer life (1838–51) than most of those that preceded it, and was for some time the only English magazine published in Canada. A series of interesting French-Canadian reviews followed; the foremost, *La Revue canadienne* (1864–1922), contained the best writings of contemporary French-Canadian men

of letters.

Maclean's Magazine (1896) has long been the best known general magazine in Canada. It is published from Toronto, the country's magazine capital, whence are issued also the *Canadian Home Journal* (1904); and *Chatelaine* (1928), the leading Canadian women's journal. Some U.S. periodicals have large circulations in Canada.

Australia and New Zealand.—The *Australian Magazine* was published in Sydney in 1821–22, and was followed by the *South Asian Register* (1827), the *Australian Quarterly Journal* (1828) and a second *Australian Magazine* (1838). The *Sydney University Magazine* (1855 and 1878–79), continued as the *Sydney University Review,* was of some importance and of literary value. Australian periodicals are strongest in the weekly field. Greatest of general popular weeklies is the *Bulletin* (1880), founded in Sydney by J. F. Archibald, which became important in the development of the country's literature and art. Largest circulation in the commonwealth was claimed in the late 1950s by the *Australian Women's Weekly* (1933), which had publication offices in all the leading cities and was said to enter one-third of Australian homes.

FRANCE

The *Journal des sçavans,* the first number of which appeared on Jan. 5, 1665, is acknowledged to be the parent of modern periodical literature. About 1663, François Eudes de Mézeray obtained a privilege for a regular literary periodical, but the idea came to nothing; and the credit for having produced the first periodical must go to Denys de Sallo, who at the time was regarded as a genius and inventor for having framed the scheme. Its intention and scope is given in the *Encyclopédie méthodique:* "Il a été inventé pour le soulagement de ceux qui sont ou trop occupés ou trop paresseux pour lire les livres entiers" ("It has been invented for the relief of those who are either too busy or too lazy to read whole books").

The severe literary and political censorship enforced in France was directly responsible for the introduction of the literary periodical into the Netherlands, where no fewer than 31 first-rate journals were issued within the century 1680–1780 by French Protestant refugees.

In this manner appeared Pierre Bayle's *Nouvelles de la république des lettres* (1684–1718), one of the principal successors of the *Journal des sçavans;* and Jean Le Clerc's *Bibliothèque universelle et historique* (1686–93)—to mention only two. A few years later, the *Mémoires pour l'histoire des sciences et des beaux-arts,* commonly known by the name of *Journal de Trévoux* (1701–67), was brought out at Paris under the auspices of the Jesuits. Their primary object was to defend religion from attack, and it was probably for this reason that the journal incurred the displeasure of Voltaire. For 30 years the printers of the little town of Trévoux were kept busy, until it became more convenient to transfer the headquarters of the journal to Paris.

Meanwhile the *Spectator* and *Tatler* were appearing in England; but the French were cautious in adopting the essay periodical, though an incomplete translation of the *Spectator* appeared in Amsterdam in 1714. It was not until 1722 that Marivaux made his unsuccessful attempt to rival the Englishmen by issuing his *Spectateur français* (1722). The *Spectateur suisse* (1723), *Le nouveau Spectateur* (1758) and others came after but were of little value. *Le Pour et contre* (1733–40), edited by the Abbé Prévost and full of anecdote and miscellaneous information, was similar in form to the English reviews.

Another periodical of high rank of the 18th century was the *Journal encyclopédique* (1756–93), founded by Pierre Rousseau, who carried on his work for many years under the protection of the count of Horion, minister of the prince bishop of Liège. When the latter died, Rousseau was compelled to transfer the journal from Liège to Bouillon on account of the philosophical articles it contained, but permission was given him to establish his presses there. Voltaire, Diderot and others contributed to the Paris *Gazette littéraire* from 1764 to 1766. During the revolutionary period, and until the abolition of the censorship in 1828, most periodicals were suspended or suppressed.

Specialized journals began in the latter half of the 17th century and continued in quantity. *Revue des deux mondes* (1829–1944) reached its greatest importance as a fortnightly in mid-19th century, when leading literary figures were contributors. It was succeeded by *Revue: littérature, histoire, arts et sciences des deux mondes* (1948). Other 20th-century reviews are *Nouvelle revue* (1879), *Mercure de France* (1890), *Revue de Paris* (1894) and *Les Oeuvres libres* (1921). *L'Illustration* (1843–1944) was long a world-famous picture magazine. *Paris-match* (1949) quickly gained circulation leadership among French weeklies by brilliant illustration and timely, informative text. Periodicals devoted to women's interests and fashions have also been very successful, as the monthly *Marie-Claire* (1954). Children's periodicals have been popular, as *Le Magasin d'éducation et récréation* (1864–1905), which published Jules Verne and was illustrated by Gustave Doré and J. L. E. Meissonier. "Comics" grew in favour, reaching a distribution of over 20,000,000 monthly at mid-20th century.

GERMANY

The *Acta eruditorum* (Leipzig, 1682–1731), the earliest of German periodicals, was not only limited in its choice of subjects to mathematics, physics and botany, but was also handicapped by the use of the Latin language. Nevertheless, such German men of science as Leibniz and the botanist Michael Ettmüller, combined to make the *Acta* a central meeting ground where the results of their researches might be read. The *Acta* had many imitators. Soon after the English periodicals of Addison and Steele had reached Hamburg, the Germans taking these, especially the *Spectator* and the *Guardian,* as models, brought out *Der Vernünftler* (1713), *Die lustige Fama* (1718) and *Discoursen der Maler* (1721). J. C. Gottsched's *Die vernünftigen Tadlerinnen* (1725–26) was the first women's journal. In 1759 F. Nicolai introduced his *Briefe, die neueste Literatur betreffend* to the world, and enlisted as collaborators Lessing and Moses Mendelssohn; it lasted six years. The *Frankfurter gelehrte Anzeigen* (1772–90), a successor of the *Franckfurtische gelehrte Zeitungen* (1736–71), followed a few years later and is chiefly interesting because Goethe wrote for it as a young man; the *Jenaische allgemeine Litteratur-Zeitung,* of which Goethe may be said to have acted as editor in chief, was issued in 1804–41. C. M. Wieland's *Der Teutsche Merkur* (1773–89) stands out as a literary periodical of the first importance, as does also the *Allgemeine Literatur-Zeitung* (1785–1849).

The periodicals issued in the various German states during the next 60 years displayed an ever-increasing political consciousness, and some indeed, such as the *Hallische Jahrbücher* (1838–43), received government support. The *Jahrbücher für wissenschaftliche Kritik* (1827–46), first published by J. F. Cotta, was a noteworthy publication of this period. By the end of the period politics had almost ousted literature from German reviews.

The revolution of 1848 was disastrous to the periodical press, and very few journals survived it. Developments in the later part of the 19th century followed much the same course as in England. Among the best-known journals of this time are the *Deutsche Rundschau* (1874), *Historische Zeitschrift* (1859), *Neue Rundschau* (1889), *Die Literatur* (1898–1942), *Deutsche Vierteljahrsschrift* (1923), *Erkenntnis* (1930–39).

The National Socialist revolution produced a further wave of suppressions, and the division of Germany into zones of occupation in 1945 resulted in many changes and gradual resumption of publication. By the 1950s some 4,000 periodicals were in course of publication. Among reviews were *Deutschland Review* (1949, Hamburg), *Die Besinnung* (1946, Nürnberg) and *Revue* (1948, Munich). *Spiegel* (1947, Hamburg) was a popular weekly; and among picture magazines were *Heute* (1945–51, Munich) and *Zeit und Bild* (1947, Frankfurt).

OTHER COUNTRIES

The Netherlands.—Apart from the journals of French origin already described, the earliest periodicals in the Netherlands were the *Examinator* (1719–20) and *Den Amsterdamschen Hermes* (1722–23). In 1837 *De Gids* was founded as the organ of liberal-

ism and at the same time of a new movement in literature and it remained an important review. *Haagsch Maandblad* (1924) is a literary monthly, and *Erasmus* (1933) an important scientific journal. There are many technical and class periodicals. The official *Radiogids* has a wide circulation.

Italy. — Conditions in Italy were long unfavourable to the growth of periodicals. Politics was not a safe subject for free comment, and the church interfered much in matters of science and literature as well as religion. Nevertheless, the *Journal des sçavans* had its imitator in Rome when Cardinal Ricci began to print *Giornale de' letterati* (1668–81); and Venice, always in the forefront in literary activities, issued the *Galleria di Minerva* (1696–1717). The rivalry, however, of both the academies and the princes acted as a continual curb, and the outlook of editors and writers remained circumscribed for a long period. G. Baretti, in *La Frusta letteraria* (1763–65), so mercilessly attacked the writers of Italy and even the ruling princes that after two years of precarious existence the *Frusta* was suppressed. *Il Caffé* (1764–66) was much influenced by French ideas. Important modern reviews have been *Nuova Antologia* (1866). Benedetto Croce's *La Critica* (1903–44), *Scientia* (1907), *La Rassegna italiana* (1918), *Rinascita* (1944) and *Italia contemporanea* (1953). *Scena Illustrata* (1865) is one of the oldest of illustrated monthlies. *Epoca* (1944) is a popular illustrated weekly.

Portugal.—*Jornal Enciclopedico* (1779–92) and *Jornal de Coinzbra* (1812–20) were the chief early Portuguese reviews. *Panorama* was largely historical and literary; Alexandre Herculano's historical tales were published in it. Most 19th-century journals were short-lived; but *Instituto* (1852) had a long life as a literary and scientific review, and *Naturalia* (1936) enjoyed wide acceptance.

U.S.S.R.—In Russia the Academy of Sciences led the way by the issue of *Yezhemyesyatchniiya Sochineniya* ("Monthly Works") (175j–64); and four years later the first private undertaking, the *Trudolyubivaya Pchela* ("Industrious Bee") (1759) with critical essays and translations from the *Spectator*, appeared. Few periodicals appeared in Russia until the 19th century, when the most representative magazines were the *Vestnik Evropy* (1802–30), edited by the historian N. M. Karamzin; the *Biblioteka dlya Chteniya* (1834–65), the first to obtain any commercial success; the *Sovremennik* (1836–66), founded by Pushkin; the *Russky Vestnik* (1856–1906), edited by the well-known publicist M. N. Katkov; the *Vestnik Evropy* (1866–1919), a continuation of the earlier *Vestnik*, to which the novelist Turgenev contributed; *Russkaya Misl* (1880–1927); *Letopis* (1915–17), edited by Maxim Gorky. The Bolshevik revolution produced a great upheaval and was responsible for an enormous output of periodicals of all kinds, but without any real freedom of the press. *Novyi Mir* ("New World") (1925) was one of the more important reviews of the Soviet regime. The Soviet publication system calls for the production of a journal in every major field of industry, technology, art. *Literaturnaia Gazetta* (1929) was the leading literary journal. Two periodicals were published from Moscow in English, German and French as well as in Russian — Soviet *Literature* (1932) and *Soviet Woman* (1945).

Scandinavian Countries. — The northern countries of Europe — Sweden, Norway and Denmark — have never lagged behind in the production of literature. The earliest periodical in Sweden was *Smanska Argus* (1732–34), a journal similar to the *Spectator*. Of modern magazines the following are worth mentioning: *Ord och Bild* (1892); *Nordisk Tidskrift* (1878), which prints historical and philosophical articles; *Nya Sverige* (1907–28), a conservative review; and the weekly *Idun* (1888). The first Norwegian periodical was *Ugentlige Korte Afhandlinger* (1760). *Samtiden,* begun by Gerhard Gran in Bergen in 1890 and moved to Oslo a decade later, was long the leading Norwegian journal. *Nye Tidender om lærde Sager* (1720–1837) was the earliest critical journal in Denmark. Leading 20th-century monthlies were *Tilskueren* (1884–1939), *Gads Danske Magasin* (1906), *Danske Magasin* (1952).

Spain. — In Spain the periodical came much later than in France, and it was in the beginning dependent on its French prototype. Political and religious censorship was as severe as it was in Italy. The earliest periodicals date from the middle of the 18th century, the best known being *Efemérides barometricomedicas matritenses* (1743–47) edited by Fernández Navarrete; the *Diario de los literatos de España* (1737–38); and *Memorial literario* (1784–1808).

Three early 19th-century periodicals are worth noting — *Miscelánea de Comercio* (1819), *Artes y literatura* (1819–21) and *El Censor* (1820–22). The influence both of the censorship and of the foreign periodical declined greatly during the regency of Maria Cristina (1833–41). Of a large number of reviews which began in the mid-19th century, mention may be made of the *Revista Ibérica* (1861–63), the *Revista de Cataluña* (Barcelona, 1862–63) and the *Revista de España* (1868–95). *España moderna* (1889–1914), *La Lectura* (1901–20), *Revista de Occidente* (1923–36; first edited by Ortega y Gasset) and *Gaceta literaria* (1927–32) were among the more important periodicals of the first quarter of the 20th century. The outstanding weekly was *Blanco y negro* (1891–1936). The *Revista hispano-americana de ciencias, letras y artes* (1921–36) was one of the better-known reviews of Latin-American interest published in Spain. Many Spanish periodicals fell victims to the strict censorship imposed by the Franco regime. *Mundo Hispánico* (1948) was a later monthly.

Switzerland. — The *Nova litteraria helvetica* (1703–15) of Zurich is the earliest literary periodical which Switzerland can show; followed by the *Bibliothèque italique* (1728–34) and the *Bibliothkque britannique* (1796–1815), both published at Geneva. The *Bibliothkque universelle* (1816) and *Revue suisse* (1838) amalgamated in 1858 as the *Bibliothèque universelle et revue suisse.* Among later periodicals may be mentioned *Revue mensuelle* (1897–1926); *Zwingliana* (1897); *Archives de psychologie de suisse romande* (1901) edited by Flournoy and Claparède; *Untersuchungen zur neueren Sprach- und Literaturgeschichte* (1903–12); *Revue de Genkve* (1920–24); and *Schweizerische Monatshefte* (1921). In the second half of the 20th century, leading monthlies were *Atlantis* (1929), *Schweitzer Journal* (1935) and *Gegenwart* (1939); and leading weeklies were *Schweitzer familien-Wochenblatt* (1881), *Patrie suisse* (1884), *Schweitzer illustrierte Zeitung* (1912) and *Weltwoche* (1933).

India. — The first Indian magazine was the *Oriental Magazine, or Calcutta Amusement* (1785–86). Several periodicals were conducted, usually for brief periods, by western missionaries. The *Hindustan Review* (1900, Patna) was founded and long edited by Sachschudananda Sinha, at Allahabad. The *Indian Review* (1900, Madras) was established by G. A. Natesan. In the course of India's economic development of the mid-20th century, a large number of professional, technical and industrial periodicals sprang up.

South Africa. — The *South African Journal* (1824, Cape Town) was the pioneer journal of this region. The periodicals of South Africa are chiefly centred in Cape Town and Johannesburg, and are largely trade and industrial journals of 20th-century growth.

Japan. — The Meiji restoration of 1868 brought a renaissance of culture and popular education in Japan and marked the beginning of magazines as distinct from newspapers. In the early 20th century the leading figure in the publication of Japanese magazines was Noma Seiji, whose nine periodicals nearly all had reached circulation in six figures. Many of the country's leading magazines survived World War II; and by the end of the occupation in 1952 there were more than 2,000 periodicals in course of publication, including popular miscellanies, women's journals, an interesting class of light literary reviews, magazines for youth and periodicals devoted to the stage, screen, radio. television and sports. There was a large group of small magazines devoted to verse. Weekly news magazines issued by leading newspapers had large circulations. Outstanding class periodicals were *Shufu No Tomo* ("Woman's Friend," 1917), *Yoiko No Tomo* ("Child's Friend," 1924) and *Shin Eiga* ("New Movies," 1938).

China. — The Christian missionaries William Milne, Robert Morrison and Liang A-fa established the first successful Chinese general magazine, under the title *Tsachihshu Maiyueh Tungchichuan* ("Chinese Monthly Magazine"). Printed in Malacca, it was circulated in Chinese territory (1815–22). The first to be published in China itself came from Canton in 1833, was moved to

Singapore four years later and published there for a decade; it was called *Tunghsiyankao Maiyueh Tungchichuan* ("Eastern-Western Monthly Magazine") and was founded by Charles Gutlaff, a missionary, but in 1837 it was taken over by the Society for the Diffusion of Useful Knowledge, a British institution. Various and numerous periodicals offering religious, philosophical, literary and scientific matter were published in the chief Chinese cities in the 19th century; but it was not until the period of Liang Chi-chao and his fellow reformers and publicists, beginning in the second decade of the 20th century, that modern periodicals came into wide circulation. Liang himself was editor, usually for brief periods, of, eight different periodicals. Among long-lived magazines were *Tung-fang Tsa-chih* ("Eastern Miscellany," 1904) and *Chiao-yü Tsa-chih* ("Educational Miscellany," 1908). The Communist revolution of 1949 resulted, after a few years, in wider distribution of periodicals than formerly; but these were controlled by the government and highly propagandist.

Central and South America.— Early gazettes and journals in Central and South American countries often partook of the nature of magazines, being miscellaneous in character; but not until the 20th century did periodicals as such flourish. By that time colour printing had been well developed, and illustrated weeklies and monthlies were widely popular. The largest Cuban magazine was the attractively illustrated *Bohemia* (1911), a weekly. In Mexico the leader was *La Familia* (1931), a fortnightly. In Brazil were two outstanding magazines in the Portuguese language—Eu *Sei Tudo* (1920), a general monthly; and *Vida Domestica* (1920), a women's journal. Argentina had many more magazines than any other South American country, as well as wider readership. *Maribel* (1932), rotogravure weekly miscellany, boasted at mid-20th century a larger circulation than any other South American magazine, though *Para Ti* (1922), also of Buenos Aires, a women's weekly, was a close second. (C. T. H. W.; F. L. K.; F. L. MT.).

UNITED STATES

The first American magazines were two Philadelphia, Pa., publications that dated their first numbers Jan. 1741. Actually first to appear was Andrew Bradford's *American Magazine*, followed in three days by Benjamin Franklin's *General Magazine*. The former lasted three months and the latter six. About 100 magazines were founded in the Colonies, most of them very short-lived. Outstanding were three Philadelphia periodicals—the *Pennsylvania Magazine* (1775–1776), edited by Thomas Paine; the *Columbian Magazine* (1786–92), called the *Universal Asylum* in its last two or three years; and Mathew Carey's *American Museum* (1787–92). Also important were Isaiah Thomas' *Royal American Magazine* (1774–75) and *Massachusetts Magazine* (1789–96); and Thomas and James Swords' *New-York Magazine* (1790–97).

More than 500 periodicals were published for shorter or longer periods in the first quarter of the 19th century; nearly 100 were being issued in 1825. There was marked development in weekly miscellanies supported by literary coteries in many cities and towns; in periodicals for women and children; in religious journals and those devoted to such reforms as antislavery and temperance; in medical, legal and agricultural journals; and in theatrical and comic papers. This class journalism increased tremendously in the next 25 years, so that by mid-19th century there were about 600 periodicals in course of publication.

Outstanding monthlies were *Godey's Lady's Book* (1830–98, Philadelphia), famous for its stenciled coloured fashion plates; *Graham's Magazine* (1826–58, Philadelphia), which began as the *Casket;* the *Southern Literary Messenger* (1834–64, Richmond, Va.); and the *Knickerbocker Magazine* (1833–65, New York city). Chief quarterlies were the *North American Review* (1815–1940), which developed from the *Monthly Anthology* (1803–11, Boston, Mass.) and had a famous line of editors, including Jared Sparks, Edward Everett, James Russell Lowell, Henry Adams, and George B. M. Harvey; *The Dial* (1840–44), famous transcendental magazine edited by Margaret Fuller, Thoreau and Emerson; and *De Bow's Review* (1846–80, New Orleans, La.). Notable weeklies were the *Youth's Companion* (1827–1929), a family periodical with a long line of famous contributors; and the *Saturday Evening Post,* founded in 1821, but brought to its later pre-eminence as a popular weekly after its purchase by Cyrus H. K. Curtis in 1897.

A **New Era, 1850.—A** new era began with the founding of *Harper's New Monthly Magazine* in New York city in 1850, with copious woodcut illustration, 144 pages and English fiction serials. A worthy competitor came in 1870, *Scribner's Monthly,* later the *Century* (1881–1930). *Scribner's Magazine* (1887–1939) was another quality illustrated monthly. By 1890 these richly illustrated general magazines surpassed anything of the kind ever before known in any country. The *Atlantic Monthly,* Boston, without illustrations, began its distinguished literary career in 1857, under Lowell's editorship. William Dean Howells, Thomas Bailey Aldrich, Walter Hines Page and Ellery Sedgwick were among its editors. Other famous monthlies of the latter 19th century were the *Galaxy* (1866–78), New York; *Overland Monthly* (1868–1935), San Francisco, whose first editor was Bret Harte; *Forum* (1886–1940), New York; *Lippincott's Magazine* (1868–1916), Philadelphia; and *Frank Leslie's Popular Monthly,* New York, which began in 1876 and from 1906 to 1956 was published as the *American Magazine.* Three prominent New York weeklies were *Harper's Weekly* (1857–1916); *The Nation,* founded by Edwin Lawrence Godkin in 1865; and *Outlook* (1870–1935), which began as *Christian Union* under Henry Ward Beecher's editorship. By 1870 there were about 1,200 periodicals in the United States, close to 2,400 in 1880, and nearly 3,000 by 1890. The great majority of these were class journals, serving business, industry and the professions.

In the 1890s came the high-class illustrated monthlies selling for 10 or 15 cents in place of the 35 cents asked by the "quality" magazines. The only one of this spectacular group to survive was the *Cosmopolitan,* founded in 1886 by John Brisben Walker; others were *McClure's Magazine* (1893–1933), *Munsey's Magazine* (1889–1929) and *Everybody's Magazine* (1899–1929). These, with the *Arena* (1889–1909), of Boston, and the weekly *Collier's* (1888–1957), were leaders in the muckraking which exposed corruption in municipal government, finance, etc., throughout the decade 1902–12. Leading muckrakers for *McClure's* were Lincoln Steffens. Ida M. Tarbell and Ray Stannard Baker, who later took over the ailing *Frank Leslie's Popular Monthly* and renamed it the *American Magazine.*

Later Magazines.— In 1922 *Reader's Digest* began as a pocket-size, adless magazine containing condensations of articles from other periodicals. By mid-century it had attained the largest circulation of any single serial publication ever known, said to be about 21,000,000 monthly, including editions distributed in most foreign countries and printed in 13 languages. It began to accept advertising ($26,500 a black and white page) in 1955. Other "digests" and pocket-size periodicals had more modest successes.

Time was founded in 1923 by Briton Hadden, who died in 1929, and Henry R. Luce. A weekly news magazine, its success had a considerable effect on the art of reporting. *Newsweek,* founded in 1933, was the most successful of its followers. In 1936 Time, Inc., launched a weekly picture magazine whose title, *Life,* was purchased from the satirical weekly (founded 1883) which had just suspended. The new *Life* made a great success and had many imitators, chief of which was the fortnightly *Look* (founded 1937).

Prominent among U.S. periodicals in the 20th century were the great illustrated magazines for women, such as *Ladies' Home Journal,* founded by Cyrus H. K. Curtis in 1883, and becoming famous in the 1890s under the editorship of Edward Bok; *Harper's Bazaar,* founded in 1867 by Fletcher Harper; *McCall's Magazine,* founded as a fashion journal in 1870; *Woman's Home Companion,* founded in Cleveland, O., as *Home Companion* in 1873 and discontinued with the number for Jan. 1957; *Good Housekeeping,* founded in Holyoke, Mass., in 1885; and Condé Nast's *Vogue,* founded in 1892, which absorbed *Vanity Fair* (1889) in 1936. A 20th-century success was *Better Homes and Gardens,* Des Moines, Ia., founded in 1922.

There were about 7,000 periodicals in the course of publication in the United States by the late 1950s.

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(F. L. MT.)

PERIODIC LAW. Dmitri I. Mendeléyev discovered in the mid-19th century that the chemical elements show a periodic recurrence of properties when they are arranged in a certain order, which is approximately the order of increasing atomic weight. The statement of this fact, which has been of inestimable value in the development of the science of chemistry, is called the periodic law; and a tabular arrangement of the elements which brings those with similar properties into juxtaposition is called the periodic table or periodic system of the elements.

It was recognized during the second decade of the 20th century that the order of elements in the periodic system is that of their atomic numbers, the integers which are equal to the positive electrical charges of the atomic nuclei expressed in electronic units; and in recent years great progress has been made in explaining the periodic law in terms of the electronic structure of atoms and molecules. This clarification has increased the value of the law, which is used as much today as it was at the beginning of the 20th century, when it expressed the only known relationship among the elements.

History of the Periodic Law.—The classification of the chemical elements is a comparatively recent problem, for it was not until about the beginning of the 19th century that the two kinds of chemical substances, elements and compounds, were clearly differentiated. The early years of the century witnessed a rapid development in analytical chemistry—the art of distinguishing different chemical substances—and the consequent building up of a vast body of knowledge of the chemical and physical properties of both elements and compounds. This rapid expansion of chemical knowledge soon necessitated classification, for on the classification of chemical knowledge are based not only the systematized literature of chemistry but also the laboratory arts by which chemistry is passed on as a living science from one generation of chemists to another. The elementary substances are few in number, about 100, with distinctive properties, whereas compound substances are extremely numerous, with properties correspondingly diversified and often overlapping. It thus occurred that the classification of elements lagged many years behind that of compounds, and, in fact, no general agreement had been reached among chemists as to the classification of elements for nearly half a century after the systems of classification of compounds had become established in general use.

J. W. Döbereiner in 1817 showed that the combining weight of strontium lies midway between those of calcium and barium, and some years later he showed that other such "triads" exist (chlorine, bromine and iodine; and lithium, sodium and potassium). J. B. A. Dumas, L. Gmelin, E. Lenssen, Max von Pettenkofer and J. P. Cooke expanded Döbereiner's suggestions between 1828 and 1854 by showing that similar relationships extended further than the triads of elements, fluorine being added to the halogens, and magnesium to the alkaline-earth metals; while oxygen, sulfur, selenium and tellurium were classed as one family; and nitrogen. phosphorus, arsenic, antimony and bismuth as another family of elements.

Attempts were subsequently made to show that the atomic weights of the elements could be expressed by an arithmetical function, and in 1862 A. E. B. de Chancourtois proposed a classification of the elements based on the new values of atomic weights given by Stanislao Cannizzaro's system of 1858. De Chancourtois plotted the atomic weights on a helical curve such that corresponding points differed by 16, the atomic weight of oxygen. This curve brought closely related elements on to corresponding points, and he suggested in consequence that "the properties of the elements are the properties of numbers," a remarkable prediction in the light of modern knowledge.

In the following year, 1863, J. A. R. Newlands proposed a system of classification of the elements in the order of atomic weights, the elements being assigned ordinal numbers from unity upward and divided into seven groups having properties closely related to the first seven known elements, hydrogen, lithium, beryllium, boron, carbon. nitrogen and oxygen. This relationship was termed the law of octaves, by analogy with the seven intervals of the musical scale. Then in 1869 Mendeléyev, as a result of an extensive correlation of the properties and the atomic weights of the elements, with special attention to valency, proposed the periodic law, by which "the elements arranged according to the magnitude of atomic weights show a periodic change of properties." Lothar Meyer had independently reached a similar conclusion, which he published after the appearance of Mendeléyev's Russian paper and of an account of it in German. (See VALENCE.)

Mendeléyev's periodic table of 1869 contained 17 columns, with two nearly complete periods (sequences) of elements, from potassium to bromine and rubidium to iodine (see Table III), preceded by two partial periods of seven elements each (lithium to fluorine and sodium to chlorine), and followed by three incomplete periods. In his 1871 paper Mendeléyev presented a revision of the 17-

TABLE I.—The Short-Period Form of the Periodic System of the Elements

Group O	I a	I b	II a	II b	III a	III b	IV a	IV b	V a	V b	VI a	VI b	VII a	VII b	VIII
	H 1														
He															
2	Li 3		Be 4		B 5			C 6		N 7		O 8		F 9	
Ne 10	Na 11		Mg 12		Al 13			Si 14		P 15		S 16		Cl 17	
Ar 18	K 19	Cu 29	Ca 20	Zn 30	Sc 21	Ga 31	Ti 22	Ge 32	V 23	As 33	Cr 24	Se 34	Mn 25	Br 35	Fe 26, Co 27, Ni 28
Kr 36	Rb 37	Ag 47	Sr 38	Cd 48	Y 39	In 49	Zr 40	Sn 50	Cb 41	Sb 51	Mo 42	Te 52	Tc 43	I 53	Ru 44, Rh 45, Pd 46
Xe 54	Cs 55	Au 79	Ba 56	Hg 80	57–71*	Tl 81	Hf 72	Pb 82	Ta 73	Bi 83	W 74	Po 84	Re 75	At 85	Os 76, Ir 77, Pt 78
Rn 86	Fr 87		Ra 88		Ac 89		Th 90		Pa 91		U 92		Np 93		Pu 94, Am 95, Cm 96

*Lanthanum and the lanthanous.

group table, the principal improvement being the correct repositioning of 17 elements. He, as well as Lothar Meyer, also proposed a table with eight columns, obtained by splitting each of the long periods into a period of seven. an eighth group containing the three central elements (such as iron, cobalt, nickel; MendelCyev also included copper, instead of placing it in group I), and a second period of seven. The first and second periods of seven were later distinguished by use of the letters "a" and "b" attached to the group symbois, which were the Roman numerals.

With the discovery of the inert gases helium, neon, argon, etc., by Lord Rayleigh and Sir William Ramsay in 1894 and the following years, MendelCyev and others proposed that a new "zero" group to accommodate them be added to the periodic table. The "short-period" form of the periodic law, with groups 0, I. II, . . . VIII, became popular, and remained in general use until recent years. A new table, devised in 1895 by J. Thomsen, was interpreted in terms of the electronic structure of atoms by Niels Bohr in 1922. In this table, Table II, there are periods of increasing length, each extending from one noble gas to the next noble gas; the table thus contains a period of 2 elements, two periods of 8 elements, two periods of 18 elements, a period of 32 elements and an incomplete period. The elements in each period are connected by tie-lines with corresponding elements in the following period. The principal disadvantage of this periodic table is the large space required by the period of 32 elements and the difficulty of tracing a sequence of closely similar elements along the slanting tie-lines. A very satisfactory compromise, shown in Table III, is to compress the period of 32 elements into 18 spaces by omitting the 14 rare earths, or lanthanons, which are indicated below. This form of the periodic table is the work of T. Bayley (1882).

The great value of the periodic law was made evident by Mendeléyev's success in 1871 in finding that, by changing 17 elements from the positions indicated by the atomic weights which had been accepted for them into new positions, their properties could be correlated with those of other elements. This change indicated that there were small errors in the previously accepted atomic weights of several of the elements, and large errors for several others, for which wrong multiples of the combining weights had been used as atomic weights. MendelCyev was also able to predict the existence and many of the properties of the undiscovered elements eka-boron, eka-aluminum, eka-silicon, eka-manganese, dvi-manganese and eka-tantalum, now identified with the elements scandium, gallium, germanium, technetium, rhenium and protactinium, respectively. Similarly, after the discovery of helium and argon, the periodic law permitted the prediction of the existence of neon, krypton, xenon and radon. Moreover, Bohr pointed out that element 72 would be expected, from its position in the periodic system, to be similar to zirconium in its properties rather than to the rare earths; this observation led G. von Hevesy and D. Coster in 1922 to examine zirconium ores and to discover the missing element, which they named hafnium.

Many of the elements in the MendelCyev and Lothar Meyer periodic tables of 1871 were required by their properties to be put in positions somewhat out of the order of atomic weights. Most of these displacements have been rectified by redeterminations of the atomic weights; three, however, remain, and are real. In the three pairs of elements argon and potassium, cobalt and nickel, and tellurium and iodine, the first element of each pair has the greater atomic weight, but the earlier position in the periodic system. The solution of this difficulty had been indicated by Newlands, who had assigned the successive ordinal numbers to the elements arranged approximately according to atomic weight.

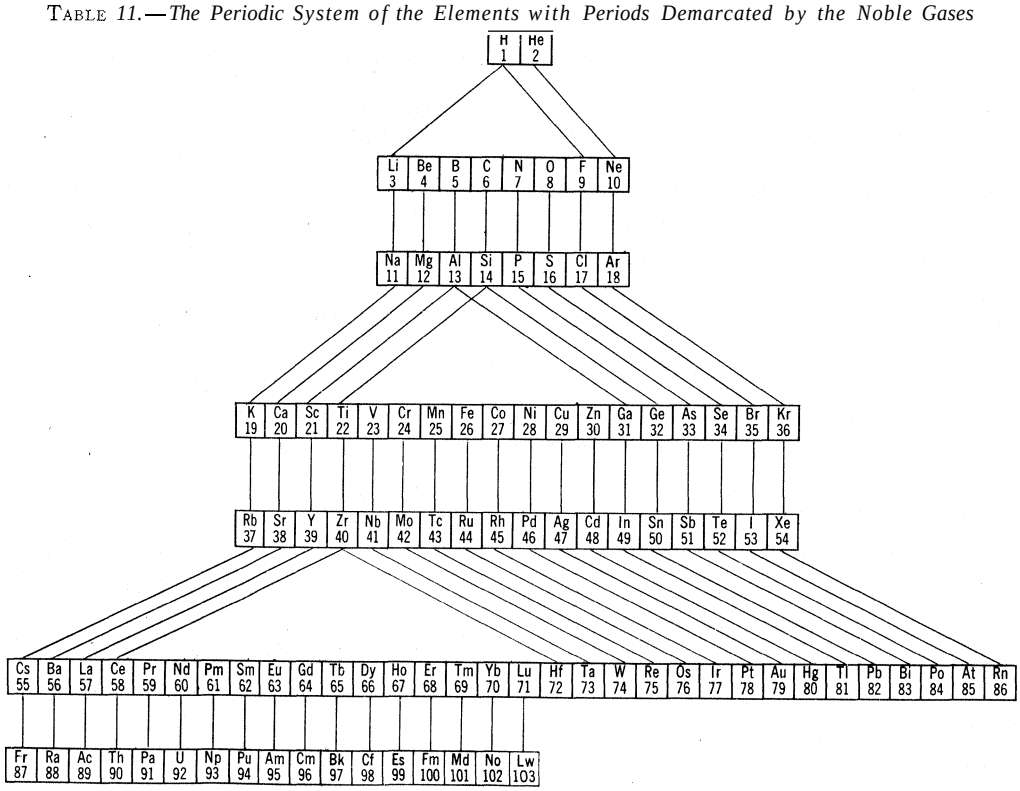
Ernest Rutherford's experiments on the scattering of alpha particles by the nuclei of heavy atoms led to the determination of the nuclear electrical charge. The ratio of the nuclear charge of the electron was noted to be roughly one-half the atomic weight. In 1911 A. van den Broek suggested that this quantity, the atomic number, might be identified with the ordinal number of the element in the periodic system. This suggestion was brilliantly confirmed in 1913 by H. G. J. Moseley's measurements of the wave lengths of the characteristic X-ray spectral lines of many elements. There is no longer any uncertainty about the position of any element in the ordered series of the periodic system. All of the elements from 1 to 103 are now known, and it is to be expected that new elements beyond 103 will be made by nuclear reactions.

The small significance of the exact atomic weight of an element to its position in the periodic system is shown by the existence of isotopes (*q.v.*) of every element, atoms which have the same atomic number but different atomic weights. The chemical properties of the different isotopes of an element are essentially the same, and all of the isotopes of an element occupy the same place in the periodic system.

The detailed understanding of the periodic system has developed along with the quantum theory of spectra and the electronic structure of atoms, beginning with the work of Bohr in 1913. Important forward steps were the formulation of the general rules of the old quantum theory by W. Wilson and A. Sommerfeld in 1917, the discovery of the exclusion principle by W. Pauli, Jr., in 1925, the discovery of the spin of the electron by G. E. Uhlenbeck and S. Goudsmit in 1925, and the development of quantum mechanics by W. Heisenberg and E. Schrodinger during the same year. The development of the electronic theory of valence and molecular structure, beginning with the discovery of the shared electron pair by G. N. Lewis in 1916, also played a very important part in explaining the periodic law.

MendelCyev stated that a natural law acquires scientific impor-

TABLE 11.—*The Periodic System of the Elements with Periods Demarcated by the Noble Gases*



tance only when it yields practical results in elucidating unexplained phenomena, in disclosing unrecognized occurrences and in evoking verifiable predictions. The periodic law has been found to be very useful indeed in the simplification of the science of chemistry through the classification of the elements; in the determination of the correct multiples of equivalent weights to be taken as the atomic weights of elements; in indicating errors in atomic weights; in the prediction of the existence and properties of new elements; and especially as a basis for chemical reasoning and prediction in the planning of experimental work. Its value has increased with increasing understanding of the law and its basis in the electronic structure of atoms, and it has now become one of the firm foundation stones of the great edifice of science.

Survey of the Elements in Relation to the Periodic System.—The long-period form of the periodic system, Table III, is used as the basis of the discussion which follows. This table has the great advantage over the short-period form, Table I, that it does not confuse the user by placing in the same group such dissimilar elements as the halogens and manganese and its congeners. It is also more useful and in some respects more satisfactory than Table II, the periodic system with groups demarcated by the noble gases. In particular, the condensation of the very long period, cesium, 55, to radon, 86, by the omission of the rare-earth metals permits the closely related elements such as copper, silver and gold to be placed close together in a compact column.

The long-period form of the periodic system of the elements, Table III, contains all of the chemical elements which have as yet been discovered or made, arranged, in the order of their atomic numbers, in seven horizontal periods, with the rare-earth metals (cerium, 58, to lutecium, 71) and the actinons (thorium, go, to lawrencium. 103) indicated separately below. The periods are of varying lengths. First, there is the hydrogen period, consisting of the two elements hydrogen, 1, and helium, 2. Then there are two periods of eight elements each: the first short period, from lithium, 3, to neon, 10; and the second short period, from sodium, 11, to argon, 18. There follow two periods of 18 elements each: the first long period, from potassium, 19, to krypton, 36; and the second long period, from rubidium, 37, to xenon, 54. The very long period of 32 elements, from cesium, 55, to radon, 86, is condensed into 18 columns by the omission of the 14 lanthanons (which are indicated separately below), permitting the remaining 18 elements, which are closely similar in their properties to corresponding elements of the first and second long periods, to be placed directly below these elements. The last period, extending from francium, 87, to lawrencium, 103, is incomplete. The properties of these elements indicate that this period is a second very long period of 32 elements. The elements from thorium to uranium are indicated in the table in two places: first, below the elements hafnium to tungsten respectively, to which they show considerable similarity in properties; and second, below the corresponding lanthanons.

The six noble gases, helium, neon, argon, krypton, xenon and radon, occur at the ends of the six completed periods, and constitute the 0 group of the periodic system. For convenience, this group is repeated at the left side of Table III. The seven elements lithium to fluorine and the seven corresponding elements sodium to chlorine are placed in the seven groups, I, II, III, IV, V, VI and VII, respectively. Each of these seven groups is joined by tie-lines with two elements of the first long series. The 17 elements from potassium, 19, to bromine, 35, are distinct in their properties, and might well be considered to constitute 17 subgroups of the periodic system. Largely for historical reasons (the use of the short-period form of the periodic system, Table I), however, it is customary to describe them as constituting 15 subgroups, the three consecutive elements iron, cobalt and nickel and their congeners in the succeeding periods being placed in a single group, VIII. The elements potassium, 19, to manganese, 25, are assigned to subgroups Ia, IIa. IIIa, IVa, Va, VIa and VIIa respectively; and the elements copper, 29, to bromine, 35, are assigned to subgroups Ib to VIIb, respectively.

It is customary to consider the first group, that of the alkali metals, as including, in addition to lithium and sodium, the metals of subgroup Ia (potassium, etc.), but not the much less similar metals of subgroup Ib (copper, etc.). Also the second group, the alkaline-earth metals, is considered to include beryllium, magnesium, calcium, strontium, barium and radium, but not the elements of subgroup IIb. The properties of the elements do not indicate unambiguously whether the boron group might be better considered to include the subgroup IIIa or the subgroup IIIb. The other four groups include the corresponding "b" subgroups: the carbon group, IV, consists of carbon, silicon, germanium, tin and lead; the nitrogen group, V, includes nitrogen, phosphorus, arsenic, antimony and bismuth; the oxygen group, VI, includes oxygen, sulfur, selenium, tellurium and polonium; and the halogen group, VII, includes fluorine, chlorine, bromine, iodine and astatine. The proposed inclusion of potassium and its congeners with lithium and sodium as group I is indicated in the table by representing the subgroup by the symbol I(a), and similarly for II(a), IV(b), V(b), VI(b) and VII(b). The ambiguity for group III, which is considered by about equal numbers of authorities to include scandium and its congeners, on the one hand, and gallium and its congeners, on the other, is not resolved in this table. Possibly Table III would be improved by deleting the tie-lines from I to Ib, II to IIb, IV to IVa, V to Va, etc.

Hydrogen is indicated by tie-lines to be related to both the alkali-metal group and the halogen group. In its chemical properties it is not closely similar to either the alkali metals or the halogens. However, it is assigned the oxidation number +1 in its compounds such as HF, and −1 in its compounds such as LiH; and it may hence be considered as being similar to a group I element and to a group VII element, respectively, in compounds of these two types, taking the place first of Li and then of F in LiF. Hydrogen is, in fact, the most individualistic of the elements: no other element resembles it in the way that sodium resembles lithium, chlorine resembles fluorine, and neon resembles helium. It is a unique element, the only element that cannot conveniently be considered a member of a group.

Ten of the elements of each long period are called the transition metals. These are usually taken to be scandium, 21, to zinc, 30 (the iron-group transition metals); yttrium, 39, to cadmium, 48 (the palladium-group transition metals); and hafnium, 72, to thallium, 81 (the platinum-group transition metals).

The periodicity in properties of the elements arranged in order of atomic number is strikingly shown by the consideration of the physical state of the elementary substances and such related properties as the melting point, density and hardness. The elements of group 0 are difficultly condensable gases. The alkali metals, in group I, are soft, metallic solids with low melting points. The alkaline-earth metals, in group II, are harder and have higher melting points than the adjacent alkali metals. The hardness and melting point continue to increase through groups III and IV, and then decrease through groups V, VI and VII. The elements of the long periods show a gradual increase in hardness and melting point from the beginning alkali metals to the centre of the period (cobalt, rhodium, iridium), and then a fairly regular decrease to the halogens and noble gases.

The valence of the elements is closely correlated with position in the periodic table, the elements in the principal groups having maximum positive valence (oxidation number) equal to the group number; and maximum negative valence equal to the difference between eight and the group number.

The general chemical properties described as metallic or base-forming, metalloid or amphoteric, and nonmetallic or acid-forming are correlated with the periodic table in a simple way: the most metallic elements are to the left and to the bottom of the periodic table; and the most nonmetallic elements are to the right and to the top (ignoring the unreactive noble gases). The metalloids are adjacent to a diagonal line from boron to polonium. A closely related property is electronegativity, the tendency of atoms to retain their electrons and to attract additional electrons, as shown by ionization potential, electron affinity, oxidation-reduction potential, the energy of formation of chemical bonds with other elements and other properties. The electronegativity depends upon position in the periodic table in the same way as nonmetallic character, fluorine

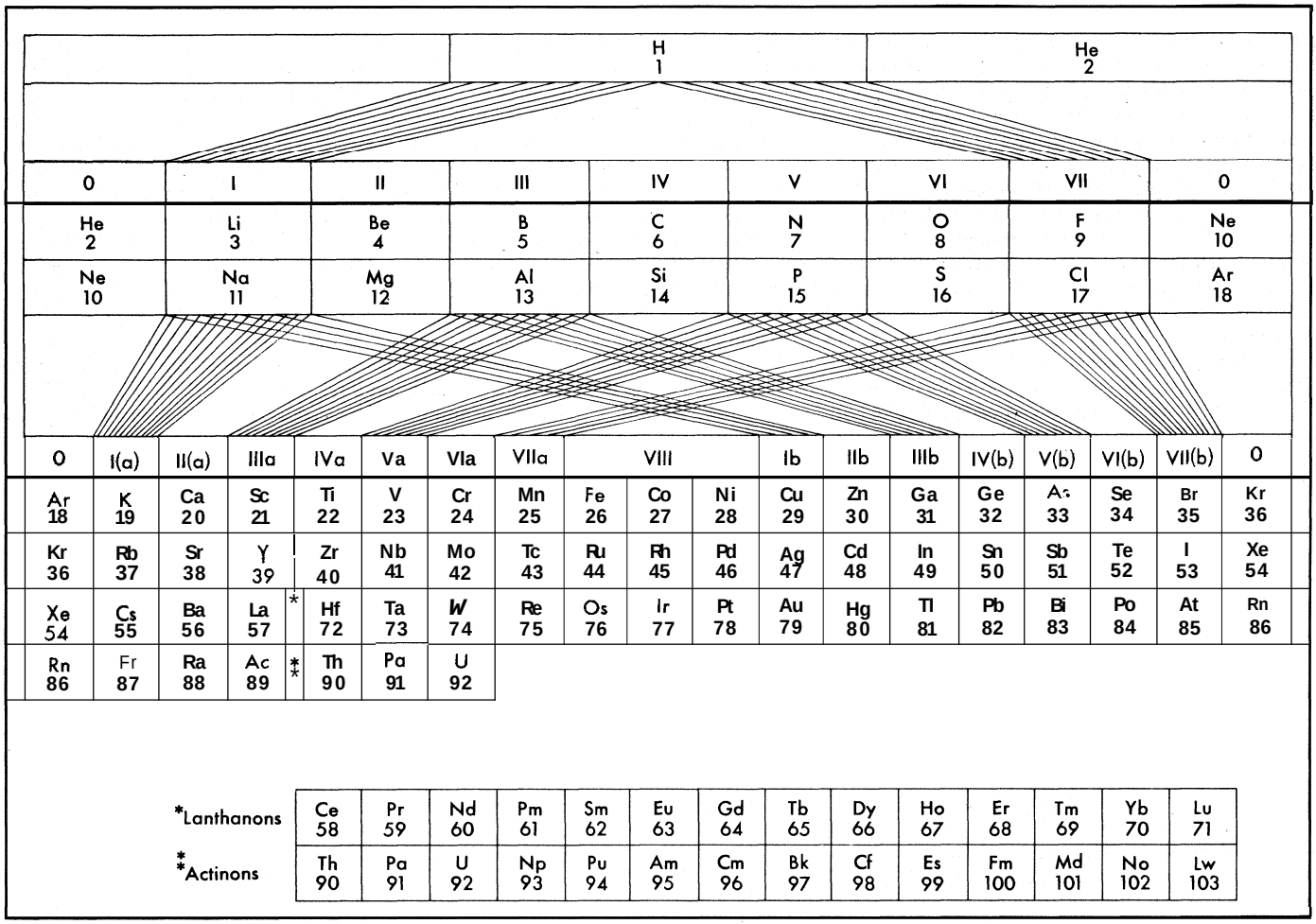


TABLE 111.—The Periodic System of the Elements

being the most electronegative element and cesium (or francium) the least electronegative (most electropositive) element.

The sizes of atoms vary regularly through the periodic system. Thus the effective bonding radius in the elementary substances in crystalline or molecular form decreases through the first short period from 1.52 Å (Angstrom unit $= 10^{-8}$ cm.) for lithium to 0.73 Å for fluorine, then rises abruptly to 1.86 Å for sodium, and gradually decreases through the second short period to 0.99 Å for chlorine. The behaviour through the long periods is more complex: the bonding radius decreases gradually from 2.31 Å for potassium to a minimum of 1.25 Å for cobalt and nickel, and then rises slightly, and falls to 1.14 A for bromine. The sizes of atoms are of importance in the determination of co-ordination number, and hence of the composition of compounds. The increase in atomic size from the upper right corner of the periodic table to the lower left corner is reflected in the formulas of the oxygen acids of the elements in their highest states of oxidation, as shown in Table IV.

TABLE IV.—*Formulas of Oxygen Acids of Elements in their Highest Oxidation State*

$H_2Be(OH)_4$	H_3BO_3	H_2CO_3	HNO_3		
	$HAl(OH)_4$	H_4SiO_4	H_3PO_4	H_2SO_4	$HClO_4$
		H_4GeO_4	H_3AsO_4	H_2SeO_4	
		$H_2Sn(OH)_6$	$HSb(OH)_6$	H_6TeO_6	HIO_4
				and	and
				H_2TeO_4	H_5IO_6

The smallest atoms group only three oxygen atoms about themselves; the next larger atoms, which co-ordinate a tetrahedron of four oxygen atoms, are in a diagonal belt; and the still larger atoms, which form octahedral oxygen complexes (stannic acid, antimonic acid, telluric acid, paraperiodic acid), lie below and to the left of this belt.

It is only the chemical and physical properties of the elements that are determined by the extranuclear electronic structure which show the periodicity described in the periodic law. The properties of the atomic nuclei themselves, such as the magnitude of the packing fraction and the power of entering into nuclear reactions, are, although dependent upon the atomic number, not dependent in the same periodic way.

The Electronic Structure of Atoms as the Basis of the Periodic System.—The noble gases, helium, neon, argon, krypton, xenon and radon, have a striking chemical property—that of forming no chemical compounds. It would be surmised that this property depends upon their possession of especially stable electronic structures. During the development of modern atomic physics and the theory of quantum mechanics, a precise and detailed understanding has been obtained of the electronic structure of the noble gases and other atoms which explains the periodic law in a thoroughly satisfactory manner.

The Pauli exclusion principle states that no more than two electrons can occupy the same orbit (or, in wave-mechanical language, orbital) in an atom, and that these two electrons in the same orbital must be paired; that is, must have their spins opposed. The orbitals in an atom may be described by a total quantum number, n, which may assume the values 1, 2, 3, . . . ; and an azimuthal quantum number, l, which may assume the values 0, 1, 2, . . . , $n - 1$. There are $2l + 1$ distinct orbitals for each set of values of n and l. The most stable orbitals, which bring the electron closest to the nucleus, are those with the smallest values of n and l. The electrons which occupy the orbital with $n = 1$ (and $l = 0$) are said to be in the K shell of electrons; the L, M, N, . . . shells correspond respectively to $n = 2, 3, 4, \ldots$. Each shell except the K shell is divided into subshells corresponding to the values 0, 1, 2, 3, . . . of the azimuthal quantum number l; these subshells are called the s, p, d, f. . . . subshells, and they can accommodate a maximum of 2, 6, 10, 14, . . . electrons.

The approximate order of stability of the successive subshells in

an atom is indicated by the above figure. The most stable shell, the K shell, is completed at helium, with two electrons. The L shell is then completely filled at neon, with atomic number 10. The atoms of the heavier noble gases do not, however, have a completed outer shell, but instead, completed s and p subshells; *i.e.*, an outer shell of eight electrons, called an octet of electrons. The d subshells and f subshells are also filled with electrons after the less stable orbitals are occupied.

The electron occupancy of the shells in the noble gas atoms is:

Electrons in	K	L	M	N	O	P	Q	shell
He 2:	2							
Ne 10:	2	8						
Ar 18:	2	8	8					
Kr 36:	2	8	18	8				
Xe 54:	2	8	18	18	8			
Rn 86:	2	8	18	32	18	8		
118:	2	8	18	32	32	18	8	

The numbers 2, 8, 18 and 32 correspond to filling the s; s and p; s, p and d; and s, p, d and f subshells, respectively.

The first period of the periodic table is complete at helium, when the K shell is filled with two electrons. The first and second short periods represent the filling of the 2s and 2p subshells (completing the L shell at neon), and the 3s and 3p subshells (at argon), leaving the M shell incomplete. The first long period begins by the introduction of electrons in the 4s orbital. Then at scandium the five 3d orbitals of the inner M shell begin to be occupied. It is the successive occupancy of these five 3d orbitals by their complement of ten electrons that characterizes the ten elements of the iron-group transition series.

At krypton the M shell is complete and there is an octet in the N shell. The second long period, of 18 elements, similarly represents the completion of an outer octet and the next inner subshell of 10d electrons.

The very long period of 32 elements results from the completion of the 4f subshell of 14 electrons, the 5d subshell of 10 electrons, and the 6s, 6p octet. The filling of the 4f orbitals corresponds to the sequence of 14 lanthanons, and that of the 5d orbitals to the 10 platinum-group transition metals.

The next period, which is incomplete, involves the 5f subshell of 14 electrons, the 6d subshell of 10 electrons, and the 7s, 7p octet. The filling of the 5f orbitals corresponds to the actinons, the elements beginning with thorium, 90.

The successive periods of the system hence correspond to the introduction of electrons into the following orbitals:

The very short period, H, He.	2	elements. 1s.
The first short period, Li to Ne.	8	elements. 2s, 2p.
The second short period, Na to Ar.	8	elements. 3s, 3p.
The first long period, K to Kr.	18	elements. 3d, 4s, 4p.
The second long period, Rb to Xe.	18	elements. 4d, 5s, 5p.
The very long period, Cs to Rn.	32	elements. 4f, 5d, 6s, 6p.
The incomplete period, Fr to 118.	32	elements. 5f, 6d, 7s, 7p.

There are advantages to replacing the K. L, M, . . . shells by a different grouping of the subshells, in which those with nearly the same energy are grouped together, in close correlation with the periodic system. The new set of shells is the following:

The helium shell.	2	electrons. 1s.
The neon shell.	8	electrons. 2s, 2p.
The argon shell.	8	electrons. 3s, 3p.
The krypton shell.	18	electrons. 4s, 4p, 3d.
The xenon shell.	18	electrons. 5s, 5p, 4d.
The radon shell.	32	electrons. 6s, 6p, 5d, 4f.
The eka-radon shell.	32	electrons. 7s, 7p, 6d, 5f.

(See ATOM.)

The Properties of the Elements of the Main Groups.— The periodicity of properties of the elements is caused by the periodicity in electronic structure. The noble gases are all chemically unreactive because their electronic structures are stable— their atoms hold their quota of electrons strongly, have no affinity for more electrons, and have no tendency to share electrons with other atoms. An element close to a noble gas in the periodic system, on the other hand, is reactive chemically because of the possibility of assuming the stable electronic configuration of the noble gas, by losing one or more electrons to another atom, by gaining one or more electrons from another atom, or by sharing electrons. *(See* VALENCE.) The alkali metals, in group I, can assume the noble-gas configurations by losing one electron, which is loosely held in the outermost (valence) shell, to another element with greater electron affinity, thus producing the stable singly charged positive ions. Similarly the alkaline-earth metals can form doubly charged positive ions with the noble-gas electronic configurations by losing the two loosely held electrons of the valence shell; the positive ionic valences of the elements of the first groups are hence equal to the group numbers. The elements just preceding the noble gases can form negative ions with the noble gas configurations by gaining electrons; the negative ionic valences of these elements are equal to the difference between eight and their group numbers.

The covalence of an atom is also determined by its electron number and the stable orbitals available to it. An atom, such as fluorine. with seven electrons in its outer shell can combine with a similar atom by sharing a pair of electrons with it, thus achieving the noble-gas configuration, with three unshared pairs and one shared electron pair in the valence shell,

The properties of elements in the same group of the periodic system are, although similar, not identical. The trend in properties from the lighter to the heavier elements may be attributed to changes in the strength of binding of the outer electrons and especially to the increasing size of the atoms.

The Transition Elements.— The nature of the three transition groups can be discussed with the iron group as an example, the other two groups being similar.

In potassium and calcium the valence electrons, outside of the argon shell, occupy the 4s orbital. Additional valence electrons, in scandium, titanium, etc., enter not the 4s subshell, but the 3d subshell, which is then completely filled, along with 4s, in zinc. The elements potassium, calcium, scandium, titanium, vanadium, chromium and manganese have maximum oxidation numbers from one to seven, respectively, corresponding to their successive positions following argon. The atoms titanium to manganese are, however, not similar to the corresponding atoms carbon to fluorine or silicon to chlorine in the short periods because they are not directly followed by a noble gas, whose stable structure they might achieve by gaining or sharing electrons. Instead, these atoms have a strong tendency to form bipositive or terpositive ions by losing two or three electrons, the remaining valence electrons occupying the 3d orbitals, which for these positive ions are more stable than the 4s orbital.

The elements copper, by losing one electron, and zinc, by losing two, can form the ions Cu^+ and Zn^{++} with a completed M shell of elections. If the 4s and 4p orbitals were much less stable than the 3d orbitals, instead of about equally stable, this electronic configuration would be similar to the neon configuration; and nickel would be a noble gas, copper an alkali metal and zinc an alkaline-earth metal. The actual, different properties of nickel, copper and zinc result from their power of using the 4s and 4p orbitals in forming chemical bonds. Nevertheless, the effect of the 18-shell configurations (of Cu^+, Ag^+, Au^+) is evident in the normal valences of the elements of subgroups Ib. IIb, IIIb, IVb, which are equal to the group numbers.

These elements may also assume other valences, one or two greater (by losing additional electrons, leaving the 3d subshell incomplete) or two less (by having the 4s orbital occupied by an unshared electron pair).

It is convenient to consider ten of the elements in each long period or very long period to be transition elements, corresponding to the introduction of ten electrons in a d subshell. There is some arbitrariness in the selection of these elements, because the sharp differentiation of s. p and d subshells for the outer electrons of an atom in a molecule or crystal is not possible; these subshells are precisely defined only for a system with spherical symmetry; *i.e.*, for a system containing only one nucleus.

Although the selection is arbitrary, it is convenient to consider the elements titanium to gallium inclusive as the first transition elements; zirconium to indium as the second; and hafnium to thallium as the third.

The **Lanthanons.**—The existence of a long series of very

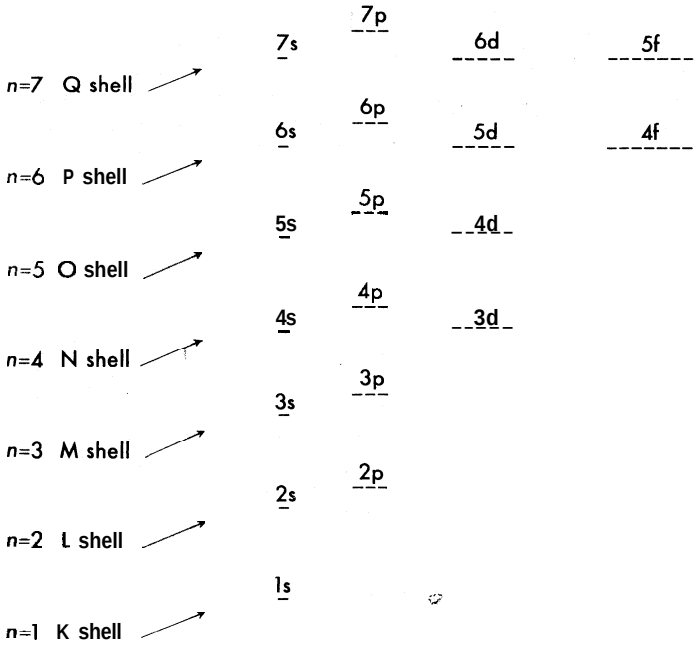


DIAGRAM REPRESENTING QUALITATIVELY THE RELATIVE STABILITY OF SUCCESSIVE ELECTRON ORBITALS IN ATOMS; THE RELATIVE ENERGY VALUES CHANGE SOMEWHAT WITH CHANGE IN ATOMIC NUMBER

closely related elements, the lanthanons or rare-earth elements, has been clarified by the development of the understanding of the electronic structure of atoms. With increase in the atomic number of the elements the seven 4f orbitals become increasingly stable, until, at lanthanum, 57, or cerium, 58, these orbitals begin to be occupied. In the terpositive gadolinium ion, 64, the 4f subshell is half-filled, with one electron in each of the seven orbitals; and in the luteciurn ion, 71, it is completely filled with its complement of 14 electrons.

The lanthanons thus comprise the 14 metals from cerium to lutecium. with the same electronic structure except for the variation from 1 to 14 in the number of 4f electrons. Often lanthanum, with the same electronic structure hut with no 4f electrons in the terpositive ion, is also included among the lanthanons, increasing their number to 15.

The 4f orbitals are deep within the atoms — there is a stable noble-gas shell of eight 5s and 5p electrons outside, as well as, in the neutral atoms, two valence electrons in the 6s orbital and perhaps one in a 5d orbital. Because the 4f orbitals are in an inner shell, the properties of the atom or ion are changed only slightly by change in the number of electrons which occupy them; hence the lanthanons are closely similar to one another in physical and chemical behaviour. This similarity was made strikingly evident by the great difficulty of separating them from the complex mineral mixtures in which they occur in nature, which caused their discovery to be spread over a period of more than a century (see RARE EARTHS).

The lanthanons all have $+3$ as principal oxidation state, corresponding to the loss of the three valence electrons to more electronegative atoms. Cerium, praseodymium and terbium also occur in oxidation state $+4$, and samarium, europium and ytterbium in oxidation state $+2$.

The Actinons.—The only important general question about the periodic system to which the answer remains doubtful is that as to the nature of the last period. Because thorium is more closely similar to hafnium than to cerium in many of its properties, and uranium is more closely similar to tungsten than to neodymium, it has been thought that the uranium elements constitute the beginning of a transition period similar to the two long periods, and involving the occupancy of the 6d subshell. However, G. T. Seaborg has pointed out that the properties of the transuranium elements suggest that these elements are members of a second series of the lanthanon type, with occupancy of the 5f orbitals beginning at thorium. It is true that uranium is unlike the lanthanons in that the $+6$ oxidation state is the most stable of its oxidation states ($+6, +5, +4, +3, +2$); but neptunium, instead of being similar to rhenium, is reported not to have a stable $+7$ state; instead, neptunium and plutonium are said to have the same oxidation states as uranium, but with a general shift in stability toward the lower oxidation states.

An answer to this question can be given by the consideration of the stability and nature of the electronic orbitals involved. Although d orbitals contribute to the formation of strong covalent bonds, inner f orbitals are not useful in this way, as is shown by the small tendency of the lanthanons to form covalent compounds. The fact that uranium does form covalent compounds shows that the 6d orbitals are stable enough to be used for this purpose; and the stability of the $+6$ oxidation state shows that the 5f orbitals of uranium are not sufficiently stable to attract any of the six valence electrons very strongly. Hence the uranium period differs from the immediately preceding period in that the 5f orbitals are less stable relative to the 6d orbitals than are the 4f relative to the 5d orbitals. However, with increase in atomic number the 5f orbitals will increase in stability more rapidly than the 6d orbitals, and ultimately the 5f orbitals will be filled. It is likely that this process has begun at neptunium; and presumably it would be completed at element 103, which would be similar to lutecium in structure and properties, with probably a greater tendency to the formation of covalent compounds. The 6d, 7s and 7p subshells would then be successively occupied, with element 118, eka-radon, as the next noble gas, though probably able to form some chemical compounds. The 14 elements from thorium to lawrencium are called the actinons.

Thus this great generalization, the periodic law, which first showed its value through Mendeléyev's prediction of the existence and properties of undiscovered elements, is again being put to the same use; the undiscovered elements of present interest being those that have greater atomic number than the known elements, and that will be sought not in nature's minerals, but in preparations made by man.

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PERIODONTAL DISEASES are diseases of the soft tissues around the teeth. Periodontal tissue includes both the tissue that surrounds the neck of a tooth, which is called the gum or gingiva; and the soft tissue that surrounds the root of a tooth, lying between the root and the bony socket of the root and known as the dental ligament or attachment membrane.

The free edge of the gingiva is like a collar that surrounds the neck of a tooth and slopes away on the outside to become continuous with the oral tissue covering the bony process of each jaw. This outer surface of the gum or gingiva is firm, pink in colour and slightly stippled (rough). As the gingiva completely surrounds the neck of a tooth, in its normal healthy condition, a shallow sulcus or crevice lies between the border of the gingiva and the line of attachment to the tooth surface. The remaining inner surface of the gingiva is normally attached to the roots of the teeth and is continuous with the deeper periodontal tissue.

The health of the gingiva is largely dependent upon the practice of regular daily hygienic care by proper tooth brushing and the use of dentifrices and mouth rinses. A surface covering of epithelium protects the soft tissue from injury and infection. Beneath the epithelium is another tissue, the connective tissue, which is well supplied with blood vessels. Protecting blood cells gather rapidly in the presence of injury or infection to heal injuries to the soft tissue and resist. the infecting agent, but where there is continuous irritation in the gingiva, inflammation results from the struggle to remove or destroy the injurious agent. This brings about the beginning of periodontal disease in its simplest form, known as gingivitis. This is a progressive disturbance if uncorrected and the gingiva restored to a healthy condition.

Gingivitis.—Gingivitis begins as a mild inflammation causing bleeding gums. It is common and seldom painful and therefore easily overlooked or neglected. It is usually a chronic condition

brought about by a low-grade infection in the gums associated with constant irritation by dental calculus, by food packing between two adjacent teeth, by the retention of food and soft deposits around the gum line, or by mechanical irritation. The commonest cause of all is the lack of thorough daily home care with a good toothbrush. Inflammation in the gingiva gradually extends into the deeper periodontal tissues, loosening them from their normal attachment to the roots of the teeth. This eventually causes a pocket to form along the root surface beneath the collar of **gum** tissue, the beginning of a periodontal pus pocket, formerly called a pyorrhea pocket. Vincent's infection, a gingivitis commonly called "trench mouth," is an acute and painful form of gingivitis caused by specific microorganisms. Some authorities consider it to be a contagious disease, and probably during the most active period of the infection it may be contagious.

Hyperplastic gingivitis, or inflammatory enlargement of the gingival tissue, often is associated with certain systemic disturbances, such as diabetes, blood diseases, metal poisoning and nutritional deficiences. A more fibrous type of gingival enlargement, known as fibrous gingival hyperplasia, is frequently associated with hormone disturbance during adolescence or pregnancy. Another form of hyperplasia appears as a side effect in the use of sodium dilantin in the treatment of epilepsy; this is a very firm, painless but disfiguring type of fibrous hyperplasia.

All these types of gingivitis are amenable to treatment and can be cured by the removal or correction of the cause. This includes thorough removal of calculus deposits, correction of mechanical irritation, control of infection and daily home care:

Periodontitis.— Periodontitis, like gingivitis, is a progressive inflammation. It involves the deeper tissue surrounding and attached to the roots of the teeth. As the pocket deepens, the support of the tooth is weakened by loss of surrounding bone. Food residue and bacteria accumulate and stagnate in the pocket. Pus is formed and discharged from the pocket opening into the mouth. Eventually the tooth loosens because of the loss of its bony support. Sometimes an acute infection occurs in a deep periodontal pocket, causing much pain followed by swelling of the surrounding tissue. This is a periodontal abscess. It is not associated with the commoner abscesses that are found at the root tip when there is infection in the root canal.

Periodontitis is curable if treated early. The pockets should be curetted and irrigated, and the roots made smooth. Very often surgical removal of the overlying unattached soft tissue wall of the pocket is necessary to eliminate the pocket. Home care is as important as care by the dentist.

Gingivosis and **Periodontosis.**—These are degenerative diseases that are difficult to understand and to control.

Gingivosis is a rather uncommon and painful condition sometimes found on the labial surface of the gingiva. The surface of the epithelium seems to peel or slough away because of degeneration of the underlying connective tissue, leaving a raw surface. The cause is unknown.

The cause of periodontosis, affecting the deeper periodontal tissue, also is not entirely clear. It seems to have several etiological factors, probably being associated with some systemic disturbance that interferes with the nutrition in this local tissue, causing it to break down. Periodontosis is characterized by drifting or separating teeth and by sudden pocket formation of considerable depth. There are seldom any calculus deposits on the affected teeth or any bleeding until a late stage of development. Injury from the occluding forces as the teeth are brought together has an important relation to destruction of the supporting bone and loosening of the teeth.

Tissues that are continuously subjected to severe stress may be affected by certain systemic factors that reduce their ability to maintain their function and to repair the damage of daily wear and tear. The gums may appear healthy while the deeper tissue along the root surfaces is degenerating. It is thought that some internal disturbance interferes with the nutrition and function of the cells in the supporting tissue of the teeth. Some diseases interfere with metabolism and thus lower the ability of the blood to nourish the tissues properly. Inherited tendencies may affect the quality of constantly developing new bone and muscle tissue. Teeth with weakened support cannot sustain the normal functional demands of occlusion. Degeneration in the deep periodontal tissues cannot be seen clinically, but when the teeth begin to separate and drift away from their normal position it becomes evident that the supporting tissue is affected and the early symptoms of periodontosis are appearing. The onset of periodontosis cannot be predicted. No one can predict which teeth will become involved in a person susceptible. The condition most commonly occurs in the third or fourth decade of life, but systemic diseases may influence an earlier or later appearance. If inflammation develops in the gingiva and the deeper tissue, the progress of the two types of disease—inflammatory and degenerative—acting simultaneously is greatly increased. Deep pockets form along the surfaces of the roots and discharge pus into the mouth. The X-ray picture reveals great loss of bony support of the affected teeth.

The anterior teeth often separate and protrude, while the posterior teeth move from their normal positions and are brought into abnormal relation with posterior teeth of the opposite jaw. This often subjects those teeth to abnormal biting stress and hastens their loss because of injury to the surrounding periodontal tissues. In the later stages of periodontosis, both the degenerative and the inflammatory symptoms become combined in a condition known as periodontitis complex.

In the early stages periodontosis can be alleviated and often cured. It is necessary to correct an unbalanced diet and to institute very thorough home care of the teeth and gums. When the teeth begin to drift, retaining appliances are necessary. Surgical removal of pockets is essential to remove diseased tissue and restore healthy underlying bone upon which new soft tissue can grow. At regular intervals dental care is required to assist in maintaining the health of the gingival and periodontal tissues.

Traumatism.—The teeth are normally held firmly within a bony socket surrounded by very dense and strong tissue fibres of the periodontal attachment or ligament. Although the teeth may seem immovable, there is a slight movement when pressure is applied horizontally. This movement is physiological up to a certain distance. The periodontal attachment tissue varies in thickness from 0.1 to 0.3 mm., which is considered normal; but the root of a tooth will crush the periodontal tissue against the bony socket if it moves more than one-half of that distance under pressure.

When the teeth are brought into occlusion the cusps of the teeth of one jaw should fit into the grooves of the teeth in the opposite jaw in cusp-to-groove contact. Many influences interfere with this ideal arrangement, causing malocclusion, which results in abnormal horizontal stress upon some tooth or teeth. Constant horizontal stress may force a tooth to move and eventually loosen it in its socket. The effect of this causes traumatic injury in the supporting tissue. This has been known as traumatic occlusion, but is more correctly called traumatism.

Periodontal Atrophy.— Atrophy is a wasting away or shrinkage of tissue. Periodontal atrophy is classed as a degenerative condition, although it is not classed as a disease. Receding gums with a healthy colour and a normal attachment to the crown or root of a tooth are an evidence of shrinkage and not of disease. When teeth have no occluding contact or function, the attachment tissue on the root surface undergoes a degenerative change, just as does almost any other unused muscle or organ. This is called disuse atrophy. Another form of atrophy, occurring late in life, is called senile atrophy. Atrophic changes in the gingival tissue may occur at any time after middle life. Brushing the teeth crosswise may cause toothbrush trauma to the gingiva and early recession of the gingival border of the gums, but does not result in periodontal disease.

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PERIOECI, in Greek PERIOIKOI, in ancient Laconia the class intermediate between the Spartan citizens and the helots (*q.v.*). Ephorus says (Strabo viii, 364 et *seq.*) that they were the original

Achaean inhabitants of the country (Gr. περίοικοι, dwellers around).

The term: however, came to denote not a nationality but a political status, and afterward included Arcadians on the northern frontier of Laconia; Dorians, especially in Cythera and in Messenia; and Ionians in Cynuria. They inhabited a large number of settlements, varying in size from important towns like Gythium to insignificant hamlets. The perioeci possessed personal freedom and some measure of communal independence, but were under the immediate supervision of Spartan harmosts (governors) and subject to the general control of the ephors. They were excluded from all Spartan offices of state and from the assembly, and, because of the absence of any legal right of marriage (ἐπιγαμία), the gulf between the two classes was impassable.

(*See* SPARTA.)

PERIPATETICS, the name given in antiquity to members of the school of Aristotle and their successors. The name was derived from the Peripatos, a covered walk in the Lyceum in Athens, where Aristotle began to teach in the year 33j B.C., on his return from Macedonia. Previously, he had attended the school of Plato in the Academy (up to Plato's death in 348–347 B.C.); it was in the Peripatos that he completed his transformation of the Platonic teaching, abandoning the doctrine of transcendent ideas and adopting in its place an empirical attitude to reality as manifested in nature and in history. This led to the most comprehensive encyclopaedic system of thought that was ever known in antiquity. (*See* ARISTOTLE.)

Aristotle's immediate successor as leader of the school was Theophrastus (*q.v.*). Neither he nor Eudemos of Rhodes (*q.v.*) made any radical change in the teaching; they concentrated rather on the development of individual aspects. Theophrastus, however, tried to strengthen the systematic unity of the whole, giving further development to nearly every part of Aristotle's doctrines. But the increasing decline of the metaphysical elements, together with the expansion of empirical methods. was preparing the way for the coming independence of the specialized subjects. Soon the Peripatos could hardly any longer be called a school of philosophy. since it had lost even its unity of ethical teaching and was disintegrating into a number of separate disciplines. Dicaearchus and Aristoxenus (*qq.v.*), abandoning the cardinal principle of Aristotelian metaphysics, renounced belief in the immortality of the soul. Furthermore. Dicaearchuj ceased to subscribe to the contemplative ideal of life preached by Theophrastus; and Aristoxenus confronted the ethics of Plato and Aristotle with a so-called Pythagorean theory reconstructed from traditional sources.

Further proof of how soon the school lost its philosophical unity is supplied by Clearchus of Soli who, like Aristoxenus and Dicaearchus. may still have been a personal disciple of Aristotle. In opposition to the other two, he clung to the idea of the soul's immortality. However, he attempted to prove this not through the dialectic methods of Plato and Aristotle but by means of popular tales about states of ecstasy, which he tried to link to primitive shamanistic traditions. In his treatment of ethical questions Clearchus seems to adhere to a general ideal of "moderation" which was not bound to any particular philosophical premisses. Thus in his treatise, *Peri Bion* in which he explains his attitude toward hedonism, the Aristotelian idea of the coexistence of several equally justified ways of life seems to have been forgotten.

A characteristic of this disintegration is the increasing number of specialized treatises on the natural sciences. Some such treatises written by Theophrastus are extant, and we know at least the titles of certain monographs on zoology, on physiology and on medicine by Strato of Lampsacus and by Clearchus. Strato moreover. in his physics, separated himself entirely from the teleological principles of Aristotle. approaching more nearly to the atomic theories of Democritus. According to the scientific qualifications of each investigator, this specialization in the sciences proved to be sometimes an advantage and sometimes a drawback: thus some Peripatetics contributed to the development of empirical disciplines of considerable stature, while others produced a number of works on the miraculous intended only for entertainment.

The achievements of the Peripatos are equally uneven in the field of the humanities. The foundation had been laid by Aristotle, who gathered material for his teaching on statecraft from political history, studied the philosophy of his predecessors as a basis for his own theories and discovered in ancient poetry important and vital examples for his own ethics. Here again the various branches became increasingly independent as time went on. Thus Demetrius Phalereus, who ruled as Macedonian governor in Athens from 317 to 307 B.C., wrote on Athenian constitutional history as well as on his own political activities. In their commentaries on the poets, the Peripatetics were able to refer back to old traditions that had begun with the explanations of Homer by the Rhapsodists; and their biographies of the poets were based on popular books on the life of Homer or Hesiod, from which they often borrowed the fictional embellishments. Aristotle, Dicaearchus, Demetrius Phalereus and Chamaeleon (a representative of the first generation of disciples) are all attested to have written works on Homer; and lyric and dramatic authors were equally favourite subjects for dissertations. The Peripatos notably stimulated the Alexandrian grammarians from Zenodotus to Aristarchus, whose editions and interpretations of the classical texts preserved that literature for posterity.

A new period in the history of the Peripatetics began in the 1st century B.C., when Andronicus of Rhodes (*q.v.*) published the long-neglected works of Aristotle and thus aroused interest in the philosophical tradition proper to the school. With Andronicus there came into being a way of interpreting the main writings of Aristotle which was to last as long as the Roman empire, reaching its climax with Alexander of Aphrodisias (*q.v.*). Admittedly Alexander interpreted Aristotle in a nominalist sense, maintaining that the universal was a mere abstraction from the particular (whereas Aristotle had in fact given it ontological priority, though conceding that our knowledge may spring from the particular). Alexander's interpretation, as Strato's long before him, involved opposition to Platonism at a time when other exponents were attempting on the contrary to smooth out as far as possible the differences between the teachings of Plato and the teachings of Aristotle.

As a synthesis of the two philosophies was actually brought about soon after Alexander's time by Plotinus, Aristotelian thought came to exert an influence in Neoplatonism (*q.v.*). This survived long after the school of the Peripatetics had perished. (F. WI.)

PERIPATUS, a genus of remarkable wormlike Arthropoda (*q.v.*) belonging to the class Onychophora (*q.v.*). The name is often loosely used to denote all members of this class, which is in many respects intermediate between the segmented worms (Annelida; *q.v.*) and the Arthropoda (insects, spiders, crabs, etc.), though most nearly related to the latter.

There are about 110 species of Onychophora, found chiefly in tropical America. tropical Africa and the East Indies. The true *Peripatus* is American.

PERISCOPE, an optical instrument used in land and sea warfare and submarine navigation to enable an observer to see his surroundings while remaining under cover, behind armour or submerged. Technicians engaged in nuclear research employ extremely long periscopes to observe the functioning of nuclear reactors from a safe distance.

A periscope always includes, among its optical elements, two mirrors or reflecting prisms to change the direction of the light coming from the scene being observed: the first reflects it down through a vertical tube and the second diverts it horizontally so that it can be viewed conveniently. There is usually a telescopic optical system, which may be very complex, which gives magnification. provides as nide an arc of vision as possible and includes a crossline or a reticle pattern which establishes the line of sight to the target. There may also be devices or accessories for estimating the range and course of the target, and for photographing through the periscope.

The simplest type of periscope is illustrated in fig. 1. It consists of a tube at whose ends are two mirrors which are parallel

to each other but at 45° to the axis of the tube. This device produces no magnification and does not give a crossline image for gun-sighting use. The arc of vision is limited by the simple geometry of the tube—the longer or narrower the tube, the smaller the field of view. Periscopes of this type found very wide use in World War II in tanks and other armoured vehicles, as observation devices for the driver, gunner and commander. When fitted with a small auxiliary gunsight telescope at the side of the tube, the tank periscope can also be used in pointing and firing the guns. By employing tubes of rectangular cross section, approximately 7 in. by 2 in., wide horizontal fields of view can be obtained—large vertical fields are not necessary in surface combat. The vertical displacement of the line of sight is of the order of one foot. Sometimes solid prisms of glass or plastic are used in place of the end assemblies pictured in fig. 1, each of which consists of a mirror and two sealing windows. The periscopes and their swivel mounts are designed and constructed so as to be as water- and dust-tight as possible. The top mirror assembly or prism may be detachable, and readily replaceable with a spare unit in case it is shattered by enemy gunfire or is otherwise damaged.

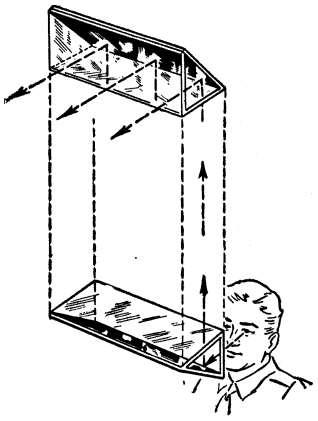

FIG. 1.— THE SIMPLE TANK PERISCOPE

Turret Periscopes.—Periscopes are installed in the gun turrets and armoured conning towers of battleships and cruisers in order that the gunnery officer can sight on the target and, if desired, can bring the guns to bear on it, when the turret is in "local control." The shape and construction of the turret may necessitate a periscope length of as much as 10 ft., for unobstructed vision. A simple instrument of the two-mirror type would have much too narrow an angular field of view; so a telescopic optical system is always employed. This may be thought of as having the effect of placing the observer's eye much closer to the top end of the periscope, thereby greatly increasing his arc of vision. It also makes possible magnification, which is necessary because the guns fire at long ranges. A crossline reticle can easily be included for gun-sighting use.

A typical optical system for such a periscope is shown schematically in fig. 2, in which the outline of the instrument is indicated also, for reference. The function of each optical part, described in order: is as follows: the upper sealing window *A*, through which light enters from the target scene; the head mirror or prism B, which reflects the incoming light down the periscope tube; the objective lens C, a cemented achromatic doublet lens which brings the light to a focus; a plano-convex collective lens D, located at this focus. and upon which the crossline or other reticle pattern may be etched; a pair of similar achromatic doublet lenses E and *F* which erect the image; the lower deflecting prism G, which turns the light into a horizontal path; the sealing plate H, at the lower end of the main periscope tube; one or more colour filters **I,** for haze and glare reduction, usually interchangeable red, yellow: polarizing and clear plates; the eyepiece. which consists of two doublet lenses, a so-called field lens *K* and an eye lens L. If it is desired to be able to illuminate the reticle for night use. the crossline may be etched on the lower sealing plate H rather than on the collective lens D. The sealing plate must then be located at the second focal point, J. The reticle markings may include several short vertical lines equally spaced on each side of the vertical crossline; these are used in estimating the deflection error of the projectiles. Moving parts outside the sealed main portion of the periscope are the interchangeable colour filters and. the eyepiece which can be adjusted in focus to suit the individual observer.

This optical system can be thought of as consisting of two astronomical telescopes. The upper one is made up of lenses C, D and E. It provides little magnification but transfers the target image and field of view down the periscope tube to lens *F*, which is the objective lens of the second telescope; K and L constitute its eyepiece. This second astronomical telescope magnifies the image in the ratio of the focal lengths of the objective and eyepiece. It also erects the image, which has been inverted in both the up-and-down and left-to-right senses by the first telescope.

The mirror or reflecting prism at the upper end of the periscope tube is so arranged that it can be tilted by means of a mechanism that is actuated by a handwheel located near the eyepiece; the line of sight may thus be carried through as much as 30° above and below the horizontal. The entire periscope can be rotated in its mount about its vertical axis through 360°, so as to scan the horizon. In order to prevent fogging of optical surfaces and the consequent loss of vision, the interior of the periscope must be thoroughly dried, filled with dry air or nitrogen and sealed tightly against the atmosphere. Gas inlet and outlet valves are ordinarily provided for this purpose.

A typical turret periscope will have an optical magnification of approximately 10 and an angular field of view of 4° to 6°. The brilliance of the image seen by the observer depends on the over-all light transmission of the instrument and on the size of the exit pupil; *i.e.*, the beam of light that emerges from the eye lens. Conditions imposed on the optical design usually permit a fairly large exit pupil, say 5 mm. in diameter, which is sufficient for day use. For night use. however, the emergent beam of light should entirely fill the pupil of the observer's eye for maximum brightness of image. This necessitates an exit pupil of 7- to 8-mm. diameter, which usually entails larger diameter optical elements throughout. with a concomitant increase in over-all size, weight and cost of the instrument. The percentage of light transmitted by an optical instrument can be greatly increased by coating all air-to-glass surfaces of the various lenses and prisms with so-called reflection-reducing films. The use of such films in the optical system of fig. 2 will increase its light transmission from around 30% to more than 50%, a gain of almost 100%. Also, the image rendition is improved in that crisper, clearer images are obtained and ghost images and flare spots are eliminated.

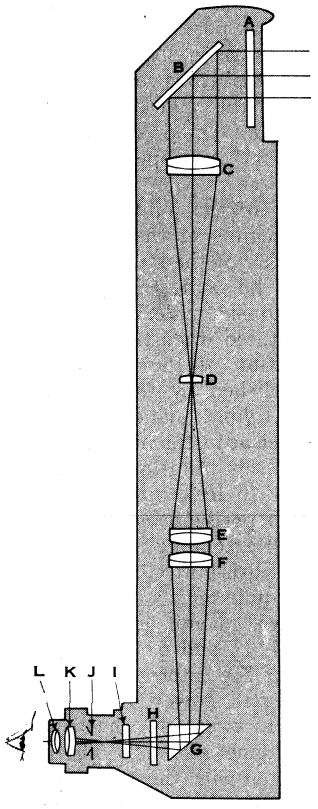

FIG. 2.—OPTICAL SYSTEM OF TURRET PERISCOPE USED IN WARSHIPS (see text)

This technique of coating optical surfaces came into wide use in military optical instruments during World War II.

Submarine Periscopes.—Periscopes used in submarines are similar in principle to the turret periscopes of warships but differ from them in certain important respects because of the following special conditions which are imposed: the submarine periscope must be much longer, and the top few feet of its length must be greatly reduced in diameter. The periscope must be capable of being raised and lowered into the hull of the submarine; it should have available both low and high optical magnifications,

The over-all length of a periscope may exceed 40 ft., and a iarge fraction of this length will be exposed, outside the hull of the submarine, at maximum extension of the periscope. Great forces are exerted on the tube in dragging it through the water when the submarine is underway submerged. Thus, the tube must be large enough to give sufficient rigidity without offering too

much resistance to motion through the water; a diameter of from 6 to 8 in. is usually selected, depending on the length. This tube must be made of a corrosion-resistant material and must be very carefully machined for perfect roundness, straightness and uniformity in diameter. since it must permit both rotation about its vertical axis and raising and lowering of the periscope in the long watertight gland through which it enters the hull of the submarine. Near the upper end of the periscope tube is a tapered portion above which is a narrow tube 2 or 3 ft. in length, surmounted by a slightly larger head which contains the entrance window and the elevating prism.

The diameter of this tube is made as small as possible, often less than 2 in., to reduce the probability of its detection by enemy observation and to cut down the size of the wake or "feather" caused when the submerged submarine is in motion with its periscope elevated into observing position.

All of the joints in the periscope tube, the sealing of the upper window and the packing of the stuffing box at the hull line must be made tight enough to withstand the considerable hydrostatic pressures encountered when the submarine submerges. Rotation of the periscope is usually accomplished by the observer, who grasps two folding handles at the lower end; proper adjustment of the stuffing box permits this rotation without allowing sea water to leak into the submarine.

The periscope is raised. or is lowered into a well extending into the hull of the boat, by a push-button-actuated electrical hoisting equipment controlled by the observer.

Two magnifications are usually provided. $1\frac{1}{2}$ and 6. The first gives the observer the impression of normal viewing, the extra power over unity being necessary to overcome the psychological effect of "tunnel vision." The field of view associated with the $1\frac{1}{2}$ pon-er is in the range 32°–40°, depending on other design considerations. Use of the higher power enables the observer to see greater target detail, but restricts the field of view to 8°–10°, one-fourth of the low-power values of angular field, but one-sixteenth the areas.

The magnification change is effected by rotating one of the folding handles at the lower end of the periscope. Rotation of the other handle moves the line of sight through angles between 10° depression below horizontal and 45° elevation. by tilting the head prism. The wide use in World War II of aircraft to hunt down enemy submarines, however. made it necessary to provide "high-angle" or sky-searching periscopes capable of viewing at such elevations as to be able to scan the entire sky, from horizon to zenith.

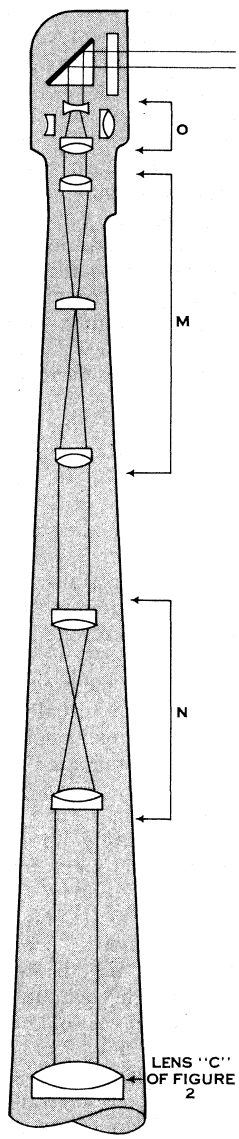

FIG. 3.—UPPER PORTION OF LONG. NARROW-TUBE SUBMARINE PERISCOPE (not to scale)

The exit pupil diameter of standard submarine periscopes is 4–5 mm. This is sufficient for day use, but not for the best performance at night, when a value of 7 mm. is needed. In order to obtain this larger light-gathering power, the size of the lenses near the head prism must be increased. Therefore, it is impossible to retain the very small diameter of the upper portion of the periscope tube.

Certain schools of thought maintain. however, that too much emphasis has been placed on. and too high a price paid for. keeping this dimension so small. The light transmission of the most complicated periscopes may be around 15%, which is undesirably low. Treatment of the air-to-glass surfaces of all the lenses and prisms with reflection-reducing films raises the transmission by as much as 200%, according to the number of surfaces involved. The resulting gain in image brightness is very noticeable and is particularly valuable during nighttime. dawn and dusk. the most favourable periods for submarine torpedo attacks.

The reticle lens has engraved upon it special telemeter scales which make possible a rough calculation of the distance of a target vessel. based on an estimate of its length or height. More accurate ranges can be determined by the special stadimeters usually built into or attached to submarine periscopes.

The optical system of a submarine periscope may be essentially that of fig. 2, except that the focal lengths and spacing of the lenses are adjusted to give a magnification of 6. However, for very long periscopes in which the narrowest possible top portion is desired, which severely restricts the diameter of the upper lenses, this optical system will not provide the observer with sufficient field of view. A solution to these difficulties is illustrated in fig. 3. In a location corresponding to above lens *C* of fig. 2 there are added two complete astronomical telescopes) *M* and *N*, each consisting of two or three lenses. The telemeter scales are then engraved on a plano-convex lens in the uppermost astronomical telescope. rather than on lens *D* of fig. 2.

In order to provide the lower magnification of $1\frac{1}{2}$ and still retain a wide field of view and sizable exit pupil. additional lenses must be added at the top end of the complete telescopic system. This is usually done as illustrated in fig. 3, by bringing into the line of sight a small four-power reversed Galilean telescope *O* which consists of two achromatic lenses, the upper of which is diverging and the lower converging. The higher magnification of 6 is obtained when these lenses are swung to the side, in the positions shown in dotted lines. The provision of movable lenses and the necessary controls in this already crowded portion of the tube calls for very careful mechanical design. The periscope just described employs the most complicated optical system used in any common military instrument. See also SUBMARINE.

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(S. S. B.)

PERISSODACTYLA, an order of hoofed, herbivorous mammals, including the tapirs. horses, rhinoceroses and their extinct relatives, in all of which the number of digits (toes) on each hindfoot is either three or one. The name Perissodactyla ("odd toes") was given by Sir Richard Owen, to distinguish the group from the Artiodactyla. or even-toed, ungulate (hoofed) mammals, in which the number of functional digits on each foot is usually either four or two.

The earliest known perissodactyls (Lower Eocene) had four toes on each forefoot and three on each hindfoot. These numbers are still retained in the feet of the existing tapirs, but in the ancestral rhinoceroses the outer digit of the forefoot (corresponding to the fifth of the human hand) gradually became reduced and finally disappeared, leaving three toes on each forefoot and three on each hindfoot. as in existing rhinoceroses.

In the horse family the earliest known members started with four functional digits in each hand and three in each foot. the only traces of the first and fifth toes of the ancestral mammals being the inner and outer wrist bones (carpals) that formerly supported these digits. In the course of time the whole foot of the early horses grew very long. the side toes were lifted off the ground. became much reduced in size and were finally eliminated. the chief traces of the second and fourth toes of the original five-toed foot being the "splint" bones, or vestigial metacarpals, on the side of the greatly enlarged middle toe. This symmetrical middle toe of the horse therefore represents the logical extreme of the initial perissodactyl tendency for the axis of symmetry to pass through the middle or third digit rather than between the third and fourth digits as in the artiodactyls.

Both the perissodactyls and the artiodactyls were originally small, swift-footed, herbivorous mammals, in which the wrist and

heel were raised far above the ground and the animals ran on the enlarged nails, or hooves, of their principal digits. The numerous resemblances between perissodactyls and artiodactyls are chiefly independently acquired adaptations to similar habits. Even in Lower Eocene times (perhaps 60,000,000 years ago) representatives of the two orders differed so greatly in skeleton and dentition that they must have been derived from widely different families of primitive placenta1 mammals of the Cretaceous epoch. The old concept of the Perissodactyla and the Artiodactyla as being suborders of a single group, the Ungulata Vera or Diplarthra, is erroneous and the two "suborders" are in fact wholly distinct.

As noted above, the oldest known perissodactyls are found in the Lower Eocene of North America and Europe. It was formerly believed that these were in turn derived from Phenacodus (*q.v.*), but more recent palaeontological research shows that *Phenacodus* was a specialized side-branch of its own order, the Condylarthra, and is definitely excluded from the ancestry of the Perissodactyla by numerous details of specialization. The direct ancestors of the Eocene Perissodactyla remain unknown. However, the comparative morphology of the dentition and of the skeleton indicates that the Perissodactyla, like other orders of placental mammals, were derived eventually from small insectivorous placental mammals of the Cretaceous period. The origin and evolution of the numerous families of perissodactyls from the Lower Eocene through many ascending horizons of the Tertiary has been intensively studied in Europe and North America, and their palaeontological history is more fully known than that of any other mammalian order.

The early Eocene perissodactyls were small animals with four toes on each forefoot and three on each hindfoot. The upper molar teeth bore four principal cusps with two oblique cross-crests running from the two inner cusps forward and outward, toward the outer side. The two main outer cusps were conical, the second set further in toward the middle than the first, so that the outer half of the crown was oblique. Each lower molar crown was more or less W-shaped in top view. The premolars were not yet molariform, although the last upper premolar (p^4) was already well on the road toward the molar pattern. The front teeth (incisors) were all present, small and not peculiarly specialized.

Horses.—From such a form the line leading to the horses began to lengthen the middle digits and lift the side toes off the ground; in the upper molar teeth the oblique cross-crests became markedly twisted, while the main outer cusps became broadly crescentic; the upper premolars gradually became more molariform until three of them equalled or even surpassed the molars in size and complexity. The subsequent evolution of the horse family is treated elsewhere (see EQUIDAE; HORSE).

Tapirs.—In the line leading to the tapirs the number of toes did not change but the animals grew larger, heavier and their feet broadened. In the cheek teeth the cross-crests became less oblique, more transverse, finally becoming two high, straight, sharp-edged ridges, shearing with similar ridges on the lower molars. The most distinctive feature is the trunk or proboscis, in which the nose and upper lip are combined into a mobile, more or less protrusile organ. The proboscis of the tapir, however, has no fingerlike projection of the tip and lacks the mobility and adaptability of that of the elephant. The corresponding alterations in the skull of the tapir are far less than in the case of the elephant, involving only a moderate retreat or retraction of the nasal bones. The middle septum or cartilage of the nose also is far more conspicuous and extended further forward (see TAPIR). Thus the skeleton as a whole retains much that was characteristic of the earliest Eocene members of the order. The feet, for instance, have the same number of digits and arrangement of all the elements as in the very earliest Perissodactyla, and the rest of the skeleton is also primitive except for the modifications of the nasal region for the support of the proboscis. Even the cross-crested molars are much like those of the Eocene lophiodonts (family Lophiodontidae), which were, however, intermediate between the tapirs and the rhinoceroses.

Palaeotheres.—The family of the palaeotheres (Palaeotheriidae) was characteristic of the Eocene of Europe and was closely related to the horse family. The typical genus, Palaeotherium, resembled a tapir in general proportions but had three instead of four toes on each forefoot; it had at most only the beginning of a proboscis; the upper molar crowns comprised a W-shaped outer wall and two oblique cross-crests united with the two conical inner cusps. The palaeotheres are connected with the horses through such small light-limbed forms as Plagiolophus.

Titanotheres.—The titanothere family (Brontotheriidae) ranged from the Lower Eocene of Wyoming to the summit of the Lower Oligocene in South Dakota, Nebraska and Saskatchewan. Representatives have also been found in the Eocene of Europe and in the Upper Eocene and Lower Oligocene of Mongolia. The oldest known titanotheres (Eotitanops) were about as large as a sheep but shaped more like a tapir except that they had no proboscis, while the nose and lips were possibly somewhat horse-like. The most distinctive character is found in the upper molar teeth, the crowns of which had a W-shaped outer wall, two conical internal cusps and vestigial cross-crests. The lower molar crowns were W-shaped. This general type of molar was retained throughout the history of the family, the chief modification being that in the later forms the W-shaped outer wall of the upper molar crowns became higher and more curved toward the mid-line of the palate, while the internal cusps remained conical and low.

During the Eocene and Lower Oligocene the titanotheres became differentiated into numerous genera and over 100 species. The fossil remains of the Oligocene were formerly abundant in the "Big Badlands" on the White river in South Dakota and Nebraska. The primitive perissodactyl numbers of four toes on the forefeet and three on the hindfeet were retained throughout the family. In the main lines leading to the Lower Oligocene end-forms the size of the body increased until a bulk surpassing that of the largest recent rhinoceros was finally attained. Of the middle-sized genera of the Middle and Upper Eocene the most notable was the genus *Palaeosyops,* comprising animals larger than tapirs, with widespreading feet, broad, rounded skull and low-crowned, circular-cusped molars. At the opposite extreme was the genus *Dolichorhinus,* with an extremely elongated skull and snout, laterally compressed but not long feet, and upper molars with deepened outer wall and flattened outer cusps. The genus Manteoceras ("prophet-horn") was more or Iess intermediate between these extremes, but possessed a small bony swelling above and in front of the eye on each side of the skull. In later forms this swelling became more and more pronounced, until in the Oligocene titanotheres it grew into huge transversely-paired bony outgrowths from the naso-frontal junction, above and in front of the eyes. The shape of these bony protuberances differed in the numerous genera and species. In the more primitive Oligocene forms the "horns" were more or less three-sided, with a pointed tip, but in the more advanced genera they were broad transversely and compressed anteroposteriorly (Brontotheriztm), or erect with cylindrical section (*Megacerops*), or club-shaped (Brontops *robustus*), or three-faced with a rounded, recurved tip (Menodus). The skulls of these genera were relatively long (*Brontotherium,* Menodus), or wide (Brontops *robustus, Megacerops*), or of intermediate proportions (*Allops*). The skeleton of the largest titanotheres abounded in adaptations for the support of the huge bodies. Whereas the earliest forms had rather narrow hands and feet, the later giants of the race had very broad four-toed forefeet, parallel to those of the hippopotamus, and broad, short, three-toed hindfeet, parallel to those of the rhinoceros. The angles of the elbows and knees, which were well bent in the earlier running forms, opened out in the larger forms as in other "graviportal" mammals, while the ilium spread widely across the back to support the weight of the viscera. The great monograph on the titanotheres by H. F. Osborn affords one of the clearest and most interesting demonstrations of the facts of evolution yet recorded.

Chalicotheres.—The family of the chalicotheres (Chalicotheriidae) has been described under ANCYLOPODA. Here it will suffice to note that the primitive hoofs grew into long curved claws which seem to have been used for scratching the ground, perhaps in search of water and succulent tubers. The earliest known chalicothere, *Eomoropus* of the Eocene of Wyoming, re-

tained the primitive perissodactyl numbers of four toes in the forefeet and three in the hindfeet, while the upper molars approximated to the Eocene perissodactyl type.

Rhinoceroses. — The family of the rhinoceroses (*see* RHINOCEROS) is connected with that of the lophiodonts by such forms as *Hyrachyus* of the Eocene of North America. *Hyrachyus* has been called "the cursorial rhinoceros" because by comparison with its massive modern relatives it was distinctly light-limbed. Somewhat smaller than a South American tapir, it resembled that animal in the general configuration of its body and limbs. It did not, however, have a proboscis and, unlike a rhinoceros, it had no horn above the nose. All its front teeth of both jaws were unspecialized, not yet like those of later rhinoceroses. Its upper molar teeth, however, had already begun to foreshadow the rhinoceros type in the obliquity and marked flattening of the outer surface of the hinder outer cusp, although the two outer main cusps were not yet submerged in the general outer wall. None of the known species of *Hyrachyus* were directly ancestral to the lines leading to the later rhinoceroses, some of the forerunners of which (named *Prohyracodon* and *Eotrigonias*) were already established during Eocene times. In *Trigonias* of the Lower Oligocene the true rhinoceros characters of the molars and premolars were well defined and the second lower incisors had begun to be enlarged as tusks. On the other hand, *Trigonias* was hornless and retained four toes on each forefoot and the upper canines, though small, were still retained. Most of the later Oligocene rhinoceroses had eliminated the fifth or outer digit of the forefoot and had also lost the upper and lower canines. In *Diceratherium,* a small rhinoceros abundant in the Lower hliocene of Nebraska, a small transversely-placed pair of oval horn-swellings developed near the tip of the nasal bones. This group became extinct during the Miocene. Meanwhile the "aceratheres," or hornless rhinoceroses of Europe, were numerous during the Oligocene and Miocene and some of them probably gave rise to the lines leading to the modern Sumatran and Indian rhinoceroses.

In addition to these central forms there were many peculiar side lines. In the Miocene and Lower Pliocene of North America and Europe were swarms of extremely short-footed hippopotamus-like rhinoceroses (*Teleoceras,* etc.), with massive heads and very high-crowned molars and a single horn on the tip of the nose. The two existing species of African rhinoceroses and the related woolly rhinoceros of the Pleistocene of Europe are very highly specialized; their exact derivation is unknown. The strangest of all was the fossil *Baluchitherium* from the Upper Oligocene of Turkestan, Baluchistan and Mongolia, a titanic animal with a skull over 4 ft. long and an estimated height at the shoulder of 13 ft.

Besides all these true rhinoceroses, there were two extinct groups to which some authors give the rank of distinct families, namely the hyracodonts and the amynodonts. The hyracodonts were small cursorial forms with rhinoceros-like molar teeth and unspecialized front teeth. Of these, the very small *Triplopus* of the Middle and Upper Eocene had exceedingly long, slender, three-toed feet. The Oligocene *Hyracodon* was much larger, — about the size of a calf.--with stockier feet. Both genera were exclusively North American. The amynodonts were larger forms, the oldest of which appears in the Upper Eocene of Utah. It was followed in the Lower Oligocene of the Big Badlands region of South Dakota by *Metamynodon,* a somewhat hippopotamus-like form with enlarged tusklike upper and lower canine teeth and very elongated oblique outer walls of the upper molars; the stout forefeet retained four digits, the spreading hindfeet had the usual three toes of the rhinoceroses. Members of the same family have been found in the Lower Oligocene or Uppermost Eocene of Burma. Europe and Rlongolia.

Origin of the Order.—The Perissodactyla as an order probably originated in the northern hemisphere, perhaps in basal Eocene times, from some as yet undiscovered relatives of the Eocene condylarths or protoungulates. By Lower Eocene times the group was well represented in western North America and western Europe and was already beginning to diverge into numerous families which have been classified by Osborn in five superfamilies, namely the Equoidea (containing the lines leading to the palaeotheres and horses). the Chalicotheroidea (or chalicotheres), the Brontotherioidea (or titanotheres), the Tapiroidea (or tapirs and lophiodonts) and the Rhinocerotoidea (or rhinoceroses, hyracodonts and amynodonts). By Upper Eocene times the order was well represented in Burma and Mongolia. It was not until late Miocene or Pliocene times that the horses and tapirs penetrated into South America, and the group never reached even the outposts of the Australian region. In Africa, which is now its greatest stronghold, it is conspicuously absent from the Upper Eocene and Lower Oligocene of Egypt and is not known until the Miocene or Pliocene. On the whole the existing Perissodactyla represent a beaten order which has been gradually crowded out by the ruminant artiodactyls. Of its surviving families, the rhinoceroses and tapirs seem doomed to extinction unless preserved by stringent regulation. The zebras, however, seem to have a better chance of survival in certain districts.

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(W. K. G.)

PERITONITIS, inflammation of the peritoneum. (*See* COELOM AND SEROUS MEMBRANES.) It may be acute or chronic and either localized or diffused.

Acute peritonitis arises commonly as a result of extension of infection from neglected appendicitis which has been permitted to become gangrenous and perforate, discharging infected fecal material into the abdominal cavity. It may also follow the perforation of a gastric or duodenal ulcer; the bursting of abscesses or cysts into the abdominal cavity; or the extension of gonorrheal infection of the uterus in the female. It may arise as a complication of abdominal surgery, usually when a leak occurs when the intestines are sutured together following the removal of a segment for cancer or some other disease. The escape of bile from the gall bladder or a bile duct into the peritoneal cavity may produce a rapidly fatal, acute peritonitis. The peritoneum loses its shiny appearance, becoming rough and granular and markedly congested. An exudate into the peritoneal cavity occurs; it is at first thin and turbid, later becoming thick and purulent with increasing amounts of fibrin. The intestines become glued together and adherent to the omentum, abdominal wall and other abdominal organs. The inflammation of the peritoneum is usually due to the aerobic and anaerobic bacteria commonly present in the intestinal tract, which overcome the resistance of the peritoneum when constantly replenished, as from a leak in the bowel, or from infected foreign material such as food or a bit of necrotic appendix.

Acute peritonitis usually begins with a chill, vomiting and pain in the abdomen with extreme tenderness so that pressure, even of the bedclothes, cannot be borne. The patient lies on the back with the knees drawn up to relax the abdominal muscles; the breathing becomes rapid and shallow and is performed by movements of the chest only. the abdominal muscles remaining quiescent, which is not the case in healthy respiration. The abdomen becomes swollen as a result of gaseous distention of the intestines, and there is usually constipation. The pulse is rapid and feeble, and the temperature rises to 104° or 105° F. There is a complete absence of intestinal peristalsis. A cold, clammy sweat appears on the forehead, and the eyes are withdrawn into the orbits. The expression is one of great anxiety, but the mind remains clear even when death approaches.

Death results from the cessation of movements in the intestinal tract so that gastric and duodenal secretions accumulate in the stomach and are lost to the body as a result of vomiting. The continued escape of the digestive secretions produces a progressive demineralization, dehydration and alteration in the chemical composition of the blood. The secretion of urine decreases and finally stops. When this factor is combated by decompression of the stomach and intestines by suction tubes and intravenous ad-

ministration of salt solution, many patients make a remarkable recovery. It is probable that paralysis of the intestines, secondary to the infection of the peritoneal cavity, is more important as the cause of death in generalized peritonitis than is invasion of the blood stream by bacteria or the absorption of poisonous materials from the peritoneal cavity.

The treatment of generalized peritonitis consists in the administration, systemically, of drugs such as penicillin, streptomycin, aureomycin or sulfadiazine; and a surgical operation designed to remove from the peritoneal cavity foreign material which serves as a nidus, or focus of infection, to close perforations of the intestinal tract and to provide drainage. Decompression of the intestinal tract by means of tubes introduced through the nose into the stomach, with constant suction, is of great value. Blood transfusions and intravenous administration of physiological solutions of sodium chloride and other salts are very helpful.

(L. R. DT.)

PERIWINKLE, any small marine snail belonging to the family Lzttorinidae. They are widely distributed shore (littoral) snails, chiefly herbivorous, usually found on rocks, stones or pilings between high and low tide marks; a few are found on mudflats and some tropical forms are found on the prop roots of mangrove trees. Of the approximately 80 species in the world, ten are known from the western Atlantic. The common periwinkle, Littorina littorea, may be found in great abundance on the rocky shores of northern Europe and northeastern North America. It is the largest, most common and widespread of the northern species It may reach a length of 1½ in. (38 mm.), is usually dark gray in colour and has a solid spiral (turbinate) shell which readily withstands the buffeting of waves.

Formerly, periwinkles were an important source of food, particularly for the poorer classes in the British Isles, France and the Netherlands In 1858 the London market consumed 76,000 bu. Since that time periwinkles have been considered a delicacy by many people and are still consumed in large quantities. In Europe they are frequently sold by street vendors particularly in seaside towns. In France. where they are known as *vignot* or vignette, the snails are usually boiled in a small amount of heavily salted water (the salt tends to loosen the animal from the shell). The meat is then either made into periwinkle soup or served with butter or a variety of sauces.

The breeding habits of periwinkles are quite variable. Littorina saxatilis, which lives high up on rocks and is often out of water for long periods of time, holds its eggs in a brood sac until the young are fully developed, at which time they emerge as tiny crawling replicas of the adult.

The common periwinkle was introduced into North America at Halifax, Nova Scotia about 1857 and has spread as far south as New Jersey. It is very common on the rocky shores of New England, and also occurs on shallow muddy bottoms, along the banks of tidal estuaries and among the roots and blades of marsh grass where the water is only moderately salty.

All species in the Littorinidae are important as a favorite food of many shore birds, particularly ducks.

In manv sections of the southern United States the term periwinkle or penny-winkle is applied to any small fresh-water snail.

See also GASTROPODA; SNAIL; SHELLS AND SHELL COLLECTING.

See J. C. Bequaert, "The Genus *Littorina* in the Western Atlantic," *Johnsonia* 1, no. 7, pp. 1–27, pl. 1–7 (1933); C. M. Yonge, The Sea *Shore* (1939). (R. *D.* T.)

PERIWINKLE, the name given to various species of the botanical genus Vinca, of the dogbane family (Apocynaceae). The name periwinkle is possibly taken from *pervinka,* the Russian name of the flower, which in turn is derived from *pervi,* "first," as it is one of the first flowers of spring. The lesser periwinkle (V. minor) with lilac-blue flowers, ¾ in. across, an evergreen, trailing perennial, has run wild throughout eastern North America. It is native to Europe and is found in the British Isles. The similar greater periwinkle (V. major), with purplish-blue flowers, 1 to 2 in. across, native to continental Europe, has become naturalized in England. The Madagascar periwinkle (V. rosea) is of worldwide distribution in the tropics.

ROCHE

PERIWINKLE (VINCA MINOR)

PERJURY, in a general sense and by etymologic origin, means lying under oath. The common definition of perjury as a criminal offense is an intentional misstatement of material fact made under oath or affirmation in a legal proceeding before a tribunal authorized to conduct the proceeding. Related offenses under modern penal codes deal with "false swearing" under other circumstances, and with non-sworn falsification in official matters.

As a transgression of spiritual significance, it was formerly in England subject only to religious sanctions administered by ecclesiastical authorities. In the 17th century in England the Court of Star Chamber began to punish the giving of false sworn testimony as a secular offense akin to obstruction of justice. Anglo-American legislation thereafter defined and expanded the offense of falsification in official matters. It was broadened to include false sworn testimony not only before judges but also in legislative and administrative hearings. Either by further enlargement of perjury, or by special enactments on "false swearing." falsification of affidavits was made punishable. Penal sanctions were extended to falsification on "affirmation" as well as oath, so that the statutes would apply to those un illing to be sworn. In the 20th century, criminal law in this area, departing entirely from the oath concept, expanded in a variety of statutes penalizing any written or even oral, misrepresentation in official inquiries or proceedings.

A classic requirement of the law of perjury is that the falsification be "material." With few exceptions, the legislatures and the courts have refused to treat trivial or irrelevant lies as felonies. Usually it is said that anything "capable of influencing the tribunal on the issue before it" is material. But the scope of perjury was sometimes restricted by stringent and arbitrary interpretations. Thus a leading New York case held that it was not perjury falsely to testify in a divorce suit that the husband had committed adultery with X on one occasion, when the divorce complaint charged only the commission of an adulterous act with X on another occasion, since only the latter was material in the suit (People v. Teal, 196 N.Y. 372, 89 N.E. 1086 [1909]). In reaction against such decisions, some codes have eliminated materiality as an element of the offense. See, for example, Indian Penal Code, par. 193; Canadian Criminal Code, par. 99(a) and 112; and the *Model Perjury Act* recommended by the commissioners on uniform state laws in 1952. More commonly, the materiality requirement has been retained for felonious perjury but eliminated in the statutory misdemeanour denominated false swearing. The American Law institute approved this solution in 1957.

To establish perjury the prosecution must prove that the statement was false and known to be so. Furthermore, it is commonly provided that the testimony of a single uncorroborated witness shall not suffice to prove falsity. On the other hand, it has been held that a person may be convicted of perjury regardless of the objective truth of the statement made, if, true or false, he did not believe it. In such case, it is said, he falsely represented his own belief.

A special problem of some importance in the law of perjury is whether a person commits the offense by lying under oath in a criminal or other proceeding directed against him. Under some legal systems, of or derived from continental Europe, defendants and other litigants are not sworn or the perjury statute has a restricted application to them. It is thought to be unfair or unrealistic to impose penal sanctions on a witness who is so obviously under pressure to give an account favourable to himself. On the same principle, in a minority of English-speaking jurisdictions, including England and the state of Georgia, the defendant in a criminal case may make an unsworn statement. Generally, however, U.S. law makes no such distinctions in favour of defendants, who, if they choose to testify, may be prosecuted for

perjury. In consequence, there have been cases where a person has been tried for crime, acquitted and subsequently convicted of perjury based upon his sworn denials of guilt in the earlier trial. See. for example, *State* v. *Leonard, 236* N.C. *126, 72* S.E. 2d *1 (1952).* Cf. *United States* v. *Williams, 341* U.S. *58* (1951), conviction of perjury for false self-exculpating testimony in prior trial where Williams was nevertheless convicted of the crime charged.

The opportunity to question a putative culprit under oath as to alleged misconduct in the remote past has also been used to secure from him sworn denials which can then be prosecuted as perjury, notwithstanding that prosecution for the original offense would be barred by the statute of limitations. It has been argued that this violates the spirit of limitations provisions, which are intended to prevent prosecution where lapse of time, death of witnesses and dimming of recollection make it difficult to determine the truth. See comment on the prosecution of Alger Hiss, *40 J. Crim. Law 344 (1949)*; Note, *102* U. *Pa. Law* **Rev.** *630, 649 (1954).*

The outer limits of the area in which the criminal law may be usefully or safely employed to repress lying are reached when legislatures undertake to penalize unsworn oral misrepresentation to any sort of official, *e.g.,* a policeman or an individual legislator making informal inquiries. In *King* v. *Manley* (1933), *1 K.B. 529,* the English court of criminal appeal affirmed conviction of a woman who falsely reported that she had been robbed, thus effecting a "public mischief" by wasting police time and public money in investigating false leads. A few statutes go so far as to punish any false statement relating to an alleged offense. The American Law institute in *1957* tentatively approved provisions on this subject in its *Model Penal Code* which would cover the offense of Manley, but would reach other oral misrepresentation to law enforcement officials only if it falsely implicates another person in crime. The danger sought to be avoided is that people might be subjected to criminal prosecution for denying their own guilt, *e.g.,* when stopped by a policeman for a traffic offense or for denying knowledge of a crime under investigation, out of fear, friendship or mere reluctance to become involved.

See also OATH AND AFFIDAVIT.

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(L. B. S.)

PERKIN, SIR WILLIAM HENRY (1838–1907), English chemist, the discoverer of aniline dyes, was born in London on March *12, 1838.* He attended the City of London school and devoted all his spare time to chemistry. In *1853* he entered the Royal College of Chemistry and studied under August W. von Hofmann, to whom he later became an assistant.

He devoted his evenings to private investigations in a rough home laboratory, and was inspired by some remarks of Hofmann's to undertake there the artificial production of quinine. In the course of his experiments *(1856)* he oxidized impure aniline with potassium bichromate, and obtained a black product from which he was able to extract a bluish substance with excellent dyeing properties. This was the first artificial or aniline dye to be prepared, and it subsequently became known as aniline purple or mauve. A patent for the process of manufacturing the dye was taken out in *1856,* and, with the aid of his father and brother, Perkin set up in *1857* works at Greenford Green, near Harrow, for the commercial production of mauve. In this way the aniline dye industry was founded.

In *1858* he and *B.* F. Duppa synthesized glycocoll, and in *1861* tartaric acid. Perkin also had an important share in the development of artificial alizarin (*q.v.*), which entirely replaced the red dye of the madder root. C. Graebe and C. T. Liebermann in *1868* prepared the substance synthetically from anthracene, but their process was not practicable on a large scale. In *1869* Perkin patented a commercial process which secured for his Greenford Green works a monopoly of alizarin manufacture for several years. He also carried out investigations on other dyes and on flavouring materials, in the course of which *(1868)* he synthesized the first artificial perfume, coumarin (*q.v.*), the odoriferous principle of woodruff and the tonka bean. He also investigated the constitution of saligenin.

About *1874* he abandoned manufacture and devoted himself exclusively to research. In *1878* he discovered the Perkin reaction for the preparation of unsaturated acids; *e.g.,* cinnamic acid which depends on the condensation of aromatic aldehydes with the salt of a fatty acid. Later he made a comprehensive study of the relation between chemical constitution and the rotation of the plane of polarization of light in a magnetic field and calculated the magnetic rotatory power of various elements and radicals.

Perkin was elected a fellow of the Royal society in *1866* and was awarded the Royal medal of the society in *1879* and the Davy medal in *1889.* He was knighted in *1906,* on the 50th anniversary of his discovery of mauve.

He died at Harrow on July *14, 1907.*

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PERKIN, WILLIAM HENRY (1860–1929), English chemist: one of the foremost synthetic organic chemists of his time, son of Sir William Perkin, was born at Sudbury on June *17, 1860.* He was educated at the Royal College of Science *(1877–79)* and then *(1880–85)* in Germany under Johannes Wislicenus and J. F. W. A. von Baeyer, whose assistant he became. In *1886* he was appointed professor at Edinburgh, in *1892* at the University of Manchester and in *1912* at Oxford. He worked particularly on camphor, terpenes, centroasymmetry, alkaloids, and their degradation products.

Perkin died at Oxford on Sept. *17, 1929.* A special issue of the *Journal* of the Chemical Society of London *(1932)* was devoted to an extended discussion of his life and works.

(R. E. O.)

PERKINS, GEORGE WALBRIDGE (1862–1920), U.S. financier who participated in many of the great financial transactions of the Morgan firm, was born in Chicago, Ill., Jan. *31, 1862.* He mas educated in the public schools and at the age of 15 entered the employ of the New York Life Insurance company as a clerk in the firm's Chicago office. He rose through the positions of assistant bookkeeper, cashier, solicitor, agency director and inspector of agencies to third vice-president by *1892.* In *1900* he became chairman of the finance committee and in *1903* vice-president.

His achievements as a business executive and financier were well recognized, and in *1900* he became a J. P. Morgan partner. In this capacity his abilities were further evidenced. He became a director of a number of firms, including the United States Steel corporation, the International Harvester company and the International Mercantile Marine company.

He was also actively involved in politics, and in *1910* he retired from the Morgan firm in order to devote more time to public and political work. He was an active member of the Progressive party and became chairman of its national executive committee. In *1912* he worked in support of Theodore Roosevelt in the presidential campaign and also contributed substantial financial support.

Perkins died at Stamford, Conn., June *18, 1920.*

(H. J. Sc.)

PERLITE (PEARLSTONE), a natural glass generally of composition equivalent to granite with concentric cracks, such that the rock breaks into small pearllike bodies or "pebbles," and formed by rapid cooling of viscous lava or magma. A rhyolite (*q.v.*), it is commonly gray or greenish but is known to occur in shades of brown, blue and red. The lustre is pearly to waxy. Prior to about *1950* perlite was virtually unknown in commerce; but in the second half of the 20th century great deposits were worked in New Mexico, Nevada, California and other western states. Production outside the United States increased very slowly. When crushed perlite is rapidly heated to its softening temperature (c. *1,500"–2,000'* F.), the contained water is converted to steam to form multitudes of tiny bubbles within the softened particles. The perlite is thus "popped" or suddenly expanded up to *20* times its original volume. This frothy glass may be considered an

artificial pumice. Because of its very low density. heat-treated perlite is a substitute for sand in lightweight wall plaster and concrete aggregate. Due to its porous nature the material is ideal for heat and sound insulation and the manufacture of insulating wallboard and acoustic plaster. Other uses include lightweight ceramic products, filters and fillers.

The spherical or perlitic cracks which characterize this rock are generally considered to be due to contraction of the cooling glass. Some studies indicate the cracks form in response to hydration. The concentric arrangement of cracks causes small pellets of glass to separate from the rest of the rock. These "pebbles" may range up to an inch across but are usually the size of lead shot. They may appear as spherules widely distributed through a sort of matrix, or they may be so closely packed as to mutually interfere and form polygon-shaped pellets somewhat resembling dried peas. The pearly lustre is attributed to reflections from the thin air films formed along the concentric fractures.

Some perlites are of intrusive origin (dikes), but others constitute major portions of lava flows. These glassy rocks may grade into nearly completely crystalline volcanic types. Like obsidian (*q.v.*) they may carry large crystals (phenocrysts) of quartz, alkali feldspar, and plagioclase and in some cases biotite or hornblende. Where phenocrystc are abundant the rock passes into vitrophyre. Crystalline bodies (see SPHERCLITE: CRYSTALLITE) may also abound, and curved or wavy trains of these are common evidence of flowage of the viscous molten material.

Microscopically some of the small glass pellets show slight double refraction indicating a strained condition in the material, and doubly refracting glass at the contact with phenocrysts suggests strain due to differential contraction.

The chemical composition, index of refraction. and specific gravity of perlite are similar to those of obsidian. The water content. however, is considerably higher (generally 3%–4%), much having been added subsequent to consolidation. (See PITCHSTONE.)

Devitrification or conversion of the glass to a microscopically fine crystalline aggregate is usually initiated spontaneously along cracks or at the surfaces of phenocrysts and spherulites. Some minutely crystalline rocks show well-developed perlitic structure and undoubtedly represent completely devitrified perlite. The localization of spherulites along curved and concentric bands in certain glass-free rocks suggests a devitrified perlite with spherulitic growth along the perlitic cracks.

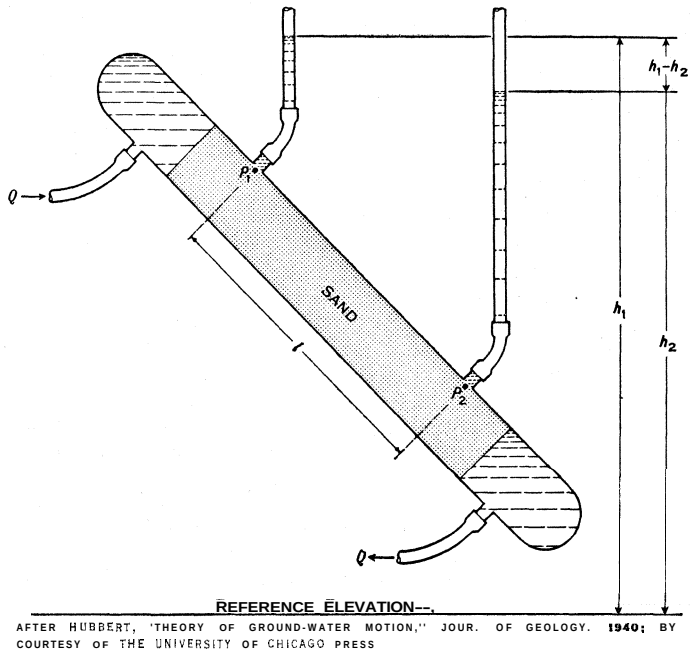
For chemical analyses of perlite and related glassy rocks, see PITCHSTONE. (C. A. CN.)

PERM, a town of the Russian Soviet Federated Socialist Republic. U.S.S.R., administrative centre of Perm *oblast*, on the left bank of the Kama river in 58° N., 56° 15' E. Pop. (1959 census) **628,000.** It has an important position on the railway since the products of the Crals converge on the town, partly by rail and partly by river. It mas planned to continue the line north of Perm, which terminated at Kotlas, to Sorok on the west of Lake Onega and thus link Perm and the Crals with Murmansk. The town manufactures agricultural machinery, especially separators for the Siberian dairy industry, and has sawmills and timber works, cardboard, match and leather factories. The Perm district was formerly occupied by a Finnish tribe, the Permyaks, speaking a language closely related to that of the Komi (Zirians); and they are still to be found on the upper Kama. In 1568 the Russian merchant princes, the Stroganovs, established a settlement there named Brukhanovo, which received the name Perm in the 17th century. In 1723 copper works were founded near the town, which under the official name of Perm became an administrative centre in **1781.** After the revolution of 1917–18 the named was changed to Molotov. It became Perm again on Oct. 3, 1958.

PERMANENT COURT OF INTERNATIONAL JUSTICE: see INTERNATIONAL COURT OF JCSTICE.

PERMEABILITY (FLUID). The permeability of a solid with respect to fluids is a measure of the facility with which fluids can penetrate or flow through the solid. Thus, of two solids, that one is the more permcable through which, under identical conditions, the greater quantity of a given fluid will pass in a fixed time. Solids owe their permeability to the existence of an internal porosity comprising a three-dimensional network of intricately branching and interconnecting channels. (See also GROUND WATER; HYDROLOGY.)

Darcy's Law. — The fluid permeability of a solid is defined and measured in terms of a flow experiment analogous to that illustrated in fig. 1. Here a liquid is made to flow through a porous solid into which two manometers along the same flowline have



AFTER HUBBERT, "THEORY OF GROUND-WATER MOTION," JOUR. OF GEOLOGY. 1940; BY COURTESY OF THE UNIVERSITY OF CHICAGO PRESS

APPARATUS FOR MEASURING THE PERMEABILITY OF SAND

been tapped. It is found experimentally (and can also be deduced theoretically) that the volume of liquid. q, crossing the unit gross area normal to the flowlines in unit time is given by

$$q=(Nd^2)(\rho/\mu)(-g\partial h/\partial l)$$

in which N is a dimensionless shape factor and d a length parameter characterizing the geometry of the solid, p and μ are the density and viscosity of the fluid. g the acceleration of gravity, and $\partial h/\partial l$ the rate of increase with distance in the flow direction of the manometer height h with respect to a reference elevation. This equation, which is knoan as Darcy's law, is valid for flow in any direction, and for all velocities small enough so that forces of inertia are negligible.

Of the three groups of factors on the right-hand side of the above equation. the first Nd^2, depends only on the pore geometry of the solid; the second, ρ/μ, is a property of the liquid; and the third. $-g(\partial h\partial l)$, is the impelling force acting upon each unit of mass of the liquid. In the past, various combinations of these factors have been taken as a measure of permeability, but opinion and usage have gradually converged toward agreement that the term "permeability" shall pertain to a property of the solid only.

Of these factors, only the first, Nd^2 (often expressed by the symbol k). satisfies this condition, and it is accordingly taken as a proper measure of the permeability of the solid. Transposing the equation, the permeability of the solid is given by

$$k=Nd^2=-\frac{q\mu}{\rho g(\partial h/\partial l)}$$

and its dimensions are $[L^2]$.

Units of Permeability. — Hence, in any consistent system of measurement in which one of the fundamental units is that of length, the unit of permeability is the square of the unit of length—for example, the square centimeter or the square foot.

For granular solids, if the mean grain diameter is taken as the characteristic length d, the factor N has an order of magnitude of 10^{-1}. Hence the permeabilities of clastic sediments, ranging

from fine silts. with mean grain diameters of 10^{-4} cm., to coarse sands. with mean grain diameters of 10^{-1} cm., vary from about 10^{-12} to 10^{-6} sq.cm. Since the useful range of permeabilities of most sedimentary rocks is from about 10^{-12} to 10^{-8} sq.cm., there would be some advantage in having a practical unit defined by 1 practical unit $= 10^{-12}$ sq.cm.

Inconsistent units in wide current use are the Meinzer unit (5.42×10^{-10} sq.cm.) and the darcy (0.987×10^{-8} sq.cm.).

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PERMEABILITY, MAGNETIC. The force between two magnetic poles varies as the product of the strengths of the poles, and inversely as the square of the distance between them. It depends also on the nature of the intervening medium. In the (centimetre-gram-second) electromagnetic system of units, unit pole is defined as one which repels an equal pole at a distance of one centimetre in empty space with a force of one dyne. Let F be the force between two poles of strengths m_1, m_2 at a distance r apart. Then, in a vacuum, $F = \frac{m_1 m_2}{r^2}$. More generally, $F = \frac{m_1 m_2}{\mu r^2}$. The constant μ depends on the' medium, and is known as the permeability. The permeability may also be defined as the ratio of the magnetic induction, B, to the magnetizing force, H; the induction being a measure of the magnetic force which would be exerted on unit pole placed in a narrow crevasse in the medium, perpendicular to the direction of the magnetic force.

Thus $\mu = B/H$. The conception of permeability is due to Michael Faraday, who spoke of it as "conducting power for magnetism," and the term was introduced by William Thomson (later Lord Kelvin) in 1872.

Substances are divided into two main magnetic classes: diamagnetics. with the permeability μ less than 1; and paramagnetic~with μ greater than 1. In diamagnetics the directions of the magnetization and the magnetizing force are opposite, in paramagnetics the same. For most substances the permeability differs very little from 1, and does not vary with the magnetizing field. A few paramagnetic substances, below certain critical temperatures, arc ferromagnetic, having magnetic properties resembling those of iron. The permeability of ferromagnetics (which include iron, nickel and cobalt and some of their alloys) is a function of the magnetic force, and generally depends on the previous history of the specimen. The permeability may be very large; the maximum for some dynamo steels and for iron-nickel alloys being greater than 100,000. A knowledge of the permeability characteristics of iron and iron alloys. in particular, is of great technological importance. Material having a high permeability for definite ranges of magnetic force is generally required in the construction of electrical machinery.

See MAGNETISM: *Magnetization* und *Permeability Curves.*

PERMEAMETER, an instrument for measuring the permeability of a sample of iron or steel, and more generally for examining the magnetic characteristics. *See* MAGNETISM: *Measurement of Magnetic Quantities: Yokes and Permeameters.*

PERMIAN PEOPLES. The term Permian is used by ethnologists and linguists outside of the Soviet Cnion to designate collectively two groups who speak closely related languages belonging to the Finno-Ugric family: Udmurt or Votyak and Komi or Zirian (Ziryen). Some Russian scholars also distinguish a third Permian branch, the Komi-Permyak, who constitute 70% of the 200.000 inhabitants of a special national area in the Sverdlovsk *oblast* of the Ural region; but this tripartite division seems to be based on politicai considerations alone, for Permyak is simply the southernmost dialect of Komi.

The common ancestors of the Udmurts and Komis separated from the westbound Volga-Finns (Cheremis and Mordvins) during the 1st millennium B.C., and continued as a uniform speech community for about 1,500 years thereafter. This period is known to specialists as the Permian (it has no connection. of course, with the geological period of the same name). The Permian community split into two branches during the 9th century A.D.

Udmurt Peoples.—Udmurt is spoken by more than 600.000 persons in the Udmurtsk-Autonomous Soviet Socialist republic (capital, Izhevsk, a U.S.S.R. industrial centre), roughly in the area between the Vyatka and Kama rivers. The Udmurts, organized in strong clan relations, are almost entirely peasants; each village was governed by a council of clan elders (kenesh), which even farm collectivization did not succeed in wiping out. The Udmurts came under Russian administration in 1587, and were successfully converted to Christianity after 1740 under the influence of Archbishop Veniamin, a man of exceptional character who set up a church in the region of Glazov.

Komi Peoples.—Komi is spoken in an immense area, from the neighbourhood of the Udmurts northward almost to the Arctic sea, and on the Kola peninsula. The Komi Autonomous Soviet Socialist Republic (capital, Syktyvkar) is the largest of all the autonomous republics in European Russia. Komi society has been shaped to a great extent by geographic location and climatic conditions, by the type of economy suitable for the area, and by Russian influence in cultural and political life. The location is responsible for the Komis' isolation and tardy progress; the uninviting climate protected them from extensive colonization until after World War II. The agricultural form of economy which prevailed for centuries remained dominant, though by no means uniform. After 1932, the Ukhta-Pechora region was gradually transformed into a mining and industrial area, and into a fuel producer for Leningrad industries; the modern development of the area is synonymous with that of three big undertakings, the oil trust. the coal trust, and the Northern Pechora Railway line. The principal focus of the new arctic mining activities is Vorkuta. In its vicinity the Komis changed after World War II from owners of large reindeer farms into workers on state farms, along with many Russian settlers. *See* also MORDVINIANS; SYRYENIANS.

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PERMIAN SYSTEM, a geological term designating the uppermost system of rocks and the final period of the Paleozoic era (the era of ancient life)—a time believed to have begun about 235,000,000 years ago, and lasting about 25,000,000 to 35,000,000 years, as indicated in the accompanying geologic time chart.

Geologic Time Chart

System and Period	Series and Epoch	Distinctive Records of Life	1,000 Years
CENOZOIC ERA			
Quaternary	Recent	Modern man	11
	Pleistocene	Early man	1,000
Tertiary	Pliocene	Large carnivores	
	Miocene	Whales, apes, grazing forms	
	Oligocene	Large browsing mammals	
	Eocene	Rise of flowering plants	
	Paleocene	First placental mammals	70,000
MESOZOIC ERA			
Cretaceous		Extinction of dinosaurs	130,000
Jurassic		Dinosaurs' zenith, primitive birds, first small mammals	160,000
Triassic		Appearance of dinosaurs	200,000
PALEOZOIC ERA			
Permian		Reptiles developed, conifers abundant	235,000
Carboniferous			
Upper (Pennsylvanian)		First reptiles, coal forests	260,000
Lower (Mississippian)		Sharks abundant	285,000
Devonian		Amphibians appeared, fishes abundant	320,000
Silurian		Earliest land plants and animals	350,000
Ordovician		First primitive fishes	400,000
Cambrian		Marine invertebrates	500,000
PRE-CAMBRIAN TIME			
		Few fossils	3,500,000–4,000,000

General Conditions of Permian Time.—The Permian was a time of crisis in world history. During much of preceding and succeeding Paleozoic and Mesozoic time: the continental areas were low and widely flooded by shallow seas, and the climate was equable over much of the earth. During the Permian, wide areas of the continents were emergent, there were extensive mountain chains and harsh climatic contrasts, with widespread deserts and continental glaciers; conditions were thus not unlike those of our modern era. Plant and animal life underwent many changes toward the end of Permian time, all species and many genera disappearing, some families and orders declining, others increasing in prominence, bringing about a change from the characteristic Paleozoic life to the characteristic Mesozoic life. (See also PALAEOBOTANY; PALAEONTOLOGY.)

Nevertheless, one should not think of these critical times as a cataclysm; their distinctive features began and ended gradually. Many of the mountain chains, such as the Appalachians of North America, had been growing since middle Paleozoic time. Permian marine invertebrates were not impoverished by the harsher conditions, but exceeded in variety and number those of some earlier periods. Many genera persisted into the Triassic, and the evolutionary forebears of Triassic life can be found in Permian strata.

Some Permian geographic and climatic features are inexplicable in terms of the modern world, and suggest a radical rearrangement of its surface between then and now. Permian rocks and fossils are much alike in all continents of the southern hemisphere and in India, and include deposits of continental glaciers. It is widely believed that these southern lands were once joined into a single continent, Gondwanaland (*q.v.*), and have since been separated either by foundering of the connections into the ocean basins, or by drifting apart of the continents. But there are as many objections to continental foundering or continental drifting as there are arguments for them, and the anomalies of Permian geography remain one of the riddles of geology.

Definition of Permian System.—The Permian system was named by Sir Roderick Impey Murchison in 1841, after a visit to European Russia. for the province of Perm not far west of the Ural mountains; rocks of the same age had long been known in western Europe, where they had been termed the Dyas in Germany, and had been considered the basal part of the New Red Sandstone in Great Britain. Murchison originally used the term for what are now called the Kungurian. Kazanian and Tartarian series. a sequence of red beds, evaporite deposits and fossiliferous limestone. The underlying Artinskian limestones of the type area were thought to be equivalent to limestones of the Carboniferous system in western Europe.

Later work has shown that the Artinskian, and even part of the Uralian beneath it (termed the Sakmarian series) is younger than the typical Carboniferous farther west. Beds between typical Permian and Carboniferous were, for a time, designated as "Permo-Carboniferous," but this usage has passed out of favour, and general practice now is to extend the base of the Permian considerably below the base originally designated.

North American stratigraphers usually put the base of the Permian at the bottom of the Wolfcamp series and the zone bearing fossils of Pseudoschwagerina, a genus of the fusulinid family of Foraminifera (*q.v.*), which is about equivalent to the bottom of the Sakmarian in Russia. It is thought that a boundary so placed can be recognized more readily than one at a higher level, and that it marks a significant stage in invertebrate evolution. European stratigraphers differ as to the classification of the Sakmarian, but some place it in the Carboniferous. On the other hand, the lower part of the German Dyas seems to be a continental equivalent of the Sakmarian and Wolfcamp.

The boundary of the Permian with the overlying Triassic can be drawn successfully in most marine sequences on the basis of characteristic invertebrate fossils, but its position is uncertain where the beds near the boundary are nonmarine and poorly fossiliferous—as they are in many places. In some areas the classification, as between Permian and Triassic, of formations and whole series has been much debated.

The classification of rocks in geologic systems is dealt with in GEOLOGY: *Historical* Geology. Additional information on the use of fossils in classifying and correlating deposits will be found in FOSSIL. See also SEDIMENTARY ROCKS; STRATIFICATION.

PERMIAN DEPOSITS

Deposits of Permian time are characterized by several distinctive assemblages, which reappear from one continent to another around the world. These types include:

(1) Red beds and other clastic rocks composed of fragments of pre-existing rocks, evaporites (gypsum, anhydrite, rock salt, potash minerals), dolomites and limestones. Red beds contain vertebrates (amphibians and reptiles) and plants, the limestones and dolomites an invertebrate fauna: mainly brachiopods. pelecypods and gastropods, relatively impoverished and without great diversity of genera and species. They were formed on extensive, flat, continental areas, partly on the surface of the land; partly in dessication basins, partly in shallow ephemeral seas, probably in a dry climate. Deposits of this type occur widely in the northern hemisphere. as in Russia, Germany, Great Britain and the mid-continent region of North America.

(2) Marine deposits, in some areas of considerable thickness—shales, sandstones, and limestones, in places with thick reefs formed by lime-secreting organisms. Rocks of this type contain a large and diversified suite of marine invertebrates—fusulinids (a group of Foraminifera), bryozoans, brachiopods, pelecypods, gastropods, ammonoids, and the last of the trilobites. Such deposits are extensive in the southern part of the northern hemisphere and into the tropics—in Eurasia from the Mediterranean eastward to Indonesia in the ancient seaway called Tethys; in North America in western Texas, and Mexico.

(3) Volcanic rocks, mainly marine—lavas. pyroclastics and tuffs. with some nonvolcanic shales and limestones. Some beds contain marine invertebrates. such as fusulinids and brachiopods, and at some localities the fish *Helicoprion.* These deposits are characteristic of the most mobile parts of the geosyncline surrounding the Pacific ocean, from California through British Columbia into Alaska. in Japan and New Zealand. An outlying volcanic sequence occurs at Las Delicias, Coahuila, Mex.

(4) Glacial and continental beds, generally with tillites near the base and a thick sequence of shales and sandstones above. with beds of coal. These deposits contain the distinctive seed fern, *Glossopteris,* and some reptiles. They are characteristic of wide areas in the continents of the southern hemisphere—southern Africa. eastern South America, Australia, Antarctica and peninsular India. Continental beds interfinger marginally in places with cold-water marine deposits containing the pelecypod *Eurydesma* and a few other invertebrates.

Permian of Europe.—Below are described some of the principal sequences of Permian rocks in the various continents, belonging to one type or another of the assemblages just listed.

The type Permian, in European Russia, lies in a broad basin that extends westward from the Ural mountains to Moscow. Thickness and nature of the rocks vary greatly across the basin, from thick clastic deposits on the east to thinner limestones on the west, but the general assemblage is of type 1, above. The following succession occurs (descending order):

EUROPEAN RUSSIA

Tartarian series.—Continental red beds, about 500 ft. thick, with many vertebrate fossils; upper part is Triassic.

Kazanian series.—In the west, marine limestone with invertebrate fossils, about 300 ft. thick, passing eastward into thicker nonmarine red beds.

Kungurian series.—Largely evaporites, with interbedded clays and marls; more than 2,500 ft. thick in the east, but thinning westward.

Artinskian series.—In the east, shales and sandstones, partly marine, partly continental, about 5,000 ft. thick, represented westward by upper part of limestones of Ufa plateau. Contains several zones of the fusulinid Schwagerina, as well as many ammonoids and brachiopods.

Sakmarian series.—In Ufa plateau, limestones 500 to 750 ft. thick, with large reef bodies, containing the fusulinid *Pseudoschwagerina,* the gastropod *Omphalotrochus,* the ammonoid *Artinskia* and other invertebrates. Passes eastward into much thicker sandstones and conglomerates. Formerly included in the Artinskian of the Urals and

in the Uralian elsewhere. Lies on earlier Uralian limestones that contain the fusulinid Triticites.

In Germany, where the Permian has been termed the Dyas, the section is somewhat thinner, but of the same general type as in Russia. The sequence is as follows (descending order):

GERMANY

Zechstein (Thuringian).—At base, a copper bearing black shale a few feet thick, the Kupferschiefer, overlain by 100 ft. of dolomitic limestone containing an impoverished marine invertebrate fauna. Above it, several thousand feet of evaporites, which give rise to the salt domes of northern Germany, and which are mined for rock salt and potash at Stassfurt.

Upper Rothliegende (Saxonian).—Red sandstones and shales with much interbedded lava.

Lower Rothliegende (Autunian).—Shales, red beds and some coal, containing *Walchia, Callipteris* and other plants. A much more local deposit than the two higher divisions, but locally attaining a thickness of several thousand feet.

The Permian of Great Britain resembles that of Germany. Its magnesian limestone appears to be the same as the dolomitic limestone of the lower Zechstein, and is likewise overlain by evaporites.

Permian of North America.—In North America the standard Permian section is that in west Texas, where most of the sequence is marine and highly fossiliferous (type 2, above), and attains a thickness of 10,000 ft. Best exposures are in the Guadalupe and Glass mountains lying, respectively, on the northwest and south sides of the Delaware basin, a depositional area of Permian time. There the sequence is as follows (descending order):

NORTH AMERICA

Ochoa *series.*—Evaporites, mainly anhydrite below and rock salt above, the latter containing workable potash-bearing layers. At top, a widespread thin dolomite (Rustler) with the only fossils in the series (brachiopods, gastropods, pelecypods). Overlain with hiatus by Upper Triassic, so relation to lowest Triassic is unknown.

Guadalupe series.—Marine sandstone, shale and thin limestone in Delaware basin, passing marginally in upper part into thick barrier reefs (Capitan limestone). Contains the fusulinids *Parafusulina* and *Polydiexodina,* the ammonoids *Waagenoceras, Timorites* and *Xenaspis,* and a rich and varied brachiopod fauna.

Leonard series.—Mainly black shale and thin-bedded limestone in Delaware basin (Bone Spring formation), passing marginally into limestone banks and small reefs. Contains the fusulinids Schwagerina and Parafusulina, the ammonoids *Perrinites* and Medlicottia, and numerous brachiopods, including Dictyoclostus *ivesi.*

Wolfcamp series.—In Glass mountains, shale with thin beds of limestone and conglomerate, but farther northwest a more solid body of limestone (Hueco). Contains the fusulinids *Pseudoschwagerina* and *Schwagerina,* the ammonoid Artinskia, the gastropod *Omphalotrochus,* and numerous brachiopods. Lies on Virgil series of Pennsylvanian (Upper Carboniferous), with Triticites and Uddenites, in places with angular unconformity.

North and northeast of the Delaware basin in the midcontinent area of central Texas, Oklahoma and Kansas, marine beds largely give place to red beds and evaporites; the Permian is of type 1.

Toward the northwest, also, the marine beds pinch out. At the Grand canyon in northern Arizona the Permian is about 2,000 ft. thick and consists. below the Triassic, of the Kaibab and Toroweap limestones. Coconino sandstone, Hermit red shale and Supai red beds. Only the Kaibab and Toroweap (with *Dictyoclostus ivesi* and *D.* bassi) are marine; the Coconino is an ancient dune deposit and the strata below are flood-plain deposits, with plant remains and reptile and amphibian tracks. Much of the sequence is of Leonard age, but the lower nonmarine beds include Wolfcamp equivalents.

Farther north, the Park City and Phosphoria formations form an interfingered set of deposits zoo to more than 1,000 ft. thick, which cover wide areas in contiguous parts of Utah, Wyoming, Idaho and Montana. They lie on Pennsylvanian, are overlain by early Triassic and cover a wide span of Permian time: parts are as old as the Leonard or Wolfcamp, but the main body, with the *Spirijerinu pulchra* brachiopod fauna! is of Guadalupe age. The Park City and Phosphoria beds interfinger eastward with the red beds of the midcontinent area and are bordered on the west by volcanic rocks of the circum-Pacific belt.

Permian of Southern Hemisphere.— Permian rocks of the southern hemisphere belong mainly to type 4, above. The section in South Africa is representative and forms the lower part of the Karroo system. The Permian part of the Karroo varies from a few thousand feet thick in most of the region to nearly 15,000 ft. in the Cape mountains on the south. It consists of the following (descending order):

SOUTH AFRICA

Beaufort series.—Interbedded sandstones and shales, probably flood-plain deposits, containing reptiles at many levels and a few *Glossopteris* in the lower part. Reptiles indicate that only lower part of series is Permian, the higher being Triassic.

Ecca series.—Mainly shale and mudstone, but with interbedded sandstone in places and coal measures in the middle in Transvaal and Natal. Contains abundant *Glossopteris-Gangamopteris* flora.

Dwyka series.—In the south, thick tillites, with shales below and above, lying conformably on upper beds of the Cape system. Farther north, the series is missing entirely in places; in others, only the tillite is present>lying on a striated pavement of pre-Cape rocks. Upper shales contain sparse marine fossils in southwest Africa, including the pelecypod *Eurydesma* and the reptile *Mesosaurus.*

The tillites of the Dwyka are boulder-bearing clays which are moraines of a continental ice sheet; striae indicate that its centre was in Transvaal or farther north, from whence the ice moved south and southwest, the thick tillites on the south probably being a terminal moraine deposited at the edge of the continent. (See also AFRICA: *Geology.*) The Dwyka tillites record a climax of glacial conditions, but relations elsewhere indicate that the period of refrigeration was prolonged; in eastern Australia boulder beds of glacial origin are interspersed through more than 10,000 ft. of section.

Correlation of the Permian rocks of the southern hemisphere with those of the northern is difficult because the *Glossopteris* flora and cold-water marine fauna of the former extend but rarely into rocks of the latter region. Age of the tillites is especially disputed, geologists placing them variously entirely in the Carboniferous, entirely in the Permian or partly in both. In northern India (Salt Range and Kashmir) and in western Australia, tillites, cold-water marine beds and beds with *Glossopteris* flora are followed by beds with marine fossils which can be correlated with the Artinskian (Leonard) of the northern hemisphere, thus suggesting that the climax of glaciation was during Sakmarian (Wolfcamp) time. In other areas, where tillites extend through a greater thickness of strata, glaciation may have begun earlier and ended later than the Sakmarian.

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PERNAMBUCO, a northeastern Atlantic state of Brazil. Area, 37,868 sq.mi.; pop. (1950) 3,395,185. It comprises a comparatively narrow coastal zone, a high inland plateau and an intermediate zone formed by the terraces and slopes between the two. Its surface is much broken by the remains of the ancient plateau which has been worn down by erosion, leaving escarpments and ranges of flat-topped mountains, called chapadas, capped in places by horizontal layers of sandstone. The coastal zone is low, well-wooded and fertile. It has a hot, humid climate, relieved to some extent by the southeast trade winds. This region is locally known as the *matas* (forests). The middle zone, called the caatinga or agreste region, has a drier climate and lighter vegetation. The inland region, called the *sertão,* is high, stony and dry and frequently devastated by prolonged droughts (*sêcas*). The climate is characterized by hot days and cool nights and is generally considered healthful. There are two clearly defined seasons: a rainy season from March to June and a dry season for the remaining

months.

The rivers of the state include a number of small plateau streams flowing southward to the São Francisco river, and several large streams in the eastern part flowing eastward to the Atlantic. The largest of the coastal rivers are the Goiana, the Capibaribe, the Ipojuca, the Sirinhaém and the Una.

The state of Pernambuco is, for the most part, agricultural, the lowlands being devoted to sugar and fruit, with coffee in some of the more elevated localities; the agreste region to cotton, tobacco, Indian corn, beans and stock; and the *sertão* to grazing and in some localities to cotton. Sugar, molasses, rum (*aguardente* or *cachaça*), tobacco and fruit are largely exported. Coconuts, cacao, bananas, mangoes and other tropical fruits are produced in profusion, but the production of foodstuffs (beans, Indian corn, mandioca, etc.) is not sufficient for local consumption. Mangabeira rubber is collected to a limited extent, and piassava fibre is an article of export. Orchids are also collected for export in the districts of Garanhuns and Timbauba. Cotton weaving and cigar making are leading manufacturing industries, after the large *engenhos* devoted to the manufacture of sugar and rum. The railways of the state concentrate at the port of Recife.

The capital of the state is Recife; pop. (1950) 512,370. There are a number of large towns in Pernambuco; the most important are: Bom Conselho, a town of the higher agreste region, Caruaru, Garanhuns, Goiana, Limoeiro, Olinda, the old colonial capital and episcopal see, Timbauba and Vitória. These towns range in population from about 10,000 to 50,000.

Pernambuco, at its inception in 1526, was settled by Christovão Jacques, who founded a settlement on the Rio Iguarassú that was afterward abandoned. The first permanent settlement was made by Duarte Coelho Pereira at Olinda in 1530, and four years later he was granted a capitania of 50 leagues extending from the mouth of the São Francisco northward to that of the Iguarassu. Adjacent to this grant on the north was the capitania of Itamaracá, granted to Pero Lopes de Souza, which covered the remainder of the present state. The *capitania* of Pernambuco was ably governed and took an active part in the expulsion of the French from the trading posts established along the coast northward to Maranhão, and in establishing Portuguese colonies in their places. In 1630 Pernambuco was occupied by the Dutch and continued under their rule until 1654. Although an active guerilla warfare was waged against the Dutch during a large part of that period, they did much to promote the agricultural and commercial interests of the colony, especially under the wise administration of Maurice of Nassau. As a result of their victory over the Dutch the people of Pernambuco developed a strong regional feeling and resentment of all foreign domination, including the Portuguese.

In 1817 Pernambuco was the scene of a revolutionary outbreak, which resulted in the temporary separation of the present states of Alagôas and Rio Grande do Norte, Ceará and Paraiba. There was another insurrection in 1822 when the Portuguese were expelled; and in 1824 dissatisfaction with the arbitrary proceedings of Dom Pedro I at Rio de Janeiro led to a separatist revolution for the formation of a new state, to be called the Federação do Equador. There was another outbreak in 1831 and frequent disorders to 1838, which culminated in another unsuccessful revolution. The population of the Pernambuco *sertão* became noted for its turbulent, lawless character, due partly to the distance from the coast where the bulk of the population is concentrated, partly to difficult means of communication and partly to the fact that this remote region became the refuge of criminals from the coast towns. (R. D' E.; R. E. P.)

PERNICIOUS ANEMIA: see ANEMIA; BLOOD.

PERNIK: see DIMITROVO.

PERON, JUAN DOMINGO (1895–), Argentine president and army officer, was born on Oct. 8. 1895, near Lobos, a small town 60 mi. S. of Buenos Aires. He was educated in military schools, becoming a full lieutenant in the army at the age of 20. He became one of the leaders of the *Grupos* de *Oficiales Unidos*, a nationalist clique of young army officers with totalitarian leanings. and played an important role in the coup d'état that overthrew the regime of Ramón S. Castillo on June 4, 1943. Although Perón held only minor official posts in succeeding governments, he was the power behind the throne. In 1944, when Gen. Edelmiro Fárrell became president, Perón was made war minister and later added the office of vice-president. He succeeded Fárrell in 1946 and was re-elected president in 1951. Before her death in 1952, Maria Eva Duarte de Perón, whom he married in Oct. 1945. participated in political activities, and was especially important in the management of labour factions and social services. The Perón government, controlled by the official Peronista party, which drew its support principally from the army and the General Confederation of Labour (C.G.T.), was essentially a military dictatorship. During his second administration, relations with the Roman Catholic Church steadily deferiorated. and he was excommunicated on June 16. 1955, after two church prelates had been expelled from Buenos Aires. On the same day the navy led an abortive attempt to depose him by force. Perón at first made conciliatory overtures but on Sept. 1 declared a state of siege. The armed revolt was resumed actively on Sept. 16 and three days later Perón resigned. On Sept. 23 Maj. Gen. Eduardo Lonardi was sworn in as provisional president. Perón, who had fled to a Paraguayan gunboat near Buenos Aires, flew to Paraguay to begin his exile.

PÉRONNE, a town of northern France, capital of an arrondissement in the *département* of Somme, on the right bank of the Somme at its confluence with the Cologne, 35 mi. E. by N. of Amiens by rail. Pop. (1954) 4,105. The Frankish kings had a villa at Pkronne, and a monastery was founded there in the 7th century by, or for, Scottish monks; a collegiate church was built and dedicated to St. Fursy, the first abbot. By about 1200 it had escheated to the French crown, and Philip Augustus gave it a charter (1209). By the treaty of Arras (1435) it was given to the Burgundians; bought back by Louis XI. it passed to Charles the Bold in 1465. On the death of Charles, in 1477, Louis X I resumed possession. In 1536 the emperor Charles V besieged Pkronne without success. It was the first town after Paris at which the league was proclaimed in 1577. Wellington took Péronne in 1815, the Germans captured it in 1871, 1911 and 1910.

PEROVSKITE, essentially calcium titanate. originally found in a chlorite schist at Achmatovsk in the Ural mountains and named after Count L. A. Perovski. Crystals are lustrous. yellow to brownish black, highly twinned cubes or octahedra (actually orthorhombic very nearly cubic symmetry). Common occurrences are as accessory constituents of basic or alkalic-basic igneous rocks or at metamorphic contacts of these rocks with limestones. The composition is $CaTiO_3$. Rare-earth elements. sodium potassium and iron substitute for Ca, and niobium and tantalum substitute to a considerable extent for Ti in the natural mineral.

The name perovskite is also applied to an important crystal structure family. including calcium titanate ($CaTiO_3$) and related natural and synthetic compounds, all possessing similar pseudocubic or cubic structures. Element substitutions in natural perovskite suggested many of the chemical variations later shown to he possible by synthesis.

The importance of this family to the electrical industry was recognized with the discovery of ferroelectricity in barium titadate, $BaTiO_3$. Members of this family, including the titanates, zirconates and niobates, have become very important to the entire electronics industry, where they are used for their high dielectric constants and as transducers (transformers of electrical energy into mechanical energy) capable of withstanding high temperatures (see ULTRASONICS). (RU. R.)

PEROXYACIDS are oxyacids which contain one or more peroxide groups, **–O–O–,** or they may be regarded as oxyacids in which an OH– group has been replaced by an –OOH group. They are formed by boron, carbon, titanium, zirconium, germanium, tin, nitrogen, phosphorus, vanadium, columbium, tantalum. sulfur, chromium, selenium. molybdenum and tungsten. Some are described under the corresponding elements: *e.g.,* peroxysulfuric acid and peroxydisulfuric acid under SULFUR. (J. B. Ps.)

PEROZ, Sassanid king of Persia. A.D. 457–484, son of Yazdegerd II. He rebelled against his brother Homizd III. and in 159 defeated and killed him with the help of the Ephthalites, or White Huns: who had invaded Bactria. He also killed most of his other

relatives, and persecuted the Christians. But he favoured the introduction of Nestorianism, in opposition to the orthodox creed of Byzantium. With the Romans he maintained peace, but he tried to keep down the Ephthalites, who began to conquer eastern Iran. The Romans supported him with subsidies, but all his wars were disastrous. Once he was himself taken prisoner and had to give his son Kavadh as hostage till after two years he was able to pay a heavy ransom. Then he broke the treaty again and advanced with a large army. But he lost his way in the eastern desert and perished with his whole army (484). (ED. M.)

PERPENDICULAR PERIOD, in architecture, the latest style of English Gothic, roughly embracing the period from 1375 to the introduction of the Renaissance, during the 16th and 17th centuries. It gains its name from the dominance of vertical lines in window tracery (*q.v.*) and wall paneling; in windows the vertical mullions sometimes carry unbroken from the sill to the under side of the arch and the upper part of the window is further subdivided by additional, smaller, vertical mullions carried by the apex of arches connecting the larger mullions. Continuous horizontal lines of arches and cornices are sometimes carried across high windows to divide the whole into many small arched lights, in each one of which could be placed the effigy of a saint in stained glass. In structure the tendency is toward the reduction of wall surface, the increase of window area, the continuity of vertical lines and supports and the lavish development of decorative vaulting by means of liernes and, later. the elimination of structural vaulting ribs altogether, and the substitution of cut-stone. traceried fan vaults. (See ARCH AND VAULT.)

Timber-trussed ceilings and roofs were developed to a point of great perfection and richness, as in that of Westminster hall, London (1395–99), and in countless simpler parish churches, *e.g.,* Chipping Norton, Holy Trinity, Hull. The period also saw the construction of many beautifully outlined and lavishly detailed church towers, usually square and without spires. Those of Gloucester cathedral (1450–57), Magdalen college, Oxford (1492–1505), the central tower at Canterbury (1495) and the west towers of York (1432–70) are typical. In decorative detail the period is marked by the introduction of the four-centred or Tudor arch. the covering of wall surfaces with ranges of traceried panels, chiefly rectangular, the general flatness of molding profiles, diminished importance of the capital, the enclosing of door and window arches within a rectangular hood mold and the replacement of the earlier naturalism in carved ornament by a rather dry. incisive and, at times, mechanical. conventionalism.

The Perpendicular period appears first in work in Gloucester cathedral about 1360, but the spread of the style was so rapid that by 1380 Perpendicular work was being built throughout the country. It was a style so vital that it yielded but slowly to the influx of Renaissance ideas; and, particularly in Oxford. its effect was felt in building well into the 17th century. (T. F. H.)

PERPETUAL MOTION or PERPETUUM MOBILE, in its usual significance, not simply a machine which will go on moving for ever, but a machine which, once set in motion, will go on doing useful work without drawing on any external source of energy, or a machine which in every complete cycle of its operation will give forth more energy than it has absorbed. Briefly, a perpetual motion usually means a machine which will create energy in the form of motion.

The earlier seekers after the "perpetuum mobile" did not always appreciate the exact nature of their quest; for we find among their ideals a clock that would periodically rewind itself, and thus go without human interference as long as its machinery would last. The energy created by such a machine would simply be the work done in overcoming the friction of its parts, so that its projectors might be held merely to have been ignorant of the laws of friction and of the dynamic theory of heat. Most of the perpetual motionists, however, had more practical views, and explicitly declared the object of their inventions to be the doing of useful work, such as raising water, grinding corn, and so on. Like the exact quadrature of the circle, the transmutation of metals and other famous problems of antiquity, the perpetual motion has now become a venerable paradox. Still, like these others, it retains a great historical interest for as a result of the vain quest, there grew up the greatest of all the generalizations of physical science, the principle of the conservation of energy.

There was a time when the problem of the perpetual motion was one worthy of the attention of a philosopher. Before that analysis of the action of ordinary machines which led to the laws of dynamics, and the discussion of the dynamical interdependence of natural phenomena which accompanied the establishment of the dynamical theory of heat, there was nothing plainly unreasonable in the idea that work might be done by the mere concatenation of machinery. It had not then been proved that energy is uncreatable and indestructible in the ordinary course of nature; even now that proof has only been given by induction from long observation of facts. There was a time when wise men believed that a spirit, whose maintenance would cost nothing, could by magic art be summoned from the deep to do his master's work; and it was just as reasonable to suppose that a structure of wood, brass and iron could be found to work under like conditions.

The principle of the conservation of energy, which in one sense is simply denial of the possibility of a perpetual motion, rests on facts drawn from every branch of physical science; and, although its full establishment only dates from the middle of the 19th century, yet so numerous are the cases in which it has been tested, so various the deductions from it that have been proved to accord with experience, that it is now regarded as one of the best-established laws of nature. Consequently, on any one who calls it in question is thrown the burden of proving his case. If any machine were produced whose source of energy could not at once be traced, a man of science (complete freedom of investigation being supposed) would in the first place try to trace its power to some hidden source of a kind already known; or in the last resort he would seek for a source of energy of a new kind and give it a new name.

If a man likes to indulge the notion that, after all, an exception to the law of the conservation of energy may be found, then provided he submits his idea to the test of experiment at his own charges without annoying his neighbours, all that can be said is that he is engaged in an unpromising enterprise. The case is otherwise with the projector who comes forward with some machine which claims by the mere ingenuity of its contrivance to multiply the energy supplied to it from some of the ordinary sources of nature and sets to work to pester scientific men to examine his supposed discovery, or attempts therewith to induce the credulous to waste their money. This is by far the largest class of perpetual-motion-mongers nowadays.

It was no doubt the barefaced fallacy of most of the plans for perpetual motion that led the majority of scientific men to conclude at a very early date that the "perpetuum mobile" was an impossibility. We find the Paris Academy of Sciences refusing, as early as 1775, to receive schemes for the perpetual motion, which they class with solutions of the duplication of the cube, the trisection of an angle and the quadrature of the circle. Stevinus and Leibnitz seem to have regarded its impossibility as axiomatic; and Newton at the beginning of his *Principia* states a principle which virtually amounts to the same thing.

The famous proof of P. de la Hire simply refers to some of the more common gravitational perpetual motions. The truth is that, if proof is to be given, or considered necessary, it must proceed by induction from all physical phenomena.

By far the most numerous class of perpetual motions is that which seeks to utilize the action of gravity upon rigid solids. We have not read of any actual proposal of the kind, but the most obvious thing to imagine in this way would be to procure some substance which intercepts gravitational attraction. If this could be had, then, by introducing a plate of it underneath a body while it was raised, we could elevate the body without doing work; then, removing the plate, we could allow the body to fall and do work; eccentrics or other imposing device being added to move the gravitation intercepter, behold a perpetual motion complete! The great difficulty is that no one has found the proper material for an intercepter.

Fig. 1 represents one of the most ancient and oftenest-repeated

of gravitational perpetual motions. The idea is that the balls rolling in the compartments between the felloe and the rim of the wheel will, on the whole, so comport themselves that the moment about the centre of those on the descending side exceeds the moment of those on the ascending side. Endless devices, such as curved spokes, levers with elbow-joints, eccentrics, etc., have been proposed for effecting this impossibility. The student of dynamics at once convinces himself that no machinery can effect any such result; because if we give the wheel a complete turn, so that each ball returns to its original position, the whole work done by the ball will, at the most, equal that done on it. We know that if the laws of motion be true, in each step the kinetic energy given to the whole system of wheel and balls is equal to that taken from the potential energy of the balls less what is dissipated in the form of heat by frictional forces, or vice versa, if the wheel and balls be losing kinetic energy—save that the friction in both cases leads to dissipation. So that, whatever the system may lose, it can, after it is left to itself, never gain energy during its motion.

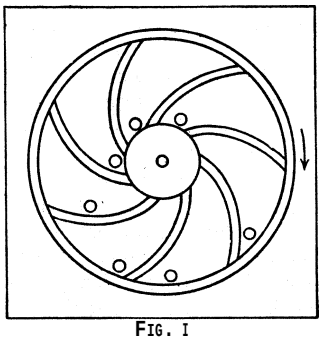

FIG. 1

The two most famous perpetual motions of history, viz., the wheels of the marquis of Worcester (d. 1667) and of Councillor Orffyreus, were probably of this type. The marquis of Worcester alludes to the marvellous performance of his machine in his *Century* of Inventions (1663): the wheel was 14 feet in diameter and bore 40 weights of 50 pounds apiece!

Orffyreus (whose real name was Johann Ernst Elias Bessler) (1680–1745) appears to have constructed more than one wheel: his last one was 12 ft. in diameter and 1 ft. 2 in. broad; it consisted of a light framework of wood, covered in with oilcloth so that the interior was concealed, and was mounted on an axle which had no visible connection with any external mover. It was examined and approved of by the landgrave of Hesse-Cassel, in whose castle at Weissenstein it is said to have gone for eight weeks in a sealed room. The most remarkable thing about this machine is that it evidently imposed upon the mathematician W. J. 'sGravesande, who wrote a letter to Newton giving an account of his examination of Orffyreus's wheel undertaken at the request of the landgrave, wherein he professes himself dissatisfied with the proofs theretofore given of the impossibility of perpetual motion, and indicates his opinion that the invention of Orffyreus is worthy of investigation. He himself, however, was not allowed to examine the interior of the wheel. The inventor seems to have destroyed it himself. One story is that he did so on account of difficulties with the landgrave's government as to a licence for it; another that he was annoyed at the examination by 'sGravesande, and wrote on the wall of the room containing the fragments of his model that he had destroyed it because of the impertinent curiosity of 'sGravesande.

The overbalancing wheel perpetual motion seems to be as old as the 13th century. Dircks quotes an account of an invention by Villard de Honnecourt, an architect whose sketchbook is still preserved in the Écoles des Chartes at Paris. De Honnecourt says, "Many a time have skilful workmen tried to contrive a wheel that shall turn of itself; here is a way to do it by means of an uneven number of mallets, or by quicksilver."! He thereupon gives a rude sketch of a wheel with mallets jointed to its circumference. It appears that Leonardo da Vinci worked with similar notions.

Another scheme of the perpetual motionist is a water-wheel which shall feed its own mill-stream. This notion is probably as old as the first miller who experienced the difficulty of a dry season. One form is figured in the *Mathematical Magic* (1648) of Bishop Wilkins (1614–1672); the essential part of it is the water-screw of Archimedes, which appears in many of the earlier machines of this class. Some of the later ones dispense with even the subtlety of the water-screw, and boldly represent a water-wheel pumping the water upon its own buckets.

Perpetual motions founded on the hydrostatical paradox are not uncommon; Denis Papin exposes one of these in the *Philosophical Transactions* for 1685. The most naïve of these devices is that illustrated in fig. 2, the idea of which is that the larger quantity of water in the wider part of the vessel weighing more will overbalance the smaller quantity in the narrower part, so that the water will run over at C, and so on continually.

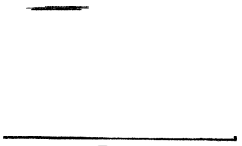

FIG. 2

Capillary attraction has also been a favorite field for the vain quest; for, if by capillary action fluids can be made to disobey the law of never rising above their own level, what so easy as thus to produce a continual ascent and overflow, and thus perpetual motion? Various schemes of this kind, involving an endless band which should raise more water by its capillary action on one side than on the other. have been proposed. The most celebrated is that of Sir William Congreve (1772–1828). EFG (fig. 3) is an inclined plane over pulleys; at the top and bottom travels an endless band of sponge, *abcd,* and over this again an endless band of heavy weights jointed together. The whole stands over the surface of still water. The capillary action raises the water in *ab,* whereas the same thing cannot happen in the part *ad,* since the weights squeeze the water out. Hence, inch for inch, *ab* is heavier than *ad;* but we know that if *ab* were only just as heavy inch for inch as *ad* there would be equilibrium, if the heavy chain be also uniform; therefore the extra weight of *ab* will cause the chain to move round continually in the direction of the arrow.

The more recondite vehicles of energy, such as electricity and magnetism, are more seldom drawn upon by perpetual-motion inventors than might perhaps be expected. William Gilbert, in his treatise *De Magnete,* alludes to some of them, and Bishop Wilkins mentions among others a machine "wherein a loadstone is so disposed that it shall draw unto it on a reclined plane a bullet of steel, which, still, as it ascends near to the loadstone, may be contrived to fall through some hole in the plane and so to return unto the place whence at first it began to move, and being there, the loadstone will again attract it upwards, till, coming to this hole, it will fall down again. and so the motion shall be perpetual." The fact that screens do exist whereby electrical and magnetic action can be cut off would seem to open a door for the perpetual-motion seeker. Unfortunately the bringing up and removing of these screens involves in all cases just that gain or loss of work which is demanded by the law of the conservation of energy. A shoemaker of Linlithgow called Spence pretended that he had found a black substance which intercepted magnetic attraction and repulsion, and he produced two machines which were moved, as he asserted, by the agency of permanent magnets. thanks to the black substance. The fraud was speedily exposed, but it is worthy of remark that Sir David Brewster thought the thing worth mentioning in a letter to the *Annales de chimie* (1818), wherein he states "that Mr. Playfair and Captain Kater have inspected both of these machines and are satisfied that they resolve the problem of perpetual motion."

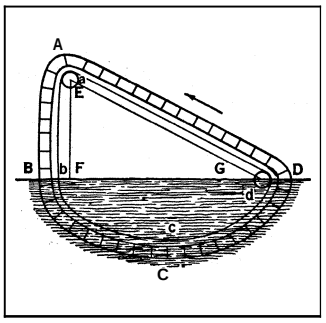

FIG. 3

One more page from this chapter of the book of human folly; the author is the famous Jean Bernoulli the elder. We translate his Latin, as far as possible. into modern phraseology. In the first place we must premise the following. (See fig. 4.) (1) If there be two fluids of different densities whose densities are in the ratio of G to L, the height of equiponderating cylinders on equal bases will be in the inverse ratio of L to G. (2) Accordingly, if the height AC of one fluid, contained in the vase AD, be in this ratio to the height EF of the other liquid. which is in a tube open at

both ends, the liquids so placed will remain at rest. (3) \Therefore, if AC be to EF in a greater ratio than L to G, the liquid in the tube will ascend; or if the tube be not sufficiently long the liquid will overflow at the orifice E (this follows from hydrostatic principles). (4) It is possible to have two liquids of different density that will mix. (5) It is possible to have a filter, colander, or other separator, by means of which the lighter liquid mixed with the heavier may be separated again therefrom.

Construction.—These things being presupposed (says Bernoulli), I thus construct a perpetual motion. Let there be taken in any (if you please, in equal) quantities two liquids of different densities mixed together (which may be had by hyp. 4), and let the ratio of their densities be first determined, and be the heavier to the lighter as G to L, then with the mixture let the vase AD be filled up to A. This done let the tube EF, open at both ends, be taken of such a length that AC:EF > 2L:G+L; let the lower orifice F of this tube be stopped, or rather covered with the filter or other material separating the lighter liquid from the heavier (which may also be had by hyp. 5); now let the tube thus prepared be immersed to the bottom of the vessel CD; I say that the liquid will continually ascend through the orifice F of the tube and overflow by the orifice E upon the liquid below.

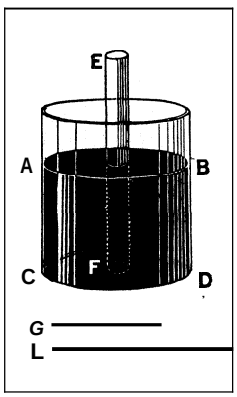

FIG. 4

Demonstration.—Because the orifice F of the tube is covered by the filter (by constr.) which separates the lighter liquid from the heavier, it follows that, if the tube be immersed to the bottom of the vessel, the lighter liquid alone which is mixed with the heavier ought to rise through the filter into the tube. and that, too, higher than the surface of the surrounding liquid (by hyp. 2), so that AC:EF = 2L:G+L; but since by constr. AC:EF > 2L:G+L it necessarily follows (by hyp. 3) that the lighter liquid will flow over by the orifice E into the vessel below, and there will meet the heavier and be again mixed with it; and it will then penetrate the filter, again ascend the tube, and be a second time driven through the upper orifice. Thus, therefore, will the flow be continued for ever.—Q.E.D.

Bernoulli then proceeds to apply this theory to explain the perpetual rise of water to the mountains, and its flow in rivers to the sea, which others had falsely attributed to capillary action—his idea being that it was an effect of the different densities of salt and fresh water.

One really is at a loss with Bernoulli's wonderful theory, whether to admire most the conscientious statement of the hypothesis, the prim logic of the demonstration, so carefully cut according to the pattern of the ancients, or the weighty superstructure built on so frail a foundation. Most of our perpetual motions were clearly the result of too little learning; surely this one was the product of too much. (G. CL.)

The foregoing article by the distinguished mathematician George Chrystal, who died in 1911, is devoted to a delusion which is still distressingly prevalent. A certain number of weak heads genuinely succeed in deceiving themselves with the old fallacies, and often spend money which they can ill afford in taking out patents for patent absurdities. No man of science who has any susceptibilities can receive their communications without a certain compassion. On the other hand we have the conscious charlatans, who prey upon a class of people, by no means extinct, which possesses great cupidity, some money, a dangerous smattering of science and no sense. The form under which the perpetual motion is presented for the benefit of the credulous and affluent has been modified of recent years, to keep pace with the march of science. Whereas formerly the perpetual motion engine was usually a mechanical arrangement of weights, wheels and water-buckets, or such like, which did work without a supply of energy, to-day the form under which the invention is presented is usually an electrical one. Frequently the vendor or inventor makes no claim to create energy out of nothing, a point to which he directs special attention, admitting that this is known to be impossible by such shrewd and learned men as the prospective purchaser of shares, but states that his machine takes in a certain amount of electrical energy and turns out a greater amount of energy—a steady supply of 20 kilowatts is turned into an output of 37.5 kilowatts, say. The popular confusion between work and power, and between volts and amperes and electrical energy renders it easy to delude the self-satisfied victim, and the plausible denial of any creation of something out of nothing makes the creation of much out of little seem comparatively reasonable.

The latest scientific invention is often made the basis of a perpetual motion claim, in more or less good faith. For instance, shortly after the liquid air machine became a commercial success, claims are put forward—not by the inventor of the machine, of course—that part of the air liquefied by such a machine could be made to furnish a source of motive power which would run the machine itself, so that a continuous and increasing supply of liquid air could be produced without input of energy, once the machine was started.

The kind of perpetual motion which has been considered in Professor Chrystal's article is against all the ordered experience which is embodied in the first law of thermodynamics. This law states the equivalence of heat and work as alternative forms of energy, and denies that energy can be created. There is, however, nothing in the first law of thermodynamics against the following line of argument: Heat is equivalent to work. It is possible to build machines which turn heat into work. Therefore it must be possible to build a machine whish will take heat from some ordinary body at atmospheric temperature, say a pond, and turn it into work. The pond will, of course, grow colder, but this need not disturb us, as for a very slight cooling we should obtain a large amount of work. For instance, a pond 200 yards across and of an average depth of 6 feet, cooling 1° centigrade, would yield 75,000 horse-power-hours if the heat lost could all be turned into work. It is usual to speak of a machine which could convert the heat of surrounding bodies into work as effecting a *perpetual* motion of *the* second kind, perpetual motion of the first kind being thet which creates energy out of nothing. A perpetual motion of the second kind involves no creation of energy, but a conversion of energy under certain conditions.

The second law of thermodynamics (see THERMODYNAMICS), which, like the first law, is an embodiment of the physical experience of generations of experimenters and observers of the first rank, denies that it is possible to derive mechanical energy from bodies by cooling them below the temperature of the surrounding object, that is, it denies precisely that a perpetual motion of the second kind is possible. For us to be able to convert heat into work we must have a source of heat above the temperature of the surrounding bodies, or, in the language of the engineer, we must have both a boiler and a condenser (although, of course, we need not actually build the condenser, but can use the surrounding air as condenser if for any reasons, such as exist in the case of the locomotive, a condenser is impracticable). The bigger the difference of temperature between the hot source of heat and the cold condenser, the bigger the fraction of the heat of the source which we can turn into work: when the temperature difference is zero we can turn none of the heat into work.

The impossibility of a perpetual motion, either of the first or of the second kind, is implicit, then, in the two great laws of Thermodynamics, which express our knowledge of the behaviour of matter in such quantities as are handled in ordinary mechanical and chemical processes. They are statistical laws, and do not apply to individual molecules, or to small collections of molecules, but to matter as we deal with it in engineering, where the smallest particle considered consists of millions of millions of millions of molecules! When we come down to micrbscopic and ultra-microscopic particles perpetual motion is possible, as exemplified by the ceaseless movement of tiny particles held in suspension in a fluid at a uniform temperature. *(See* BROWNIAN MOVEMENT.) Such movement of microscopic particles, however, does not enable us to derive useful work from the heat agitation of the liquid, that is, from the perpetual motion of the molecules themselves.

It does not contradict, but supplements our knowledge of the behaviour of matter in bulk, which tells us that perpetual motion is a mechanical impossibility. (E. N. DA C. A.)

PERPETUITY, in lam the tying-up of an estate for a lengthened period for the purpose of preventing or restricting alienation. As being opposed to the interest of the State and individual effort, the creation of interests indefinite in time has been considerably curtailed, and the rule against perpetuities in Great Britain now forbids the making of an executory interest unless beginning within the period of any fixed number of existing lives and an additional period of 21 years (with a few months added, if necessary, for the period of gestation). The rule applies to dispositions of personal property (see TRUST) as well as of real property. Section 163 of the Law of Property Act, 1925, enacts in effect that a remainder to children at an age in excess of 21 years is to be read as at 21 years, thereby making the remainder legal instead of void (see also ss. 164–166 of the Law of Property Act, 1925). There are certain exceptions to the rule, as in the case of limitations in mortmain and to charitable uses, and of a perpetuity created by act of parliament. In the United States the English common-law rule against perpetuities obtains in many of the States; in others it has been replaced or reinforced by statutory rules. (*See* Gray on *Alienation.*) The general tendency of American legislation is to favour tying up estates to a greater extent than was formerly approved.

PERPIGNAN, a town of France, capital of the *département* of Pyrénées-Orientales, on the Têt, 7 mi. from the Mediterranean and 42 mi. S. by W. of Narbonne by rail. Pop. (1954) 63,863. I'erpignan dates at least from the 10th century. In the 11th and 12th centuries it was a capital of the counts of Roussillon, from whom it passed in 1112 to the kings of Aragon. In the 13th century it belonged to the kingdom of Majorca, and its sovereigns resided there until, in 1344, that small state reverted to the kings of Aragon, who in 1349 founded a university at Perpignan. When Louis XI occupied Roussillon as security for money advanced by him to the king of Aragon. Perpignan resisted the French arms and yielded only in 1475. Roussillon was restored to Aragon by Charles VIII and Perpignan was again unsuccessfully besieged in 1512 under Francis I. Later on, however, the inhabitants, angered by the Spanish governor, surrendered the town to Louis XIII. The citadel held out until 1642. and the place was formally ceded to France by the treaty of the Pyrenees (1659). In 1602 the bishopric of Elne was transierred to I'erpignan.

On the south the town is overlooked by a citadel enclosing a castle (13th century) ,of the kings of Majorca. The chapel is a mixture of the Romanesque, Pointed and Moorish styles. The ramparts surrounding the citadel are the work of Louis XI, Charles V and Vauban. The cathedral of St. Jean (14th to 16th centuries) has a remarkable 17th-century reredos.

PERRAULT, CHARLES (1628–1703), French writer of fairy tales and influential literary controversialist, was born in Paris. Jan. 13, 1628. Three of his four brothers are also noteworthy: PIERRE (1611–*c.* 1680), an official in the revenue department who upheld the Moderns against the Ancients in the preface to his translation of Alessandro Tassoni's La *Secchia rapita* (Le *Seau enlevé,* 1678) and in *Critique* des *deux tragédies d'Iphigénie d'Euripide et* de *M. Racine* (unpublished); CLAUDE (1613–1688), a doctor of medicine whose activities as an architect were derided by Boileau in *L'Art poétique,* book iv (1673,; NICOLAS (1624–1662), a doctor of theology who inclined to Jansenism.

After studying law, Charles Perrault began work under his brother Pierre but won some reputation about 1660 as a writer of burlesque verse and amourous poems. From 1663, when J. B. Colbert assumed the protection of literature and the arts, Perrault did important work under him. envisaging the establishment of a general academy such as Napoleon was later to set up in the Institut. Elected to the Xcademie Française in 1671, he died in Paris on the night of May 15–16! 1703.

Perrault is chiefly remembered for his charming fairy tales, *Histoires ou contes du temps* passe' (with the alternative title *Contes de* ma *mère l'Oye*), published in 1697 but written, according to the abbe J. B. du Bos, sometime earlier, to amuse Perrault's children. The tales are notably free from the affectation and spurious naïveté that disfigure other fairy tales of the period. In his own time, however, Perrault was most important as the champion, in the Acadkmie Française, of the Moderns against the Ancients (from 1672 on). His poem "Le *Siècle de* Louis *le* Grand," read to the Académie on Jan. 27, 1687, was an outspoken polemic that provoked Boileau to protest forcefully on the spot. Perrault, however, maintained his attitude in his *Parallèle* des *Anciens* et des *Modernes* (1688–92).

The most systematic and the most radical of the Moderns, he believed that the human mind made continuous progress and that a nation's literature corresponded to its state of civilization, so that ancient literature was inevitably coarser and more barbarous than modern. Shocking to his contemporaries and to later critics, Perrault's extremism makes his thought a historic landmark in the revolt against the humanist tradition.

See P. Bonnefon, "Charles Perrault . . . ," three articles, ***Revue d'histoire littéraire de la France*** (1904–05), *a* most important study; also A. Adam, *Histoire de la littérature française au XVIIe siècle,* vol. iii and v (1952–56). **(AE. A.)**

PERRERS (or DE WINDSOR), **ALICE** (d. 1400), mistress of the English king Edward III, belonged probably to the Hertfordshire family of Perrers, although it is also stated that she was of humbler birth. She entered the service of Edward's queen, Philippa, before 1366, and was married to Sir William de Windsor, deputy of Ireland (d. 1384). Her intimacy with the king began about 1366. Alice was accused of interfering in the courts of law to secure sentences in favour of her friends, and the parliament of 1376 forbade all women from practising in the law courts. Alice was banished. but John of Gaunt allowed her to return to court in June 1376, and the parliament of 1377 reversed the sentence against her. She was again banished in June 1377; but this sentence was annulled two years later, and Alice regained some influence at court.

PERRIN, JEAN BAPTISTE (1870–1942), French physicist. who was awarded the Nobel prize for physics in 1926 for his extensive studies on the motion (called Brownian movement) and distribution of small particles suspended in a liquid, was born at Lille, on Sept. 30, 1870. He was educated at the École Normale Supérieure in Paris and from 1898 to 1910 was professor of physical chemistry in the University of Paris. He was elected a member of the French Académie des Sciences in 1923 and was president in 1938. His researches were mainly concerned with colloids. Brownian movement and the determination of absolute molecular weights. He was the first to establish experimentally (1895) that cathode rays consist of negatively charged particles. His researches on Brownian movement gave experimental confirmation of Albert Einstein's theoretical studies in which it had been shown that such suspended particles should follow the gas laws even to the extent of giving a means of determining Avogadro's number (N), an important physicochemical constant, namely, the number of molecules in a gram molecule of any gas. the number obtained by Perrin being 6.8×10^{23}. His book, Les *Atomes* (1913; 3d ed., 19-10), describing this work, became a classic. He died in New York city on April 17, 1912. (D. MCK.)

PERROT, SIR JOHN (*c.* 1527–1592), lord deputy of Ireland, the son of Mary Berkley (afterward wife of Thomas Perrot), was generally reputed to be a son of Henry VIII, and was attached to the household of William Paulet; 1st marquess of Winchester. Perrot was knighted at the coronation of Edward VI and though imprisoned during Mary's reign on the charge of harbouring heretics. he received the castle and lordship of Carew in Pembrokeshire, and at the beginning of Elizabeth I's reign was entrusted with the naval defense of South Wales. In 1570 Perrot became lord president of Munster, in which capacity he hunted down James Fitzmaurice Fitzgerald, whose submission he received in 1572. Perrot resented the reinstatement of Gerald Fitzgerald, 15th earl of Desmond, and after vainly seeking his own recall left Ireland without leave in July 1573 and, presenting himself at court, was allowed to resign his office, in which he was succeeded by Sir William Drury. He returned to his Welsh home, where he was occupied with his duties as vice-admiral of the Welsh seas.

In 1584 Perrot succeeded Arthur Grey. Lord Grey de Wilton, as lord deputy of Ireland, and was instructed to divide the confiscated estates of the earl of Desmond among English landlords who were to supply English labour. But his plans were disturbed by the raids of the Macleans and the MacDonnells, invited to Ulster by Sorley Boy, whom he reduced to submission in 1586. In 1585 Perrot, succeeded in completing the "composition of Connaught," a scheme for a contract between Elizabeth and the landholders of the province by which the queen should receive a small quitrent. During his career as lord deputy he had established peace, and had deserved well of Elizabeth, but his indiscretions had made him numerous enemies. A plan for the conversion of the revenues of St. Patrick's cathedral. Dublin, to provide funds for the erection of two colleges led to a quarrel with Adam Loftus, archbishop of Armagh, and in Jan. 1588 he returned to London in disgrace. After his return a forged letter purporting to be from him to Philip II of Spain gave colour to a charge of treason. He was found guilty, but died in the Tower in Sept. 1592.

PERRY, BLISS (1860–1954), U.S. writer, chiefly known as an essayist and critic. was born at Williamstown, Mass., Nov. 25, 1860. He graduated from Williams college in 1881 (A.M., 1883), continuing his studies at the universities of Berlin and Strasbourg. He was professor of English at Williams college, 1886–93; professor of oratory and aesthetic criticism at Princeton university, 1893–1900; professor of English literature at Harvard university, 1907–30; and Harvard lecturer at the University of Paris, 1909–10. He was editor of the *Atlantic Monthly,* 1899–1909. His autobiographical *And Gladly Teach* appeared in *1935.* Perry died at Exeter, N.H., Feb. 13. 1954.

PERRY, MATTHEW CALBRAITH (1794–1858), **U.S.** naval officer, who concluded the first treaty between Japan and the United States, was born at South Kingston. R.I., April 10, 1794. He was commanding officer (1838–40) of the "Fulton II," first U.S. steam warship. In 1843 (with the honorary rank of commodore) he commanded a squadron that was sent to Africa, under the terms of the Webster-Ashburton treaty, to aid in suppressing the slave trade. During the Mexican War; Perry commanded a naval force that captured Frontera and Tabasco, thereby cutting, off Mexico from Yucatan; and in March 1847, his unit carried out a bombardment that permitted the landing of troops at Veracruz.

In March 1852, Perry was appointed commander of a naval expedition to be sent to Japan to induce the government to establish diplomatic relations with the U.S. After studying the situation, Perry concluded that Japan's traditional isolation policy would be altered only if superior naval forces were displayed and if the Japanese officials were approached with a "resolute attitude.'! He decided "to demand as a right, and not to solicit as a favour, those acts of courtesy which are due from one civilized country to another. . . ." With two frigates and two sailing vessels he entered the fortified harbour of Araga on July 8, 1853. He refused to obey Japanese orders to leave and sent word that if the Japanese government did not delegate a suitable person to receive the documents in his possession, he would "go on shore with a suitable force and deliver them personally, be the consequences what they might." A high Japanese official was finally dispatched and, amid much ceremony, the U.S. documents were delivered. Perry then reported that he would return the following year, with a much larger naval force, to receive a reply to Pres. Millard Fillmore's request ior a treaty.

In Feb. 1854 Perry reappeared in Edo (modern Tokyo) bay with more ships than before and on March 31 concluded the first treaty between the Cnited States and Japan. The presents given by Perry to celebrate the occasion filled several boats and included a model railway, telegraph instruments, modern guns. telescopes and other items that served to impress the Japanese with the technological and scientific achievement of the west.

The treaty merely assured better treatment of shipwrecked seamen and permitted U.S. ships to obtain fuel and supplies at two Japanese ports. But it demonstrated the military government's inability to enforce its traditional isolation policy and thus contributed to the collapse of the feudal regime and to the modernization of Japan.

The success of the expedition made Perry a recognized authority on the far east. Through his nritings and speeches he stressed the danger of British and Russian expansion and urged that the United States play a more active role in the orient. He died in New Tork city, March 4. 1358.

See also JAPAN: *History:* The *Opening of Japan.*

See the official record. *Narrative of the Expedition of an American Squadron to the China Seas and Japan* (1856); Edward M. Barrows, *The Great Commodore* (1935). (D. M. BR.)

PERRY, OLIVER HAZARD (1785–1819), U.S. naval officer, who commanded the United States fleet at the battle of Lake Erie during the War of 1812, was born at South Kingston, R.I.. on Aug. 23. 1785. He entered the navy as midshipman (1799) with his father, Christopher Raymond Perry (1761–1818). a captain in the navy, and saw service against the Barbary pirates. At the beginning of the War of 1812 he was in command of a flotilla at Newport, but was transferred (Feb. 1813) to the Great Lakes. He served with Commodore Isaac Chauncey, and then was sent from Lake Ontario to Lake Erie, where he took up the chief command at the end of March 1813. With the help of a strong detachment of officers and men from the Atlantic coast he equipped a squadron consisting of one brig, six schooners and one sloop, with which superior force he completely defeated the British squadron under Capt. Robert Barclay off Amherstburg. Perry commanded the "Java" in the Mediterranean expedition of 1815–16.

He died of yellow fever at Port of Spain in Trinidad on Aug. 23, 1819.

See O. H. Lyman, *Commodore O. H. Perry and the War on the Lakes* (1905); James Cooke Mills, *Oliver Hazard Perry and the Battle of Lake Erie* (1913); and Charles Oscar Paullin (ed.), *The Battle of Lake Erie* (1918).

PERRY is an alcoholic beverage made by fermenting pear (*q.v.*) juice. Mostly it is produced in those northern countries, of temperate climate, where it is easier to grow pears and apples than grapes. Dessert pears cannot be used for perry; the fruit must have "vintage" qualities, and where the soil is suitable for cider (q v.) orchards it will also bear perry orchards successfully. In England, in Herefordshire, Worcestershire, Gloucestershire and in parts of Monmouthshire, Somerset and Kent, perry orchards flourish; they like best a sandy loam. In France only a little perry is produced in Brittany, but in Germany it is preferred to cider. Formerly there was a large production of perry in the eastern states of the United States.

Many English varieties of perry pears, such as Barland, Holmer, Huffcap and Taynton Squash, can be traced to the end of the 17th century. The origin of some varieties, for instance Cheat Boy, Longland and Blakeney, cannot be traced, but others can be dated to the 18th century (such as Buff) or to the early 19th century (Aylton Red). It was then that perry lost popularity; the orchards became derelict and were widely uprooted.

After World War II popular taste in Britain adopted sparkling perry and pear juice is imported from Switzerland, as it possesses "vintage" quality when blended with English pear juice.

See R. Hogg, *The Apple and Pear as Vintage Fruits* (1886).
(C. C. H. F.)

PERSE, SAINT JOHN (pseudonym of MARIE RENÉ AUGUSTE ALEXIS LEGER) (1887–), French poet and diplomatist, who was awarded the Nobel prize for literature in 1960. He was born at St. Léger des Feuilles, Guadeloupe, March 31, 1887, studied at the universities of Bordeaux and Paris and in 1914 entered the diplomatic service. He went to China and was successively consul at Shanghai and secretary at Peking. In 1921 he attended the Washington Disarmament conference as an expert on far eastern affairs. He was later secretary to Aristide Briand. In 1933 he was appointed secretary general of the foreign ministry, with the rank of ambassador. Dismissed from office in 1940, and deprived of French citizenship by the Vichy government, he went to the United States, where he worked in the Library of Congress. He continued to live there after the liberation of France, although his French citizenship was restored and he retained an estate on the Riviera.

His early poetry, published before his diplomatic career gained

momentum, includes *Éloges* (1904–08) and Images *à Crusoe* (1909), and shows the influence of Symbolism, though he later developed a more personal style. The language of his poetry, admired, especially by poets, for its precision and purity, is difficult, and he has made little appeal to the general public. His best known early work is the long poem *Anabase* (1925; Eng. trans. by T. S. Eliot, 1930). In the poems written in exile—Exil (1942). Vents (1946), Amers (1957) and Chronique (1960)—he achieved a more deeply personal note and, by some American readers. was regarded as an embodiment of the French national spirit: intellectual yet passionate, deeply conscious of the tragedy of life, a man of affairs with an artist's feeling for perfection and symmetry.

PERSEPHONE was the daughter of Zeus and Demeter. In cult and in mythology Demeter and Persephone were closely associated, being known together as the two goddesses, the venerable or august goddesses, 'sometimes as the great goddesses. The latter is often called *Korē* ("the Maiden"); whether this results from the identification of two different goddesses, or not, is uncertain. She is the consort of Hades (pee PLUTO), who carried her off as she was gathering flowers.

Demeter sought her in vain; in her sorrow, she caused a famine, and men would have died of hunger if Zeus had not persuaded Hades to let Persephone go. But she had eaten, in the underworld, the seed of a pomegranate, and thus she could not stay away from him for ever. So it was arranged that she should spend two-thirds (according to later authors, one-half) of every year with her mother and the heavenly gods, and should pass the rest of the year with Hades beneath the earth. There can be little doubt that this is a mythological expression for the growth of vegetation in spring and its disappearance in autumn. As wife of Hades Persephone sent spectres, ruled the ghosts, and carried into effect the curses of men. From the head of a dying person she, or *Thanatos* (Death), was supposed to cut a lock of hair which had been kept sacred and unshorn through life (Virgil, *Aen.*, iv. 698 et seq., Eurip. *Alc.*, 74–76).

On the other hand, in her character of goddess of spring Persephone was honoured with flower-festivals in Sicily and at Hipponium in Italy. Sicily was a favourite haunt of the two goddesses, and ancient tradition affirmed that the whole island was sacred to them. The Sicilians claimed to be the first on whom Demeter had bestowed the gift of grain, and hence they honoured the two goddesses with many festivals. They celebrated the festival of Demeter when the grain began to shoot, and the descent of Persephone when it was ripe. Demeter and Persephone were worshipped together by the Athenians at the greater and less Eleusinian festivals, held in autumn and spring respectively (see MYSTERY). At Rome Persephone's name was corrupted into Proserpina; she was sometimes identified with the native Latin goddess Libera. The pomegranate was Persephone's symbol. and the pigeon and cock were sacred to her In works of art she appears with a cornucopia or nith ears of wheat and a cock. As the wife of Hades she was represented with the insignia of royalty and a torch. The regular form of her name was Persephone, but various other forms occur: Phersephone, Persephassa, Phersephassa, Pherrephatta, etc.

For bibliography see under DEMETER.

PERSEPOLIS, an ancient city of Persia, situated some 40 m. N E of Shiraz, not far from where the small river Pulwar flows into the Kur (Cyrus). The site is marked by a large terrace with its east side leaning on *Kuh-i-Rahmet* ("the Mount of Grace '). The other three sides are formed by a retaining wall, varying in height with the slope of the ground from 14 to 41 ft.; on the west side a magnificent double stair, of very easy steps, leads to the top. On this terrace are the ruins of a number of colossal buildings, all constructed of dark-grey marble from the adjacent mountain. The stones were laid without mortar, and many of them are still in situ. Especially striking are the huge pillars, of which a number still stand erect. These ruins, for which the name "Sad-Sutun" ("the 100 columns"), can be traced back to the 4th century, are now known as *Takht-i-Jamshid* ("the throne of Jamshid"). That they represent the Persepolis captured and partly destroyed by Alexander the Great has been beyond dispute at least since the time of Pietro della Valle.

Behind Takht-i-Jamshid are three sepulchres hewn out of the rock in the hillside, the façades, one of which is incomplete, being richly ornamented with reliefs. About 8 m. N.N.E., on the opposite side of the Pulwar, rises a perpendicular wall of rock, in which four similar tombs are cut, at a considerable height from the bottom of the valley. The modern Persians call this place Naksh-i-Rustum ("the picture of Rustam") from the Sassanian reliefs beneath the opening, which they take to be a representation of the mythical hero Rustam. That the occupants of these seven tombs were kings might be inferred from the sculptures, and one of those at Naksh-i-Rustam is expressly declared in its inscription to be the tomb of Darius Hystaspis, concerning whom Ctesias relates that his grave was in the face of a rock, and could only be reached by means of an apparatus of ropes. Ctesias mentions further, with regard to a number of Persian kings, either that their remains were brought "to the Persians," or that they died there. Now we know that Cyrus was buried at Pasargadae (*q.v.*) and if there is any truth in the statement that the body of Cambyses was brought home "to the Persians" his burying-place must be sought somewhere beside that of his father. In order to identify the graves of Persepolis we must bear in mind that Ctesias assumes that it was the custom for a king to prepare his own tomb during his lifetime. Hence the kings buried at Naksh-i-Rustum are probably, besides Darius, Xerxes I., Artaxerxes I. and Darius II. Xerxes II.. who reigned for a very short time, could scarcely have obtained so splendid a monument, and still less could the usurper Sogdianus (Secydianus). The two completed graves behind Takht-i-Jamshid would then belong to Artaxerxes II. and Artaxerxes III. The unfinished one is perhaps that of Arses, who reigned at the longest two years, or, if not his, then that of Darius III. (Codomannus), who is one of those whose bodies are said to have been brought "to the Persians" (see Arian iii. 22, 1). Another small group of ruins in the same style is found at Takht-i-Tā'us, on the Pulwar.

Since Cyrus was buried in Pasargadae, which moreover is mentioned in Ctesias as his own city, and since, to judge from the inscriptions, the buildings of Persepolis commenced with Darius I., it was probably under this king, with whom the sceptre passed to a new branch of the royal house, that Persepolis became the capital (see PERSIA: Ancient History) of Persia proper. As a residence, however, for the rulers of the empire, a remote place in a difficult alpine region was far from convenient, and the real capitals were Susa, Babylon and Ecbatana. This accounts for the fact that the Greeks were not acquainted with the city until it was taken and plundered by Alexander the Great.

In 316 B.C. Persepolis was still the capital of Persis as a province of the great Macedonian empire. The city gradually declined; but the ruins of the Achaemenidae remained as a witness to its ancient glory. It is probable that the principal town of the country, or at least of the district, was always in this neighbourhood. About A.D. 200 we find there the city Istakhr (properly Stnkhr) as the seat of the local governors. There the foundations of the second great Persian empire were laid. and Istakhr acquired special importance as the centre of priestly wisdom and orthodoxy. The Sassanian kings have covered the face of the rocks in this neighbourhood. and in part even the Achaemenian ruins, with their sculptures and inscriptions, and must themselves have built largely here. although never on the same scale of magnificence as their ancient predecessors. The Romans knew as little about Istakhr as the Greeks had done about Persepolis, in spite of the fact that for four hundred years the Sassanians maintained relations, friendly or hostile, with the empire.

At the time of the Arabian conquest Istakhr offered a desperate resistance, but the city was still a place of considerable importance in the 1st century of Islam, although its greatness was speedily eclipsed by the new metropolis Shiraz.

In the 10th century Istakhr had become an utterly insignificant place, as may be seen from the descriptions of Istakhr, a native (c. 950), and of Mukaddasi (c. 985). During the following centuries Istakhr gradually declines, until, as a city, it ceased to

exist. This fruitful region, however, mas covered with villages until the frightful devastations of the 18th century; and even now it is, comparatively speaking, well cultivated. The "castle of Istakhr" played a conspicuous part several times during the Mohammedan period as a strong fortress. It was the middlemost and the highest of the three steep crags which rise from the valley of the Kur, at some distance west or northwest of Naksh-i-Rustum.

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PERSEUS, in Greek legend, son of Danae and Zeus. When Perseus was grown to manhood Polydectes, king of Seriphus, cast his eye on Danae, and, in order to rid himself of the son, exacted of him a promise that he would bring him the head of the Gorgon Medusa. The Gorgons (*q.v.*) dwelt with their sisters, the Graeae, in the west. Guided by Hermes and Athena, Perseus came to the Graeae. They were three hags, with but one eye and one tooth between them. Perseus stole the eye and the tooth, and would not restore them till the Graeae had guided him to the Nymphs, from whom he received the winged sandals, a wallet (κίβισις, resembling a gamekeeper's bag) and the helmet of Hades, which rendered him invisible. Thus equipped and armed by Hermes with a curved sword (*harpe*), he came upon the Gorgons as they slept, and cut off Medusa's head, while with averted eyes he looked at her reflection which Athena showed him in the mirror of her shield. Perseus put the Gorgon's head in his wallet, and fled, pursued by Medusa's sisters, to Ethiopia, where he delivered Andromeda (*q.v.*) from a sea-monster and afterward married her. With her he returned to Seriphus in time to rescue his mother from Polydectes, whom with all his court he turned to stone by showing them the Gorgon's head. Perseus then gave the head of Medusa to Athena, and, with Danaë and Andromeda, hastened to Argos to see his grandfather, Acrisius, once more. But before his arrival Acrisius, fearing the oracle, had fled to Larissa in Thessaly. Thither Perseus followed him, and unwittingly slew his grandfather by the throw of a discus. Ashamed to return to Argos, Perseus gave his kingdom to Megapenthes (Acrisius' nephew) and received from him Tiryns in exchange. There he reigned and founded Mideia and Mycenae and became the ancestor of the Persides, among whom were Eurystheus and Heracles. *See* E. S. Hartland, The *Legend of Perseus* (1894–96).

BY COURTESY OF THE METROPOLITAN MUSEUM OF ART

PERSEUS AND ANDROMEDA, FROM A COPY OF THE ORIGINAL IN THE CAPITOLINE MUSEUM, ROME

PERSEUS, in astronomy, a constellation of the northern hemisphere, called after the Greek legendary hero. It contains a double cluster forming an interesting object for low-power telescopes. The second brightest star in the constellation is the famous eclipsing variable Algol (*q.v.*). A number of naked-eye stars—of which α Persei is the brightest—make up a loose cluster, which is located at a distance of about 400 light years from the sun. The double cluster itself is much more remote; its distance is of the order of 7,000 light years.

PERSEUS OF MACEDONIA (b. *c.* 212 B.C.), the last king of Macedonia, eldest son of Philip V. He had his brother Demetrius killed, and thus cleared his way to the throne in 179. War broke out with Rome in 171 B.C. when P. Licinius Crassus attacked him. Perseus defeated Crassus at Callinicus in Thessaly, but in 168 he was routed at Pydna by L. Aemilius Paulus. He died in captivity at Xlba Fucens. (*See* MACEDONIAN EMPIRE.)

PERSHING, JOHN JOSEPH (1860–1948), U.S. soldier, was born near Laclede, Mo., on Sept. 13, 1860—destined to as astonishing a rise from humble circumstances as Joseph Joffre, the first French commander in chief in World War I.

He taught school to gain the means to study at the Kirksville, Mo., normal school and then competed for entry into the U.S. Military academy. In 1886, he was commissioned in the 6th cavalry and saw service against the Apaches in Arizona. In 1890, during an uprising of the Sioux, he served in Dakota, in charge of the Indian scouts. In 1891 he was appointed military instructor at the University of Nebraska, where he graduated in the law school. After being instructor in tactics at the U.S. Military academy, he served in Cuba through the Santiago campaign (1898), where he earned from his commander the tribute, "Pershing is the coolest man under fire I ever saw." Soon afterward he showed that he was more than merely brave and energetic, for, sent to the Philippines, he pacified by 1903 the fanatical Moros of Mindanao. In 1905 he went to Japan as military attach& and witnessed part of the campaign in Manchuria. As a reward for his Philippines service, Pres. Theodore Roosevelt in 1906 promoted him from captain to brigadier general, passing him over 862 senior officers. He returned to the Philippines as commander of the department of Mindanao and governor of the Moro province. Returning in 1913, he was sent from San Francisco in 1916 to command the expedition into Mexico against Francisco Villa, and after the death of Maj. Gen. Frederick Funston in 1917 he succeeded as commander on the Mexican border.

On the U.S. entrance into World War I Pershing was chosen to command the American expeditionary force in Europe, an honour gained perhaps not only by his record of achievement but also by his proofs in Mexico of extreme loyalty to government authority under hampering circumstances. With his staff he reached England on June 9, 1917, and four days later landed in France. To pass from guerrilla expeditions in jungle, mountain and desert to the vast siege then in progress—or stagnation—on the western front was an extreme test, but in compensation for a military experience limited to small expeditions he brought a trained administrative sense, with the will and knack of carrying through plans under difficulties. From the start Gen. Pershing insisted that the integrity of the U.S. army be preserved, making a firm stand against French tutelage and against the French desire to infuse the new blood of U.S. manpower into its own military system. And while the Washington war department was contemplat'ng a limited liability war, Pershing in France was methodically laying the foundation for an army of 3,000,000 men—stamped with the Pershing seal. If this plan, inevitably slow in fruition, imposed a severe strain on the exhausted Allies, it was justified not only by the proverbial warning against "putting new wine into old bottles"; for the alternative would have demanded an unprecedented sacrifice of national prestige. If the realization of an independent U.S. army would be, as Pershing felt, a serious blow to German morale, it was also likely to uplift the military spirit and self-confidence of the United States not only for the moment but for all time.

The disasters of early 1918 seemed to show that a great risk had been taken in pursuit of this ideal, and they led Pershing to place all his resources freely at Marshal Ferdinand Foch's disposal. But as soon as the crisis began to pass he reverted to his policy, and at St. Mihiel in September it was consummated by the victory of the first U.S. army in the first entirely U.S. operation. This was followed by the Meuse-Argonne battle (*q.v.; see* also WORLD WAR I) under Pershing's direction. If the attainment of its aims was slower and more costly than had been expected, Pershing had accepted the actual battleground in deference to his allies and against his own preference for a blow toward Metz. Even so, it is probable that he underrated the difficulties of breaking through a strongly organized trench system, as well as the causes that had sapped the offensive spirit of the French. He had a Grant-like ruthlessness, similarly lacking the personal magnetism which leads men to lay down their lives gladly, but he had the character which compels men not only to die but to work, grumbling perhaps but respecting him.

It was a just recognition of his achievement in creating almost

from nothing the vast structure of the national army that, in Sept. 1919, congress created the rank of general of the armies. As such he was the highest ranking military officer in U.S. history, outranking even generals of the army. In 1921 he was appointed chief of staff and during his tenure of office designed the new permanent framework of the U.S. army. He also served as chairman of the American Battle Monuments commission and in 1931 published My *Experiences* in *the World War*. After 1941 he lived in retirement in quarters built for him at Walter Reed hospital in Washington, D.C. He died there July 1j, 1948, and was buried in Arlington National cemetery. (B. H. L. H.; X.)

PERSHORE, a town and rural district on the Avon river in the South Worcestershire parliamentary division of Worcestershire. Eng., 9 mi. S.E. of Worcester by road. Pop. (rural district, 1961) 17,599. Market gardening and fruit growing (especially plums) are the staple industries. The churches of Holy Cross, a former mitred Benedictine abbey, the nave of which has entirely disappeared, and St. Andrew, mainly early 15th century, face one another.

PERSIA (IRAN), a kingdom of western Asia. In 193j the name "Iran" was officially adopted for the state previously known to other countries as Persia. On Oct. 2j, 1949, however, it was announced that the Tehran government reverted to the name "Persia" in foreign languages.

Persia is bounded on the north by the U.S.S.R. and the Caspian sea; on the east by Afghanistan and Pakistan; on the south hy the Persian gulf and the Gulf of Oman; and on the west by Iraq and Turkey, The total area of Persia is about 636,293 sq.mi. and the length of the frontiers is about 2.750 mi.

Frontiers. — The frontier with the U.S.S.R. is that laid down in the treaty of Turkmanchai (Turkman) (1828), further defined in a convention of July 8, 1893, and modified in minor details in 1951. It has two sections divided by the Caspian sea. Its eastern section joins the Afghan frontier at the Zulfikar defile. The Afghan frontier was defined in 1881 and in the convention of July 8, 1893 From the Siah Kuh (where it joins the Pakistan frontier) to the Kuh-i-Malik Siah it follows a line fixed by Sir Frederick Goldsmid in 1872 and by Sir Henry MacMahon in 1903–05. The southern boundary is the coast line from Gwatar to the mouth of the Shatt-al-Arab. The islands nearest to the Persian coast are Persian territory. They are, from east to west, Hormuz, Larek, Qishm (Kishm), Hangam, Farur, Qais, Hinderabi, Shnikh Shuaib, Kharag and Khargu. On the west, the frontier with Turkey starts from Mt. Ararat and meets the Persian, Turkish and Iraqi boundaries at Rudbar-i-Haji Bey. From this point the frontier line with Iraq extends about 550 mi. to the Shatt-al-Arab; it then follows the low-water line to the mouth but includes the anchorages of Khorramshahr (formerly Mohammerah) and Abadan in Persia. This is the line relerred to in the treaty of Erzerum (1847), demarcated in 1914 by Perso-Turkish commissioners assisted by British and Russian commissioners with arbitral powers. and reaffirmed by an agreement between Iraq and Persia in 1937.

Geology. — Little is known with certainty of the geology of wide areas of Persia, notably in the north and east. The search for oil has made the southwest the best-known region. Only late investigations provided information concerning the structures and deposits of the central plateau.

A Pre-Cambrian land surface subsided locally in Cambrian times, and limestones and shales with rock salt and gypsum beds were laid down in the Zagros and in central Persia. Quiescent conditions during the Palaeozoic era were interrupted by the subsidence which led to Devonian deposits in the northwest. In Permian times the country was covered by the great Tethys sea with shore lines to north and south near the present frontiers of Persia. except for a great gulf covering the present site of the Caspian sea. Within the Tethys basin were laid down the thick Jurassic limestones of the Zagros.

In middle Cretaceous times intensive folding affected the Persian area and narrowed the Tethys geosyncline, but heavy sedimentation still went on toward Mesopotamia, Upper Cretaceous deposits, mainly limestones, being laid down in the southern Zagros region to a thickness of 3,000 ft. During the Tertiary period deposition continued but in a steadily shrinking sea. Renewed pressure from inner Asia in Pliocene times led to the intense folding which moulded the Zagros ranges into their present form, a great series of parallel folds running northwest to southeast. The east-uest folds of the Makran and those with a southwest to northeast trend reaching toward the Suleiinan mountains originated at the same period. In the northwest movement was mainly along the fault lines already established and was accompanied by intense volcanic activity.

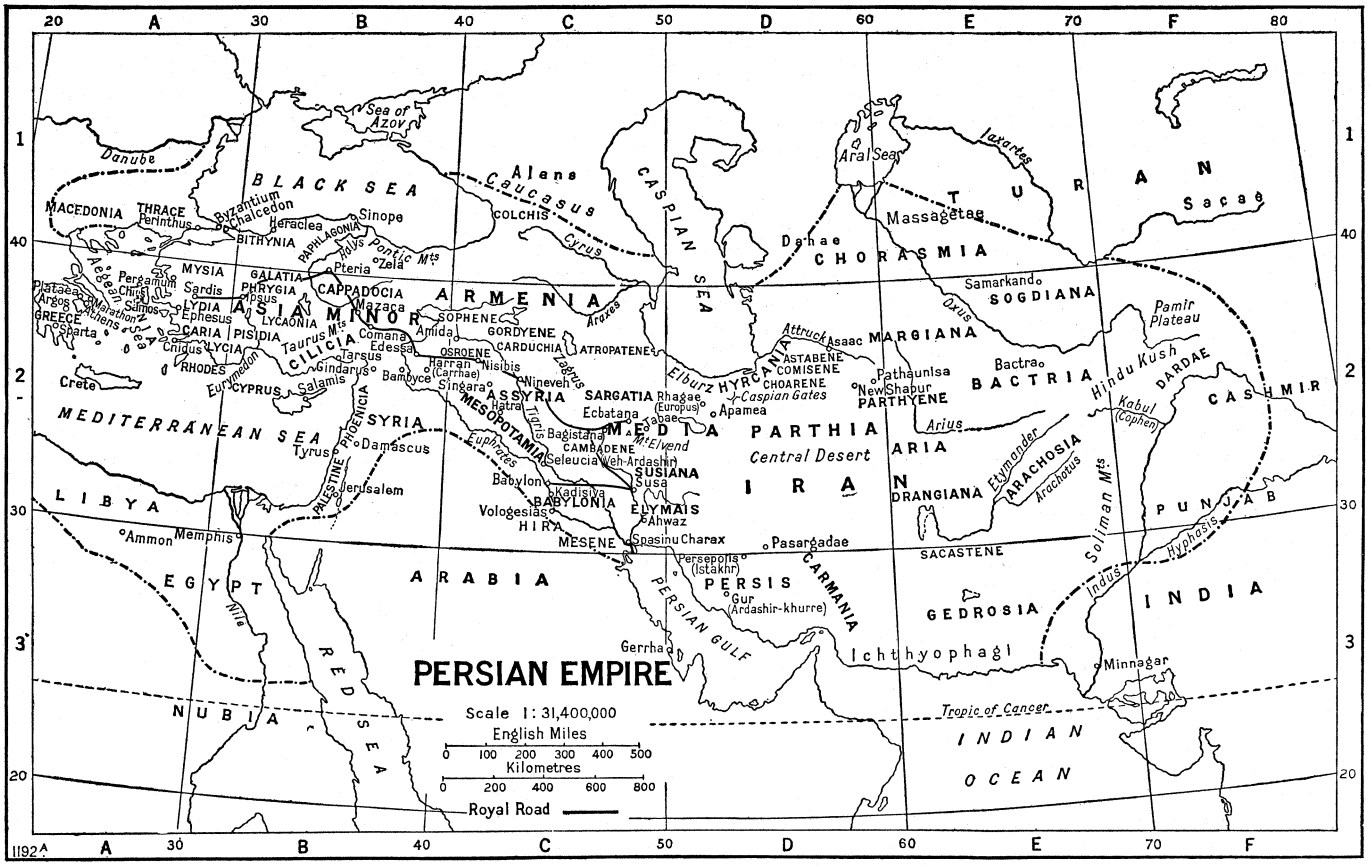
Though there is still room for much disagreement over details, the broad picture of the structure of Persia seems tolerably clear. The central plateau, if not an actual fragment of either Angaraland or Gondwanaland. appears to have acted as though it were, transmitting to its margins the outward pressures originating from the former; *i.e*, irom the northeast. Though the Zagros ranges have a long geological history they are mainly the result of these pressures as exerted in Tertiary times. The northern ranges, including the Elburz. have a similar origin, though too little is known of them to fix the age or detailed succession of the earth movements which formed them. Only in the lake district of Azerbaijan has fracturing rather than folding been the main factor in determining the topography.

Physical Geography. — Persia includes the major part of the Iranian plateau, a moderately high region enclosed within a great loop of the Alpine-Himalayan fold mountain system. The mountain border is sharply marked in the west by the Zagros ranges, on the north by the Elburz range and on the east by the Suleiman range, overlooking the Indus plains. The eastern third of the plateau falls within the borders of Afghanistan and Baluchistan. The border ranges converge in the Armenian massif to the northwest and the Hindu Kush to the northeast. Persia thus consists of a central plateau with wide depressions separated by low folds and a high mountainous fringe which sharply marks it off from surrounding lowlands.

The obvious division of the country is into plateau and mountains, but the mountains are so varied in character that it is more convenient to treat them in three sections — the Zagros and their extension to the Makran, the Elburz and Khurasan ranges of the north and the eastern highlands — and to treat the central plateau in a fourth section.

1. *The Zagros folds* include the ranges of the west and southwest and fall into three subregions. The northernmost, beyond the 35th parallel, is mainly an area of faulted blocks and basins which have been subjected to heavy erosion. The saline waters of the shallow Lake of Urmia (Daryacheh-i-Rizaiyeh) occupy the lowest parts of the greatest of these basins. Altitudes on the plateau surface decrease to the southeast so that geographically the subregion forms a transition between Armenia and the Persian interior. A group of great volcanic cones (*e.g.*, Savalan, 14.200 ft.) forms a distinctive feature and is associated with the fault system. The annual range of temperature is probably unequalled anywhere, the winters being bitterly cold and snowy, the summers very hot and arid. The plateaus afford only poor grazing but the basins where irrigated are very productive and support, for Persia, a dense population. Tabriz, 3; mi. from the unhealthful shores of the Lake of Urmia, is a great market at a centre of route convergence and the second city of Persia. It guards the main entry to the country from Turkey and European Russia.

The ranges of the central Zagros subregion are of the Appalachian tqpe; *ie.*, numerous parallel ranges and valleys corresponding closely to the underlying fold structure. They form a belt about 12j mi. wide between the inner foothills and the Mesopotamian plain as far south as the 27th parallel. Overthrusting on the inner margins exposes rocks as old as the Cambrian, the high central area is of Jurassic limestones, and the western edge is largely made up of massive Tertiary limestones. Between these overdrained ridges are long, secluded valleys, often rich in agricultural produce (*e.g.*, the Rhurramabad basin) but extremely difficult of access. As in the northern subregion, the melting of the heavy winter snows and springs irom the limestones maintain perennial streams. These issue through tangs, deep narrow defiles,



to the western lowlands. Thus the Poul-i-Tang, only 10 ft. wide, carries a stream 25 ft. deep at low-water level. The country is mainly pastoral with seasonal migration between valley and upland (transhumance). The chief population centres are on the few cross routes; *e.g.*, Kermanshah on the way from Tehran to Baghdad and Shiraz on the Bushire-Isfahan road. Oil occurs in the shallow anticlines of the foothills on the Mesopotamian margin, especially in the basin of the Karun river. The reservoir rock is the fissured Asmari limestone which is capped by the shales of the Fars series, both of Miocene age. Geological and topographic conditions make the exploitation of the deposits cheap and easy. Few wells are needed to work the field, and gas and water pressures make pumping from the bores unnecessary. With careful siting of the pipe lines the oil flows under gravity alone to the refining centre at Abadan. A lesser field is exploited west of Kermanshah for local needs.

The third region, the Makran, fronts the Arabian sea. Here the general fold direction is east-west from Bandar Abbas to the borders of Baluchistan. Sandstones not limestones are the dominant rock type. A narrow coastal lowland rises quickly to a plateau at about 2,000 ft. which is capped by scarped hills rising to 7,000 ft. Short streams in deep valleys run directly to the sea. In this extremely arid region fish is the main product. Dried, it is exported or used as local food for both man and beast, being fed to sheep and camels. Some of the inner valleys grow dates.

2. *The northern highlands* fall into two distinct sections—the Elburz mountains and associated hills and the border ranges of Khurasan—which together form the shorter link in the Alpine-Himalayan system between the Armenian knot and the Hindu Kush. The Elburz range stretches in a great arc around the southern shores of the Caspian sea and is built of steep, narrow folds, fractured at a few places and including a number of volcanic cones. The greatest of these is the snow-capped Demavend (18,600 ft.). The slope to the Caspian is very steep, summits of 10,000 ft. occurring within ten miles of the water's edge. In a region of very heavy rain this gives rise to many torrential streams which flow in deep gorges directly to the Caspian. The southern and drier side is less eroded but has steep scarps overlooking immense gravel spreads. Some of the streams issuing from the hills reach immense alluvial fans. Where deposits are fine enough to be irrigated they prove very fertile.

The Caspian plain, never more than 70 mi. wide and often much less, rises gently at first from a marshy lagoon coast left behind by the shrinking sea. The steeper ground behind it up to 8,000 ft. carries dense deciduous forest except where it has been cleared and cultivated. A great range of crops—including such subtropical plants as rice, cotton and tea—is raised, and the region was long famous for its silk production. It is much the most densely peopled area in Persia (2,000,000 to 3,000,000 out of a total of 13,000,000).

The Elburz range declines in height to the east and finally vanishes on the edge of the Atrek trough. East of this gap the ranges trend from northwest to southeast. The northern series, the Kopet-dagh (10,000 ft.), is separated from a southern series, the Kuh-i-Aleh and Kuh-i-Binalud, by a wide valley drained to the west by the Atrek and to the east by the Kashuf. This formed the invasion route and trade highway from the Merv steppes toward Tehran and the Caspian. The uplands are poor grazing grounds, but the valley has much cultivated ground, especially near Meshed, where the production of wheat and barley justifies the description of that city as the granary of eastern Persia. It is also a great city of pilgrimage. Kuchan, near the centre of the valley, is notorious for the frequency and severity of its earthquakes.

3. *The* eastern *uplands* do not form a real mountain border on that side of Persia, the true edge of the plateau being far away to the east. Indeed the eastern frontier of Persia cuts right across the grain of the country. In the north it follows the gorges of the lower Hari Rud where that river cuts through the folds; in the centre it crosses the great Seistan depression; and in the south it traverses the east-west ridges of the Makran. The border country is a barren, almost uninhabited region, cursed with an extremely low rainfall, extreme seasonal changes of temperature and most violent winds. These cause severe blizzards in the winter. From the beginning of June the "wind of 120 days" blows with-

out ceasing and with great force from the northwest, building sand dunes and creating dust storms. The lowest part of the Seistan basin is occupied by a fresh-water lake, the Hamun, which is fed by the Helmund river coming from the Afghan highlands. The delta has almost completely filled the lake. suggesting the early history of other depressions now dry. A few people live in the reedy marshes while others raise grain crops and pasture a few cattle on the delta fringe, where irrigation'is possible though difficult.

4. *The central plateau* is far from being the flat, featureless country so often pictured. It is crossed by two mountain lines which faintly mirror the great marginal folds. The more western runs southeastward from near Mianeh to Kerman with heights of 14,000 ft. near the latter city. Between it and the Zagros lie the Isfahan and other basins. Another mountain series follows a more southerly trend from the region of Nishapur to the Baluchistan border. thus separating the Seistan basin from the central desert region. Both mountain series are fold ranges with centres of volcanic activity and exposures of ancient crystalline rocks with which are associated ore deposits (*e.g.,* lead at Anarak, iron near Kerman).

The floors of the valleys between the ridges often show sand dunes and shallow salt lakes. Where fresh water draining from the hills can be tapped by tunnelling beneath the gravel-covered slopes cultivation is carried on. Caravan traders have for centuries followed the routes which link these oases. These form a sort of inner circle to the important highways joining the larger centres of early Persian culture situated in the wider and more generally fertile basins along the inner face of the border ranges. Thus the inner route Kerman-Yezd-Qum (Kum) runs parallel to that linking Shiraz-Isfahan-Hamadan-Tehran.

The areas between the two mountain series form desert basins. These are floored with thick deposits of detritus from the mountains. often over lake deposits of Tertiary and Quaternary age. These basins sink to levels 6,000 to 7,000 ft. below the bordering ranges; this explains their rainless character and very high summer temperatures. Several types of desert surface are recognized and given special names. Firm surfaces of gravel or hard sand are termed *dasht*. areas without either water or vegetation of any kind are known as *lut*, while the black muddy marshes covered with crusts of salt are called *kavir*. The *kavir* are particularly feared by travellers as the salt crusts are of uncertain thickness and may cover water channels or areas of liquid mud of considerable depth.

Climate. — The climate of Persia is markedly continental in character. The summer monsoon of India reaches the eastern districts only after crossing the Indus plains and the mountains of Afghanistan and Baluchistan. Except over the coast lands, therefore. where it is humid and oppressive, the summer is extremely dry and hot. Seistan, for example, has a July mean temperature of 90° F., and the noonday heat is fierce everywhere below 5,000 ft., though there are refreshingly cool nights in the interior. The transition from summer to winter and from winter to summer is abrupt, except on the Caspian sea where there is a short autumn season. In winter the border highlands toward Turkistan are too low to prevent the inflow of intensely cold and dry air from Siberia; *e.g.,* Meshed has a January mean temperature of 34° F. and 0.8 in. of rain. On the other hand, the mountain barriers of the south and west are high enough to prevent the spread of maritime influences from the Persian gulf, the Caspian and the Mediterranean. These ranges have thus a humid outer face and a dry inner one. The height of the plateau itself contributes to the cold of winter. The northwest (Tabriz) district is probably the coldest; mean temperatures toward the south rapidly become higher. Frost, often severe, is experienced everywhere except near the Makran coast. In northwest Persia and the Zagros mountains snow falls heavily and frequently between November and March. In sheltered hollows on Demavend and other high summits it may remain all year. Elsewhere the thaw begins in March or April, freeing the pastures for the annual migration of the pastoral tribes and flooding the streams which give water for irrigation. The snow cover in the colder regions protects the crops from severe frost, and the harvest greatly depends on it.

Rain mainly results from depressions originating in the Mediterranean area and hence is heaviest in the high northwest and also on the Caspian sea, with 20–50 in. The recorded fall to the south and east of the mountains shows great irregularity. varying at Tehran, for example, from 4 in. to more than 20. in. and at Bushire from less than 2 in. to more than 26 in. In general, however, rainfall decreases toward the east and south, and an arid zone with less than four inches fall in an average year stretches from the northern salt deserts to the Makran coast and from Seistan to Isfahan. Most rain falls between September and April.

Vegetation. — It has been estimated that there are considerably more than 5,000 species of seed-bearing plants in Persia, of which a great number are endemics. Knowledge on the subject is, however, very incomplete.

On the Caspian coast lands, where rainfall is abundant. a lush vegetation and almost tropical forests of creeper-covered trees are found. Large areas have been cleared for cultivation. Behind this belt the northern slopes of the Elburz range are clothed in forests containing a wide variety of trees in nhich oak, hornbeam, maple, ash, elm and, on the lomer slopes. nitch hazel predominate. Conifers are very rare. The southern slopes of the Elburz are entirely different; though they look barren, there are scattered patches of shrubs and herbs. Various species of *Astragalus,* many of which are endemic, are common there and in other desert parts In northern Khurasan the rainfall is lower, the forests disappear and most of the country has a semidesert appearance. *Artemisia* dominates the hills below grass steppes, while in the lower-lying parts halophytes (mainly belonging to the goosefoot family or Chenopodiaceae) grow in the salty districts, tamarisk on the fringe of the desert and camel thorn in the arid parts. The northwestern provinces are steppe and semidesert. Dwarf iris crocus (particularly near the Lake of Urmia) and many other flowers appear in the spring, folloned in June by members of the Caryophyllaceae, the yellow *Phlomis armeniaca*, borage. thyme and other herbs. On the Zagros ranges there is a wide variety of shrubs and herbs, including liquorice, tamarisk, chenopodiaceous plants and many geophytes Except for the highlands, where poplars and willows grow on the river banks, conditions are so unfavourable to plant gronth in eastern and southern Persia that xerophqtes and halophytes are the only types found. Along the shores of the Persian gulf plant growth is generally poor except in the north where date and other fruit gardens are found and the tamarisk and tamarind flourish.

Fauna. — Detailed knowledge of the fauna of Persia is incomplete; W. T. Blandford. who wrote in 1876, remained an important authority, although his work became out-of-date in matters of detail.

The lion (the national emblem of Persia) was formerly common in parts of the southwest but is now almost extinct. The tiger is still found in the forests of Mazanderan and the leopard in Asterabad and Kerman. Cheetahs, jackals, wolves and wildcats are widely distributed. The brown bear wild goat, Persian squirrel, hyena. jerboa, mongoose, fox and Indian crested porcupine occur in suitable localities. Two types of nild sheep have been identified, and the Persian gazelle and fallow deer are common; the red deer lives in the Elburz; the roe deer is found there also and in Kurdistan. The wild boar is common in well-watered districts; the wild ass moves in the desert regions of the east.

In addition to a large number of resident birds, including many western European species, others visit Persia to breed or to winter or pass through the country on migration. More than 400 species are known. There are marked variations in the types within any given species found in different parts of the country. There are four species of partridge of which the chukar is the commonest. Other game birds include sand grouse and snipe. Many varieties of duck visit all parts of Persia in winter and swans and geese are found on the Caspian coast and in Seistan. Notable summer visitors are the nightingale and cuckoo. Various types of owl are found and also falcons, buzzards and kestrels. Eagles are rare except for the booted eagle and the sea eagle, which is found on the Caspian. Large numbers of pelicans breed

on the northern shores of the Persian gulf and flamingos are found there also and in Seistan.

Most of the rivers of Persia are too short and too variable in flow to contain a wide variety of fish. The chub, barbel and trout are found in the rivers draining the Elburz mountains, and the northern rivers contain catfish, chub and other species. Various kinds of carp live in the rivers of the south. The Caspian sea (*q.v.*) and the lower reaches of the rivers flowing into it are rich in fish, of which the sturgeon and Caspian salmon are of special importance.

Among the few amphibia, frogs and toads are found where it is wet enough. The Greek tortoise is common except at high altitudes. The agamids are the commonest lizards and racers (*Coluber)* the commonest snakes; there are many poisonous vipers.

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(K. C. B.; T. HER.)

ARCHAEOLOGY

Pre-Achaemenid **Period.**—Palaeolithic cultures in Iran are known from surface-found artifacts and from caves excavated by the University museum of the University of Pennsylvania, Philadelphia, in 1949 near Kermanshah and the Caspian sea. The transition to village life with pottery and agriculture is found at Bakun B and in a cave east of Susa corresponding typologically to the cultures of Jarmo and Hassunah in northern Iraq. At the time of the Samarra, Halaf and Ubaid periods of Iraq, Persia was settled with villages made possible by the development of agriculture and the domesticating of animals. During this time two distinct cultural areas existed, one in the northeast (Siyalk, Rayy, Hissar, Anau) and the other in the west and southwest (Giyan, Susa, Bakun). The northeast is characterized by red-surfaced pottery, the west and southwest by buff-coloured ceramics, both of which are artistically painted with geometric and representational designs. In their most developed form both cultures had the technical equipment necessary for civilized life—the potter's wheel and kiln, open-moulded and hammered copper tools, houses built of mould-made, sun-dried mud bricks, woven cloth; they evidently also had a burial ritual, and human and animal pottery figurines have been found.

In the early part of the 4th millennium B.C. new cultures replaced the old. Two successive cultures with gray, unpainted pottery evolved in the northeast, disappearing c. 2000 B.C. Elsewhere remains have been found only in Khuzistan (Susa, Ghazir), which is culturally linked to Iraq. New types of painted pottery typify the west thereafter (Giyan, Susa, Tall-i-Chagal near Persepolis). Ritual rock relief scenes at Kurangun in the southwest are attributed (by E. Herzfeld) to this time. Thenceforth until Achaemenian rule, Elam (Susa) was the civilized, literate province of Iran, culturally similar to Sumer and Babylonia.

In the 2nd millennium two cultures occupied the west between Susa and Kermanshah, the earlier with rock-lined, cist tombs and painted pottery with tripod feet, the later with amphorae painted with bird designs. A much-defaced relief at Naksh-i-Rustam may indicate Elamite rule in the province of Fars. To the end of this millennium is assigned a cemetery at Siyalk whose gray, unpainted pottery has Caucasian connections.

With the exception of an Iron Age cemetery at Siyalk, with elaborately painted vessels showing relations with the Caucasus and Phrygia, known archaeological remains of the early 1st millennium are confined to the west. The last settlement at Giyan continued after 1000 B.C. At this time a remarkable art in bronze developed in the provinces of Luristan and southern Azerbaijan, with striking representations of animals, horse trappings being numerous and striking. The chief finds (discovered mainly in graves) comprise cast bronzes finished with engraving. but at Kuh-i-Dasht (a settlement with a temple) the material was chiefly *repoussé*, principally pins with large disk heads, presenting an elaborate religious repertoire with west Asiatic affiliations. No settlements of these Assyrian provinces are archaeologically known. though such are shown on Assyrian reliefs.

Achaemenid Empire.—Little survives from the short-lived Median empire, which grew up under Assyrian influence in north Persia, though treasures found in Azerbaijan in 1947 either are of Median date or include Median works of art. In contrast, the monuments of its Achaemenid successors are numerous. Oldest is the royal city of Pasargadae built by Cyrus (549–529 B.C.). This consists of a palace complex in a walled garden, a tower, a walled temple precinct and the king's tomb. Near or at the southeast corner of the palace area wall was a gate building, a rectangular, columned hall with doors flanked by bull colossi and small side rooms, one with a winged genius on its doorjamb. To the northwest was a similar hall but with columned porticoes on each of three sides, a square room in each of two corners, and on the fourth side another portico the over-all length. Still a third version of the type, north of this, had porticoes on both the long sides of the central hall with small rooms at its ends. The main halls range in length from 78 to 111 ft. and vary in proportions from almost square to approximately 3:1; all apparently had clerestory lighting. The type was evidently developed from an earlier form of wooden trabeated structure. The walls themselves were of mud brick, although stone was used for the foundations, for the pillars, for the doorways and for tall blocks at the outer corners of the porticoes which were notched at the top to contain roof beams.

No evidence exists for the presence of an upper story in any Achaemenian building; indeed, the exceptional slimness of the columns would render it impracticable. The roofs must have been flat and covered with mud plaster. Black and white stones were strikingly combined in some of the interior finish. The impost blocks consisted of addorsed forequarters of horned lions or bulls. Minor buildings, both in the official precincts and in the town, must have been built of sun-dried bricks and *pisé*, traces of which remain some distance away.

The tomb of Cyrus stands in a small court. On a stone platform rises a little gabled building, obviously the stone reproduction of a simple wooden house; very probably it was copied from an ancient type of dwelling that must have been widely disseminated. Elevating it on the six-level base, however, gave it special status. On a natural hill overlooking the site is a stone-built platform which was part of a citadel enclosing a pocket in the hills. The tomb is paralleled by a similar but unfinished structure, possibly the tomb of Cambyses, lying between Persepolis and Naksh-i-Rustam.

The rectangular, walled temple court contained two altars and, on one side, an oblong rectangular temple platform of mud brick, almost 230 ft. long. more than 115 ft. wide and nearly 20 ft. high, stepped up in at least four levels.

The tower at Pasargadae and the structure at Naksh-i-Rustam (near Persepolis) which is its pendant have sometimes been considered fire temples (*e.g.*, F. Wachtsmuth, in A. U. Pope and P. Ackerman (eds.), *A Survey of Persian Art From Prehistoric Times to the Present,* vol. i, p. 311 [1938]), but are more convincingly identified as tombs and have similarly been persuasively interpreted as copies of an anterior dwelling type (E. Herzfeld, *Archaeological History of Iran.* p. 35 [1935]). They are both tall rectangular buildings of yellow limestone, with a doorway and two tiers of blind windows in black limestone; the interior contains a small chamber but is solid for half its height; neither light nor air could be admitted except through the door, which was carefully constructed so that when closed it hermetically sealed the chamber. The exterior scheme reproduces the effect of wooden or stone corner posts with clay walls between them, and the stereotomy does not accord with the structural design. The simulated doors and windows imply three stories, though these are not consistently related on the three sides; and projecting under the roof are imitation beam ends. Tower dwellings are known to have been used in Armenia, and bronzes from that region illustrate two versions of the type, with significant relations to the actual buildings in Persia.

Darius commemorated his stormy accession by a great inscription and relief carved, perhaps in 516 B.C., upon the cliff at Behistun (Bisitun), near the scene of one of his victories. He is shown, attended by two nobles at his back, planting his foot

upon the prostrate body of the Magian, behind whom comes a line of nine other rebels, standing in chains; the last, a Scythian wearing a tall, pointed hat, was carved later than the others, obliterating part of the inscription. The symbol of the god Ahura Mazda, which floats in the air above the prisoners. is carved after the manner of the Assyrian Assur, and many of the other details, as well as the plan of the relief, show Assyrian influence. But the figures project farther from the background, so that the forms have more rounding than was necessary in Mesopotamia, while the region of the eyes and the folds of the drapery are carved in a more naturalistic style than had ever been seen in Assyrian work.

Between 520 and 515 B.C. Darius began the building of a new capital at Persepolis, 25 mi. S.W. of Pasargadae. A great terrace was constructed on a spur of rock at the valley's edge and encircled by a wall including a ridge of the mountains to its east. This was a fort in contrast with the walled park at Pasargadae. Access to the fort was gained by a gate building whose front and rear entrances were guarded by pairs of huge bulls. The terrace was levelled at three different heights. On these varying levels stood the royal buildings, the most imposing being audience halls, the *apadana* begun by Darius and the hundred-column hall begun by Xerxes. Palaces were built'by Darius (the *tachara*) and by Xerxes (the *hadish),* while one of Darius III's was unfinished and of inferior quality. Other buildings were a treasury or administrative centre and a storehouse begun by Darius and developed by his successors, a harem belonging to Darius and Xerxes, an entrance building to the palace area and the site of a temple or another palace. These structures generally faced on courtyards which were connecting links rather than focuses as in Babylonia.

The usual building plan consisted of a columned portico leading to a pillared hall surrounded by minor rooms. The *apadana,* however. had two porticoes reached by double stairs on which were magnificent reliefs representing new year ceremonies. On one side are shown courtiers, and guards watching tribute bearers from all the empire mount the other side of the stairs. The treasury was without entrance portico and consisted of a complex of large rectangular and square, columned halls, subsidiary rooms between and two courts, one with a pair of orthostat reliefs.

These structures were built, like the palaces of Cyrus, of unbaked brick reinforced with stone, but differ from them in many particulars. Thus the two-colour scheme is abandoned; the pillared rooms are usually square; walls are broken by stone windows and niches of the same size and shape; these and the doors bear the petal cavetto cornice characteristic of Egyptian work; the columns have fluted shafts instead of smooth, their bases (after Darius) and caps have elaborate floral ornaments, and they end in large impost blocks composed of addorsed *protomes* of two identical couchant animals — bulls; winged, human-headed bulls; lions; and fantastic lions — all stylized and powerfully rendered. The ceilings were carried on thick beams resting on the animal impost blocks. The façades of the kings' tombs show the ends of the beams penetrating to the exterior of the building. On the cornice above is an ornamental frieze, with a floral design on glazed brick at the *apadana.*

The stone stairs, doors and sometimes windows were decorated with splendid reliefs. In addition to the scene of the *apadana* stairs, others show courtiers in attendance or servants bearing food to the palaces. Sculpture within the buildings was confined largely to doorjambs on which the king is seen enthroned in audience (as in the treasury orthostats) or leaving the palace with attendants, or a hero is shown fighting with rampant bull or mythical monsters. While Achaemenid sculpture was deeply indebted to the long Mesopotamian tradition and perhaps to Median art. it shows particular qualities, and some marked superiorities of its own, especially in the sensibility and inner life of its human forms. This is probably connected with the mysterious. rapid development of Greek sculpture in the 6th century B.C. from rigid formality to vital flexibility.

The palace at Susa. built by Darius and rebuilt by Artaxerxes II (404–358) after a fire, was entirely different in conception from the buildings of Pasargadae and Persepolis. Instead of consisting of self-contained units, the Susa palace was laid out on the Assyrian plan, with successive rooms opening onto central courts. Of these there were three in a row. The entrance, on the east, led into a large court surrounded by service buildings, and beyond that was the much smaller central court. On the south side of this were little rooms; on the north were two identical parallel halls, long and narrow, one beyond the other; and at right angles to them, on the west, a long narrow passage leading north to an independent structure, a columnar audience hall similar to that of Xerxes at Persepolis.

The smallest western court again had the pair of long narrow halls, but on the south side and on the north were two large square halls, side by side, with anterooms, while on the other sides were the royal apartments. Still farther west was a very large hall, mith a direct entrance, also, in the middle of the west wall.

The decoration consisted partly of stone reliefs similar to those at Persepolis and partly of glazed brick panels, already in use locally centuries earlier, executed here with blue. white, yellow and green glazes. At the east portal were found glazed-brick winged bulls and spearmen of the guard. In the central court were the winged disk of Ahura Mazda and a pair of confronted sejant regardant crowned sphinxes. In the west court were griffins and more winged bulls and spearmen.

Further examples of Achaemenian stone relief sculpture are preserved on the rock-cut tombs of the kings. Of those at Naksh-i-Rustam near Persepolis, one bears the inscription of Darius, while the remaining three are usually connected mith the names of his immediate successors. The three similar tombs in the cliff behind the platform of Persepolis doubtless belong to later members of the dynasty, and their sculptures exhibit inferior qualities. In every case the central part of the sculpture, 60 ft. wide, represents the façade of a palace, and above (as though upon the roof) is set a dais, supported by figures of subject races, upon which the king worships the gods, whose presence is indicated by the symbol of Ahura Mazda and the moon. The interiors of the tombs are simple chambers with niches cut in the rock for the reception of bodies; but a skeleton was found at Susa buried in a bronze tub and, from the Greek accounts of his tomb, the same practice seems to have been followed in the burial of Cyrus.

Apart from the royal remains nothing is known of the buildings of the age; houses must all have been of mud brick and no further temples or other public buildings are known. The only private sculptures of the age are a couple of reliefs found near the capital of the satrap of northern Asia Minor. The Xchaemenid art, as it is known, was essentially dynastic, confined to the king and his courtiers. The same condition extends to the minor arts; the gold and silver ornaments and vessels (such as comprise the British Museum's "Treasure of the Oxus"), the stone vases, the engraved gems. are all luxuries suited only to the houses of rich nobles. A lobed silver mine bowl bearing an inscription of Artaxerxes I recalls Esther i, 7 (P. Ackerman, *Guide* to *the Exhibition* of *Persian Art,* 2nd ed., p. 322 [1940]; and for illustrations *see* A. U. Pope and P. Ackerman [eds.], *A Survey of Persian Art,* iv, Plates 77–127 [1938]).

Hellenism. — In some statuettes from the Oxus treasure the Greek influence is overwhelming, but these may be later than the destruction of the Achaemenid empire by Alexander, which brought with it the eclipse of Asiatic art. In Syria and north India, however, the Achaemenian palace was imitated during the Hellenistic age, while in Mesopotamia and Persia it was ignored in the fashion for Hellenism. Apparently under both Macedonian and Parthian rule a Hellenistic style was adopted in Persian buildings, and in the Parthian rock carvings of Behistun Hellenistic methods are applied to oriental subjects of royal glorification. Characteristically Hellenistic are bronze sculptures found at Shami in temple ruins (Sir Aurel Stein, Old *Routes* of *Western Iran,* pp. 150–152 [London, 1940]). Another temple of the Hellenistic period was excavated in the plain below Persepolis. Parthian archaeology is otherwise known only from excavations at Rayy and Susn.

Sassanian Empire. — The Sassanids (*c.* A.D. 224–651) restored Persia to its former predominance, with the result that art flour-

ished once more within the borders of their ancestral principality. The traditions of the Parthian empire, however, were retained under the new rulers, and it is possible that among the great mass of Sassanian material are included a few objects which in reality should be described as Parthian; the intaglio seals, which were numerous, are especially difficult to date accurately. Since the Sassanid monarchy was modelled on the Achaemenid, the main features of the Persepolitan palace were preserved—the great hall for public levees and the hall for private audiences with small adjacent offices—but these features were united into one and the same building.

Moreover, the method of construction was radically different from that of the preclassical period; instead of mud-brick walls carrying flat mud roofs on wooden ceilings, walls of small-cut stones or burned bricks bound with niortar carried barrel vaults over the offices or corridors and domes over the halls. The barrel vault had already been employed on a grand scale in the palace at Hatra, which dates from the 1st or 2nd century A.D. The development of the dome is still obscure but it seems to have proceeded in the east rather than in the west: the Pantheon in Rome has a hemispherical roof, constructed on the lines of a barrel vault, over a building itself following the same curve, while the use of the dome over a square chamber with squinches was an invention of Parthian Persia.

The principal Sassanian ruins in Fars are at Firuzabad, Girra, Shapur and Sarvistan. Several buildings have been excavated at Shapur, where mosaic floors were found, and a town at Kasr Abu Nasr near Shiraz. In Khuzistan is the Ivan-i-Karkha and also bridges at Dizful and Shustar, in Iraq Ctesiphon, Dastajird and excavated palaces at Kish and Hira. On the Iraq-Iran road are Kasr-i-Shirin, Hawsh-Kuri, Taq-i-Girra and Taq-i-Bustan; and in the north the excavated palaces near Rayy and at Damghan. Small ruins include several fire temples. Firuzabad was built by the first Sassanid king, and Sarvistan shows a further development of the same plan.

In Firuzabad, a large vaulted entrance flanked by side chambers forms a block which is connected with a triple row of domed rooms, and these in turn lead to the small rooms that surround the great court. The blank external walls are relieved by arcades and pilasters of no structural import, as at Hatra and in Roman Syria, while arched doorways and niches break the line of inner walls, and a cornice with the Egyptian cavetto rises incongruously over the arch to emphasize the resemblance to Persepolis. At Ctesiphon, in the palace built during the next reign, the entrance again serves as audience hall, but at Sarvistan a shallow porch communicates with the great domed hall, and this again leads into a court behind, while the smaller rooms to right and left form separate entities which communicate with the outside as well as with the central block. The result has more the character of a residence than has Firuzabad, which might serve in case of need as a fortress.

The walls were usually decorated with stucco reliefs or other applied work; legend says that the walls of Ctesiphon were encrusted with precious stones, suggesting that some kind of coloured ornamentation, perhaps mosaics, was present. Persian influence may be traced in pictures in the caves of Chinese Turkistan, and presumably that influence was directly pictorial. Statues must have been as rare as under the Achaemenids, and in the normal course of events Moslem prejudice would prevent their survival; indeed a fallen and broken statue near Shapur, the colossus of a standing king, is the sole example.

There remain a few statuettes attributable to the Sassanian period, but the characteristic sculpture of the epoch was the rock-cut relief, in which, as in other forms of art, the relationship to Achaemenian work is noticeable; indeed the carvings of the Sassanids were sometimes placed next to monuments of the earlier dynasty with the deliberate intention of provoking comparison. For instance, a relief of the first king, Ardashir. is cut in the cliff of Naksh-i-Rustam, which holds the tombs of Darius and his successors. Here the god Ahura Mazda (on the right) hands the king the symbol of sovereignty, a large ring tied round with ribbons; a servant holds a fly whisk over the king's head. Beneath the feet of each horse is a human figure, that on the right representing Ahriman, the evil spirit, the other the last of the Parthian kings. This relief, though less adept than later works, yet exemplifies most of the virtues and defects of Sassanian sculpture; in monumental power the style has had few rivals, but it suffers from laboured symmetry, heaviness and a lack of grace in the minute details.

The Sassanian silverwork is outstanding, even allowing for the fact that a number of pieces previously accepted as Sassanian proved on reinvestigation to be instead contemporary Syrian productions. By far the greatest collection is in the Hermitage museum, Leningrad, with smaller groups and single pieces in Paris, London and New York city. The most typical vessels are shallow wine bowls, about 8 to 11 in. across, and the most distinctive technique is inset *repoussé* sections of the figures in high *repoussé* (including even small portions in full round) made of a separate sheet of silver, attached by inserting the edges into slits cut in the beaten foundation plate. Other parts of the design and details are engraved, and usually some areas are parcel gilt. Hollow vessels are decorated with the usual *repoussé*. Many wine bowls are worked in champlevé, with the background cut away leaving the design in low flat relief. Some, especially post-Sassanian continuations of the style, are only engraved. The most important theme is the king, as a rule mounted, hunting, but other court scenes are shown as well as animals, real and fantastic, and birds, with stylized plants. Splendid bronze vessels also were made, especially large ewers distinguished in form (for illustrations *see* Takon Ivanovich Smirnoff, *L'Argenterie orientale* [Leningrad, 1909]; Orbeli and Trever, *Orfèvrerie sasanide* [1935], A. U. Pope and P. Ackerman [eds.], *op.cit.*, vol. iv, Plates 203–246).

The Sassanian coins provide a series of royal "portraits," showing the distinctive identifying crown of each monarch.

Sassanian Persia was also famous for its patterned silks, best known from representations in the Taq-i-Bustan reliefs. These are characterized by formally rendered animal and bird patterns, each commonly framed in a roundel, often pearled. The designs were widely copied in the near east for centuries, and are reproduced in wall paintings and stone carvings in mediaeval Europe. The fabulous "Spring Carpet" of Chosroes II, symbolizing a garden (*see* RUGS AND CARPETS), which was seized and cut up by the Arab conquerors and sold for great sums, was evidently an embroidery (or tapestry), heavily encrusted with metal threads and jewels. Toward the end of the 3rd century sculpture and also coins reached their peak of perfection. Reliefs of the middle of the dynasty tend to be traditional and have less vitality. Vividly pictorial in treatment is the latest group of reliefs, cut by order of Chosroes II (590–628), in which an Indian influence seems to account for some details.

After the Moslem conquest, the manufacture of plate and silks continued without appreciable alteration, and Sassanian motives, long surviving the dynasty, were taken into the arts of nearly every region of the east. Thus the characteristic recumbent animals, framed in varied scrolling foliate branches, were used in the caliphs' palace at Samarra, the Sassanian animal type was adopted both in Iraq and in Chinese Turkistan. Byzantine patterns have their exact Sassanian prototypes, and in many respects the decorative work of Persia remained for long unchanged. Sassanian influence reached Europe when naturalism had ceased to satisfy, and the development of the Byzantine school must have been stimulated by contact with its formal ideals.

See also BISITUN; ECBATANA; PASARGADAE; PERSEPOLIS; SUSA.)

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HISTORY

The name "Persia" in its strict significance denotes the area inhabited by the people designated as Persians; *i.e.*, the district known in antiquity as Persis (*q.v.*), the modern Fars. In the west,

following classical usage, custom extended the designation to the whole Iranian plateau and then to the political state occupying most of that plateau.

Ancient Ethnography. — In historical times the major portion of Iran was occupied by peoples of Indo-European origin, calling themselves Aryans (Arya; Zend. Airya) and their language Aryan —so in the inscriptions of Darius; it was the same name as was used by the consanguineous tribes of India aho were their nearest relations. The whole country is designated Ariana (Zend, Airyana)—'the land of the Aryans"—the original of the Middle Persian "Eran" and the modern "Iran"; the Greek geographers Eratosthenes and Strabo were in error when they limited the name to the eastern districts of Iran. Thus the name "Iranian" is understood to comprehend all these people of Aryan derivation.

Besides the Iranians, numerous tribes of alien origin were found in Iran. In Baluchistan the eponymous Iranian inhabitants, who penetrated there only a few centuries ago, are even today found side by side with the ethnologically and philologically distinct group of the Brahui, who are probably connected with the Dravidians of India. In them we may trace the original population of these districts; and to the same original population may be assigned the tribes which settled there in antiquity: the Paricanii and Gedrosii (Gadrosii), and the Myci (Herodotus iii, 93, vii. 68; the Maka of Darius, the modern Makran), to whom the name "Xethiopians" is also occasionally applied (Herod. iii, 94, vii, 70). In Media the Greek geographers mention a people of Anariacae (Strabo xi, 508, 514; Pliny, *Natural* History, vi, 48; Ptolemy vi, 25; in Polybius v, 44 9, Ἀναριάκαι); *i.e.*, "non-Aryans." To these the Tapuri, Amardi, Caspii and especially the Cadusii or Gelae—situated in Gilan on the Caspian—probably belonged.

In the chain of the Zagros there are similar non-Aryan groups: the Guti, Lullubi, Cossaei, Barahshi. Ellipi and, in Elam (Elymais or Susiana), the Elamites (Elymaeans). These peoples are generally designated. for want of a better term, "Caucasian," and belong to the ethnic substratum later conquered by the Indo-Europeans.

That the Iranians probably came from the east to their later home is indicated by their close relationship to the Indians. with whom they previously formed a single people, bearing the name "Arya." Their residence must have lain chiefly in the great steppe which stretches north of the Black sea and the Caspian, through south Russia, to Turan (Turkistan) and the Oxus and Iaxartes. For there traces of Iranian peoples are continually discovered. The names and words of the Scythians (Scoloti) in south Russia. which Herodotus has preserved, are for the most part perfectly transparent Iranian formations, identified by K. Zeuss and K. V. Mullenhoff; among them are many proper names in Aria- (Αριο) and *aspa* (-horse, -αδπος; Zend, *aspa*). The predatory tribes of Turan (*e.g.*, the Massagetae) seem to have belonged to the same stock. These tribes are distinguished by the Iranian peasants as Dahae (Gr. Δάαι), "enemies," "robbers"; by the Persians as Sacae (Saka; *q.v.*); and by the Greeks as Scythians.

From the region of the steppes the Aryans must have penetrated into the cultivable land of eastern Iran; thence one part spread over the district of the Indus and then on to the Ganges; another moved westward to Zagros and the borders of the Semitic world.

The date of this migration cannot yet be determined with certainty. We know only that the Aryans of India already occupied the Punjab in the Vedic era, c. 1200 B.C. On the other hand, Aryan names appear in contemporary documents from the 16th century in Mesopotamia and Syria. In the kingdom of Mitanni (in northern Mesopotamia) the Aryan origin of the dynasty is prqved by the names of the kings (Artatama, Shutarna, Artasumara, Dushratta); in a treaty the Indian gods Mitra and Varuna, Indra and the Nasatyas are invoked by the side of the Mitannian gods, and in the archives of Boghaz Keui a book on horse races written by a Mitannian named Kikkuli was found, in which Indian numerals and other Indian words are used. Among the dynasts of Syria and Palestine whose letters to their sovereign, the Pharaoh of Egypt, are preserved in the archives of Tel el Amarna (about 1400 B.C.), many bear Iranian names (*e.g.*, Artamanya. Arzawiya, Shuwardata), and their portraits are represented in Egyptian reliefs (*e.g.*, in the tomb of Haremhab, now in Leyden). Here their features are of a European character, totally different from those of the Semites and of the Hittites. Later still. in the Assyrian inscriptions we occasionally meet with Iranian names borne by north Syrian princes—*e.g.*, Kundaspi and Kustaspi (=Hystaspis).

But it appears that toward the middle of the and millennium before Christ, in the time of the Hyksos empire, the early Iranian tribes made a great forward movement to the west, at first probably in the role of mercenaries. In the Egyptian and Hittite texts they form a ruling military class under the Aryan name "Marianni"; *i.e.*, warriors. Some of their leaders founded principalities of their own in Mesopotamia, Syria and Palestine, much as did the Germans under the Roman empire. With this we may probably connect the well-known fact that it was about this very period (1700 B.C. approximately) that the horse made its appearance in Babylonia, Egypt and Greece, where for centuries afterward its use was confined to war and the war chariot. Before this it was as foreign to the Babylonians as to the Egyptians under the 12th dynasty. On the other hand, it had been familiar to the Aryans from time immeinorial; indeed they have always been peculiarly a people of riders. Thus it is quite conceivable that they brought the horse with them into western Asia; and the quarter from which it came is sufficiently indicated by the fact that the Babylonians wrote the word "horse" with a group of signs denoting "ass of the east."

These Aryan warriors and dynasts in the west were extirpated in the many wars with the Egyptians, Hittites and Assyrians. or absorbed by the native population. At the same time the great highland of Iran was occupied by the Iranians. who were divided into nuinerous tribes, these, again, being subdivided into minor tribes and clans. The principal, according to the inscriptions of Darius—which closely agree with Herodotus—are the following, several of them being also enumerated in the *Avesta*:

1. The Medes (Mada) in the northwest (see MEDIA).

2. The Persians (Parsaj in the south (see PERSIS). To these belong the Carmanians and the Utians (Yutiya), mentioned by Darius as inhabiting a district in Persis (Behistun III, 40).

3. The Hyrcanians (Varkana in Darius; Zend, Vehrkana) on the eastern comer of the Caspian, in the fertile district of Asterabad.

4. The Parthians (Parthyaei; Persian, Parthava) in Khurasan (see PARTHIA).

5. The Arians (Ἀρεῖοι, Persian, Haraiva), in the vicinity of the Arius river (Hari Rud), which derived its name from them. This name, which survives in the modern Herat, has no connection with that of the Aryans.

6. The Drangians (Zaranka in Darius; Sarangians in Herod. ii, 93, 117, vii, 67), situated south of the Arians, in the northnest of Afghanistan (Arachosia) by the western affluents of Lake Hamun, and extending to the present Seistan.

7. The Arachotians (Persian, Harauvati), in the district of the Helmund and its tributaries round Kandahar. They are mentioned in the lists of Darius and by the Greeks after Alexander. In Herodotus their place is taken by the Pactyans, whose name survives to the present day in the word "Pushtu," with which the Afghans denote their language (Herod. iii, 102; iv. 44; vii. 67, 85). Probably it was the old tribal name. Xrachosia being the local designation. The Thamanaeans, who appear in Herodotus (iii, 93, 117), must be classed with them.

8. The Bactrians (Persian, Bakhtri), on the northern declivity of the Hindu Kush, as far as the Oxus. Their capital was Bactra, the modern Balkh (see BACTRIA).

9. The Sogdians (Persian, Sugudu), in the mountainous district between the Oxus and Iaxartes.

10. The Chorasmians (Khwarizmians; Persian, Uvarazmiya) in the great oasis of Rhiva. which still bears the name "Khwarizm." They stretched far into the midst of the nomadic tribes.

11. The Margians (Persian, Margu), on the river Margus (Murghab), chiefly inhabiting the oasis of Merv. which has preserved their name. Darius mentions the district of Margu but like Herodotus omits them from his list of peoples, so that ethnographically they are perhaps to be assigned to the Arians.

12. The Sagartians (Persian, Asagarta); according to Herodotus

(vii, 85), a nomadic tribe of horsemen, speaking, as he expressly declares, the Persian language. Herodotus describes them (i, 125) as a subordinate nomad clan of the Persians. They, with the Drangians, Utians and Myci, formed a single satrapy (Herod. iii, 93). Ptolemy (vi, 2, 6) speaks of Sagartians in the eastern Zagros in Media.

13. Mention has already been made of the nomadic peoples (Dahae, Dahans) of Iranian derivation who occupied the steppes of Turkistan as far as the Sarmatians and Scythians of south Russia about 700 B.C. That these were conscious of their Aryan origin is proved by the names "Ariantas" and "Ariapeithes" borne by Scythian (Scolot) kings (Herod. iv, 76, 87). Still they were never counted as a portion of Iran or the Iranians. To the settled peasantry, these nomads of the steppe were always "the enemy" (Dana, Daha, Δάαι, Dahae). Side by side with this name we find "Turan" and "Turanian," a designation applied both by the later Persians and by modern writers to this region. The origin of the word is obscure, but it is perhaps derived from an obsolete tribal name. It has no connection whatever with the much later "Turks," who penetrated there in the 6th century after Christ. Though found neither in the inscriptions of Darius nor in the Greek authors, the name "Turan" must nevertheless be of great antiquity; for not merely is it repeatedly found in the Avesta, under the form "Tura," but it occurs in a hymn which, without doubt, originates from Zoroaster himself and in which "the Turanian Fryana" and his descendants are commemorated as faithful adherents of the prophet (Yasna, 46, 62).

The dividing line between Iranian and Indian is drawn by the Hindu Kush and the Suleiman mountains of the Indus district. The valley of the Kabul (Cophen) has been occupied by Indian tribes, especially the Gandarians; and the Satagydae (Persian, Thatagu) who lived there were presumably also of Indian stock. The non-Aryan population of Iran itself has been discussed above. Of its other neighbours, we must here mention the Saka or Sacae, a warlike equestrian people in the mountains of the Pamir plateau and northward, who were probably also of Aryan origin. Herodotus relates that the Persians distinguished "all the Scythians"—*i.e.*, all the northern nomads—as Saka; and this statement is confirmed by the inscriptions of Darius. The Babylonians employ the name "Gimiri" (Gimirrai; *i.e.*, Cimmerians) in the same sense.

Beginnings **of** History.—The southwestern Zagros region early became a part of Elam, whose royal capital in Sumerian times was Awan but was subsequently shifted to Susa. Throughout the 2nd millennium Elam was involved in the history of Babylonia and under Shilhak-Inshushinak (1165–51 B.C.) became the greatest empire of the area. This empire, built too rapidly, collapsed at his death, and for four centuries the records are silent regarding the area of Susa and Anshan. For the central Zagros, long since overrun by the Aryan push to the west, a connected chain of historical evidence begins in 836 B.C. when, under Shalmaneser (Salmanassar) II, the Assyrians for the first time penetrated farther into the mountains of the east. There they subdued a few Median tribes as well as some non-Iranian peoples. These wars were continued under successive kings, till the Assyrian power in these regions attained its zenith under Sargon (*q.v.*). In 715 B.C. Sargon led into exile the Median chief Deioces (*q.v.*), a vassal of the Mini (Mannaeans), with all his family, and subjugated the princes of Media as far as the mountain of Bikni (Elburz) and the border of the great desert. At that time 28 Median "town lords" paid tribute to Nineveh; two years later (713 B.C.), no fewer than 46 paid tribute.

Early in the 7th century B.C. Achaemenes (Hakhamanish) had carved out for himself a dominion in Parsumash, to the northeast of Susa. His son Teispes (Chishpish) took Anshan from the waning power of Elam. Although apparently at first subdued by the Mede Pharortes, he was able subsequently to take advantage of the Scythian invasion of Media (653–625) to press on down through the Zagros valleys to the district of Parsa, known to the Greeks as Persis and made famous by his descendants. It was natural for Teispes to divide his realm between his sons Ariaramnes (640–615) and Cyrus I (640–600). Yet it was not long before Cyaxares brought the Iranian plateau again under Median control (625) and made both these Persians his vassals, even denying to Ariaramnes and his heirs, Arsames and Hystaspes (Hystaspes was the father of Darius I) the title of king. For the history of the empire Cyaxares founded see MEDIA.

In 612 B.C. Nineveh, the capital of the Assyrian empire, was conquered and destroyed by Cyaxares and Nabopolassar of Babylon, and the provinces were divided by the victors. Not only was Median power extended over Iran, but in the west Armenia and Cappadocia were subdued by Cyaxares. In a war with the Lydian empire the decisive battle was broken off by the celebrated eclipse of the sun on May 28, 585 B.C., foretold by Thales (Herod. i, 74). After this a peace was arranged by Nebuchadrezzar of Babylon and Syennesis of Cilicia, recognizing the Halys river as the borderline. The great powers of the near east remained in this state of equilibrium during the first half of the 6th century B.C.

THE ACHAEMENID EMPIRE, 6TH–4TH CENTURIES B.C.

Cyrus the Great *(559–529)* **and** Darius *I* **(522–486).**—The balance, however, was disturbed when the Persian Cyrus, king of Anshan, Parsumash and Parsa, revolted against his suzerain Astyages, the son of Cyaxares, and three years later defeated him at Pasargadae (*q.v.*). Shortly afterward Astyages was taken prisoner, Ecbatana reduced and the Median empire replaced by the Persian. The Persian tribes were welded by Cyrus into a single nation, and now became the foremost people in the world (see CYRUS; PERSIS). At first Nabonidus of Babylon hailed the fall of the Medes with delight and took the opportunity of occupying Harran (Carrhae). But before long he recognized the danger that threatened from that quarter. Cyrus and his Persians paid little heed to the treaties which the Median king had concluded with the other powers, and the result was a great coalition against him, embracing Nabonidus of Babylon, Amasis of Egypt, Croesus of Lydia and the Spartans, whose highly efficient army seemed to the oriental states of great value. In the spring of 546 B.C. Croesus opened the attack. Cyrus flung himself upon him, bent him at Pteria in Cappadocia and pursued him to Lydia.

A second victory followed on the banks of the Pactolus; by the autumn of 546 Sardis had already fallen, and the Persian power advanced at a bound to the Mediterranean. During the next few years the Greek littoral towns were reduced, as were the Carians and Lycians. The king of Cilicia voluntarily acknowledged the Persian suzerainty. In 539 Nabonidus was defeated and Babylon occupied, while, with the Chaldaean empire, Syria and Palestine also became Persian. The east of Iran was further subdued, and after Cyrus met his end (529 B.C.) in a war against the eastern nomads (Dahae, Massagetae), his son Cambyses conquered Egypt (525 B.C.). Cyprus and the Greek islands on the coast of Asia Minor also submitted, Samos being taken by Darius. On the other hand, an expedition by Cambyses against the Ethiopian kingdom of Napata and Meroe came to grief in Nubia. The usurpation of the kingdom by Smerdis (522 B.C.) and his death at the hands of Darius was the signal for many insurrections in Babylon, Susiana, Persis, Media, Armenia and many of the eastern provinces. But within two years they were all crushed by Darius and his generals.

The causes of this astonishing success, which in the brief space of a single generation raised a previously obscure and secluded tribe to the mastery of the whole orient, can be discerned only partially from the evidence at our disposal. The decisive factor was of course their military superiority. The chief weapon of the Persians, as of all Iranians, was the bow, which accordingly the king himself holds in his portraits; *e.g.*, on the Behistun rock and the coins (darics). In addition to the bow the Persians carried short lances and short daggers. But it was not by these weapons, nor by hand-to-hand fighting, that the Persian victories were won. They overwhelmed their enemy under a hail of arrows and never allowed him to come to close quarters. While the infantry knelt to shoot, the cavalry swarmed round the hostile squadrons, threw their lines into confusion and completed their discomfiture by a vigorous pursuit. In a charge the iniantry also might employ lance and dagger; but the essential point was that the archers should be mobile and their use of the bow unhampered. Conse-

quently only a few distinguished warriors more shirts of mail. The rank and file merely carried a light, hide-covered shield. Thus the Persian army was lost if heavy-armed hoplites succeeded in gaining their lines. In spite of all their bravery they succumbed to the Greek phalanx when once the generalship of a Miltiades or a Pausanins had brought about a handsto-hand conflict; and it was with justice that the Greeks—Aeschylus, for instance—viewed their battles against the Persian as a contest between spear and bow. None the less, till Marathon the Persians were successful in discomfiting every enemy' before he could close, whether that enemy consisted oi similarly accoutred bowmen (as the Medes), of cavalry armed with the lance (as the Lydians) or of heavily armoured warriors (as the Babylonians, Egyptians and Greeks).

To all this should be added the superiority of their leaders; Cyrus especially must have been an exceedingly able general. Obviously, also, he must have understood the art of organizing his people and arousing the feeling of nationality and the courage of self-sacrifice. In his time the Persians were a strong, manly peasantry, living in a healthful climate and accustomed to all hardships—a point repeatedly emphasized in the tales preserved by Herodotus as the cause of their successes (*e.g.*, Herod. ix, 122). Herodotus. however, also records (i, 135) that the Persians were "of all mankind the readiest to adopt foreign customs, good or bad." a sentence which is equally applicable to the Romans and which goes far to explain not merely the successes of both nations but also the character of their empires.

Administration of the **Empire:** the Peoples.—The fundamental features of the imperial organization must have been attributable to Cyrus himself. Darius (*q.v.*) followed in his steps and completed the vast structure. His role, indeed, was peculiarly that of supplementing and perfecting the work of his great predecessor. The organization of the empire was planned throughout on broad, free lines; there was nothing mean or timorous in it. The great god Ahura Mazda, whom king and people alike acknowledged, had given them dominion "over this earth afar, over many peoples and tongues"; and the consciousness was strong in them that they were masters of the world. Thus their sovereign styled himself the "king of kings" and the "king of the lands"—that is to say, of the whole civilized world, for the provinces remaining unsubdued on the extreme frontiers to the west, the north and the east were in their view almost negligible quantities. And far removed as the Persians were from disavowing their proud sense of nationality ("a Persian, the son of a Persian, an Aryan of Aryan stock," says Darius of himself in the inscription on his tomb), yet equally vivid was the feeling that they ruled the whole civilized world, that their task was to reduce it to unity. And by the will of Ahura Mazda they were pledged to govern it aright.

This is most clearly seen in the treatment of the subject races. In contrast with the Assyrians and the Romans, the Persians invariably conducted their wars with great humanity. The vanquished kings were honourably dealt with, the enemy's towns were spared except when grave offenses and insurrections. as at Miletus and Athens, made punishment imperative, and their inhabitants were treated with mildness.

Like Cyrus. all his successors welcomed members of the conquered nationalities to their service, employed them as administrators or generals and made them grants of land; and this not only in the case of Medes, but also of Armenians, Lydians. Jews and Creeks. The whole population of the empire was alike bound to military service. The subject contingents stood side by side with the native Persian troops; and the garrisons—in Egypt, for instance—were composed of the most varied nationalities.

Among the subject races the Medes particularly stood high in favour. Darius in his inscriptions always names them immediately after the Persians. They had held sway before the Persians and were the more civilized people. Their institutions, court ceremonial and dress were all adopted by the Achaemenids. Thus the tribal distinctions began to recede, and the ground was prepared for that amalgamation of the Iranians into a single, uniform nation which under the Sassanians was completely perfected—at least for the west of Iran.

The lion's share, indeed, fell to the dominant group itself. The inhabitants of Persis proper—from which the eastern tribes of Carmanians, Utians, etc., were excluded and formed into a separate satrapy—paid no taxes. Instead they brought the best of their possessions (*e.g.*, a particularly fine fruit) as a gift to their king on festival days; peasants meeting him on his excursions did the same (Plutarch, Artaxerxes, 4, 5; Dinon *ap.* Aelian, Varia Historia, i, 31; Xenophon, Cyropaedia, viii, 5, 21, 7, 1). In recompense for this, he distributed on his return rich presents to every Persian man and woman—the women of Pasargadae, who were members of Cyrus' tribe, each receiving a piece of gold (Nicolaus of Damascus, fragment 66; Plutarch, *Alexander*, 69). He was always the people's king as far as his Persians were concerned. At his accession he was consecrated in the temple of a warrior goddess (Anaitis?) at Pasargadae and partook of the simple meal of the old peasant days—a mess of figs, terebinths and sour milk (Plut., *Artax.*, 3). The Persians swore allegiance to him and prayed to Ahura Mazda for his life and the welfare of the people, while he vowed to protect them against every attack and to judge and govern them as did his fathers before him (Herod. i, 132; Xen., Cyr., xviii. 5, 25, 27). For helpers he had at his side the "lawbearers" (databara Dan. iii, 2, and in Babylonian documents; *cf.* Herod. iii, 31, v, 25, vii, 194; Esther i, 13, etc.). These —the Persian judges—were nominated by the king for life and generally bequeathed their office to their sons. The royal decision was based on consultation with the great ones of his people, and such was the case with his officials and governors everywhere (cf. the Book of Ezra).

Every Persian able to bear arms was bound to serve the king—the great landowners on horseback, the commonalty on foot. The noble and well-to-do, who did not need to till their fields in person, were pledged to appear at court as frequently as possible. Their children were brought up in company with the princes "at the gates of the king," instructed in the handling of arms, in riding and hunting, and were introduced to the service of the state and the knowledge of the law as well as the commandments of religion. Then such as proved their worth were called to high office and rewarded, generally with grants of land.

The highest rank was held by the descendants of the six great families. The Greeks class them and the king together under the name of "the seven Persians." These enjoyed the right of entering the royal presence unannounced, and possessed princely estates in the provinces. Besides these, however, numbers of other Persians were dispatched to the provinces, settled there and endowed with lands. There existed, in fact, under the Achaemenids a strong colonizing movement, diffused through the whole empire; traces of this policy occur more especially in Armenia, Cappadocia and Lycia. but also in the rest of Asia Minor and not rarely in Syria and Egypt. These colonists formed the nucleus of the provincial military levy and were a tower of strength to the Persian dominion. They composed, moreover, the Persian council and viceregal household of the satraps, exactly as the Persians of the home country composed that of the king.

Though the idea of the world empire of Persia was thus deeply impressed, care was nevertheless exercised that the general duties and interests of the subject races should receive due consideration. We find their representatives, side by side with the Persians, occupying every sort of position in the regal and viceregal courts. They took their part in the councils of the satraps, as they did in military service (*cf.* the evidence of Ezra); and they, too, were rewarded by bounties and estates. To wield a peaceful authority over all the subjects of the empire, to reward merit and to punish transgression—such was the highest task of king and officials.

On his native soil Cyrus had built a town, with a palace and a tomb, in the district of Pasargadae (now the ruins of Murghab). This Darius replaced by a new capital, deeper in the centre of the country, which bore the name "Persian" (Parsa), the Persepolis (*q.v.*) of the later Greeks. But the district of Persis was too remote to be the administrative centre of a world empire. The natural centre lay, rather, in the ancient fertile tract on the lower Tigris and Euphrates. The actual capital of the empire was therefore Susa, where Darius I and Artaxerxes II erected their magnificent palaces. The winter months the kings spent chiefly

in Babylon, the hot summer in the cooler situation of Ecbatana, where Darius and Xerxes built a residence on Mt. Alvand, south of the city. From a palace of Artaxerxes II in Ecbatana itself, the fragments of a few inscribed columns (published by B. T. A. Evetts in Zeitschrift fur *Assyriologie,* v [Leipzig, 1890]) have been preserved. The kings visited Persis and Persepolis at their coronations but only occasionally afterward.

Method of Government. — Within the empire, the two great civilized states incorporated by Cyrus and Cambyses, Babylon and Egypt, occupied a position of their own. After his defeat of Nabonidus, Cyrus proclaimed himself "king of Babel," and the same title was borne by Cambyses, Smerdis and Darius. In Egypt Cambyses adopted in full the titles of the Pharaohs. In this we may trace a desire to conciliate the native population, with the object of maintaining the fiction that the old state still continued. Darius went still further. He encouraged the efforts of the Egyptian priesthood in every way, built temples and enacted new laws in continuance of the old order. In Babylon his procedure was presumably similar, though there is no local evidence. But he lived to see that his policy had missed its goal. In 486 B.C. Egypt revolted and was only reduced by Xerxes in 484. It was this, probably, that induced Xerxes in 484 to renounce his title of king of Babel and to remove from its temple the golden statue of Bel-Marduk (Merodach), whose hands the king was bound to clasp on the first day of each year. This proceeding led to two insurrections in Babylon (probably in 484 and 479 B.C.), which were speedily repressed. After that the kingship of Babel was definitely abolished. In Egypt the Persian kings still retained the style of the Pharaohs, but we hear no more of concessions to the priesthood or to the old institutions and, apart from the great oasis of Rharga, no more temples were erected.

At the head of the court and the imperial administration stood the commandant of the bodyguard — the 10,000 "immortals," often depicted in the sculptures of Persepolis with lances surmounted by golden apples. This grandee, whom the Greeks termed "chiliarch," corresponds to the modern vizier. In addition there were seven councillors (Ezra vii, 14; cf. Esther i, 14). Among the other officials, the "eye of the king" is frequently mentioned. To him was entrusted the control of the whole empire and the superintendence of all officials.

Administration: Language. — The orders of the court were issued in a very simple form of the cuneiform script, probably invented by the Medes. This consisted of 36 signs, almost all of which denote single sounds. In the royal inscriptions, a translation into Elamite and Babylonian was always appended to the Persian text. In Egypt one in hieroglyphics was added, as in the inscriptions of the Suez canal; in the Grecian provinces, another in Greek (*e.g.,* the inscription of Darius on the Bosporus; Herod. iv, 37, cf. iv, 91). The cuneiform script could be written only on stone or clay. Thus there has been discovered in Babylon a copy of the Bisitun (*q.v.*) inscription preserved on a block of dolerite (F. H. Weissbach, Babylonische *Miscellen,* p. 24 [Berlin, 1900 *et seq.*]). For administrative purposes, however, it would seem that this inconvenient material was not employed, its place being taken by skins (*διφθέραι*, parchment), the use of which was adopted from the western peoples of the empire. On these were further written the journals and records kept at the court (*cf.* Diodorus 11, 22, 32; Ezra iv, 15, v, 17, vi, 2; Esther vi, 1, ii, 23). With such materials the cuneiform script could not be used; instead, the Persian language was written in Aramaic characters, a method which later led to the so-called Pahlavi; *i.e.*, Parthian script. This mode of writing was employed in the state services from Darius I, and so may explain the fact that, under the Achaemenids, the Persian language rapidly declined and in the inscriptions of Artaxerxes III appears only in a neglected guise.

Side by side with Persian, Aramaic, which had long been widely diffused as the speech of commerce, enjoyed currency in all the western half of the empire as a second dominant language. Thus all deeds, enactments and records designed for these provinces were furnished with an official Aramaic version (Ezra iv, 7). To the three cuneiform inscriptions of his tomb at Naksh-i-Rustam Darius added an Aramaic version; and of the account of his deeds in the inscription in Behistun he distributed copies in Aramaic over his empire; large fragments of one of these, written in beautiful characters, have been preserved in the papyri of the Jewish garrison at Elephantine, together with numerous documents in the same tongue.[1] The coins minted by the satraps and generals usually bear Aramaic inscriptions. The Demotic in Egypt was employed in private documents. In the Hellenic provinces of the empire Greek replaced Aramaic (cf. the letter to Pausanias in Thucydides i, 129; an edict to Gadatas in Magnesia: G. Cousin and G. Deschamps, Bulletin de *correspondance héllénique,* xii, 204 [Athens, 1888]; C. F. W. Dittenberger, Sylloge *Inscriptionum* Graecarum, ii, 3rd ed. [Leipzig, 1915–24]; so, also on coins) — a clear proof that the Persians had already begun to recognize the independent and important position of Greek civilization.[2]

Provincial **Organization.**—Darius I divided the Persian empire into 20 great provinces, satrapies, with a "guardian of the country" (*khshathrapavan;* see SATRAP) at the head of each. A list is preserved in Herodotus (iii, 89 et seq.); but the boundaries were frequently changed. Each satrapy was again subdivided into several minor governorships. The satrap was the head of the whole administration of his province. He levied the taxes, controlled the legal procedure, was responsible for the security of roads and property and superintended the subordinate districts. The heads of the great military centres of the empire and the commandants of the royal fortresses were outside his jurisdiction; yet the satraps mere entitled to a body of troops of their own, a privilege which they used to the full, especially in later periods. The satrap was held in his position as a subject by the controlling machinery of the empire, especially the "eye of the king"; by the council of Persians in his province, with whom he was bound to debate all matters of importance; and by the army. In the hands of the messengers (Pers. *ἀστάνδαι* or *ἄγγαροι*, a Babylonian word;) the government dispatches traveled "swifter than the crane" along the great imperial highways, which were all provided with regular postal stations (cf. the description of the route from Susa to Sardis in Herod. v, 52).

Within the satrapies the subject races and communities occupied a tolerably independent position; for instance the Jews, under their elders and priests, convened a popular assembly in Jerusalem (cf. the books of Ezra and Nehemiah). They also enjoyed, as a rule, the privilege of deciding lawsuits among themselves. The pressure of despotism was manifest, not so much in that the king and his officials consistently interfered in individual cases, but that they did so on isolated and arbitrary occasions, and then swept aside the privileges of the subject, who was impotent to resist.

The subject population can be divided into distinct groups. In the desert (as among the Arabian and Turanian nomads), in wild and sequestered mountains (as in Zagros in north Media, and Mysia, Pisidia, Paphlagonia and Bithynia in Asia Minor) and also in many Iranian tribes, the old tribal constitution, with the chieftain as its head, was left intact under the imperial suzerainty. The great majority of the civilized provinces were subdivided into local administrative districts governed by officials of the king and his satraps. These the Greeks named *ἔθνη*, "peoples." Within these, again, there might lie large town settlements, such as Babylon, Jerusalem, the Egyptian cities, Tarsus and Sardis, whose internal affairs were controlled by the elders or the officials of the community. On the same footing were the dominions of the high priests, with their great temple property — Bambyce in Syria, the two Comanas in Cappadocia and so forth. Vast districts were either converted into royal domains (*παράδεισοι*) with great parks and huntinggroundsunder royal supervision,or else bestowed by the king on Persians or deserving members of the subject peoples (the "benefactors"). Many of these estates formed respectable principalities; *e.g.,* those of the house of Otanes in Cappadocia, of Hydarnes in Armenia, Pharnabazus in Phrygia, Demaratus in Teuthrania, Themistocles in Magnesia and Lamp-

[1] A. H. Sayce and **A. E. Cowley,** *Aramaic Papyri Discovered at Assuan* (London, 1906); E. Sachau, *Aramäische Papyri und Ostraka aus einer jüdischer Militärkolonie für Elephantine* (1911); **A. E. Cowley,** *Aramaic Papyri of the Fifth Century* (Oxford, 1923).

[2] F. H. Weissbach, *Die Keilinschriften der Achämeniden* (Leipzig, 1911) (transcriptions and translation of all the texts).

sacus. They were absolute private property, handed down from father to son for centuries, and in the Hellenistic period not rarely became independent kingdoms. These potentates were styled by the Greeks δυνάσται or μόναρχοι.

The last class, quite distinct from all these organizations, was formed by the city-states (πόλεις) with an independent constitution — whether a monarchy (as in Phoenicia), an aristocracy (as in Lycia) or a republic with council and popular assembly (as in the Greek towns). The essential point was that they enjoyed autonomy. This was only to be seen in the extreme western provinces of the empire, among the Phoenicians, Greeks and Lycians, whose cities were essentially distinct from those of the east. Indeed to Greek eyes the eastern cities were only great villages (κωμοπόλεις). It is readily intelligible that the character of the city-states should have proved practically incomprehensible to the Persians, with whom they came into perpetual collision. The Persians sought, as a rule, to cope with the difficulty by transferring the government to individual persons who enjoyed their confidence, the "tyrants" of the Greek towns. Only Mardonius, after his suppression of the Ionic revolt — which had originated with these very tyrants — made an attempt to govern them by the assistance of the democracy (492 B.C.).

Economic Problems. — The provinces of the empire differed as materially in economy as in organization. In the extreme west a money currency in its most highly developed form — that of coinage minted by the state or an autonomous community — had developed since the 7th century among the Lydians and Greeks. In the main portion, however, of the oriental world — Egypt, Syria, Phoenicia and Babylonia — the old mode of commerce was still in vogue, conducted by means of gold and silver bars, weighed at each transaction; a money currency did not begin to make headway in these districts until the 4th century B.C. In the eastern provinces the primitive method of exchange by barter still held the field. Only in the auriferous and civilized frontier districts of India (the Punjab) did a system of coinage find early acceptance. There Persian and Attic money was widely distributed, and imitations of it were struck, in the 5th and 4th centuries B.C.

Thus the empire was compelled to grapple with all these varied conditions and to reconcile them as best it might. At the court, "natural economy" was still the rule. The officials and oriental troops received payment in kind. They were fed "by the table of the king," from which 15,000 men daily drew their sustenance (cf. Heraclides of Cyme in Athenaeus iv, 145 B, etc.) and were rewarded by gifts and assignments of land. The Greek mercenaries, on the contrary, had to be paid in currency; nor could the satraps of the west dispense with it. The king, again, needed the precious metals not merely for bounties and rewards but for important enterprises in which money payment was imperative. Consequently the royal revenues and taxes were paid partly in the precious metals, partly in natural produce — horses and cattle, grain, clothing and its materials, furniture and all articles of industry (cf. Theopompus, fragment 124, 125, etc.). The satraps, in addition to money payments, also levied contributions "for their table," at which the officials ate (Nehemiah v, 14).

The precious metals brought in by the tribute were collected in the great treasure houses at Susa, Persepolis, Pasargadae and Ecbatana, where gigantic masses of silver and, more especially, of gold were stored in the bullion or partially wrought into vessels (Herod. iii, 96; Strabo xv, 731, 735; Arrian iii, 16, etc.) exactly as was the case more than 2,000 years later in the shah's treasure chamber. When the king required money he minted as much as was necessary. A reform in the coinage was effected by Darius, who struck the daric (Persian, *zariq; i.e.*, "piece of gold"; the word has nothing to do with the name of Darius), a gold piece of 130 gr., this being equivalent to 20 silver pieces ("Median shekels," σίγλοι) of 86.5 gr. The coinage of gold was the exclusive prerogative of the king; silver could be coined by the satraps, generals, independent communities and dynasts.

Attempt at Consolidation. — The extent of the Persian empire was, in essentials, defined by the great conquests of Cyrus and Cambyses. Darius was no more a conquistador than Augustus. The task he set himself was to round off the empire and secure its borders. For this purpose he subdued the mountain tribes in Asia Minor and Armenia and advanced the frontier as far as the Caucasus, Colchis alone remaining an independent kingdom under the imperial suzerainty. So, too, he annexed the Indus valley and the auriferous hill country of Kafiristan and Kashmir (Κάσπιοι or Κάσπειροι; Herod. iii, 93, vii, 67, 96; Stephen of Byzantium), as well as the Dardae in Dardistan on the Indus (Ctesias, India fr. 12, 70, etc.). From this point he directed several campaigns against the Amyrgian Sacae (Saka), on the Pamir plateau and northward, whom he enumerates in his list of subject races and whose mounted archers formed a main division of the armies dispatched against the Greeks. It was obviously an attempt to take the nomads of the Turanian steppe in the rear and to reduce them to quiescence which led to his unfortunate expedition against the Scythians of the Russian steppes (c. 512 B.C.; see DARIUS).

Side by side with these wars, we can read, even in the scanty tradition at our disposal, a consistent effort to further the great civilizing mission of the empire. In the district of Herat, Darius established a great water basin designed to facilitate the cultivation of the steppe (Herod. iii, 117). He had the course of the river Indus explored by the Carian captain Scylax of Caryanda, who then navigated the Indian ocean back to Suez (Herod. iv, 44) and wrote an account of his voyage in Greek. The desire to create a direct communication between the seclusion of Persis and the commerce of the world is evident in his foundation of several harbours, described by Nearchus, on the Persian coast. But this design is still more patent in his completion of a great canal, already begun by Necho, from the Nile to Suez, along which several monuments of Darius have been preserved. Thus it was possible, as says the remnant of a hieroglyphic inscription there discovered, "for ships to sail direct from the Nile to Persia, over Saba." In the time of Herodotus the canal was in constant use (ii. 158; iv, 39); afterward, when Egypt regained its independence, it decayed, till restored by the second Ptolemy. Even the circumnavigation of Africa was attempted under Xerxes (Herod. iv, 43).

Religion. — It has already been mentioned that in his efforts to conciliate the Egyptians Darius placed his chief reliance on the priesthood, and the same tendency runs throughout the imperial policy toward the conquered races. Thus Cyrus himself gave the exiled Jews in Babylon permission to return and rebuild Jerusalem. Darius allowed the restoration of the Temple; and Artaxerxes I, by the protection accorded to Ezra and Nehemiah, made the foundation of Judaism possible (see JEWS: Earliest Times to *the* Mediaeval). Analogously, in an edict of which a later copy is preserved in an inscription, Darius commands Gadatas, the governor of a domain (παράδεισος) in Magnesia on the Maeander, to observe scrupulously the privileges of the Apollo sanctuary. With all the Greek oracles — even those in the mother country — the Persians were on the best of terms. And since these might reasonably expect an enormous extension of their influence from the establishment of a Persian dominion, we find them all zealously mediatizing during the expedition of Xerxes.

For the development of the Asiatic religions, the Persian empire was of prime importance. The erection of a single, vast, world empire cost them their original connection with the state and compelled them to address themselves not to the community at large but to individuals; to promise not political success nor the independence of the people but the welfare of the man. Thus they became at once universal and capable of extension by propaganda. With this they entered into keen competition one with the other. These developments are most clearly marked in Judaism, but after the Achaemenid period they are common to all oriental creeds, though our information about most is scanty.

The exact nature of the religion of the Achaemenid kings is a subject of controversy. That Darius, Xerxes and Artaxerxes I were loyal servants of the great Ahura Mazda all are agreed, but there are different estimates of their understanding of the religion of Zoroaster (*q.v.*), either in its purity or its Magian adaptation and adulteration. Some scholars make Zoroaster a contemporary of Cyrus and Darius (or, at least, of the latter's father, Vishtaspa), but fe would claim that even Darius was a member of the prophet's community. Darius' inscriptions may indicate a mono-

theistic spirit in the prophet's tradition, but his rule of a vast empire certainly showed no fanaticism in enforcing the worship of Ahura Mazda. At his court were Magian priests and rites, and there during Xerxes' reign were enacted the cultic rites of the Haoma (Vedic Soma), so abominated by Zoroaster (cj. G. G. Cameron, Persepolis *Treasury* Tablets [1948]). Whatever the exact form of the Persian religion, there is evidence that it was vigorously spread by the Iranians throughout the empire, especially in Armenia and Cappadocia, where the religion took deep root among the people, as also in Lydia and Lycia. Unlike Judaism, Zoroastrianism was not exclusive and intolerant, and it found little difficulty in recognizing other gods as subordinate to Ahura Mazda. Consequently the foreign cults and creeds often reacted upon the Persian and strange syncretisms developed.

The gorgeous cult of the gods of civilization (especially of Babylon), with their host of temples, images and festivals, exercised a corresponding influence on the mother country. The unadulterated doctrine of Zoroaster could not become a permanent popular religion, for the masses could make little of its abstractions and its omnipotent, omnipresent deity; they needed concrete divine powers, standing nearer to themselves and their lot. Thus the old figures of the Aryan folk religion returned to the foreground, there to be amalgamated with the Babylonian divinities. The goddess of springs and streams (of the Oxus in particular) and of all fertility — Ardvisura Anahita, Anaitis—was endowed with the form of the Babylonian Ishtar and Belit. She was now depicted as a beautiful and strong woman, with prominent breasts, a golden crown of stars and golden raiment. She was worshipped as the goddess of generation and all sexual life (cf. Herod. i, 131, where the names of Mithras and Anaitis are interchanged), and religious prostitution was transferred to her service (Strabo xi, 532; xii, 559).

At her side stood the sun-god Mithras, represented as a young and victorious hero. Both deities occupied the very first rank in the popular creed, while to the theologian they were the most potent of the good powers — hlithras being the herald and propagator of the service of light and the mediator between man and Ahura Mazda, who faded more into the background. Thus, in the subsequent period, the Persian religion appears purely as the religion of Mithras. The festival of Mithras was the chief festival of the empire, at which the king drank and, mas drunken, and danced the national dance (Ctesias, fr. 55; Duris, *fr.* 13). This development culminated under Artaxerxes II, who, according to Berossus (*fr.* 16 *ap.* Clement of Alexandria. Protrepticus, i, 5, 65), first erected statues to Anaitis in Persepolis. Ecbatana, Bactria, Susa, Babylon, Damascus and Sardis. The truth of this account is proved by the fact that Artaxerxes II and Artaxeraes III are the only Achaemenids who in their inscriptions invoke Anaitis and Mithra side by side with Ahura Mazda. Other gods who came into prominence were the dragon slayer Verethragna (Artagnes) and the Good Thought (Vohumano, Omanos); and even the Sacaean festival was adopted from Babylon (Berossus, fr. 3; Ctesias, *fr.* 16; Strabo xi, 512, etc.). The chief centres of the Persian cults in the west were the district of Acilisene in Armenia (Strabo xi, 532, etc.), the town of Zela in Cappadocia (Strabo xii, j59) and several cities in Lydia.

Achaemenid Art. — The position of the Persian monarchy as a world empire is characteristically emphasized in the buildings of Darius and Xerxes in I'ersepolis and Susa. The peculiarly national basis, still recognizable in Cyrus' architecture at Pasargadae. recedes into insignificance. Influences are evident not only from the old Median architecture but also from Egypt, Babylon, to some extent Greece and, in the rock-cut tombs, probably from Asia Minor. Yet the result is Persian, for all these elements are combined into an organic unity, a great style which made possible the greatest architectural complex that the ancient east created. Nor were the complementary arts, sculpture and metalwork, any less distinguished. Silver and a few gold vessels of great dignity remain, jewellery of impressive richness and finely carved cylinder seals. Gut finally, with the collapse of the empire, the imperial art vanished also; when 500 years later a new native dynasty arose under the Sassanids, a characteristically Persian art grew up again, using traditions of its Achaemenid predecessors, though with many differences, above all in structural methods.

Sources for the Period. — The history of the Persian empire was often written by the Greeks. The most ancient work preserved is that of Herodotus, who is a very valuable source for the period up to 479 B.C. His material was drawn partly from sound tradition, partly from original knowledge — as in the account of the satrapies and their distribution, the royal highway, the nations in Xerxes army and their equipment. There is also much that is admittedly fabulous: for instance, the stories of Cyrus and Croesus, the conquest of Babylon, etc. Forty years later (s. 390 B.C.), the physician Ctesias of Cnidus, who for 17 years (414–398) remained in the service of Artaxerxes II, composed a great work on the Persian history, known to us from an extract in Photius and numerous fragments. Ctesias possesses a more precise acquaintance with Persian views and institutions than Herodotus, and where he deals with matters that came under his own cognizance he gives much useful information. For the early period, on the other hand, he proves only how rapidly the tradition had degenerated since Herodotus; here his narrative can be used only in isolated cases: and that with the greatest caution. Of more value was the great work of Dinon of Colophon (c. 340), which we know from numerous excellent fragments; and on the same level may be placed a few statements from Heraclides of Cyme, which afford especially important evidence on Persian institutions. To these must be added the testimony of the other Greek historians (Thucydides, Ephorus, Theopompus, etc., with the histories of Alexander), and, before all, that of Xenophon in the *Anabasis* and *Hellenica.* The *Cyropaedia* is a didactic romance, written with a view to Greek institutions and rarely preserving genuine information on the I'ersian empire. Of oriental sources, only the contemporary books of Ezra and Nehemiah are of much importance; important also are a few statements in the much later Esther romance. Berossus' history of Babylon contained much valuable and trust\\-orthy information, but next to nothing has survived. The *Babylonian Chronicle* gives important detail on the rise of Cyrus to power (cf. Sidney Smith. *Babylonian Historical* Texts, pp. 110 ff., col. ii, 11, 1–4 [London, 1924]). In Persia itself, memories of the empire and its significance evidently lingered in oral tradition. For a more detailed account of the empire in these sources see EZRA AND NEHEMIAH, BOOKS OF; HERODOTUS. The scanty number of original documents from the time of the Achaemenids (among them a large quantity of business contracts from Babylonia, dated after the years of the kings) has been greatly increased by the Aramaic documents from Elephantine (see above), from the time of Darius II, which throw light on the administration and the judicial procedures in Egypt (cf. Eduard Meyer, "Zu den aramaische Papyri am Elephantine," *Sitzungsberichte der preussischen* Akademie der *Wissenschaften* [Berlin, 1911), and by the 85 treasury drafts in Elamite found in the Persepolis treasury and dated in the reigns of Darius and Xerxes (*cf.* G. G. 'Cameron, *op. cit.*), along with the much less significant thousands found in the fortification walls of Persepolis. On the struggle of the Egyptians for independence in the 4th century we obtain some information from the so-called Demotic *Chronicle,* published in 1914; cf. Eduard Meyer, "Aegyptische Documente aus der Perserzeit," *Sitzungsberichte* der *Berlinen Akademie* (Berlin, 1915), reprinted in *Kleine Schriften,* vol. ii, and ed. (Halle, 1924). There are also the long-known Achaernenid inscriptions to which there have been additions from Persepolis (for definitive discussion, cf. R. G. Kent, "Old Persian Texts." *Journal* of *Near* Eastern Studies, vol. i, pp. 415–423; vol. ii, 105–116, 302–313; vol. iii, 232–233; vol. iv, 39–52, 228–233 [1942 et *seq.*]).

The external history of the empire is treated under the individual kings (see also history sections of articles EGYPT; GREECE; etc.). The order is as follows:

Cyrus (559–529); conquered the Medes in 550; king of Babylon from 539
Cambyses (529–522)
Smerdis (Gaumata) (522)
Darius I (522–486)
Xerxes I (486–465)

Artaxerxes I (465–424)
Xerxes II and Secydianus or Sogdianus (424–423)
Darius II Nothus (423–404)
Artaxerxes II (404–358)
Artaxerxes III Ochus (358–338)
Arses (338–336)
Darius III (336–330)

The chronology is exactly verified by the Ptolemaic canon, by numerous Babylonian and a few Egyptian documents and by the evidence of the Greeks. The present article gives only a brief conspectus of the main events in the history of the empire.

The Wars Against Greece.—Though Darius, unlike Cyrus and Cambyses, made no new expeditions of conquest, a great empire which is not bounded by another equally great but touches on many small tribes and independent communities is inevitably driven to expansion. It has already been shown that the attempt of Darius to control the predatory nomads in the north led to his expedition against the Scythians; this, again, led to the incorporation of Thrace and Macedonia, whose king, Perdiccas, submitted. And since a great portion of the Mediterranean coast line belonged to the empire, further complications resulted automatically. In contrast with the Greeks, Carthage took the part of Persia. Darius, indeed. numbers the city—under the name of Karka—among his dominions; as also the Maxyans (Maciya) on the Syrtes (F. C. Andreas, *Verhandlungen* d. *xiii oriental. Congresses,* p. *97* [Hamburg, 1902]). But above all, the Greek cities, with their endless feuds and violent internal factions, were incessant in their appeals for intervention. Nevertheless, Darius left European Greece to itself until the support accorded to the Ionian and Carian insurgents by Athens and Eretria (499 B.C.) made war inevitable. But the expeditions of Mardonius (492) and Datis (490) and even the carefully prepared campaigns of Xerxes, in conjunction with Carthage, completely failed (480–479). On the fields of Marathon and Plataea the Persian archers succumbed to the Greek phalanx of hoplites; but the actual result was decided by Themistocles, who had meanwhile created the Athenian fleet which at Salamis proved its superiority over the Perso-Phoenician armada, thus precluding the success of the land forces.

The wreck of Xerxes' expedition was the turning point in the history of the Persian empire.' The superiority of the Greeks was so pronounced that the Persians never found courage to repeat their attack. On the contrary, in 466 B.C. their army and fleet were again defeated by Cimon on the Eurymedon, the sequel being that the Greek provinces on the Asiatic coast, with all the Thracian possessions! were lost to Persia. In itself, indeed, this loss was of no great significance to such a vast empire, and the attempts of Athens to annex Cyprus and conquer the Nile valley, in alliance with the rebellious Egyptians, ended in failure. Athens, in fact, had not sufficient strength to undertake a serious invasion of the empire or an extensive scheme of conquest. Its struggles with the other Hellenic states constrained it, by the peace of Callias (448), definitely to renounce the Persian war; to abandon Cyprus and Egypt to the king; and to content itself with his promise, not that he would surrender the littoral towns, but that he would abstain from an armed attack upon them. The really decisive point was, rather, that the disasters of Salamis and Plataea definitely shattered the offensive power of the empire; that the centre of gravity in the world's history was shifting from Susa and Babylon to the Aegean sea. The Achaemenid power was beginning to suffer that inner disintegration which is the ever-recurrent doom of dynasties, if not of states. The oriental empire belonged to the past; the immediate future belonged to the Hellenes.

Decay of the Empire.—Thus the great empire was reduced to immobility and stagnation—a process which was assisted by the deteriorating influences of civilization and world dominion upon the character of the ruling race. The Persians continued to produce brave and honourable men; but the influences of the harem, the eunuchs and similar court officials made appalling progress, and men of energy began to find the temptations of power stronger than their patriotism and devotion to the king. Thus the satraps aspired to independence, not merely because of unjust treatment, but also through avarice or because conditions were favourable. As early as 465 B.C. Xerxes was assassinated by his powerful vizier (chiliarch) Artabanus, who attempted to seize the reins of empire in fact if not in name. Bagoas (*q.v.*), the murderer in 338 of Artaxerxes III, was another who seized power thus. To these factors must be added the degeneration of the royal line. Kings like Xerxes and, more especially, Artaxerxes I and Artaxerxes II, so far from being gloomy despots, were good-natured potentates, but weak, capricious and readily accessible to personal influences. The only really brutal tyrants were Darius II, who was completely dominated by his bloodthirsty wife, Parysatis, and Artaxerxes III, who, though he shed rivers of blood and all but exterminated his whole family, was successful in uniting once more the empire, which under the feeble sway of his father had been threatened with dissolution.

The upshot of these conditions was that the empire never again undertook an important enterprise, but neglected more and more its great civilizing mission. In considering, however, the subsequent disorders and wars, it must be borne in mind that they affected only individual portions of the empire, and only on isolated occasions involved more extensive areas in long and serious strife. For most of the provinces the Achaemenid dominion was synonymous with two centuries of peace and order. Naturally, however, the wild tribes of the mountains and deserts, who could be curbed only by strict imperial control, asserted their independence and harassed the neighbouring provinces. Among these tribes were the Carduchians in Zagros, the Cossaeans and Uxians in the interior of Elam, the Cadusians and other non-Aryan tribes in northern Media, the Pisidians, Isaurians and Lycaonians in the Taurus and the Mysians in Olympus. All efforts to restore order in these districts were fruitless, and when the kings moved their court to Ecbatana they were actually obliged to purchase a free passage from the mountain tribes (Strabo xi, 524; Arrian iii, 17, 1).

The kings (*e.g.*, Artaxerxes II) repeatedly took the field in great force against the Cadusians, but unsuccessfully. When in 400 Xenophon marched with the mercenaries of Cyrus from the Tigris to the Black sea the authority of the king was nonexistent north of Armenia, and the tribes of the Pontic mountains, with the Greek cities on the coast, were completely independent. In Paphlagonia the native dynasts founded a powerful though short-lived kingdom, and the chieftains of the Bithynians were absolutely their own masters. The frontier provinces of India were also lost. Egypt, which had already revolted under Libyan princes in the years 486–484 and again with Athenian help in 460–454, finally asserted its independence in 404. Thereafter the native dynasties repelled every attack, till they succumbed once more before Artaxerxes III and Mentor of Rhodes.

In the other civilized countries the old passion for freedom had been completely obliterated, and after the days of Darius I—apart from the Greek. Lycian and Phoenician towns—not a single people in all these provinces dreamed of shaking off the foreign dominion. All the more clearly, then, was the inner weakness of the empire revealed by the revolts of the satraps. These were facilitated by the custom—one quite contrary to the original imperial organization—which entrusted the provincial military commands to the satraps. who began to receive great masses of Greek mercenaries into their service. Under Artaxerxes I and Darius II these insurrections were still rare. But when the revolt of the younger Cyrus against his brother (401) had demonstrated the surprising ease and rapidity with which a courageous army could penetrate into the heart of the empire—when the whole force of that empire had proved powerless to prevent 12,000 Greek troops, completely surrounded and deprived through treachery of their leaders, from escaping to the coast; when they escaped without even a serious attack—then, indeed, the imperial impotence became manifest. After that revolts of the satraps in Asia Minor and Syria were of everyday occurrence, and the task of suppressing them was complicated by the foreign wars which the empire had to sustain against Greece and Egypt.

At this very period, however, the foreign policy of the empire gained a brilliant success. The collapse of the Athenian power before Syracuse (413 B.C.) induced Darius II to order his satraps Tissaphernes and Pharnabazus, in Asia Minor, to collect the trib-

ute overdue from the Greek cities. In alliance with Sparta (see PELOPONNESIAN WAR), Persia intervened in the conflict against Athens, and it was Persian gold that made it possible for Lysander to complete its overthrow (404). True, war with Sparta followed immediately, over the division of the spoils, and the campaigns of the Spartan generals in Asia Minor (399–395) were all the more dangerous as they gave occasion to numerous rebellions. But Persia joined the Greek league against Sparta, and in 394 Pharnabazus and Conon annihilated the Lacedaemonian fleet at Cnidus. Thus the Spartan power was crippled; the upshot of the long-protracted war was that Sparta ruefully returned to the Persian alliance, and by the peace of Antalcidas (*q.v.*), concluded in 387, not only renounced all claims to the Asiatic possessions but officially proclaimed the Persian suzerainty over Greece. Ninety years aftet Salamis and Plataea the goal for which Xerxes had striven was actually attained and the king's will was law in Greece. In the following decades no Hellenic state ventured to violate the king's peace, and all the feuds that followed centred on the efforts of the combatants — Sparta, Thebes, Athens and Argos — to draw the royal powers to their side (see GREECE: History).

But for these successes the empire had to thank the internecine strife of its Greek opponents rather than its own strength. Its feebleness when thrown on its own resources is evident from the fact that during the next years it failed both to reconquer Egypt and to suppress completely King Evagoras of Salamis in Cyprus. The satrap revolts, moreover, assumed more and more formidable proportions, and the Greek states began once more to tamper with them. Thus the reign of Artaxerxes II ended, in 358 B.C., with a complete dissolution of the imperial authority in the west. His successor, Artaxerxes III Ochus, succeeded yet again in restoring the empire in its full extent. In 355 he spoke the fatal word which a second — or rather a third — time demolished the essentially unsound power of Athens. In 342 he reduced Egypt, and his generals Mentor and Memnon, with his vizier Bagoas (*q.v.*), crushed once and for all the resistance in Asia Minor. At his death in 338, immediately before the final catastrophe, the empire to all appearances was more powerful and more firmly established than it had been since the days of Xerxes.

THE HELLENISTIC DOMINION, 4TH-2ND CENTURIES B.C.

The Rise of Hellenism. — These successes were won only by means of Greek armies and Greek generals. Simultaneously the Greek civilization — diffused by mercenaries, traders, artists, prostitutes and slaves — advanced in ever-greater force. In Asia Minor and Phoenicia we can clearly trace the progress of Hellenism (*q.v.*), especially by the coinage. But the vital point is that the absolute superiority of the Hellene was recognized as incontestable on both sides. The Persian sought to protect himself against danger by employing Greeks in the national service and turning Greek policy to the interests of the empire. In the Greek world itself the disgrace that a people called to universal dominion and capable of wielding it should be dependent on the mandate of an impotent Asiatic monarchy was keenly felt by all who were not yet absorbed in the rivalry of city with city. The spokesman of this national sentiment was Isocrates. but numerous other writers gave expression to it, notably the historian Callisthenes of Olynthus. Union between Greeks, voluntary or compulsory, and an offensive war against Persia was their aim.

Nor was the time for its fulfilment far distant. The new power which now rose to the first rank, created by Philip of Macedon, had no ingrained tendency inimical to the Persian empire. Its immediate purpose was rather Macedonian expansion, at the expense of Thrace and Illyria, and the subjection of the Balkan peninsula. But in its efforts to extend its power over the Greek states it was bound to make use of the tendencies which aimed at the unification of Greece for the struggle against Persia, and this ideal demand it dared not reject.

Thus the conflict became inevitable. In 340 Artaxerxes III and his satraps supported the Greek towns in Thrace — Perinthus and Byzantium — against Macedonian aggression; in 338 he concluded an alliance with Demosthenes. When Philip, after the victory of Chaeroneia, had founded the League of Corinth (337) embracing the whole of Greece, he accepted the national ideal and in 336 dispatched his army to Asia Minor. That he never entertained the thought of conquering the whole Persian empire is certain. His ambitions would have been satisfied with the liberation of the Greek cities and, perhaps, the subjection of Asia Minor as far as the Taurus. With this his dominion would have attained much the same compass as the later dominion under Lysimachus; this was as much as Isocrates hoped.

Alexander. — Philip's assassination in 336 fundamentally altered the situation. In the person of his son, the throne was occupied by a soldier and statesman of genius, saturated with Greek culture and Greek thought and intolerant of every goal but the highest. To conquer the whole world for Hellenic civilization by the aid of Macedonian spears, and to reduce the whole earth to unity, was the task that this heir of Heracles and Achilles saw before him. This idea of universal conquest was with him a conception much more strongly developed than that which had inspired the Achaemenid rulers, and he entered on the project with full consciousness. In fact, if we are to understand Alexander, it is important to remember that he died at the beginning of his career, at the age of 33. How Alexander conquered Persia, and how he framed his world empire, cannot be related in detail here. (See ALEXANDER III THE GREAT; MACEDONIAN EMPIRE; HELLENISM [for later results]). The essential fact, however, is that after the victory of Gaugamela (Oct. 1, 331 B.C.) and, still more completely, after the assassination of Darius — avenged, according to the Persian laws, on the perpetrators — Alexander regarded himself as the legitimate head of the Persian empire and therefore adopted the dress and ceremonial of the Persian kings. With the capture of the capitals the Persian war was at an end and the atonement for the expedition of Xerxes was complete — a truth symbolically expressed in the burning of the palace at Persepolis.

Now began the world conquest — not in the sense of the "world kingdom" concept that subsequent to Alexander grew to comprehend specifically a plan to conquer the Mediterranean shores to the Pillars and in the Alexander Romance had the great Macedonian actually accomplishing this feat, but in the more general and accepted sense of the vast Persian empire, whose ruler had become the nearest approach of the orient to its ancient ideal of universal king and whose domain Alexander probably expected to secure and extend. The basis of this new world order was to be the union of Macedonia and Persia, which Alexander began even while campaigning in the east and carried forward upon his return from India. The adoption of the Persian court ceremonial of prostration and deification of Alexander were aimed to support this program. This was readily accepted in Persia. but reluctantly in Greece, although at the Olympian festival of 324 B.C. the command was issued to all the cities of Greece to recognize him as god and to receive the exiles home. Simultaneously, in Persia the union of the two countries was consummated by a great marriage feast at Susa, at which all Alexander's supreme officers, with about 10,000 Macedonians, were wedded to Persian wives. The hlacedonian veterans were released and the army reorganized, with Persians serving on an equal footing. At this critical juncture Alexander died in Babylon, on June 13, 323 B.C.

The Diadochi.—Alexander left no heir. Consequently, his death not only ended the scheme of universal conquest but led to an immediate Macedonian reaction. The army, which was considered as the representative of the people, took over the government under the direction of its generals. The Persian'wives were practically all discarded and the Persian satraps removed — at least from all important provinces. But the attempt to maintain the empire in its unity proved impracticable, and almost immediately there began the embittered war, waged for several decades by the generals (Diadochi) for the inheritance of the great king (See PTOLEMIES; SELEUCID DYNASTY.) It was soon obvious that the eastern rulers, at all events, could not dispense with the native element. Peucestas, the governor of Persis, there played the role of Alexander and won the Persians completely to his side, for which he was dismissed by Anitgonus in 315 (Diodorus Siculus xix, 48). A similar position was attained by Seleucus — the only one of the Diadochi who had not divorced his Persian wife, Apama

—in Babylonia, which he governed from 319 to 316 and regained in the autumn of 312. While Antigonus, who since 315 had striven to win the kingdom of Alexander for himself, was detained by the war with his rivals in the west, Seleucus, with Babylon as his headquarters, conquered the whole of Iran as far as the Indus. In northern Media alone, which lay outside the main scene of operations and had been only partially subject to the later Achaemenids, the Persian satrap Atropates, appointed by Alexander, maintained his independence and bequeathed his province to his successors. His name is borne by north Media to the present day—Atropatene, modern Azerbaijan or Adherbaijan. So, too, in Armenia the Persian dynasty of the Hydarnids held its ground. To these must be added, in the east of Asia Minor, the kingdoms of Pontus and Cappadocia, founded *c.* 301 by the Persians Mithradates I and Ariarathes I. These states were fragments of the Achaemenid empire which had safely transferred themselves to the Hellenistic state system.

The **Seleucids.**—The annexation of Iran by Seleucus Nicator led to a war for the countries on the Indian frontier, Seleucus' opponent being Sandracottus or Chandragupta Maurya (*q.v.*), the founder of the great Indian empire of Maurya (Palimbothra). The result was that Seleucus abandoned to the Indian king not merely the Indian provinces but even the frontier districts west of the Indus (Strabo xv, 689–724), receiving as compensation 500 elephants. with other presents (Appian, Syriaca, 55; Justin xv. 4; Plut., Alex., 62; Athen. i, 18 D). His next expedition was to the west to assist Lysimachus, Ptolemy and Cassander in the overthrow of Antigonus.

The battle of Ipsus, in 301, gave him Syria and the east of Asia Minor, and from that time he resided at the Syrian town of Antiochia on the Orontes. Shortly afterward he handed over the provinces east of the Euphrates to his son Antiochus, who in the following years, till 282, exercised in the east a very energetic and beneficial activity, which continued the work of his father and gave the new empire and the oriental Hellenistic civilization their form. In his campaigns Alexander had founded several cities in Bactria, Sogdiana and India in which he settled his veterans, and before his death he had begun or planned the foundation of Greek cities in Media and other parts of Iran. These plans were now executed by the Seleucids on the largest scale. Most of the new cities were based on older settlements; but the essential point is that they were peopled by Greek and Macedonian colonists and enjoyed civic independence with laws, officials, councils and assemblies of their own—in other words, an autonomous constitution under the suzerainty of the empire. A portion, moreover, of the surrounding land was assigned to them. Thus a great number of the country districts—the ἔθνη above mentioned—were transformed into municipal corporations and were thereby withdrawn from the immediate government of the king and his officials (satraps or strategoi), though they were still subject to their control except in the cases where they received unconditional freedom and so ranked as "confederates." The native populations of these villages and rural districts at first had no civic rights but were governed by the foreign settlers. Soon, however, the two elements began to coalesce; in the Seleucid empire, the process seems generally to have been both rapid and complete. Thus the cities became the main factors in the diffusion of Hellenism, the Greek language and the Greek civilization over all Asia as far as the Indus. At the same time they were centres of commerce and industrial life; this, in conjunction with the royal favour and the privileges accorded them, continually drew new settlers (especially Jews), and many of them developed into great and flourishing towns (cf. Eduard Meyer, *Blüte* und Niedergang des *Hellenismus in* Asien [Berlin. 1925]; see further under HELLENISM).

Shortly after his conquest of Babylonia Seleucus had founded a new capital. Seleucia (*q.v.*), on the Tigris, his intention being at once to displace the ancient Babylon from its former central position and to replace it by a Greek city. This was followed by a series of other foundations in Mesopotamia, Babylonia and Susiana (Elam). "Media," says Polybius (x, 27), "was encircled by a sequence of Greek towns, designed as a barrier against the barbarians." Among those mentioned are Rhagae (Rayy), which Seleucus metamorphosed into a Hellenic city, Europus, Laodicea, Apamea and Heraclea (Strabo xi, 525; Pliny vi, 43). To these must be added Achaea in Parthia and, farther to the east, Alexandria Arion in Aria, the modern Herat; also Antiochia Margiana (Strabo xi, 514, 516; Pliny vi, 46, 93), now Merv, and many others; further, Alexandria in Arachosia, near Kandahar, and the towns founded by Alexander on the Hindu Kush and in Sogdiana.

Thus an active Hellenic life soon arose in the east; Greek settlers must have come in numbers and founded new cities which afterward formed the basis of the Graeco-Bactrian kingdom (cf. W. W. Tarn, The Greeks in Bactria and *India*, 2nd ed. [Cambridge, 1951]). Antiochus' general Demodamas crossed the Iaxartes and set up an altar to the Didymaean Apollo (Pliny vi, 49). Another general, Patrocles, took up the investigation of the Caspian, already begun by Alexander. In contrast with the better knowledge of an older period, he came to the conclusion that the Caspian was connected with the ocean and that it was possible to reach India on shipboard by that route (Strabo ii, 74, xi, 518; Pliny vi. 38). Seleucus' project to connect the Caspian with the Sea of Azov by a canal is mentioned by Pliny (vi, 31). To Patrocles is attributable the information that an active commerce in Indian wares was carried on with the shores of the Black sea, through the Caspian (Strabo xi, 509).

While Hellenism was thus gaining some footing throughout the east, the native population remained absolutely passive. Apart from the rude mountain tribes, no national resistance was dreamed of for a long time. The Iranians quietly accepted the foreign yoke, and the higher classes adopted the external forms of the alien civilization even though they actually retained their own characteristics. Eratosthenes, for instance, speaks (*ap.* Strabo i, 66) in high terms of the Iranians (Ariani), ranking them (as well as the Indians, Romans and Carthaginians) on a level with the Greeks in their capacity for adopting city civilization. The later Parsee tradition contends that Alexander burned the sacred books of Zoroaster, the Avesta, and that only a few fragments were saved and afterward reconstructed by the Arsacids and Sassanids. This is absolutely unhistorical. The Persian religion was never attacked by the Macedonians and Greeks. Under their dominion, on the contrary, it expanded with great vigour, not only in the west (Armenia, north Syria and Asia Minor, where it was the official religion of the kings of Pontus and Cappadocia), but also in the east, in the countries of the Indian frontier. That the popular gods—hfithras, Anaitis, etc.—had come to the forefront has already been mentioned. This movement, however. was void of all national character and ran on precisely the same lines as the movement in the Syrian, Jewish and Egyptian cults. Only in Persis itself did the national character of the religion survive side by side with the memory of their old imperial position; there a local Persian dynasty continued to rule in the centre of the province at Istakhr (see PERSIS).

Decline of the **Seleucids.**—In 282 B.C. Seleucus took the field against Lysimachus, and the next year annexed his dominions in Asia Minor and Thrace. In 280 he was assassinated in crossing to Europe, and his son Antiochus I mas left supreme over the whole empire. From that time onward the Seleucid empire was never at rest. Its gigantic extent, from the Aegean to the Indus, everywhere offered points of attack to the enemy. The Lagidae especially, with their much more compact and effective empire, employed every means to weaken their Asiatic rivals; and auxiliaries were found in the minor states on the frontier—Atropatene, Armenia, Cappadocia, Pontus and Bithynia, Galatia, Pergamum, Rhodes and other Greek states. Moreover, the spread of Greek civilization and city life had created numerous local centres, with separate interests and centrifugal tendencies, struggling to attain complete independence and perpetually forcing new concessions from the empire. Thus the Seleucid kings, courageous as many of them were, were always battling for existence

These disturbances severely affected the borders of Iran. In Parthia two brothers, Arsaces and Tiridates, revolted against their Seleucid satrap and founded an independent kingdom and the Parthian era, beginning 247 B.C. This nas the year of the death of Antiochus II. who had been so harried by Ptolemy II Philadel-

phus and so absorbed in the defense of his western provinces that he was unable to hold the eastern area in line. Although Diodotus, satrap of Bactria, was married to a sister of Seleucus II (247–226), by the time of his death (c. 230 B.C.) he may have become independent (cf. W. W. Tarn, *op. cit.*, p. 74). Certainly his son Diodotus II so acted. allying himself with the Parthian king and Seleucid enemy, Tiridates I. The latter was forced in 228 to retreat before Seleucus II. Seleucus, however, could not consolidate his eastern victories since he had to hurry home to settle a dynastic revolt. Meanwhile Diodotus II was slain by Euthydemus, son-in-law of the now widowed sister of Seleucus II, and under him and his son Demetrius the independence of the Graeco-Bactrian state was firmly established (Polybius x, 28 et seq., 480 et seq., xi, 34; Justin xli. 5).

Greater success attended Antiochus III the Great (223–187). At the beginning of his reign (220) he subdued, with the help of his minister Hermias, an insurrection of the satrap Molon of Media, who had assumed the royal title and was supported by his brother Alexander, satrap of Persis (Polyb. v, 40 ff.). He further seized the opportunity of extorting an advantageous peace from Ring Artabazanes of Atropatene, who had considerably extended his power (Polyb. v, 55). He waged an unsuccessful war with Ptolemy IV for the conquest of Coele-Syria, but suppressed the revolt of Achaeus in Asia Minor and recovered the former provinces of the empire in that quarter.

Antiochus then led a great expedition into the east designed to restore the imperial authority in its full extent. He first removed (211) the Armenian king Xerxes by treachery (Polyb. viii, 25; John of Antioch, fr. j3) and appointed two governors, Artaxias and Zariadris, in his place (Strabo xi, 531). During the next year he reduced the affairs of Media to order (Polyb. x, 27); he then conducted a successful campaign against Arsaces of Parthia (209) and against Euthydemus of Bactria (208–206). In spite of his successes he concluded peace with both kingdoms, rightly considering that it mould be impossible to retain these remote frontier provinces permanently. He next renewed his old friendship with the Indian king Sophagasenus (Subhagasena) and received from him 150 elephants (206). Through Arachosia and Drangiane, in the valley of the Etymander (Helmund), he marched to Carmania and Persis (Polyb. xi, 34). Both there and in Babylonia he reestablished the imperial authority and in 205 undertook a voyage from the mouth of the Tigris through the Arabian gulf to the town of Gerrha in Arabia (now Bahrein) (Polyb. xiii, 9).

Shortly afterward, however, his successful campaign against Ptolemy V Epiphanes led to a war with Rome in which the power of the Seleucid empire was shattered (190 B.C.), Asia Minor lost and the king compelled to pay a heavy contribution to Rome for many years. In order to raise money he plundered a wealthy temple of Bel in Elam, but was killed by the inhabitants in 187 (Diod. xxviii, 3, xxix, 15; Strabo xvi, 744; Justin xxxii, 2; St. Jerome [Hieronymus] on *Daniel* xi, 19; Eusebius, *Chronica,* i, 253). The consequence of this enfeeblement of the empire was that the governors of Armenia asserted their independence. Artaxias founded the kingdom of Great Armenia and Zariadris the kingdom of Sophene on the Euphrates and the sources of the Tigris (Strabo xi, 531). In other districts! also. rebellions occurred; and in the east, Euthydemus and his successors (Demetrius, Eucratides, etc.) began the conquest of the Indus region and the Iranian borderland (Arachosia, Aria). (*See* DEMETRIUS; EUCRATIDES; MENANDER.)

The energetic Seleucids fought desperately against their fate. Antiochus IV Epiphanes (175–163) restored once more the eastern dominion, defeated Artaxias of Armenia (Appian, *Syrians,* 45; Diod. xxxi, 17 A; St. Jerome on *Dan.* xi, 40), restored several towns in Babylonia and subdued the Elymaeans. His attempt, however, to plunder the sanctuary of Nanaia failed (Polyb. xxxi, 11; *cf.* Maccabees, i, 6, ii, 1, 13; App., *Syr.,* 66). Persis, also, and Media were still subject to him. He tried to strengthen Hellenism throughout his empire by settling Greek colonists and mercenaries in the native towns—then, also, in Babylon and Jerusalem—and granting them the right of Greek cities. But after his death at Gabae (Isfahan) in Persis (163 B.C.; *cf.* Polyb. xxxi, 11; Macc. i, 6, ii, 9; Josephus, *Antiquitates Judaicae,* xii, 9, 1), the Romans took advantage of the dynastic broils to destroy the Seleucid empire. They reduced its army and fleet and favoured every rebellion, among others that of the Jews. In spite of all. Demetrius I Soter (162–150) succeeded' in suppressing (159) a revolt of Timarchus of Miletus. governor of Babylon, who had occupied Media, assumed the title of "great king" and been recognized by the Romans (App., Syr., 45–47; Trogus, *Prologi,* 34; Diod. xxxi, 27 A; cf. the coins of Timarchus). See also ANTIOCHUS; HELLENISM; SELEUCID DYNASTY.

THE PARTHIAN EMPIRE, 2ND CENTURY B.C.–3RD CENTURY A.D.

The Arsacids.—Meanwhile, in the east, the Arsacids had begun their expansion. Phraates I (*c.* 176–171) subdued the Mardians in Elburz. His brother Mithradates I (c. 171–138) had to sustain a difficult war with Eucratides of Bactria, but eventually succeeded in wresting from him some districts on the Turanian frontier. Indeed, he penetrated beyond the Indus (Diod. xxxiii, 18; Orosius v. 4, 16). In the west he conquered Media and then subdued Babylonia. He further reduced the Elymaeans, sacked their temple in the mountains and captured the Greek city of Seleucia on the Hedyphon (Strabo xvi. 744; Justin xli, 6). The Seleucids, meanwhile, were harassed by aggravated disorders and insurrections. Nevertheless, in 140 Demetrius II Nicator took the field in order to save the east! but was defeated and captured. Shortly afterward Mithradates I died. His son Phraates II (c. 138–128) was attacked in 130 by Antiochus Sidetes, the brother of Demetrius II, on which the Parthian king released the latter. Antiochus pressed successfully on. and once more recovered Babylonia, but in 129 was defeated in Media and fell in a desperate struggle. With this battle the Seleucid dominion over the countries east of the Euphrates was definitely lost. The Babylonian towns, especially Seleucia, were handed over by Phraates to the Hyrcanian Himerus, who punished them severely for their resistance.

During these wars great changes had taken place in eastern Iran. In 159 Mongolian tribes, whom the Chinese call Tue-chi and the Greeks Scythians. forced their way into Sogdiana and. in 139, conquered Bactria (Strabo xi. 571; Justin xlii, 1; Trog., Prol., 41). From Bactria they tried to advance farther into Iran and India. Entering into an alliance with Antiochus Sidetes, they assailed the Parthian empire. Phraates II marched to encounter them, but was himself defeated and slain and his country ravaged far and wide. His successor, Xrtabanus II (also numbered I; c. 128–123), the uncle of Phraates, also fell in battle against the Tokharians, the principal Scythian tribe (Justin xlii, 1, 2; Johannes Xntiochen. *fr.* 66); but his son Mithradates II, called the Great (*c.* 123–91), defeated the Scythians and restored for a while the power of the Arsacids. He also defeated Artavasdes, the king of Great Armenia; his son Tigranes (*q.v.*), a hostage in the hands of the Parthians, was redeemed only by the cession of 70 valleys (Strabo xi, 532). When Tigranes attempted to seize Cappadocia, and the Roman praetor P. Cornelius Sulla advanced against him. Mithradates in 92 B.C. concluded the first treaty between Parthia and Rome (Plut., *Sulla,* v; Livy, *epit.* 70).

The dynastic troubles of the Seleucids in Syria gave Mithradates an opportunity for successful intervention (Jos., *Ant. Jud.,* xiii, 13, 4; 14, 3). Shortly afterward he died and with his death the Arsacid power collapsed for the second time. The possession of the western provinces and the dominant position in western Asia passed to Tigranes, who wrested from the Parthians Mesopotamia and the suzerainty of Atropatene, Gordyene. Adiabene and Osroene. Simultaneously began a new and severe conflict with the Scythians. Parthian coins probably dating from this period (W. W. Wroth, *Catalogue of the Coins of Parthia,* p. xxx and p. 40 [London, 1903]) mention victorious campaigns of Parthian kings and a conquest of the provinces of Aria, Margiane and (?) Traxiane (*cf.* Strabo xi, 505). But the confusion of the situation is shown by the fact that in 77 B.C. the octogenarian king Sinatruces was seated on the Parthian throne by the Scythian tribe of the Sacaraucians (cf. Strabo xi, 511; Trog., Prol., 42). The names of his predecessors are not known. Obviously this period was marked by continual dynastic feuds (cf. Trog., Prol., 42).

Not until Sinatruces' successor, Phraates III (70–*c.* 57), was the kingdom again in a settled state.

A fact of decisive significance was that the Romans now began to advance against Tigranes. In vain Mithradates of Pontus and Tigranes turned to the Parthian king, Tigranes even proffering restitution of the conquered frontier provinces. Phraates, though rightly distrusting Rome, nevertheless concluded a treaty with Lucullus (69 B.C.) and with Pompey, and even supported the latter in his campaign against Tigranes in 66. But after the victory it was manifest that the Roman general did not consider himself bound by the Parthian treaty. When Tigranes had submitted, Pompey received him into favour and extended the Roman supremacy over the vassal states of Gordyene and Osroene, though he had allured the Parthian king with the prospect of the recovery of his old possessions as far as the Euphrates. Phraates complained, and simultaneously attacked Tigranes, now a Roman vassal (64). But when Pompey refused reparation Phraates recognized that he was too weak to begin the struggle with Rome and contented himself with forming an alliance with Tigranes, in the hope that the future would bring an opportunity for revenge (Dio Cassius xxxvi, 3, 5, xxxvii, 5 ff.; Plut., Luc., 30; Plut., Pomp., 33, 38; cf. Sallust's letter of Mithradates to Arsaces).

Although Phraates III had not succeeded in regaining the full power of his predecessors, he felt justified in again assuming the title "king of kings"—which Pompey declined to acknowledge—and even in proclaiming himself as god (Phlegon, fr. 12 *ap.* Photius cod. 97; and on part of his coins), but about 57 B.C. he was assassinated by his sons Orodes and Mithradates.

Organization.— The Parthian empire as founded by the conquests of Mithradates I and restored first by Mithradates II and again by Phraates III was, to all exterior appearance, a continuation of the Achaemenid dominion. Thus the Arsacids now began to assume the old title "king of kings" (the shahanshah of modern Persia), though previously their coins, as a rule, had borne only the legend "great king." The official version, preserved by Arrian in his Parthica (*ap.* Phot. cod. 58; see PARTHIA), derives the line of these chieftains of the Parnian nomads from Artaxerxes II.

In reality, however, the Parthian empire was totally different from its predecessor, both externally and internally. It was anything but a world empire. The countries west of the Euphrates never owned its dominion, and even of Iran itself not half was subject to the Arsacids. There were indeed vassal states on every hand, but the actual possessions of the kings—the provinces governed by their satraps—consisted of a rather narrow strip of land, stretching from the Euphrates and north Babylonia through southern Media and Parthia as far as Arachosia (northwest Afghanistan), and following the course of the great trade route which from time immemorial had carried the traffic between the west of Asia and India. We still possess a description of this route by Isidore of Charax, probably dating from the Augustan period (in K. Müller, Geographi graeci *minores*, vol. i [Paris, 1855]; see also Isidore of Charax, tr. by W. H. Schoff, Parthian Stations [1914], in which is contained a list of the 18 imperial provinces known also to Pliny [vi, 112; cf. 41]. Isidore, indeed, enumerates 19, but Sacastene, which he includes, formed no part of the Parthian empire, as has been shown by A. von Gutschmid).

The Provinces.— The lower provinces (*i.e.*, the districts west of Parthia) are: (1) Rfesopotamia, with northern Babylonia, from the Euphrates bridge at Zeugma to Seleucia on the Tigris; (2) Apolloniatis, the plain east of the Tigris, with Artemita; (3) Chalonitis, the hill country of Zagros; (4) Western Media; (5) Cambadene, with Bagistana (Behistun), the mountainous portions of Media; (6) Upper Media, with Ecbatana; (7) Rhagiane or Eastern Media. Then with the Caspian Gates—the pass between Elburz and the central desert, through which lay the route from west Iran to east Iran—the upper provinces begin: (8) Choarene and (9) Comisene, the districts on the verge of the desert; (10) Hyrcania; (11) Astabene, with the royal town Asaac on the Attruck; (12) Parthyene with Parthaunisa, where the sepulchres of the kings were laid; (13) Apavarcticene (now Abiward, with the capital Kelat); (14) Margiane (Merv); (15) Aria (Herat); (16) Anauon, the southern portion of Aria; (17) Zarangiane, the country of the Drangians, on the lake of Hamun; (18) Arachosia, on the Etymander (Helmund), called by the Parthians "White India," extending as far as Alexandropolis (Kandahar), the frontier city of the Parthian empire.

On the lower Etymander, the Sacae (Saka) had established themselves—obviously on the inroad of the Scythian tribes—and after them the country was named Sacastene (now Sejistan, Seistan). Through it lay the route to Kandahar, and for this reason the district is described by Isidore, though it formed no part of the Parthian empire.

The Vassal States.— Around these provinces lay a ring of numerous minor states, which as a rule were dependent on the Arsacids. They might, however, partially transfer their allegiance on the rise of a new power (*e.g.*, Tigranes in Armenia) or a Roman invasion. Thus it is not without justice that the Arsacid period is described in the later Persian and Arabian tradition as the period of "the kings of the part-kingdoms"—among which the Ashkanians (*i.e.*, the Arsacids, from Ashak, the later pronunciation of the name; Arshak = Arsaces) had won the first place. This tradition, however, is nebulous in the extreme; the whole list of kings which it gives is totally unhistorical, only the names of one Balash (= Vologaeses) and of the last Ardewan (= Artabanus) having been preserved. The period from the death of Alexander to the Sassanid Ardashir I is put by the Persian tradition at 266 years; this was afterward corrected, after Syro-Grecian evidence, to 523 years. The actual number is 547 years (*i.e.*, 323 B.C. to A.D. 224). The statements of the Armenian historians about this period are also absolutely worthless.

The ten most important of the vassal states were:

1. The kingdom of Osroene (*q.v.*) in the northeast of Mesopotamia with Edessa as capital, founded c. 130 B.C. by the chieftain of an Arabian tribe, the Orrhoei, which established itself there.

2. To this must be added the numerous Arabian tribes of the Mesopotamian desert, under their chiefs, among whom one Alchaudonius came into prominence in the period of Tigranes and Crassus. Their settlement in Mesopotamia was encouraged by Tigranes, according to Plutarch (*Luc.*, 21) and Pliny (vi, 142). In later times the Arabic town Atra in an oasis to the west of the Tigris, governed by its own kings, gained special importance.

3 and 4. To the east of the Tigris lay two kingdoms: Gordyene (or Cordyene), the country of the Carduchians (now Bohtan), a wild mountainous district south of Armenia; and Adiabene (Hadyab), the ancient Assyria, on either side of the Zab (Lycus).

5. On the farther side of Zagros, adjoining Adiabene on the east, was the kingdom of Atropatene in north Media, now often simply called Media (*q.v.*).

While the power of Armenia was at its height under Tigranes (86–69 B.C.) all these states owned his rule. After the victories of Pompey, however, the Romans claimed the suzerainty, so that during the next decades and the expeditions of Crassus and Antony they oscillated between Rome and Parthia, though their inclination was generally to the latter. For they were all orientals and, consciously or unconsciously, representatives of a reaction against that Hellenism which had become the heritage of Rome. Also, the loose organization of the Parthian empire afforded them a greater measure of independence than they could hope to enjoy under Roman suzerainty.

6. In the south of Babylonia, in the district of Mesene (the modern Maisan), after the fall of Antiochus Sidetes in 129 B.C., an Arabian prince, Hyspaosines or Spasines (in a cuneiform inscription of 127, on a clay tablet dated after this year, he is called Aspasine), founded a kingdom which existed until the rise of the Sassanian empire. Its capital was a city (modern Khorramshahr, or Mohammerah) first founded by Alexander on an artificial hill by the junction of the Eulaeus (Karun) with the Tigris and peopled by his veterans. The town, originally named Alexandria and then rebuilt by Antiochus IV as Antiochia, was refortified with dikes by Spasines, and named Spasinu Charax ("the wall of Spasines"), or Charax (Pliny vi, 138 ff.). In the following centuries it was the main mercantile centre on the Tigris estuary.

The kingdom of Mesene, also called Characene, is known from occasional references in various authors, especially Lucian (*Ma-*

crobii, 16), as well as from numerous coins, dated by the Seleucian era, which allow us to frame a fairly complete list of the kings.' The Arabian dynasty speedily assimilated itself to the native population, and most of the kings bear Babylonian-in a few cases Parthian—names. The official language mas Greek, until, on the destruction of Seleucia (A.D. 164), it was replaced on the coinage by Aramaic. Another Babylonian dynast must have been Hadadnadinaches (*c.* 100 B.C.), who built in Tello the fortified palace which was excavated by G. C. E. Chocquin de Sarzec.

7. East of the Tigris lay the kingdom of Elymais (Elam), to which belonged Susa and its modern representative Ahwaz, farther down on the Eulaeus. The Elymaeans (Elamites), who had already offered a repeated resistance to the Seleucids, were subdued by Mithradates I, as mentioned above; but they remained a separate state which often rebelled against the Arsacids (Strabo xvi, 744; cf. Plut., Pomp., 36; Tacitus, Annals, vi, 50). Of the kings who apparently belonged to a Parthian dynasty, several bearing the name Camnascires are known to us from coins dated 81 and 71 B.C. One of these is designated by Lucian (Macrobii, 16) "king of the Parthians"; while the coinage of another, Orodes, displays Aramaic script (Allotte de la Fuÿe, Revue numismatique, 4th series. vol. vi, p. 92 ff. [1902]). The kingdom, which is seldom mentioned, survived till Ardashir I. In its neighbourhood Strabo mentioned "the minor dynasties of the Sagapenians and Silacenians" (xvi, 745). The Uxians, moreover, with the Cossaeans and other mountain tribes, maintained their independence exactly as under the later Achaemenids (Strabo xvi, 744; Pliny vi, 133).

8. In the district of Persis, the local dynasts became independent after the time of Antiochus IV. They perpetuated the Achaemenian traditions. and on their coins—which bear the Persian language in Aramaic characters; i.e., the so-called Pahlavi—appear as zealous adherents of Zoroastrianism and the fire cult (see PERSIS). They were forced, however, to acknowledge the suzerainty of Parthia, to which they stood in the same position as the Persians of the time of Cyrus and his forefathers stood to the Median empire (cf. Strabo xv, 728, 733, 736; Lucian, Macrobii, 1 j). In later times, before the foundation of the Sassanid dominion, Persis disintegrated into numerous small local states. Even in Carmania there were independent kings, one of whom gave his name to a town, Vologesocerta (Balashkert).

9. The east of Iran—Eactria with Sogdiana, eastern Arachosia and Gedrosia—was never subject to the Arsacids. There the Graeco-Bactrian and Graeco-Indian kingdoms held their own until, in 139 B.C., they succumbed before the invading Mongolian and Scythian tribes (see BACTRIA and works quoted there). But in the Indus district the Greek kings held their ground for an appreciably longer period and. for a while. widely extended their power (see MENANDER of India). Among the kings then following. known only from their coins. there appears a dynasty with Iranian and sometimes peculiarly Parthian names which seems to have reigned in the Punjab and Arachosia. Its best-known representative, Gondophares or Hyndopherres, to whom legend makes the apostle Thomas write. reigned over Arachosia and the Indus district from about A.D. 19 to 45 (W. W. Tarn, op. cit., p. 353 et seq.). Further, about A.D. 70, the Periplus of the Erythraean Sea mentions that the great commercial town of Minnagar in the Indus delta was under Parthian kings, "who spent their time in expelling one another." Here, then, it would seem there existed a Parthian dynasty which probably went back to the conquests of Mithradates I (cf. Vincent A. Smith, "The Indo-Parthian Dynasties From About 120 B.C. to A.D. 100," Zeitschrift der deutschen morgenländischen Gesellschaft, lx [Leipzig, 1906]; E. Herzfeld, "Sakastan," Archaeologische Mitteilungen aus Iran, iv [Berlin, 1931–32]). Naturally such a dynasty would not long have recognized the suzerainty of the Arsacids. It succumbed to the Indo-Scythian empire of the Kushana, who had obtained the sovereignty of Bactria as early as about A.D. 50 and then pressed onward into India. In the period of the Periplus (*c.* A.D. 50) the Scythians were already settled in the Indus valley (pp. 38, 41, 48); their dominion reached its zenith under Kanishka, whose date is controversial, either A.D. 78–103 (cf. W. W. Tarn, op. cit., p. 352) or after A.D. 128 (Sir John Marshall in Journal of the Royal Asiatic Society, pp. 3–32 [London, 1947]).

This empire of the Kushana merits special mention here, because of its peculiar religious attitude, which we may gather from the coins of its kings, on which an alphabet taken from the Greek is employed (cf. Sir Aurel Stein: "Zoroastrian Deities on Indo-Scythian Coins," Babylonian and Oriental Record, vol. i [London, 1887]). Kanishka, as is well known, had embraced Buddhism, and some of his coins bear the image and name of Buddha. Iranian divinities, however, predominate on his currency: Mithras (Mihro or Helios); the moon, Mah (also Selene); Athro, the fire; Orthragno (Verethragna); Pharro = Farna (Hvarena), "the majesty of kingship"; Teiro = Tir (Tistrya, "the archer"); Nana (Nanaia); and others. Here, then, was a perfect example of syncretism, as in the Mithras cult in Armenia, Asia Minor and, still further, in the Roman empire. Buddhism and Zoroastrianism were wedded in the state religion and, in characteristic Indian fashion, were on the best of terms with one another.

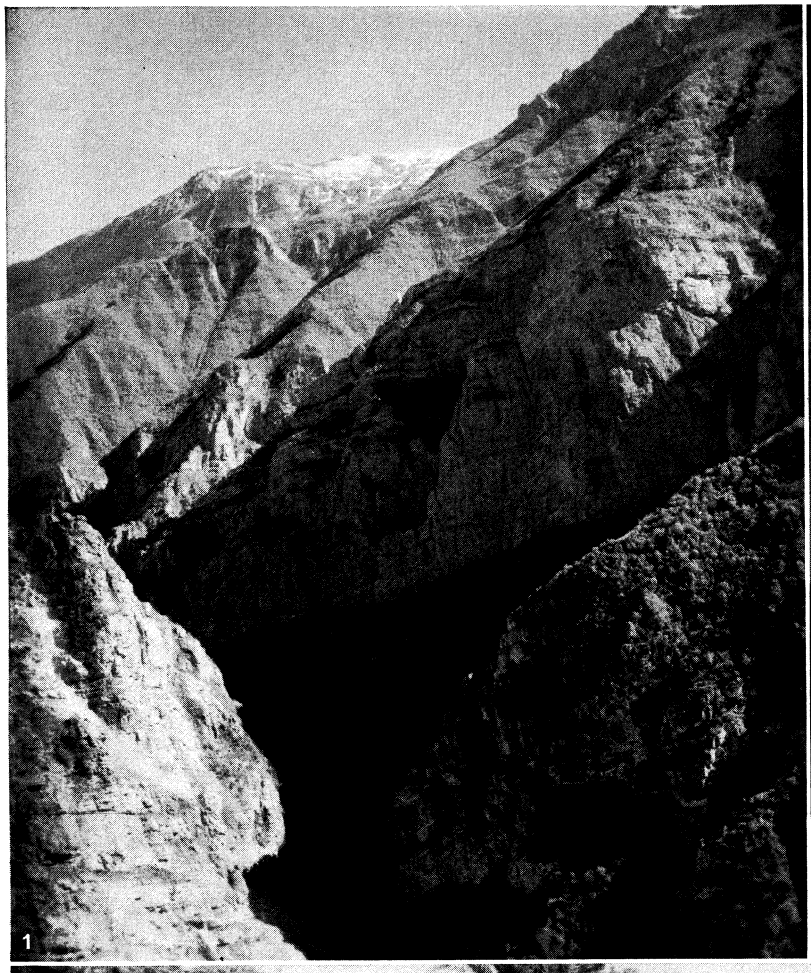
10. Originally a part of the Turanian steppe belonged to the Arsacids; it was the starting point of their power. Soon, however, the nomads (Dahae) gained their independence and, as we have seen, repeatedly attacked and devastated the Parthian empire in conjunction with the Tokharians and other tribes of Sacae and Scythians.

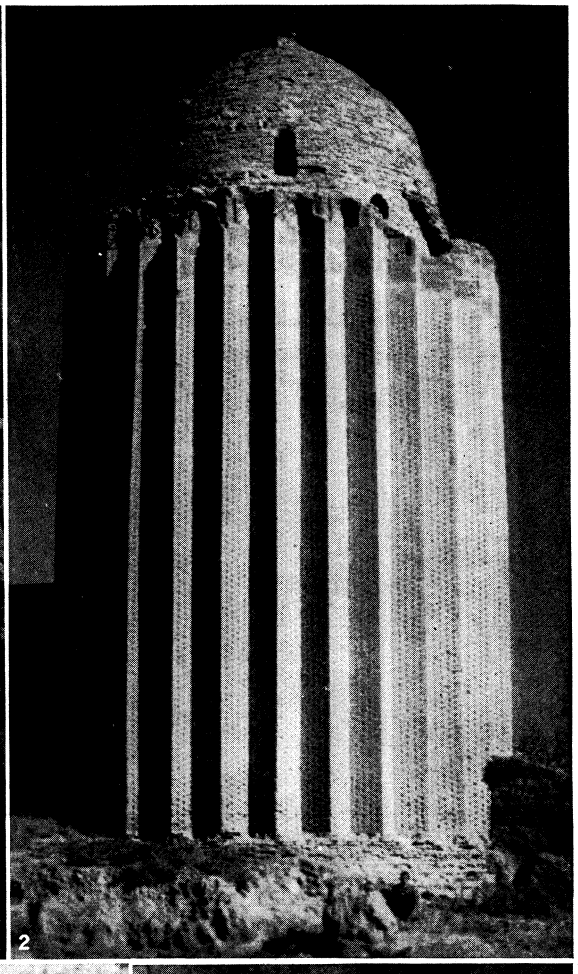
The Character of the *Empire.*—It may appear surprising that the Arsacids made no attempt to incorporate the minor states in the empire and create a great and united dominion, such as existed under the Achaemenids and was afterward restored by the Sassanids. This fact is the clearest symptom of the inner weakness of their empire and of the small power wielded by the "king of kings." In contrast alike with its predecessors and its successors, the Arsacid dominion was peculiarly a chance formation—a state which had come into existence through fortuitous external circumstances and which had no firm foundation within itself or any intrinsic raison d'dtre.

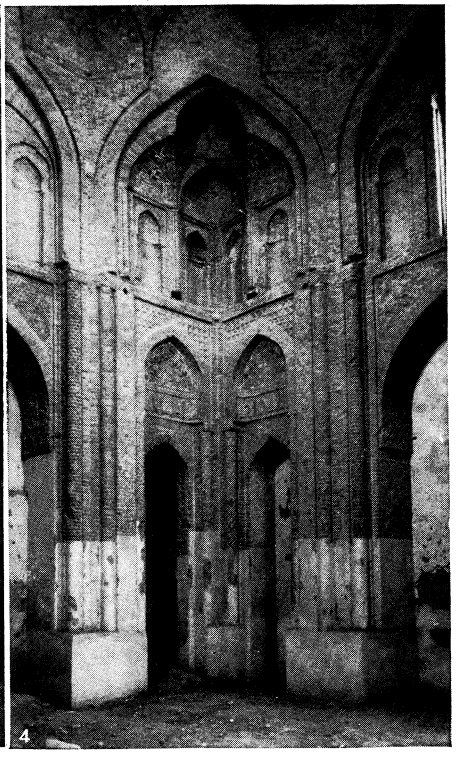
Three elements of widely differentkinds contributed to its origin and defined its character. It was sprung from a predatory nomad tribe (the Parnian Dahae, Scythians) which had established itself in Khurasan (Parthia), on the borders of civilization, and thence gradually annexed further districts as the political situation or the weakness of its neighbours allowed. Consequently these nomads were the main pillar of the empire, and from them were obviously derived the great magnates, with their huge estates and hosts of serfs, who composed the imperial council, led the armies, governed the provinces and made and unmade the kings (Strabo xi, 515; Justin xli, 2; the former terming them συγγενεῖς, "kinsmen," of the king, the latter probuli). Of these great families that of Surenas held the privilege of setting the diadem on the head of the new king (Plut., Crassus, 21; Tac., Ann., vi, 42).

The military organization, moreover! was wholly nomadic in character. The nucleus of the army was formed of armoured horsemen, excellently practised for long-distance fighting with bow and javelin, but totally unable to venture on a hand-to-hand conflict, their tactics being rather to swarm round the enemy's squadrons and overwhelm them under a hail of missiles. When attacked they broke up, as it seemed, in hasty and complete flight, and, having thus led the hostile army to break its formation, they rapidly reformed and renewed the assault. How difficult it was for infantry to hold their own against these mounted squadrons was demonstrated by the Roman campaigns, especially in broad plains like those of Mesopotamia. In winter, however, the Parthians were powerless to wage war, as the moisture of the atmosphere relaxed their bows. The infantry, in contrast with its earlier status under the Persians, was wholly neglected, but every magnate put into the field as many mounted warriors as possible, chiefly servants and bought slaves who, like the Janissaries and Mamelukes, were trained exclusively for war. Thus Surenas, in 53 B.C., is said to have put at the king's disposal 1,000 mailed horsemen and 10,000 men, including the train, which also comprised his attendants and harem (Plut., Crass., 21; description of the military

[1] Cf. J. A. Saint-Martin, *Recherches sur l'histoire et la geographie de la Mésène et de la Characène* (Paris, 1838); J. T. Reinaud, *Mémoire sur le commencement et la fin du royaume de la Mésène et de la Kharacène* (Paris, 1861); E. Babélon, "Numismatique et chronologie des dynastes de la Characene," *Journal international d'archéologie numismatique*, i (Athens, 1898).



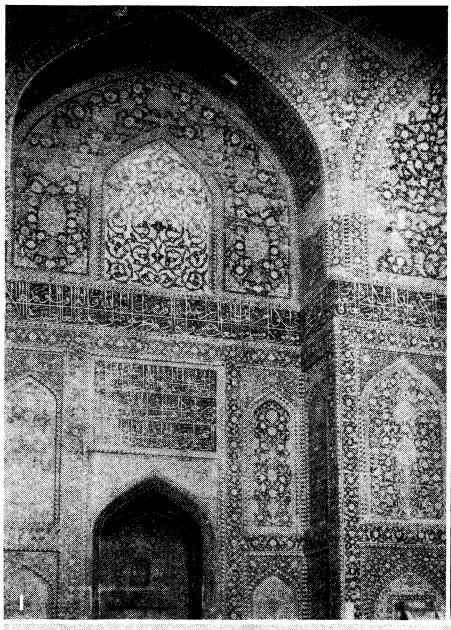


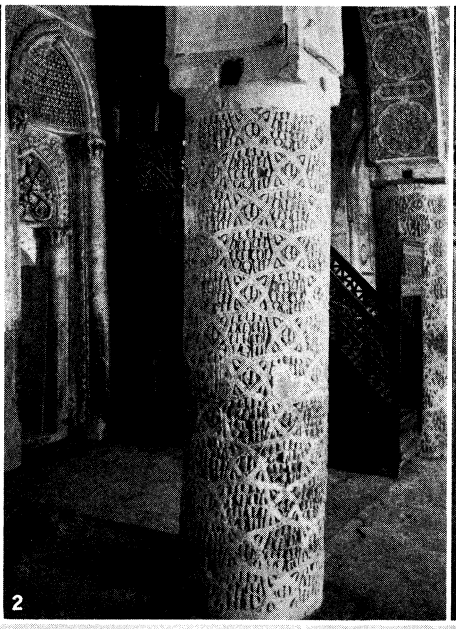


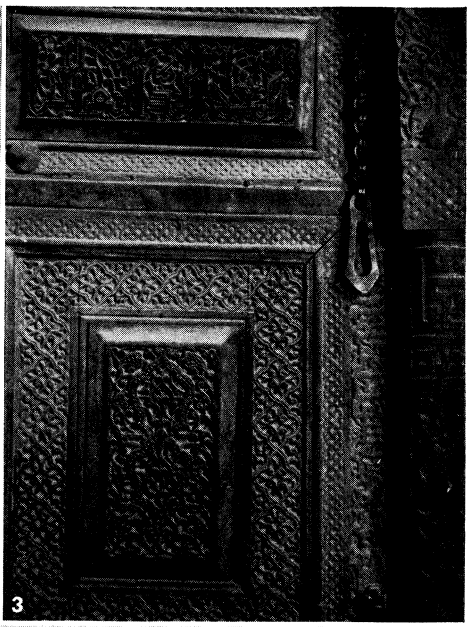
IRANIAN INST., ARCHITECTURAL SURVEY, PHOTO, POPE

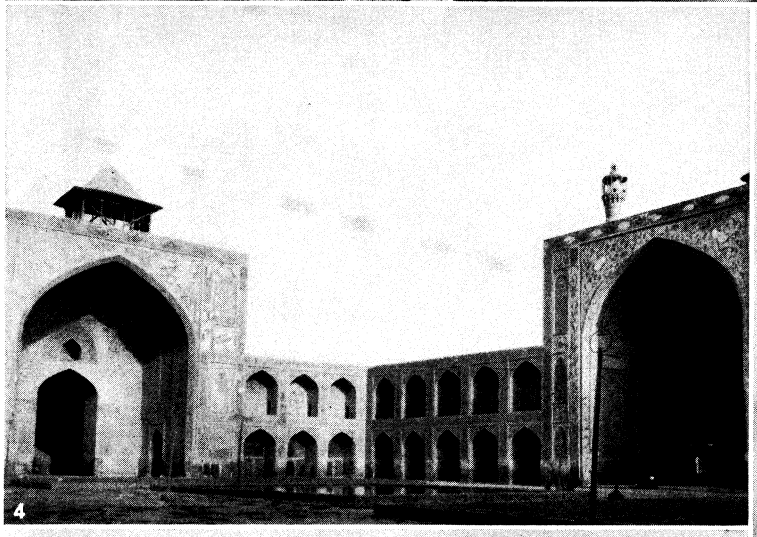
1. In the Elburz mts., the Chalus pass
2. Funeral tower, Bistarn, N. Persia (dated 1300)
3. Gulshan gardens in the oasis of Tabas, E. Persia
4. Masjid-i-Jāmi, Isfahan (dated 1088)

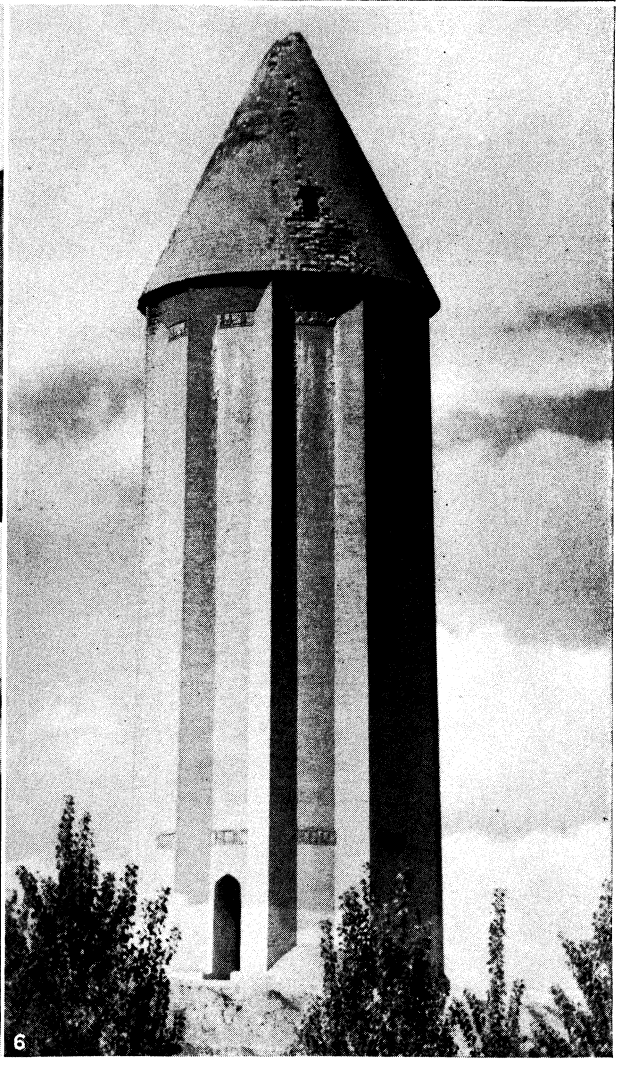
PERSIA





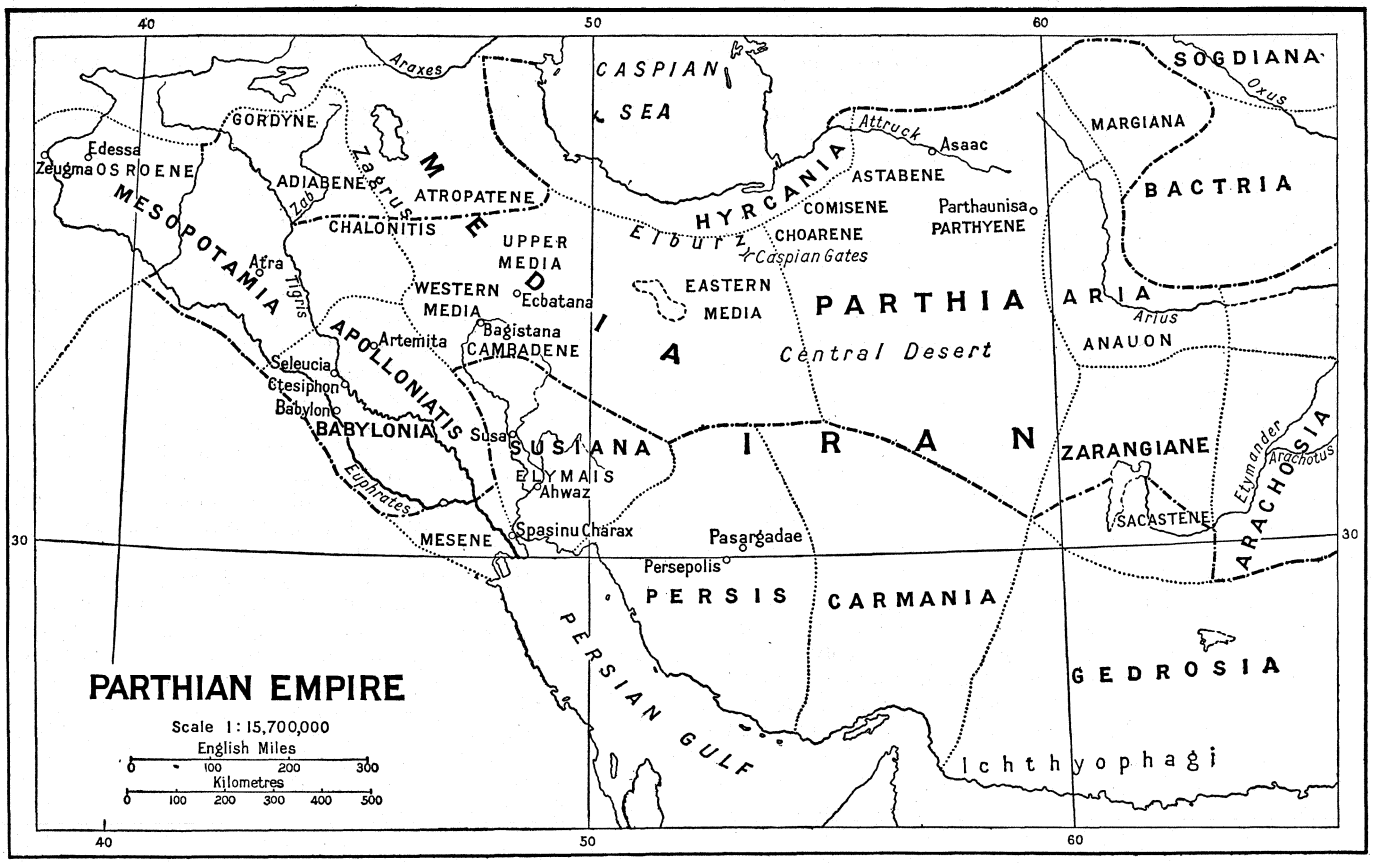






IRANIAN INST., ARCHITECTURAL SURVEY, PHOTO. POPE

1. Interior of the sanctuary, Masjid-i-Shah, Isfahan (dated 1611)
2. Interior of the mosque at Nayin, central Persia (c. 960)
3. Detail of carved wood doors, Bistam (beginning of 14th century)
4. Courtyard of the Masjid-i-Shah, Isfahan
5. The Meidan-i-Shah (Royal plaza) at Isfahan, showing the Royal mosque (Masjid-i-Shah) and the Royal palace (Ali Kapu), both built by Shah Abbas
6. Gunbad-i-Qabus (1006), funeral tower at Gurgan. N.E. Persia



DRAWN BY JOHN BARTHOLOMEW & SON, LTD., EDINBURGH

PARTHIA. THE THICKER BROKEN LINE MARKS THE BOUNDARIES OF PROVINCES UNDER CONTINUOUS PARTHIAN RULE. THE BOUNDARIES OF THE EMPIRE CONTINUALLY VARIED, AND THE OUTLINES OF CERTAIN VASSAL PROVINCES ARE SHOWN

organization in Dio Cass. 40, 15; Justin xli, 2). In the army of 50,000 mounted men which took the field against Mark Antony there were, says Justin, only 400 freemen.

How vital was the nomadic element in the Parthian empire is obvious from the fact that in civil wars the deposed kings consistently took refuge among the Dahae or Scythians and were restored by them. But in Parthia these nomads were amalgamated with the native peasantry and had adopted their dress and manners as well as their religion. Even the kings, after the first two or three, wore their hair and beards long in the Iranian fashion, whereas their predecessors were beardless.

Although the Arsacids were strangers to any deep religious interest (in contrast with the Achaemenids and Sassanids), they acknowledged the Persian gods and the leading tenets of Zoroastrianism. They erected fire altars and even obeyed the command to abandon all corpses to the dogs and fowls (Justin xli, 3). The union, moreover, recommended by that creed between brother and sister—and even son and mother—occurred among them. And besides the council of the nobility, there was a second council of "Magians and wise men" (Strabo xi, 515).

Again, they perpetuated the traditions of the Achaemenid empire. The Arsacids assumed the title "king of kings" and derived their line from Artaxerxes II. Further, the royal apotheosis, a very ancient Asiatic conception so common among them and recurring under the Sassanids, was a direct development of Iranian views. At the side of the great god Xhura Mazda there stood a host of subordinate divine beings who executed his will—among these the deified heroes of legend, to whose circle the king was now admitted, since on him Xhura Mazda had bestowed victory and might.

This gradual absorption by the Iranians of the Parthian empire is shown by the way later Iranian traditions, and Firdousi in particular, apply the name of the "Parthian" magnates (*Pahlavan*) to the glorious heroes of the legendary epoch. Consequently, also, the language and writing of the Parthian period, which were retained under the Sassanids, received the name "Pahlavi"; *i.e.*, "Parthian." The script was derived from the Aramaic.

But to these oriental elements must be added that of Hellenism, the dominant world culture, which had penetrated Parthia and Media. It was indispensable to every state which hoped to play some part in the world and was not so utterly secluded as Persis and Atropatene; and the Arsacids entertained less thought of opposition as they were destitute of an independent national basis. All their external institutions were borrowed from the Seleucid empire: their coinage with its Greek inscriptions and nomenclature; their Attic standard of currency; and, doubtless, a great part of their administration also. In the towns Greek merchants were everywhere settled. Mithradates I even followed the precedent of the Seleucids in building a new city, Arsacia, which replaced the ancient Rhagae (Rayy, Europus) in Media. The further the Arsacids expanded, the deeper they penetrated the province of Hellenism: the first Mithradates himself assumed, after his great conquests, the title of *Philhellene*, "the protecter of Hellenism," which mas retained by almost all his successors. Then follow the surnames *Epiphanes*, "the revealed god"; *Dikaios*, "the just"; *Euergetes*, "the benefactor." All were essentially Greek in their reference and also were regularly borne by all the kings. After the conquest of the Euphrates and Tigris provinces it was imperative that the royal residence should be fixed there. But as no one ventured to transfer the royal household and the army, with its hordes of wild horsemen, to the Greek town of Seleucia, and thus disorganize its commerce, the Arsacids set up their abode in the great village of Ctesiphon on the left bank of the Tigris, opposite Seleucia, which accordingly retained its free Hellenic constitution (see CTESIPHON; SELEUCIA). Orodes I spoke good Greek, and Greek tragedies were staged at his court (Plut., *Crass.*, 33).

In spite of this, however, the rise of the Arsacid empire marks the beginning of a reaction against Hellenism—not a conscious or official reaction, but a reaction which was all the more effective

because it depended on the impetus of circumstances working with all the power of a natural force. The east was turning away from the Mediterranean and the Hellenic world, feeling that it could derive no fresh powers from that quarter and that, consequently, the influence of the oriental elements must steadily increase. This process can be most clearly traced on the coins—almost the sole memorials that the Parthian empire has left. From reign to reign the portraits grow poorer and more stereotyped and the inscriptions more neglected, till it becomes obvious that the engraver himself no longer understood Greek but copied mechanically the signs before his eyes, as is the case with the contemporary Indo-Scythian coinage and also in Mesene. Indeed, after Vologaeses I (51–79), the Aramaic script is occasionally employed. The political opposition to the western empires, the Seleucids first, then the Romans, precipitated this development. Naturally enough the Greek cities beheld a liberator in every army that marched from the west and were ever ready to cast in their lot with them—a disposition for which the subsequent penalty was not lacking. The Parthian magnates, on the other hand, with the army, would have little to do with Greek culture and Greek modes of life, which they contemptuously regarded as effeminate and unmanly. They required of their rulers that they should live in the fashion of their country, practise arms and the chase and appear as oriental sultans, not as Grecian kings.

These tendencies taken together explain the radical weakness of the Parthian empire. It was easy enough to collect a great army and achieve a great victory; it was absolutely impossible to hold the army together for any longer period or to conduct a regular campaign. The Parthians proved incapable of creating a firm, united organization, such as the Achaemenids before them and the Sassanids after them gave to their empire. The kings themselves were toys in the hands of the magnates and the army, who, tenaciously as they clung to the anointed dynasty of the Arsacids, were utterly indifferent to the person of the individual Arsacid. Every moment they were ready to overthrow the reigning monarch and to set another on his throne. The kings, for their part, sought protection in craft, treachery and cruelty, and succeeded only in aggravating the situation. More especially they saw an enemy in every prince and the worst of enemies in their own sons. Assassination was thus common in the royal household, and frequently it was merely a matter of chance whether the father acted before the son or the son before the father. The conditions were the same as obtained later under the Mohammedan caliphate and the empire of the Ottomans. The internal history of the Parthian dominion is an unbroken sequence of civil war and dynastic strife.

For the literature dealing with the Parthian empire see PARTHIA.

The Wars With Rome.—These conditions elucidate the fact that the Parthian empire, though founded on annexation and perpetually menaced by hostile arms in both the east and the west, never took a strong offensive after the days of Mithradates II. It was bound to protect itself against Scythian aggression in the east and Roman aggression in the west. To maintain, or regain, the suzerainty over Mesopotamia and the vassal states of that region, and also over Atropatene and Armenia, was its most imperative task. Yet it always remained on the defensive and even so was lacking in energy. Whenever it made an effort to enforce its claims, it retreated as soon as it was confronted by a resolute foe.

Thus the wars between Parthia and Rome did not proceed from the Parthians—deeply injured though they were by the encroachments of Pompey—but from Rome itself. Rome had been obliged, reluctantly enough, to enter upon the inheritance of Alexander the Great and since the time of Pompey had subjected the Hellenistic countries as far as the Euphrates. Thus the task now faced the Romans of annexing the remainder of the Macedonian empire, the whole east from the Euphrates to the Indus, and of thereby saving Greek civilization (cf. Plut., *Comparatio Niceas et Crassus,* 4). The aristocratic republic quailed before such an enterprise, though Lucullus at the height of his successes entertained the thought (Plut., *Luc.,* 30). But the ambitious men whose goal was to erect their own sovereignty on the ruins of the republic took up the project. With this objective M. Licinius Crassus, the triumvir, in 54 B.C. took the aggressive against Parthia, the occasion being favourable because of the dynastic troubles between Orodes I, the son of Phraates III, and his brother Mithradates III. Crassus met his death through treachery after his army was routed at Carrhae (June 9, 53 B.C.). With this Mesopotamia was regained by the Parthians and King Artavasdes of Armenia now entered their alliance. But, apart from the ravaging of Syria (51 B.C.) by Pacorus, the son of Orodes, the threatened attack on the Roman empire neither materialized then nor during the civil war of Caesar and Pompey.

At the time of his assassination Caesar was intent on resuming the expedition of Crassus. The Parthians formed a league with Brutus and Cassius, as previously with Pompey, but gave them no support until in 40 B.C. a Parthian army led by Pacorus and the republican general Labienus harried Syria and Asia Minor. But it was easily repulsed by Ventidius Bassus, Mark Antony's lieutenant. Pacorus himself fell on June 9, 38 B.C., at Gindarus in northern Syria. Antony then attacked the Parthians in 36 B.C. and penetrated through Armenia into Atropatene, but was defeated by Phraates IV—who in 37 B.C. had murdered his father, Orodes 11—and was compelled to retreat with heavy losses. The continuation of the war was frustrated by the conflict with Octavian. Armenia alone was again subdued in 34 B.C. by Antony, who treacherously captured and executed King Artavasdes.

The **Pax** Romans.-The Romans expected Augustus to take up the work of his predecessors, annihilate the Parthian dominion and subdue the east as far as the Indians, Scythians and Seres (cf. Horace and the other Augustan poets). But Augustus disappointed these expectations. His whole policy and the needs of the newly organized Roman empire demanded peace. His efforts were devoted to reaching a *modus vivendi,* by which the authority of Rome and its most vital claims might be peacefully vindicated. This the weakness of Parthia enabled him to do without much difficulty. His endeavours were seconded by the revolt of Tiridates II, before whom Phraates IV was compelled to flee (32 B.C.) until he was restored by the Scythians. Augustus lent no support to Tiridates in his second march on Ctesiphon (26 B.C.), but Phraates was all the more inclined on that account to stand on good terms with him. Consequently in 20 B.C. he restored the standards captured in the victories over Crassus and Antony and recognized the Roman suzerainty over Osroene and Armenia. In return the Parthian dominion in Babylonia and the other vassal states was left undisputed.

Thus it was due not to the success and strength of the Parthians but largely to the principles of Roman policy as defined by Augustus that the Parthian empire appears as a second great independent power, side by side with Rome. The precedence of the Caesars, indeed, was always admitted by the Arsacids; and Phraates IV soon entered into a state of dependency on Rome by sending (9 B.C.) four of his sons as hostages to Augustus—a convenient method of getting rid of them without killing them. In 2 B.C., however, Phraates was assassinated by his favourite wife, Musa, and her son Phraates V. In the subsequent broils a Parthian faction obtained the release of one of the princes interned in Rome as Vonones I (A.D. 8). He failed, however, to maintain his position for long. He was a stranger to the Parthian customs, and the feeling of shame at dependency on the foreigner was too strong. So the rival faction brought out another Arsacid, resident among the Scythian nomads, Artabanus III, who easily expelled Vonones —only to create a host of enemies by his brutal cruelty and to call forth fresh disorders.

Similar proceedings were frequently repeated in the period that followed. In the intervals the Parthians made several attempts to reassert their dominion over Armenia and there install an Arsacid prince; but on each occasion they retreated without giving battle as soon as the Romans prepared for war. The dynasty of Atropatene was finally deposed, however, and the country placed under an Arsacid rules. Actual conflict with Rome broke out under Vologaeses (Volagases) I (51–79), who made his brother Tiridates king of Armenia. After a long war in which the Roman army was commanded by G. Domitius Corbulo, a peace was concluded in 63, confirming the Roman suzerainty over

Armenia but recognizing Tiridates as king (see CORBULO, GNAEUS DOMITIUS). Tiridates himself visited Rome and was there invested nith the diadem by Nero (66). After that Armenia continued under the rule of an Arsacid dynasty.

These successes of Vologaeses were counterbalanced by serious losses in the east. He was hampered in an energetic campaign against Rome by attacks of the Dahae and Sacae. Hyrcania also revolted and asserted its independence under a separate line of kings. A little later the Alans (Alani), a great Iranian tribe in the south of Russia—the ancestors of the Ossets—broke for the first time through the Caucasian passes and ravaged Media and Armenia—an incursion which they often repeated in the following centuries.

Progress of Anti-Hellenism.—On the other side, the reign of Vologaeses I mas characterized by a great advance in the oriental reaction against Hellenism. The line of Arsacids which came to the throne in the person of Artabanus II (AD. 10) stood in open opposition to the old kings with their leanings to Rome and their at least external tinge of Hellenism. The new regime obviously laid much more stress on the oriental character of its state, though Philostratus in his life of Apollonius of Tyana (in reality a fantastic romance which contains scarcely any historical information) states that Vardanes I (A.D. 39–47), the rival king to the brutal Gotarzes (A.D. 38–51), was a cultivated man (Vit. Ap., i, 22, 28, 31 et seq.); and Vologaeses I was distinguished by his excellent relations with his brothers Pacorus and Tiridates, the kings of Media and Armenia. But the coins of Vologaeses I are quite barbarous, and for the first time on some of them appear the initials of the name of the king in Aramaic letters by the side of the Greek legend. The Hellenism of Seleucia was now attacked with greater determination. For seven years (37–43) the city maintained itself in open rebellion (Tac., Ann., xi, 8), until at last it surrendered to Vardanes, who in consequence enlarged Ctesiphon, which was afterward fortified by Pacorus II (A.D. 78–96: V. Ammianus Marcellinus, 23, 6, 23); although one of his coins, dated 115/116, was found at Seleucia, fdr which cf. R. H. McDowell, Coins From *Seleucia* on the Tigris, p. 193 (1935). In the neighbourhood of the same town Vologaeses I founded a city, Volagesocerta (Balashkert), to which he attempted to transplant the population of Seleucia (Pliny vi, 122; cf. T. Noldeke, *Zeitschrift* der *deutschen morgenländischen* Gesellschaft, xxviii, 100 [1874]). Another of his foundations was Volagesias (the Arabian Ullais), socth of Babylon on the Euphrates, which did appreciable damage to the commerce of Seleucia and is often mentioned in inscriptions as the destination of the Palmyrene caravans.

After Vologaeses I came a period of great disturbances. The literary tradition is lacking, but the coins and isolated literary references prove that during the years 77 to 147 two kings, and sometimes three or more, were often reigning concurrently: Artabanus IV, 80–81; Osroes, 109/110–128/129; Vologaeses II, 105/106–147; Vologaeses III, 148–192; Vologaeses IV, 191–207/208; Vologaeses V, 207/208–222/223; Artabanus V, c. 213–227; Artavasdes, *c.* 227–228/229?; *cf.* N. C. Debevoise, *A* Political History of *Parthia,* p. 270 (1938).

The coinage of this period, increasingly poor, indicates a marked cultural deterioration within the empire. Obviously the empire can have seen little peace during these years, a fact which materially assisted the aggressive campaigns of Trajan (113–117). Trajan resuscitated the old project of Crassus and Caesar, by which the empire of Alexander as far as India was to be won for western civilization. In pursuance of this plan he reduced Armenia, Mesopotamia and Babylonia to the position of imperial provinces. On his death, however, Hadrian immediately reverted to the Augustan policy and restored the conquests. Meanwhile the rise in the east of the powerful Indo-Scythian empire of the Kushana doubtless limited still further the Parthian possessions in eastern Iran.

An era of quiet seems to have returned with Vologaeses III, and no more is heard of rival kings. With the Roman empire a profound peace had reigned since Hadrian (117), which was first disturbed by the attack of Marcus Aurelius and Aelius Verus in 162, This war, which broke out on the question of Armenia and Osroene, proved of decisive significance for the future development of the east, for in its course Seleucia was destroyed by the Romans under Avidius Cassius (164). The downfall of the great Greek city sealed the fate of Hellenism in the countries east of the Euphrates. Greek culture practically vanished and gave place to Aramaic; it is significant that from that time the kings of Mesene stamped their coinage with Aramaic legends. This Aramaic victory was powerfully aided by the ever-increasing progress of Christianity, which soon created an Aramaic literature of which the language was the dialect of Edessa, a city in which the last king of Osroene, Abgar IX (179–214), had been converted to the faith. After that Greek culture and Greek literature were accessible to the orientals only in an Aramaic dress. Vologaeses III is probably also the king Valgash who, according to a native tradition preserved in the *Dinkart,* began a collection of the sacred writings of Zoroaster—the origin of the Avesta which has come down to us. This would show how the national Iranian element in the Parthian empire was continually gathering strength.

The Roman war was closed in 165 by a peace which ceded northwest Mesopotamia to Rome. Similar conflicts took place in 195–202 between Vologaeses IV (191–208) and Septimius Severus, and again in 216–217 between Artabanus V (213–227) and Caracalla. They failed, however, to affect materially the position of the two empires.

THE SASSANIAN EMPIRE, *c.* A.D. 224–651

Ardashir I (226–241).—That the Arsacid empire should have endured 400 years after its foundation was the result not of internal strength but of chance working in its external development. It might have existed equally well for centuries more. But under Artabanus V the catastrophe came. In his days there arose in Persis—precisely as Cyrus had arisen under Astyages the Mede—a great personality. Ardashir (Artaxerxes) I, son of Papak (Babek), the descendant of Sasan, was the sovereign of one of the small states into which Persis had gradually been divided. His father, Papak, had taken possession of the district of Istakhr, which had replaced the old Persepolis, long a mass of ruins. Thence Ardashir I, who reigned from about A.D. 208, subdued the neighbouring potentates—disposipg of his own brothers among the rest. Ardashir's seizure of Carmania, Isfahan, Susiana and Mesene quickly led to war with his suzerain, Artabanus V. The conflict lasted several years and the Parthians were worsted in three battles. The last of these (224) witnessed the fall of Artabanus, though a Parthian king, Artavasdes—one of the sons of Artabanus and known only from his own coins—appears to have retained a portion of the empire for some time longer. The members of the Arsacid line who fell into the hands of the victor were put to death; a number of the princes found refuge in Armenia, where the Arsacid dynasty maintained itself until 429.

Ardashir subdued Seistan (Sakastan), Gurgan (Hyrcania), Abharshahr (modern Khurasan), Merv (Margiana), Balkh (Bactria), Khwarizm (Chorasmia). Afterward the king of Kushana and the kings of Turan (Quzdar, south of Quetta) and of Makran recognized him as sovereign. The victorious Ardashir also took possession of the palace of Ctesiphon and assumed the title "king of the kings of the Iranians" (*βασιλευς βασιλεων 'Αριανων*).

The new empire founded by Ardashir I—the Sassanian or neo-Persian empire—was essentially different from that of his Arsacid predecessors. It was, rather, a continuation of the Achaemenid traditions which were still alive on their native soil. Consequently the national impetus, already clearly revealed in the title of the new sovereign, again became strikingly manifest. The Sassanian empire was once more a national Persian or Iranian empire (see ARDASHIR). The religious element was, of course, inseparable from the national, and Ardashir, like all the dynasts of Persis, was an ardent devotee of the Zoroastrian doctrine and closely connected with the priesthood. In his royal style he assumed the designation "Mazdayasnian" (*Μασδάσνος*), and the fire cult was everywhere vigorously disseminated. Simultaneously the old claims to world dominion made their reappearance. After the defeat of Artabanus, Ardashir, as heir of the Achaemenids, formulated his pretensions to the dominion of western Asia (Dio. Cass.

80, 3; Herodian vi, 2, 4; Zonar xii, 15; similarly under Shapur II: Ammian. Marc. xvii, 5, 5). He attacked Armenia, though without permanent success (cj. A. von Gutschmid, Zeitschrijt der *deutschen morgenländischen* Gesellschaft, vol. xxxi, p. 47 [1877], on the fabulous Armenian account of these wars), and dispatched his armies against Roman Mesopotamia. They strayed as far as Syria and Cappadocia. The inner decay of the Roman empire and the widespread tendency of its troops to mutiny and usurpation favoured his enterprise. Nevertheless the armies of Alexander Severus, supported by the king of Armenia, succeeded in repelling the Persians, though the Romans sustained severe losses (231–233).

Toward the end of his reign Ardashir resumed the attack while his son Shapur I (241–272) reduced Nisibis and Carrhae and penetrated into Syria, but was defeated by Gordian III at Resaena (243). Soon afterward, however, the Roman empire seemed to collapse utterly. The Goths defeated Deciu's (251) and harried the Balkan peninsula and Asia Minor, while insurrections broke out everywhere and the legions created one Caesar after the other. Then Shapur resumed the war, subdued Armenia and plundered Antioch. The emperor Valerian, who marched to encounter him, was overthrown at Edessa and taken prisoner (260). The Persian armies advanced into Cappadocia; but there Ballista or Balista (d. c. 264) beat them back and Odaenathus (Odainath), prince of Palmyra (*q.v.*), rose in their rear, defeated Shapur, captured his harem and twice forced his way to Ctesiphon (263–265). Shapur was in no position to repair the defeat or even to hold Armenia, so that the Sassanid power failed to pass the bounds of the Arsacid empire. Nevertheless Shapur I, in contrast with his father, assumed the title "king of the kings of the Iranians and non-Iranians" (*βασιλευς βασιλεων, Αριανων και Αναριανων*; *shahan* shah Eran ut Aneran), thus emphasizing his claim to world dominion. His successors kept the title, little as it corresponded to the facts, for the single non-Iranian land governed by the Sassanids was, as under the Parthians, the district of the Tigris and Euphrates as far as the Mesopotamian desert; western and northern Mesopotamia remained Roman.

Organization.— The Sassanid ruler was the representative of the "kingly majesty," derived from Ormuzd (Ahura Mazda), which appears in the Avesta as the angel Kavaem Hvareno, "the royal glory," and according to legend, once beamed in the Iranian kings, unattainable to all but those of royal blood. A sculpture that frequently recurs in the rock reliefs of Ardashir I and Shapur I represents the king and the god Ormuzd both on horseback, the god in the act of handing to his companion the ring of sovereignty. Thus it is explicable that all the Sassanids, as many of the Arsacids before them, included the designation of "god" in their formal style. From this developed (as already under the Arsacids) a strict principle of legitimacy. It applied, however, to the whole royal house, precisely as it did later in the Ottoman empire. The person of the individual ruler was a matter of indifference. He could readily be removed and replaced by another; but no usurper who was not of the legitimate blood could hope to become the genuine king. Therefore the native tradition carried the Sassanid line back to the Achaemenids and, still further, to the kings of the legendary period.

Officially the king was all powerful, and his will, guided by the god and bound up in his law, was unfettered. Externally, he was surrounded by all the splendour of sovereignty: on his head he wore a great and resplendent crown, varying with each different ruler; he was clothed in gold and jewels; around him was a brilliant court, composed of his submissive servants. He sat in dazzling state on his throne in Ctesiphon. All who would approach flung themselves to the ground; life and death depended on his nod. Among his people he was accounted the fairest, strongest and wisest man of the empire; from him was required the practice of all piety and virtue, as well as skill in the chase and in arms—especially the bow. Ardashir I and his successors, moreover, endeavoured to establish the validity of the royal will by absorbing the vassal states and instituting a firmer organization. Nevertheless they failed to attain the complete independence and power of the Achaemenids. Not strong enough to break up the nobility, with its great estates, they were forced to use it and still further to promote its interests; while their dependence on its good will and assistance led inevitably to incessant gifts of money, lands and men. This state of affairs had also prevailed under the later Achaemenids and had materially contributed to the disintegration of the empire and the numerous insurrections of the satraps.

But the older Achaemenids held an entirely different position, and hardly a single Sassanid enjoyed even that degree of power which was still possessed by the later Achaemenids. It was of fundamental importance that the Sassanian empire could not make good its claim to world dominion; and, in spite of the title of its kings, it always remained essentially the kingdom of Iran—or rather west Iran, together with the districts on the Tigris and Euphrates. This fact, again, is most closely connected with its military and administrative organization. The external and internal conditions of the empire were in mutual reaction. The empire, which in extent did not exceed that of the Arsacids with its vassal states, was protected on the east and west by the great deserts of central Iran and Mesopotamia. For the defense of these provinces the mounted archers, who formed the basis of the army, possessed adequate strength; and though the Scythian nomads from the east or the Romans from the west might occasionally penetrate deep into the country, they never succeeded in maintaining their position. But the power of the neo-Persian empire was not great enough for further conquests. Though its army was capable and animated by a far stronger national feeling than that of the Parthians, it still consisted of levies from the retinue of the magnates led by their territorial lords; and although these troops would stream in at the beginning of a war they could not be kept permanently together. For, on the one hand, they were actuated by the most varied personal interests and antipathies, not all of which the king could satisfy; on the other hand, because of the natural character and organization of his dominions, he could not maintain and pay a large army for any length of time. Thus the great hosts soon melted away and a war begun successfully ended ingloriously and often disastrously. Under such circumstances an elaborate tactical organization employing different kinds of arms, or the execution of a comprehensive plan of campaign, was out of the question. The successes of the Sassanids in the east were gained in the later period of their dominion; and the Roman armies, in spite of decay in discipline and military spirit, still remained their tactical and strategical superiors. A great victory might be won; even an emperor might be captured, like Valerian; but immediately afterward successes such as those gained against Shapur I (who was certainly an able general) by Ballista and Odaenathus of Palmyra, or the later victories of Carus, Julian and others, demonstrated how far the Persians were from being on an equality with the Romans. That Babylonia permanently remained a Sassanian province was a result chiefly of the geographical conditions and of the political situation of the Roman empire, not of the strength of the Persians.

Among the magnates six great houses—seven if we include the royal house—were still regarded as the foremost, precisely as under the Achaemenids, and from these were drawn the generals, crown officials and governors (*cf.* Procopius, Persica, i, 6, 13 et seq.). In the last of these positions were princes of the blood, who then bore the royal title (shah). Some of these houses—whose origin the legends derive from King Gushtasp (*i.e.*, Vishtaspa), the protector of Zoroaster (J. Marquart, *Zeitschrift* der *deutschen* morgenlandischen Gesellschajt, vol. xlix, p. 628 et seq. [1895])—already existed under the Arsacids; *e.g.*, the Suren (Surenas) and Karen (Carenes; Tac., Ann., xii, 12 et seq.), who had embraced the cause of the victorious dynasty at the correct moment and so retained their position. The name Pahlavan, moreover, which denoted the Parthian magnates, passed over into the new empire. Below these there was an inferior nobility, the dihkans ("village lords") and the "knights" (*aswar*), who, as among the Parthians, took the field in heavy scale armour. To an even greater extent than under the Arsacids the empire was subdivided into a host of small provinces, at the head of each being a marzban ("boundary lord," "lord of the marches"). These were again grouped in four great districts. With each of these local potentates the king could

deal with as scant consideration as he pleased, always provided that he had the power to make himself feared. But to break through the system or replace it by another was impossible. In fact he was compelled to proceed with great caution whenever he wished to elevate a favourite of humbler origin to an office which custom reserved for the nobility. Thus it is all the more worthy of recognition that the Sassanian empire was a fairly orderly empire, with an excellent legal administration, and that the later sovereigns did their utmost to repress the encroachments of the nobility, to protect the commonalty and to carry out a just system of taxation.

Religious Development. — Side by side with the nobles ranked the spiritual chiefs, now a far more powerful body than under the Arsacids. Every larger district had its upper Magian (*Magupat*, mobed; *i.e.*, "lord of the Magian"). At their head was the supreme mobed, resident in Rhagae (Rayy), who was regarded as the successor of Zoroaster. In the new empire, of which the king and people were alike zealous professors of the true faith, their influence was extraordinarily strong (*cf.* Agathias ii, 26)—comparable with the influence of the priesthood in later Egypt and, even more, in Byzantium and mediaeval Christendom. 4s has already been indicated, the essential difference between the Sassanid empire and the older Iranian states lay in their religious attitudes. But in detail the fluctuations were so manifold that it is necessary at this point to enter more fully into the history of Persian religion (*cf.* especialiy H. Gelzer, "Eznik und die Entwickelung des persischen Religions-systems," *Zeitschrift fur armenische Philologie*, vol. i, p. 149 *et seq.* [Marburg, 1903]).

The Persian religion spread more and more widely after the Achaemenian period. In the Indo-Scythian empire the Persian gods were zealously worshipped; in Armenia the old national religion was almost entirely banished by the Persian cults (H. Gelzer, "Zur armenischen Gotterlehre," in *Berichte über die Verhandlungen der Königlich sachsischen der Wissenschaften xu Leipzig, pkililogisch-historische Classe* [1896]); in Cappadocia, north Syria and the west of Asia Minor, the Persian gods were e erywhere adored side by side with the native deities. It was in the 3rd century that the cult of Mithras, with its mysteries and a theology evolved from Zoroastrianism, attained the widest diffusion in all Latin-speaking provinces of the Roman dominion. It even seemed for a while as though the *Sol invictus Mithras*, highly favoured by the Caesars, would become the official deity in chief of the empire. But in all these cults the Persian gods were perfectly tolerant of other native or foreign divinities; vigorous as was their missionary zeal, it was yet far removed from an attack on other creeds. Thus this Parseeism always bears a syncretic character, and the supreme god of Zoroastrian theory, Ahura Mazda (*i.e.*, Zeus or Jupiter), in practice yields place to his attendant deities, who work in the world and are able to lead the believer, who has been initiated and keeps the commandments of purity, to salvation.

But meanwhile in its Iranian home and especially in Persis the religion of Zoroaster was undisturbed by the proceedings of the outside world. There the poems of the prophet and fragments of ancient religious literature survived, understood by the Magians and rendered accessible to the faithful laity by versions in the modern dialect (Pahlavi). There the opposition between the good spirit of light and the demons of evil—between Ormuzd (Ahura Mazda) and Ahriman—still remained the principal dogma of the creed; and all other gods and angels, however estimable their aid. were but subordinate servants of Ormuzd. whose highest manifestation on earth was not the sun god Mithras but the holy fire guarded by his priests. There all the prescriptions of purity—partly connected with national customs and impossible of execution abroad—were diligently observed; even the injunction not to pollute the earth with corpses, but to cast out the dead to vulture and dog, was obeyed in its full force. At the same time Ahura Mazda preserved his character as a national god, who bestowed on his worshippers victory and world dominion. In the sculptures of the Sassanids, as also in Armenian traditions, he appears on horseback as a war god. Here again the theology was further developed and an attempt made to annul the old dualism by envisaging both Ormuzd and' Ahriman as emanations of an original principle of infinite time (Zervan), a doctrine which long enjoyed official validity under the Sassanids until, in the reign of Chosroes I, "the sect of Zervanites" was pronounced heretical.' But, above all, the ritual and the doctrine of purity were elaborated and expanded, and there was evolved a complete and detailed system of casuistry dealing with all things allowed and forbidden, the forms of pollution and the expiation for each, etc., which in its arid and spiritless monotony vividly recalls the similar prescriptions in the Pentateuch. The consequences of this development mere that orthodoxy and literal obedience to all priestly injunctions assumed an importance far greater than previously; from that time the great comniandment of Zoroastrianism, as of Judaism, was to combat the heresies of the heathen, a movement which had already had an energetic representative in the prophet himself. Heathenish cults and forbidden manners and customs were considered a pollution to the land and a deep insult to the true God. Therefore the duty of the believer was to combat and destroy the unbeliever and the heretic. In short, the tolerance of the Achaemenids and the indifference of the Arsacids were replaced by intolerance and religious persecution.

Religion of the **Sassanids.**—Such were the views in which Ardashir I grew up, and in their energetic prosecution he found a potent instrument for the building up of his empire. It has previously been mentioned that Vologaeses III had already begun a collection of the holy writings; the task was resumed under Ardashir. At his order the orthodox doctrines and texts were compiled by the high priest Tansar; all divergent theories were prohibited and their adherents proscribed. Thus arose the *Avesta*, the sacred book of the Parsees. Above all, the sacred book of laws, the *Vendidad*, breathes throughout the spirit of the Sassanian period in its intolerance, its casuistry degenerating into absurdity, and its soulless monotony. Subscription to the restored orthodox doctrine was to the Iranian a matter of course. Ardashir imprisoned the schismatics for a year; if at the end of this period they still refused to listen to reason they were executed. It is even related that in his zeal for uniformity of creed Ardashir wished to extinguish the holy fires in the great cities of the empire and the Parthian vassal states, leaving only that which burned in the residence of the dynasty. This plan he was unable to execute. In Armenia, also, Ardashir and Shapur, during the period of their occupation, sought to introduce the orthodox religion, destroyed the heathen images—even those of the Iranian gods which were there considered heathen—and turned the shrines into fire altars (H. Gelzer *loc. cit.*, p. 135). Shapur I, who appears to have had a broader outlook, added to the religious writings a collection of scientific treatises on medicine, astronomy, mathematics, philosophy, zoology, etc., partly from Indian and Greek sources.

A short time afterward, the Roman empire followed the example of the Sassanids and attempted to enforce unity of creed on all subjects. With Decius (250) began the systematic persecution of the Christians. For, meanwhile, the Christian religion had travelled far in east and west, spread with equal zeal and equal exclusiveness and intolerance. In the countries of the Tigris and Euphrates. now altogether Aramaic, Christianity had gained a firm footing.[2] But its missionary enterprise stretched over the whole of Iran and even farther. The time had come when. in the western and eastern worlds alike! the religious question was for large masses of people the most important question in life, and the diffusion of their own creed and the suppression of all others the highest and holiest of tasks. The man who thinks thus knows no compromise, and so Zoroastrianism and .Christianity confronted each other as mortal enemies. Still, the old idea that every religion contained a portion of the truth, and that it was possible to borrow something from one and amalgamate it with another, had not yet lost all its power. From such a con-

[1] It may *be observed that this* innovation *was also* known *to the* Mithras *cult of the* west, *where Zervan appears as* αἰών.

[2] *For the propagation* and history *of the Christians in the* Sassanid *empire, cf. J. Lahourt, Le Christianisme dans l'empire perse sous la dynastic sassanide (Paris,* 1904); C. von Harnack, *The Mission and Expansion of Christianity in the First Three Centuries, tr. by J.* Moffatt, *and ed.* (London, 1908); J. B. Chabot, *Synodicon orientale* (Paris, 1902), *a* collection *of the acts of* the Nestorian *synods* held *under the rule of the Saisanids.*

ception arose the teaching of Mani or Manes. Knowledge of Manichaeism (*q.v.*) was greatly increased by the discovery of many fragments of its literature in eastern Turkistan (Turfan); but these fragments are surpassed in importance by a large Chinese manuscript in the British Museum containing translations of Manichaean hymns and ritual (cf. E. Waldschmidt and W. Lenz, Journal of the Royal Asiatic Society, 116f [1926]; "Die Stellung Jesu im Manichaeismus," *Abhandlungen* der *preussichen* Akademie [1926]; also Sitzungsberichte der Akademie der *Wissenschaften,* philosophisch-historiche Klasse, pp. 480 et seq. [1933]). It is clearly seen that Manichaeism originated from a Gnostic sect. Mani, a Persian from Babylonia, proclaimed himself as the last and greatest apostle of Jesus and as the paraclete announced in the Gospel of John. But with the Gnostic interpretation of the Gospel he tried to combine the doctrines of Zoroaster and of Jesus to create a new universal religion. He is said to have made his first appearance as a teacher on the coronation day of Shapur I. He found numerous adherents, both at court and among the great of the empire. Even the king was impressed, until In a great decisive debate the Magians gained the predominance. None the less Mani found means to diffuse his creed far and wide over the whole empire. Even the heir to the throne, Hormizd I (272–273), was favourably disposed to him; but Shapur's younger son, Bahram I (273–276), yielded to sacerdotal pressure and Mani was executed. After that Manichaeism was persecuted and extirpated in Iran. Yet it maintained itself not merely in the west, penetrating far into the Roman empire from its centre at Babylon, but also in the east, in Khurasan and beyond the bounds of the Sassanian dominion. There the seat of its pontiff was at Samarkand; from there Manichaeism penetrated into central Asia, where, buried in the desert sands which entomb the cities of eastern Turkistan, numerous fragments of the works of Mani and his disciples, in the Persian language (Pahlavi) and Syrian script, and in an east Iranian dialect called Sogdian which was used by the Manichaeans of central Asia, have been discovered.

Art and Literature.— Like the Arsacids, the Sassanian kings resided in Ctesiphon, where at least part of the great vaulted hall of the vast palace built by Chosroes I is still standing. On the ruins of Seleucia, on the opposite bank of the Tigris, Ardashir I built the city of Veh-Ardashir ("good is Ardashir"), and later kings made various additions to it. In Susiana, where the ancient capital of the Persian empire had been, Shapur I built the great city of Gunde-Shapur. Meanwhile, Iran itself was regaining its old prestige, especially the new capital, Istakhr, immediately adjacent to the Achaemenid ruins of Persepolis (now known as Hajiabad). Farther to the southeast Ardashir I also built Gur (modern Firuzabad), so called from the Sassanian name Ardashir-Khurre ("the glory of Ardashir"). On these sites, and others in Fars, Khuzistan, Iraq-i-arab and scattered places, are Sassanian ruins in which were combined Parthian elements, Achaemenid details and typical Sassanian features; these buildings served in turn as models for the structures of the caliphs.

After its long quiescence under the Arsacids, native art underwent a general renaissance which, though not aspiring to the Achaemenian creations, was still of no small importance. Of the Sassanian rock sculptures, some have already been mentioned; besides these, numerous intaglio stamp seals have been preserved. The metalwork, carpets and fabrics of this period enjoyed a high reputation; they were widely distributed and greatly influenced western art.

In the intellectual life and literature of the Sassanian era, the main characteristic was the complete disappearance of Hellenism and the Greek language. Ardashir I and Shapur I still appended Greek translations to some of their inscriptions, but all of later date are written in Pahlavi alone. The coins invariably bear a Pahlavi legend—on the obverse the king's head with his name and title, on the reverse a fire altar (generally with the inscription "fire of Ardashir, Shapur, etc."; *i.e.,* the fire of the royal temple) and the name of the place of coinage, usually abbreviated. Elements of western culture were still brought in by the Aramaeans (Syrians), who were connected with the west by their Christianity and whose translations spread Greek literature through the orient. But there also developed a rather extensive Pahlavi literature. It began with the translations of the sacred books (the Avesta), but it was not limited to religious subjects; it included belles-lettres, modernizations of the old Iranian epics and native traditions—*e.g.,* the surviving fabulous history of Ardashir I—ethical tales, etc., with translations of foreign literature, principally Indian—one instance being the book of tales Kalilah and Dimnah, dating from Chosroes I (see SYRIAC LITERATURE).

Foreign Policy.—In foreign policy the problems under the Sassanian kings[1] remained, as af old, the defense and, when possible, the expansion of the eastern and western frontiers. In the first two centuries of the Sassanian empire practically nothing is known of its relations with the east. Only occasional notices show that the inroads of the oriental nomads had not ceased and that the extent of the empire had by no means exceeded the bounds of the Parthian dominion—Sacastene (Seistan) and western Afghanistan.

Far to the east, the Kushans had become limited to Bactria, with Kabul and Gandhara, and were subject to the Sassanids until after the rise of the Gupta empire in India in the 4th century. In the west the old conflict for Osroene and northern Mesopotamia (now Roman provinces), with the fortresses of Edessa, Carrhae and Nisibis, still smouldered. The Sassanids were all the more eager to regain Armenia, since there the Arsacid dynasty still survived and turned for protection to Rome, with whom, in consequence, new wars perpetually broke out. In the reign of Bahram II (276–293), the emperor Carus, burning to avenge the disaster of Valerian, invaded Mesopotamia without meeting opposition and reduced Coche (near Seleucia) and Ctesiphon; but his sudden death in Dec. 283 prevented further success, and the Roman army returned home. Bahram, however, was unable to take advantage of this as his brother Hormizd (Hormuzd) was in arms, supported by the Sacae and other tribes (Mamertinus, Panegyricus Maximiniano, 7, 10; Genethliacus *Maximiniano,* 5, 17). He chose, consequently, to buy peace with Diocletian by means of presents. After his death (293), his uncle Narses was forced by his nobles to rebel against Bahram III and gained the crown. In memory of his victory he erected a great tower at Paikuli, in the mountains west of the upper Diyala, which was discovered in 1843 by Sir Henry Rawlinson and explored in three expeditions by E. Herzfeld (published by Herzfeld, *Paikuli* [Berlin, 1924]; additional report published in Zeitschrift der *deutschen* morgenlandischen Gesellschaft, N.F. v, pp. 269–275 [1926]). The monument is covered with busts of him and with a long inscription in the two forms of Pahlavi writing, the Parthian and the Persian, of which many blocks have been preserved. It contains an account of the way in which he defeated his opponent, and gives at the end a long list of the kings and dynasts who sent embassies of congratulation at his accession, headed by the Kushanshah of India and the Caesar of Rome After his victory Narses occupied Armenia and defeated the emperor Galerius at Callinicum (296). But in the following year he sustained a severe reverse in Armenia, in which he lost his war chest and harem. He then concluded a peace, by the terms of which Armenia remained under Roman suzerainty, and the steppes of northern Mesopotamia, with Singara and the hill country on the left bank of the Tigris as far as Gordyene, were ceded to the victor (Ammian. Marc. xxv, 7, 9; Petrus Patricius, *fr.* 13, 14; Rufus, *brev.* 23). In return Narses regained his household. This peace, ratified in 297,

[1] List of kings:
Ardashir I, 226–241
Shapur I, 241–272
Hormizd (Hormuzd) I, 272–273
Bahram I, 273–276
Bahram II, 276–293
Bahram III, 293
Narse (Narses), 293–302
Hormizd II, 302–309
Shapur II, 310–379
Ardashir II, 379–383
Shapur III, 383–388
Bahram IV, 388–399
Yazdegerd I, 399–421
Bahram V Gor, 421–438
Yazdegerd II, 438–457
Hormizd III, 457–459
Peroz, 459–484
Balash, 484–488
Kavadh I, 488–531 (Jamasp, 496–498/9)
Chusroes (Khosrau) I Anushirvan, 531–579
Hormizd IV, 579–590
Chusroes II Parvez, 590–628
(Bahram Chobin and Bistam, 590–596)
Kavadh II Sheroe, 628
Ardashir III, 628–629
(Shahrbaraz, 629)
(Boran and others, 629–632)
Yazdegerd III, 632–651
On most of these kings there are

completely expelled the Sassanids from the disputed districts and lasted for 40 years.

After the death of Hormizd II (302–309), the son of Narses, the nobles imprisoned or put to death his adult sons. one of whom, Hormisdas, later escaped to the Romans, who used him as a pretender in their wars. Shapur II (310–379), a posthumous child of the former king. was raised to the throne. proof that the great nobles held the sovereignty in their own hands and attempted to order matters at their own pleasure. Shapur, however, when he came to manhood proved himself an independent and energetic ruler.

Renewed Conflict With **Rome.**—Meanwhile the Roman empire had become Christian, the sequel of which was that the Syro-Christian population of Mesopotamia and Babylonia—even more than the Hellenic cities in former times—gravitated to the west and looked to Rome for deliverance from the infidel yoke. On similar grounds Christianity, as opposed to Mazdaism enforced officially by the Sassanids, became predominant in Armenia. Between these two great creeds the old Armenian religion was unable to hold its own; as early as 294 King Tiridates was converted by St. Gregory the Illuminator and adopted the Christian iaith. For this reason the Sassanid empire was the more constrained to champion Zoroastrianism. It was under Shapur II that the compilation of the *Avesta* was completed and the state orthodoxy perfected by the chief mobed, Aturpad. All heresy was proscribed by the state, defection from the true faith pronounced a capital crime, and the persecution of the heterodox—particularly the Christians—began (*cf.* C. E. Sachau, "Die rechtlichen Verhaltnisse der Christen in Sassanidenreich," in *Mitteilungen des Seminars für orientalische Sprachen für Berlin*, x, Abt. 2 [Berlin and Stuttgart, 1907]). Thus the duel between the two great empires became simultaneously a duel between the two religions.

In such a position of affairs a fresh war with Rome was inevitable.[1] It was begun by Shapur in 337, the year that saw the death of Constantine the Great. The conflict focused upon the Mesopotamian fortresses: Shapur thrice besieged Nisibis without success. but reduced several others, including Amida *(359)* and Singara (360), and transplanted great masses of inhabitants into Susiana. The emperor Constantius conducted the war feebly and mas consistently beaten in the field. But in spite of all. Shapur found it impossible to penetrate deeper into the Roman territory. He was hampered by the attack of nomadic tribes in the east, among whom the Chionites now begin to be mentioned. Year after year he took the field against them *(353–358)*, until finally he compelled them to support him with auxiliaries (Ammian. Marc. *14, 3*, 16, *9;* 17, 5; 18, *4, 6)*. With this war is evidently connected the foundation of the great town New-Shapur (Nishapur) in Khurasan.

By the resolution of Julian *(363)* to begin an energetic attack on the Persian empire, the conflict, after the lapse of a quarter of a century, assumed a new phase. Julian pressed forward to Ctesiphon but succumbed to a wound; his successor, Jovian. soon found himself in such straits that he could extricate himself and his army only by a disgraceful peace at the close of *363*, which ceded the possessions on the Tigris and the great fortress of Nisibis and pledged Rome to abandon Armenia and its Xrsacid protégé, Arsaces III, to the Persian.

Shapur endeavoured to occupy Armenia and introduce the Zoroastrian orthodoxy. He captured Arsaces III by treachery and compelled him to commit suicide; but the Armenian magnates proved refractory, placed Arsaces' son Pap on the throne and found secret support among the Romans. This all but led to a new war, but in *374* Valens sacrificed Pap and had him killed in Tarsus. The subsequent invasions of the Goths, in battle with whom Valens fell at Adrianople (378), definitely precluded Roman intervention; and the Armenian troubles ended when (*c.* 390) Bahram IV (388–399) and 'l'heodosius the Great concluded a treaty by which the extreme west of Armenia was abandoned to the Romans and the remainder was confirmed in the Persian possession. Thus peace and friendship could at last exist with Rome, and in 408 Yazdegerd I contracted an alliance with Theodosius II. In Armenia the Persians immediately removed the last kings of the hduse of Arsaces (430), and thenceforward the main portion of the country remained a Persian province under the control of a *marzban,* though the Armenian nobles still made repeated attempts at insurrection. The introduction of Zoroastrianism was abandoned; Christianity was already far too deeply rooted. But the sequel to the Roman sacrifice of Armenian interests was that the Armenian Christians now seceded from the orthodoxy of Rome and Constantinople and organized themselves into an independent national church *(see* ARMENIAN CHURCH). This church mas due, before all, to the efforts of the catholicos Sahak (390–439), whose colleague Mesrob by his translation of the Bible laid the foundations of an Armenian literature.

From Yazdegerd I **to** the Turks.—In the interior of the Sassanian empire the old troubles broke out anew on the death of Shapur II *(379)*. At first the nobles raised his aged brother Ardashir II to the throne, then in *383* deposed him and enthroned Shapur's son as Shapur III. In *388*, however, he was assassinated, as was also his brother Bahram IV in *399*. But the son of the latter, Yazdegerd I (399–421), was an energetic and intelligent sovereign, who held the nobles within bounds and severely chastised their attempts at encroachment. He even sought to emancipate himself from the Nagian church, put an end to the persecutions and allowed the Persian Christians an individual organization. In the Persian tradition he is consequently known as "the Sinner." In the end he was probably assassinated. So great was the bitterness against him that the nobles would admif none of his sons to the throne. One of them, however, Bahram V, found an ally in the Arab chief Mondhir, who had founded a principality in Hira, west of the lower Euphrates; and, as he pledged himself to govern otherwise than his father, he received general recognition. This pledge he redeemed and he is in consequence the darling of Persian tradition, which bestows on him the title of Gor ("the Wild Ass") and is eloquent on his adventures in the chase and in love. This reversal of policy led to a Christian persecution and a new war with Rome. Bahram, however, was worsted, and in the peace of 422 Persia agreed to allow the Christians free exercise of their religion in the empire, while the same privilege was accorded to Zoroastrianism by Rome. Under Bahram's son Yazdegerd II (438–457), who revived the persecutions of the Christians and the Jews, a short conflict with Rome again followed (441), while at the same time war prevailed in the east against the tribe of Kidarites, also named Huns.

There a new foe soon arose in the shape of the Ephthalites (Haital), also known as the "White Huns," a barbaric tribe which shortly after 450 raided Bactria and ended the Kushana dominion (Procop., *Pers.*, i, *3)*; soon they extended their invasions to India, where they destroyed the Gupta empire about 500. These Ephthalite attacks harassed and weakened the Sassanids, exactly as the Tokharians had harassed and weakened the Arsacids after Phraates II. Peroz (459–484) fell in battle against them; his treasures and family were captured and the country devastated. His brother Balash (484–488), being unable to repel them, mas deposed and blinded, and the crown was bestotved on Kavadh I (488–531), the son of Peroz. As the external and internal distress still continued. he was dethroned and imprisoned, but took refuge among the Ephthalites and was restored in *499* by their assistance—like so many Arsacids by the arms of the Dahae and Sacae. To these struggles obviously must be mainly attributed the fact that in the whole of this period no Roman war broke out. But, at the same time, the religious duel had lost in intensity, since among the Persian Christians the Nestorian doctrine was now dominant. Peroz had already favoured Nestorianism and in *483* it was officially adopted by a synod, after which it remained the Christian church of the Persian empire, its head being the patriarch of Seleucia-Ctesiphon.

Kavadh proved himself a vigorous ruler. On his restoration he brought about order in the interior. In *502* he attacked the Romans and captured and destroyed Amida (the modern Diarbekr), but was compelled to ratify a peace because of an inroad of the Huns. Toward the close of his reign (527) he resumed the

[1] For the succeeding events *see* also under ROME: *Ancient History;* and articles on the Roman emperors and Persian kings.

war, defeating Belisarius at Callinicum (531) with the zealous support of the wild Arab Mondhir II of Hira. On his death his son Chosroes I concluded a peace with Justinian (532), pledging the Romans to an annual subsidy for the maintenance of the Caucasus fortresses. In his home policy Kavadh was reminiscent of Yazdegerd I. Like him he had little inclination to the orthodox church and favoured Mazdak, the founder of a communistic sect which had made headway among the people. Kavadh thought that this sect might be used as a weapon against the nobles, for Mazdak demanded that the rich should live less luxuriously and should distribute their superfluous wealth. Another feature of his doctrine was the community of wives. The crown prince Chosroes was on the other hand wholly orthodox, and toward the close of his father's reign, in conjunction with the chief Magian, he carried through the condemnation of the Mazdakites, who were butchered in a great massacre (528). Chosroes I (531–579), surnamed Anushirvan ("the Blessed"), then restored the orthodox doctrine in full, publishing his decision in a religious edict. At the same time he produced the official exposition of the *Avesta*, an exegetical translation in the popular tongue (Pahlavi), and declared its contents binding. Defection from Zoroastrianism, and therefore Christian preaching, was punished with death, though the Syrian martyrologies prove that the kings frequently ignored these proceedings as long as it was at all possible to do so.

Chosroes I was one of the most illustrious sovereigns of the Sassanian empire. From him dates a new and equitable adjustment of the imperial taxation, which was later adopted by the Arabs. His reputation as an enlightened ruler stood so high that when Justinian, in 529, closed the school of Athens, the last Neoplatonists bent their steps to him in hopes of finding in him the true philosopher-king. Their disillusionment, indeed, was speedy and complete, and their gratitude was great when, by the conditions of the armistice of 549, he allowed their return. From j40 onward he conducted a great war against Justinian which, though interrupted by several armistices, lasted till the 50 years' peace of 562. The net result, indeed, was merely to restore the *status* quo; but during the campaign Chosroes sacked Antioch and transplanted the population to a new quarter of Ctesiphon (540). He also extended his power to the Black sea and the Caucasus; on the other hand, a siege of Edessa failed (544).

A second war broke out in 572, chiefly on the question of Armenia and the Caucasus territory. During this, in 575, Chosroes ravaged Cappadocia; but the campaign in Mesopotamia was unsuccessful. In the interval between these two struggles (570) he dispatched assistance to the Arabs of Yemen, who had been assailed and subdued by the Abyssinian Christians; after that period Yemen remained nominally under Persian suzerainty until its fate was sealed by the conquests of Islam.

The Turks.—Meanwhile, about 560, a new nation had sprung up in the east, the Turks. Chosroes concluded an alliance with them against the Ephthalites and so conquered Bactria south of the Oxus, with its capital, Balkh. That the alliance with the Turks should soon change to hostility and mutual attack was inevitable from the nature of the case; in the second Roman war the Turkish khan was leagued with Rome.

Chosroes bequeathed this war to his son Hormizd IV (579–590), who, in spite of repeated negotiations, failed to re-establish peace. Hormizd had not the ability to keep his father's authority, and he further affronted the Magian priesthood by declining to proceed against the Christians and by requiring that, in his empire, both religions should dwell together in peace. Eventually, he succumbed to a conspiracy of his nobles headed by the general Bahram Chobin, who had defeated the Turks but was afterward beaten by the Romans. Hormizd's son, Chosroes II, was set up against his father and forced to acquiesce in his execution. But immediately new risings broke out, in which Bahram Chobin—though not of the royal line—attempted to secure the crown, while simultaneously a Prince Bistam entered the lists. Chosroes fled to the Romans and the emperor Maurice undertook his restoration at the head of a great army. The people flocked to his standard; Bahram Chobin was routed (591) and fled to the Turks, who slew him, and Chosroes once more ascended the throne of Ctesiphon; Bistam held out in Media until 596. Maurice made no attempt to turn the opportunity to Roman advantage, and in the peace then concluded he even abandoned Nisibis to the Persians.

Chosroes II (590–628) is distinguished by the surname of Parviz ("the Conqueror"), though in point of fact he was immeasurably inferior to a powerful sovereign like his grandfather, or even to a competent general. He lived, however, to witness unparalleled vicissitudes of fortune. The assassination of Maurice in 602 impelled him to a war of revenge against Rome, in the course of which his armies—in 608 and again in 615 and 626—penetrated as far as Chalcedon opposite Constantinople, ravaged Syria, reduced Antioch (611), Damascus (613) and Jerusalem (614), and carried off the holy cross to Ctesiphon; in 619 Egypt was occupied. Meanwhile the Roman empire was at the lowest ebb.

The great emperor Heraclius, who assumed the crown in 610, took years to create the nucleus of a new military power. This done, however, he took the field in 623 and repaid the Persians with interest. Their armies were everywhere defeated. In 624 he penetrated into Atropatene (Azerbaijan) and there destroyed the great fire temple; in 627 he advanced into the Tigris provinces. Chosroes attempted no resistance, but fled from his residence at Dastagerd to Ctesiphon. These proceedings, in conjunction with the avarice and licence of the king, led to revolution. Chosroes was deposed and slain by his son Kavadh II (628); but Kavadh died in a few months and absolute chaos resulted. A list of kings and pretenders—among them the general Shahrbaraz and Boran, a daughter of Chosroes—followed rapidly on one another, until finally the nobles united and in 632 elevated a child to the throne, Yazdegerd III, grandson of Chosroes. In the interval—presumably in the reign of Queen Boran (629–630)—peace was concluded with Heraclius, the old frontier being apparently restored. The cross had already been given back to the emperor.

The Arabs.—Thus the 100 years' struggle between Rome and Persia, which had begun in 527 with the attack of the first Kavadh on Justinian, had run its fruitless course, utterly enfeebling both empires and consuming their powers. Room was given to a new enemy which now arose against both states and both religions—the Arabs. In the same year that saw the coronation of Yazdegerd 111—the beginning of 633—the first Arab squadrons made their entry into Persian territory. After several encounters the fate of the Sassanian empire was decided at the battle of Kadisiya, fought in 637 on one of the Euphrates canals. A little previously, in Aug. 636, Syria had fallen in a battle on the Yarmuk (Hieromax), and in 639 the Arabs penetrated into Egypt. The field of Kadisiya laid Ctesiphon, with all its treasures, at the mercy of the victor. The king fled to Media, where his generals attempted to organize the resistance; but the battle of Nehavend (641) decided matters there. Yazdegerd sought refuge in one province after the other, until, at last, in 651 he was assassinated in Merv (see CALIPHATE).

Thus ended the empire of the Sassanids, no less precipitately and ingloriously than that of the Achaemenids. By 650 the Arabs had occupied every province to Balkh and the Oxus. Only in the secluded districts of northern Media (Tabaristan), the "generals" of the house of Karen (Spahpat, Ispehbed) maintained themselves for a century as vassals of the caliphs—exactly as Atropates and his dynasty had done before them.

The fall of the empire sealed the fate of its religion. The Moslems officially tolerated the Zoroastrian creed, though occasional persecutions were not lacking. But little by little it vanished from Iran, with the exception of a few remnants (chiefly in the oasis of Yezd), the faithful finding a refuge in India at Bombay. These Parsees have preserved but a small part of the sacred writings; but they still number their years by the era which dates from Yazdegerd III, the last king of their faith and the last lawful sovereign of Iran, on whom rested the god-given royal glory of Ormuzd.

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(ED. M.; A. U.P.; T. C. Y.)

FROM THE FALL OF THE SASSANIDS TO THE RISE OF THE SAFAWIDS, 651-1502

The Arab Caliphates.— After the Arab conquest the greater part of Persia was divided into four provinces: Khuzistan and Fars, attached to Basra; Media or Persian Iraq, attached to Kufa; Khurasan; and Seistan. Arab tribal forces were established in a number of garrison towns (such as Qum and Shiraz), the largest bodies of them being settled in Khurasan (Nishapur, Merv, Herat, and later on Balkh, Bukhara and Samarkand), to serve as the effectives for further conquests in central Asia. The Arabs interfered little with the Persian population or their religions. For the most part the feudal nobility (dihkans) and the small principalities in the east were left in possession of their lands and privileges, subject to good behaviour and the payment of a stipulated rate of taxation or tribute, for which the local dihkans acted as collectors. Relations between the Arab administration and the feudal classes seem to have been generally good, and a contingent of Iranian troops assisted the Arabs in the conquests in Transoxiana (notably under Kutaiba ibn Muslim, 705–715) and in repelling the later counterattacks of the central Asian Turks. There is abundant evidence that the Arabs intermarried extensively with the Iranian population and that at an early date the mingling of the two speeches had begun to lay the foundations of the modern Persian language by a process of fusion not unlike that by which modern English emerged from the mixture of Anglo-Saxon with Norman French.

On the other hand, increasing fiscal pressure under the later Omayyads caused discontent among the cultivators and townsmen, as well as among a number of *dihkans.* The social strains resulting from the old feudal system also were intensified as large numbers of Persians were converted to Islam, with its equalitarian ideals. These discontents mere exploited by the missionaries of Arab revolutionary groups opposed to the Omayyad caliphate, and particularly, from 745, by an emissary of the Abbasid family named Abu Muslim (see CALIPHATE). By clever tactics he took advantage of the tribal feuds by which the Arabs in Khurasan were divided; and, adding his weight to a general rising of the Yemenite (or southern Arab) faction, he drove the Omayyad governor, Nasr ibn Sayyar, out of Khurasan and, on the occupation of Iraq by the Khurasanian forces, succeeded in supplanting the Omayyads by the Abbasid caliphate (750).

The Abbasid caliphs based their military power upon a standing army of Khurasanians, both Arabs and Persians, stationed at Baghdad, and their administration, under the influence of Khurasanian nobles, notably the Barmecides (*q.v.*), was closely assimilated to the former Sassanian regime. When, however, the second Abbasid caliph, al-Mansur, suspicious of Abu Muslim's power and designs in Persia, murdered him in 754, a series of insurrections by his followers disturbed the peace in Khurasan for about 50 years. After the overthrow of the Barmacides a serious general rising broke out and Harun al-Rashid died at Tus on the way to suppress it (809).

The government of Khurasan passed to his son al-Ma'mun, who restored order but quarrelled with his brother, the caliph al-Amin. A new Khurasanian army was raised, commanded by the Persian general Tahir ibn Husain, who besieged and captured Baghdad and killed al-Amin (813). After much fighting the Khurasanians re-established the caliph's control over the Arab provinces, but when a fresh insurrection threatened to break out in Persia under Mazdakite leadership al-Ma'mun found it necessary to appoint Tahir viceroy of Khurasan and the east (820). Tahir was succeeded by his sons, and until 872 the Tahirids constituted a practically independent dynasty, and at the same time held the command of the caliphs' Khurasanian guard at Baghdad. During the half century of Tahirid government Persia as a whole reached probably one of the highest levels of general prosperity that it ever enjoyed. Favoured by a regular administration and internal peace and security, industry and agriculture flourished and commerce expanded by land and sea to all parts of Asia.

Minor Dynasties.—While the Tahirid dynasty represented a continuation in new terms of the alliance between the Abbasid caliphate and the Sunni feudal aristocracy of Persia, the growing weakness of the caliphate encouraged the rise of other autonomist or opposition movements. From about 825 to 898 the Arab family of Abu Dulaf ruled the region of Hamadan, nominally as governors for the caliphs, and Mazanderan (which had been subdued only in 769) was again largely in the hands of local chiefs. In Azerbaijan the Mazdakite or khorrami sectaries held out against the imperial armies for many years. From 865 the authority of the Abbasid caliphate and the feudal regime of the Tahirids began to be faced with more serious challenges. From the beginning of the Omayyad caliphate a section of the Arab tribesmen at Kufa had maintained the doctrine that the only legitimate rulers were the descendants of Mohammed through Ali, the fourth caliph, and their supporters were known as the Shi'ah or "party" of Ali (see ISLAM). Among the Persian and Persianized population of Iraq, Shi'ism had become a symbol of opposition to the Omayyad caliphate, but it had gained little foothold in Persia itself, except in the Kufan colony of Qum and among some of the followers of Abu Muslim. During the reign of Harun al-Rashid an Alid refugee won a temporary following in the mountainous region of Dailam, in the Elburz range, northwest of Tehran. In 865 the Alids re-established themselves in Dailam as leaders of a popular revolution, and for many centuries Dailam was to remain the principal and permanent base of Shi'ism in Persia. About the same time another revolt broke out in Seistan, led by Yakub ibn Laith. The forces behind this revolt appear to have been discontented *ghazis* or frontier warriors. Within a few years Yakub had occupied all eastern and southern Persia from Balkh to Shiraz and driven the Tahirids from Khurasan. Although defeated in an attempt to march on Baghdad, he and his brother Amr maintained themselves until 900, when they were defeated and their eastern territories annexed by the Samanid Ismail ibn Ahmad.

The Samanids, who had been governors of Transoxiana under the Tahirids, built up a strong and prosperous feudal kingdom in Khurasan and central Asia, distinguished by extensive commerce, learning and all the arts of civilization. It was under their rule that modern Persian revived as a language of culture and a distinctively Persian-Moslem (though by no means Shi'ite) civilization began to emerge and that Islam spread among the Turks of central Asia. In western Persia, however, they were checked by the Shi'ite mountaineers of Dailam, who were now, under the leadership of Merdawij ibn Ziyar, flooding into the lowlands. From about 932 the Dailamites were organized by a group of three brothers, sons of Buya (Buwaih), a former officer under the Samanids. The eldest, Ali, established himself in Fars. Hasan in Media and Ahmad in Kerman and Khuzistan; and the Ziyarids were pushed back into Tabaristan and Gurjan. In 946 Ahmad (Mu'izz

ad-Dawla) occupied Baghdad and deposed the reigning caliph. Though for political reasons the Buyids maintained the Abbasid caliphate, the genera! administration was taken over by their own viziers, several of whom were distinguished patrons of letters and the arts. The outstanding figure among the Buyids was Hasan's son, Fana-Khusru, entitled Adud ad-Dawla (949–982), who endeavoured to stem the economic disorders and disturbances arising from the ravages of the Dailamite troops, their conflicts with the Turkish troops and the growing breakdown of administration.

Gnder the Buyids was first established the new type of political organization which under many later dynasties replaced the old system of centralization under a single sovereign. The Buyid territories were held as a kind of family estate; the members governed various portions as independent rulers, but accorded a certain general authority to the eldest or most powerful. Almost inevitably, however, the later generations became involved in rivalries and warfare which made them an easy prey to their enemies and led to much devastation and misery. During the period of their expansion, the Buyids had been linked in a loose association with the Kurds (though these mere Sunnis), who also set up a number of minor dynasties in the north and west (Hasanwaihids in Kurdistan, Rawwadids in Azerbaijan, Marwanids in Diarbekr, Shaddadids in Arran). Early in the 11th century the Buyid province of Media was annexed by the Kurd Ibn Kakwaih, and the remainder fell ultimately to the new Turkoman invaders.

Ghaznevids and **Seljuks.**—After the middle of the 9th century, the practice grew up in all Moslem kingdoms of purchasing Turkish prisoners and slaves from central Asia (Mamelukes) and forming them into regiments of guards. As each dynasty weakened, its Turkish officers acquired an increasing measure of control and occupied the chief political offices at the capital and in the provinces. This led in due course to armed rivalries and revolts, by which the power and authority of the dynasty were undermined. The Samanids, after their conquest of Afghanistan, had established a Turkish officer as governor in Ghazni; this officer's son, Alptegin, ousted by a rival from his command in Khurasan, withdrew to Ghazni in 962 and defied the Samanid prince. He was succeeded by his son and several of his Mamelukes, the third of whom, Sabuktegin (976–997), made his peace with the Samanids and obtained the government of Khurasan in addition to Ghazni. Sabuktegin was succeeded after a year's interval by his son Mahmud of Ghazni (*q.v.;* 998–1030), the first of the great military sultans, under whom the Moslem invasion of India began. When the Turkish Ilkhans (see below) destroyed the Samanid kingdom, Mahmud kept them out of Khurasan and finally forced them to acknowledge his suzerainty. His government was a centralized military despotism in which the old feudal structure was gradually broken down; his administrative officers, however, were drawn from the landowning classes in Khurasan, where the old traditions of the Tahirids were still preserved; and their strong Sunni sympathies contributed to Mahmud's championship of the Abbasid caliphs against the Buyids and other Shi'ite sectaries.

At the end of the 10th century the converted Turkish tribes of central Asia had, under the leadership of the Ilkhans, occupied Transoxiana. Among the nomadic Turkoman groups that had migrated into the country, one, the Ghuzz, was transported by Mahmud to Khurasan. During a struggle between Mahmud's sons, the Ghuzz, led by Tughril and Chakir of the Seljuk family, allied themselves with the nobles of Khurasan, defeated the Ghaznevid army at Dendenkan (1040) and set out on the conquest of western Persia (see SELJUKS). Tughril entered Baghdad in 1055, and he and his successors Alp Arslan (1063–72) and Malik-shah (1072–92), aided by the great Khurasanian vizier Nizam ul-Mulk, united the whole of Persia, with Iran and Syria, under their rule. Each province was assigned to a Seljuk prince (*malik*), whose army was maintained by military fiefs (ikta). After Malik-shah's death the rivalries of these princes led to renewed disintegration, except in Khurasan where his son Sanjar maintained order until 1153. Most of the other principalities were taken over piecemeal by former officers of the Seljuk army, called atabegs. who founded new dynasties, the most important of which in Persia were the atabegs of Azerbaijan and the Salghur Turkomans of Fars. Favoured by this disintegration, the Shi'ite sect of the Assassins (*q.v.*) firmly established themselves in the highlands of Dailam, and by their terrorism contributed to the demoralization of the governing classes.

The massive immigration of Turkoman tribes accompanying the Seljuks also made heavy inroads on the economy of Persia. Much cultivated land was turned into pasture, and only the walled cities and fortresses provided a measure of security for their environs, from which the revenues of the military fiefs were drawn. The devastation was increased when fresh bands of Ghuzz swarmed into Khurasan, defeated and captured Sanjar and looted its cities, before moving on to occupy Kerman and to extinguish the Seljuk principality there. Sanjar's territories were disputed between his former vassals, the shahs of Khwarizm (Khiva), and the chiefs of Ghor in Afghanistan; eventually the Khwarizm-shah Takash (1172–99) conquered Khurasan and Isfahan, and his son Ala ud-Din Mohammed (1199–1220) drove out the Ghorids, conquered the rest of Persia and occupied Transoxiana. Their armies, recruited mainly from the half-pagan Kipchaks of the steppes, added to the general rapine and disorder, and the Khwarizm-shah Mohammed himself devastated the border lands of Transoxiana in his conflicts mith the Turkish khans in central Asia.

Mongols.—It is thus historically false to represent the Mongol invasions as suddenly and ruthlessly tearing down a flourishing civilization and prosperous economy and reducing Persia to a desert. Their effect was rather to intensify the process of nomadization, by destroying most of the cities—especially those of Khurasan during the first invasion under Jenghiz Khan (*q.v.*) in 1220—and disrupting the organizations in which the old traditions of Persian-Islamic culture were still cultivated. It was as if, in mediaeval Europe, the cities and schools of Italy and France had been laid in ruins and their populations killed or dispersed. Except for a few individuals in the service of the Mongols, learning and culture survived only in the peripheral regions! of which Fars was the most important. There is therefore some symbolic truth in the popular view of the Mongols, in so far as they finally destroyed the social and economic foundations upon which the culture of Persia had rested, even if more and more precariously, for a thousand years.

Under the successors of Jenghiz Khan the Mongols extended their power over the whole of Persia and consolidated it by a fresh invasion led by his grandson Hulagu, who destroyed the Assassin fortresses in 12 j6 and captured Baghdad in 1258, putting the last of the Abbasid caliphs to death. Hulagu thus became the first of the new "provincial dynasty" (Ilkhans) of Persia, which, though nominally subordinate to the Mongol Great Khan in China, governed their territories as autonomous princes until 1335.

The **Ilkhans.**—Except for occasional conflicts with their Mongol kinsmen of the Golden Horde to the north and the Jaghatai khanate to the east, the external policy of the Ilkhans was directed for about 50 years toward the conquest of Syria. This brought them into conflict with the Mamelukes of Egypt (see EGYPT: *History*) and some ineffectual negotiations mith the crusaders and the Christian powers, but their ephemeral seizures of Aleppo and Damascus in 1260 and 1303 were terminated by crushing defeats.

In internal affairs the most constructive policy of the Ilkhans was their interest in trade, which was directed through Azerbaijan to the Black sea and made Tabriz into a centre of international commerce. They introduced a new system of administration and taxation which continued into the Safawid period but was constantly impeded by tribal risings and military disturbances. Religious questions also created many difficulties. The early Mongols were Buddhists, but were generally tolerant toward Moslems and all other religious communities. The third Ilkhan, Ahmed Takudar, adopted Islam in 1282 but was dethroned by the Mongol nobles and replaced by his nephew Arghun, under whom there was a reaction against the Moslems. His employment of a Jewish doctor, Sa'd ad-Dawla, as finance minister in 1288, and the latter's severe measures against the Moslems, led to such general disorder and discontent that Sa'd ad-Dawla's downfall and execution was followed by violent pogroms in all the provinces. A still more disastrous attempt was made in 1294 to issue paper

currency, in imitation of the Chinese *chau,* but without monetary backing. In the following year Arghun's son Ghazan was raised to the throne. although he was already converted to Islam, and set on foot an impressive series of measures of reform. Most of them aimed at reconstituting the pre-Mongol land system, including military fiefs, and restoring order and security, but Ghazan's early death (1304) prevented him from carrying them through.

Although the economic results of Ghazan's reign were quickly dissipated, the political and religious results were important. Islam again became the official religion of the state, and its religious and social institutions benefited from state support. Most of the Mongol nobles and tribesmen in Persia had by now been converted to Islam? and the faith was making rapid progress also in the neighbouring khanate in central Asia. The reign of Ghazan's brother Uljaitu (1304–16) was a period of relative tranquillity and moderate prosperity. Under his nephew Abu Sa'id (1316–35) the internal and external forces of disruption became too strong to hold down. Powerful officers contended for control of the Ilkhanate, and after his death set up rival successions of puppet princes. The contest was won finally by the Mongol Jelairs, whose chief Hasan Buzurg (1336–56) established them in power in Iraq and Azerbaijan.

Out of the confusion which attended the decay of the Ilkhans, Fars and Herat (in both of which local dynasties had continued under Mongol rule for several decades) regained independence, Herat under its former Ghorid princes, known as the Kurts, Fars under the dynasty of Muzaffar. Besides the Jelairs, other nomadic chiefs governed parts of Persia, notably in Luristan. A more remarkable phenomenon was the success of an association of local bands in Khurasan, who called themselves Serbadars and controlled most of the province, an instance of the new kind of associations which were growing up (mostly in relation to some Sufi leader or group; see below) among the general population, in reaction to the political anarchy of the preceding centuries. The most notable political event of the period was the failure of an attempt by the Golden Horde to seize Azerbaijan (1357), while the economic decay of Persia was accentuated both by the disruption of trade routes and by disastrous plagues.

Whatever elements of urban culture survived these disasters were almost entirely destroyed by Timur (*q.v.*). The Mongol Ilkhans had only with much difficulty protected the eastern frontier against the Jaghatai-khans of Transoxiana. This task, on passing to the Kurt kings of Herat, was eased for a time by internal dissensions in the Jaghatai khanate. But when, between 1370 and 1380, Timur recreated a centralized power at Samarkand, they were powerless to resist, and after the fall of Herat in 1381 he swept over Persia without meeting effective opposition. Later risings were put down with ruthless cruelty; city after city was destroyed and their populations were massacred, except for the craftsmen who were transported to Samarkand to embellish the conqueror's capital. (H. A. R. G.)

Timurids and Turkomans.—Timur died as he was setting out on an expedition to China (1405), and his conquests were divided between numerous descendants, of whom his sons Miranshah (d. 1407) and Shahrukh held western and eastern Persia respectively, and a grandson, Pir Mohammed, held Fars. The devastation and depopulation of Persia had left only three centres of power outside Transoxiana; these were Herat, Fars and Tabriz, and the conflicts of the next century developed into a struggle between Herat and Tabriz. Rivalries and warfare among the Timurids weakened them against the Turkomans of Azerbaijan and Armenia, themselves grouped in two rival confederacies, the Kara-Koyunlu (Black Sheep) and Ak-Koyunlu (White Sheep). The Black Sheep were at first the more powerful, and their chiefs Kara Yusuf (1388–1420) and Iskandar (1420–38) repeatedly occupied Azerbaijan and Mesopotamia. Nevertheless Shahrukh (1405–47) succeeded in time in reuniting most of Timur's empire under his rule. Unlike his father, he devoted himself to restoring some measure of prosperity and made of his capital Herat the centre of a renewed and artistically brilliant Persian culture. He was succeeded by his son Ulugh Beg (1447–49), formerly governor of Samarkand; Ulugh Beg's name was made famous by the astronomical tables (*zij*) drawn up under his patronage, but in his time the Uzbeg Turkomans began to challenge the Timurid government in Transoxiana. His murder was followed by further struggles among the Timurids, during which the Black Sheep under Jahanshah (1435–67) extended their rule over Iraq, Fars and Isfahan (1453). Scarcely had Miranshah's grandson Abu Sa'id established his power in the east than Jahanshah invaded Khurasan and seized Herat (1458), but the growing power of the White Sheep under Uzun Hasan brought about an agreement between Abu Sa'id and Jahanshah to divide Persia between them. Defeated by the Ottoman Turks in 1461, Uzun Hasan turned against the Black Sheep and defeated and killed Jahanshah (1467), whose son appealed to Abu Sa'id for assistance. Rejecting Uzun Hasan's overtures for peace, Abu Sa'id marched into Azerbaijan and was defeated and killed (1469). The White Sheep were now supreme in the west, but were preoccupied with the growing Ottoman power, and the Timurids remained in possession of Herat, where the sultan Husain Baykara (1469–1504) maintained a brilliant and luxurious court. After the deaths of Uzun Hasan (1478) and his son Ya'kub (1490), the White Sheep confederacy began to break up, and western Persia and Iraq gradually became fragmented between petty governments, which opened the way to the conquests of the Safawids.

THE SAFAWIDS, 1502–1736

The **Sufi** Movement. — Mention has already been made of the new types of political association under religious sponsorship which had come into existence in Persia. These organizations arose from the development of religious guilds or fraternities linked by common veneration of a particular religious teacher (*sheikh* or *pir*), within the general movement of Islamic mysticism or Sufiism (*q.v.*). After the destruction of the older Persian-Islamic culture under the Mongols, it was the Sufi movement which supplied and maintained a common basis of religious culture among the mass of the Persian people and the Turkoman immigrants, and stimulated a succession of great poets (Sa'di, Rumi, Hafiz, Nizami, Jami), in whom the poetic genius of Persia reached its climax.

In most cases the Sufi fraternities were entirely pacific, but where all public law and order had disappeared they furnished a means of organizing self-defense and tolerable conditions in their local areas. More particularly, among the Turkomans they served to create a bond of solidarity among local groups in support of local chiefs. The great majority of these Sufi associations were Sunni or orthodox in doctrine, but in most of them the memory of the caliph Ali was held in special veneration, as the reputed founder or ancestor of the fraternity. During the Mongol period a Sufi congregation was founded by Safi ud-Din (1252–1334), who claimed to be a descendant of the Imams, at Ardabil, in a region traditionally devoted to Shi'ism, and his successors, called after him Safawis, gradually adopted the Shi'ah faith. His grandson Khoja Ali (d. 1429) gained the respect of Timur, who released at Khoja Ali's intercession his Anatolian Turkoman prisoners. These, known as the Rumlu, were settled at Ardabil and formed the first group of armed adherents of the Safawids. Khoja Ali's grandson Sheikh Junaid came into conflict with the Black Sheep, and after an unsuccessful attack on Trebizond allied himself by marriage with Uzun Hasan, but was killed in battle in Shirvan in 1460. His young son Haidar married a daughter of Uzun Hasan and the Greek princess Katerina; he greatly expanded the Safawid military organization by enrolling further groups of Turkomans from Syria, Karaman and elsewhere, and devised for them their peculiar red cap with 12 gores from which they got the nickname of *kizilbash* (redheads). In 1488 Haidar renewed the campaign against Shirvan, but was defeated and killed by the alliance of its prince with the White Sheep. His sons, after several years of imprisonment, again became involved in hostilities with the White Sheep. The youngest of them, Ismail (b. 1487), escaped to Lahijan, where he remained in concealment until 1499, when he returned to Ardabil, took command of his Turkoman adherents and renewed the war in Shirvan with success, capturing Baku (1500). He then turned to deal with the White Sheep and after defeating

them at Shurur occupied Tabriz (1502).

Ismail I (1502–24).—On the conquest of Tabriz Ismail took the title of shah, although it was several years before he could subdue all the provinces held by local potentates. The White Sheep were finally defeated and Fars was occupied in 1503, and by 1508 all western Persia and Iraq had been conquered. From the first Ismail set himself zealously to establish the Shi'ah doctrine in his dominions; the Sunnis, who were in the majority in the cities, were coerced into conformity and the Sunni theologians extirpated. Simultaneously the Uzbeg Turkomans, who were as rigidly Sunni as Ismail was Shi'ah, had put an end to ,the Timurid line in Transoxiana (1500) and after the death of Husain Baykara had invaded Khurasan and captured Herat (1507), under the command of Shaibani Khan, a descendant of Jenghiz Khan. The rivals inevitably came into conflict and in Dec. 1510 Ismail heavily defeated the Uzbegs near Merv. Shaibani Khan perished in the battle and his skull was mounted in gold to serve as a drinking cup for the shah. By his victory Ismail united all Persia under his rule, but the Uzbegs remained masters of Transoxiana.

The attachment of the national and religious sentiment of the Persians to the Safawid house was, however, evoked still more strongly by the conflict which now opened with the other great Sunni power to the west, the Ottoman Turkish empire. It began after the accession of the sultan Selim I in 1512 (see TURKEY: History), and continued intermittently for more than two centuries. The rise of a Shi'ah family to the throne of Persia would naturally excite deep religious animosity, and the sultan determined to extirpate it before it struck roots. As a preliminary measure he sought out and put to death 40,000 of his subjects who were believed to belong to the heretical sect. He then marched to the Persian frontier.

Selim commanded the most formidable army of the period, consisting of thousands of long-service musketeers—the celebrated Janissaries—a strong artillery and a division of cavalry. Ismail, on the other hand, depended entirely on his tribesmen, who were commanded by their chiefs. The Persian attempt to attack on both flanks was defeated by the deadly fire of .the musketry and artillery. Ismail displayed the greatest gallantry, killing the aga of the Janissaries, but he was wounded and nearly taken prisoner; after suffering terrible losses, the survivors fled from the field. Selim massacred his prisoners and then marched on Tabriz, which submitted. Because of the lack of supplies, which caused a mutiny, the victor was obliged to evacuate Tabriz, but he annexed Georgia, Diarbekr and Kurdistan. Of far greater importance was the deadly blow given to Persian morale, since it was realized that a force led by the shah, although able to defeat the Uzbegs. was no match for a Turkish army. It is stated that, after this defeat, Ismail never smiled again. He died in 1524, deeply regretted by his subjects. He is described by the Venetian Angiolello in the following words: "He is fair, handsome and pleasing; not very tall, but of a light and well framed figure. His hair is reddish, he only wears moustachios. He is as brave as a gamecock and stronger than any of his lords."

Shah Tahmasp (1524–76).—The eldest son of Ismail succeeded to the throne when a boy. The Ottoman Turks renewed the war under Suleiman the Magnificent, who repeatedly invaded Persia, taking Tabriz and advancing as far into the interior as Sultaniya on one of his campaigns. He also captured Van, which was considered to be impregnable. Tahmasp followed an entirely defensive policy and is the theme of Milton's lines:

> As when the Tartar from his Russian foe,
> By Astracan, over the snowy plains,
> Retires, or Bactrian Sophi, from the horns
> Of Turkish crescent, leaves all waste beyond
> The realm of Aladule, in his retreat
> To Tauris and Casbeen.

(Paradise *Lost,* x, lines 431–436. The Sophi is the Safawid monarch, Aladule is Ala ad-Dawla Dhu'l-Quadar [the Alidoli of contemporary Italian travellers] and Tauris and Casbeen are, respectively, Tabriz and Kazvin.)

These lines reveal a remarkable knowledge of the political situation in Persia and there is every reason to believe that Milton gained his information from the account given by Anthony Jenkinson, who had conceived the bold plan of trading with Persia across Russia. Descending the Volga, he crossed the Caspian sea and came to Shemakha, where he was well received by the Persian governor. At Kazvin, he presented the letters of Queen Elizabeth, but the fanatical shah replied: "Oh thou unbeliever, we have no need to have friendship with the unbelievers." The shah, who was treating with Suleiman at the time, indeed thought of sending Jenkinson's head as a suitable gift to the sultan, but the intrepid Englishman finally returned to England with good profits to show for the risks he had run.

As the years passed, fanaticism lessened and both powers grew weary of the constant warfare. Negotiations were opened and the sultan stated that "so long as the frontiers were respected, there would be no hostilities." Turkey considered that it was dealing with a defeated power. At the same time, the sultan wished to reduce his commitments in Asia. It is of especial interest to note that Ogier de Busbecq, the ambassador of the emperor at Constantinople, stated that: "It is only the Persian who stands between us and ruin."

In 1576 Tahmasp ended his long reign, leaving Persia much weaker than he had found it. After his death there was a period of anarchy, furious animosities being unchained among various rivals for power. Throughout this period the position of Persia was one of confusion, but it was destined to be followed by a reign during which the dynasty reached its zenith.

The Accession of Shah Abbas I.—The 16th century was a wonderful period, both in Europe and in Asia. It was a time of great rulers, Charles V, Elizabeth I, Suleiman and Akbar constituting a remarkable group in which Shah Abbas (1587–1628) can fittingly take his place. And yet, how unpromising were the prospects of the child who was destined to make Persia a great power. Left by his father Khudabanda in Khurasan as its nominal ruler, throughout his boyhood he was a mere puppet in the hands of rival chiefs. His guardian, the Shamlu chief, fought the chief of the Ustajlu, and Abbas took part in the fight, having his horse shot under him. The Ustajlu chief, having won the day, stopped the pursuit to throw himself at the feet of young Abbas and secured his person. At this period Khudabanda, who was almost blind and entirely unfitted to reign, was attempting to enforce his authority in Fars, but Abbas was proclaimed shah by his new guardian, who advanced on Kazvin and occupied it. The unfortunate Khudabanda was thereupon deserted by his followers and shortly afterward died; Abbas, who matured quickly, put his guardian to death and seized the reins of power.

War With the Turks.—In view of Turkish predominance, the position of Abbas was far from enviable. In 1587 a Turkish force surprised and defeated a Persian army. This victory culminated in the occupation of the western provinces of Persia, from Georgia in the north to Khuzistan in the south. Abbas realized that he could not face the Turks and wisely decided to make peace with the sultan as a temporary expedient, although it meant bringing Turkey on to the Caspian sea in the north and into the valley of the Karun in the south.

To add to Abbas' troubles, the Uzbegs attained the zenith of their power at this time under Abdullah II, who ruled an empire stretching from Khotan to Balkh. He invaded eastern Khurasan and menaced Meshed. Abbas endeavoured to relieve the city, but illness delayed his movements and it was taken and sacked. After Abdullah's death the shah, profiting by dissensions among the Uzbegs, regained most of Khurasan in 1597–98, but the Uzbegs' power swiftly revived under their new chiefs of the house of Astrakhan, and Shah Abbas, after being severely deieated near Balkh, was compelled to leave that city in the possession of the victors.

Early in 1599 an English adventurer, Sir Anthony Sherley. his brother Robert and a number of other Europeans arrived at the Persian court on an unofficial mission from the earl of Essex, its object being to induce the shah to combine with the princes of Christendom against the Turks, and also to improve commercial relations between England and Persia. The shah was at that time much concerned at the inferiority of his army to that of the Turks. His forces consisted only of tribal levies which, besides being

largely untrained and lacking in discipline, owed allegiance not to him but to their chiefs. With the aid of the Sherley brothers and a cannon founder whom they had brought with them, the shah set about the reorganization of his army. Dispensing with most of the levies, he formed three main corps of regular troops, namely, the *qullar* ("slaves"), the *tufangchis* ("musketeers") and the artillery; all these men were paid by the crown and were under its direct control. The *qullar,* who formed the cavalry, were not in fact slaves, but were so called because they were recruited for the most part from Caucasia from where the Persians were in the habit of taking slaves; like the Turkish Janissaries, the *qullar* were mostly of Christian descent. Shah Abbas took a further step to free himself from dependence on the tribal chiefs and at the same time to curb their power and influence when he formed a new tribe called the Shah Seven or "friends of the shah." Thousands of tribesmen abandoned their chiefs to join this tribe and serve directly under the shah. By these means and thanks very largely to Robert Sherley, Shah Abbas was able to form in a comparatively short time a formidable, well-trained force consisting of cavalry, infantry and artillery. Shah Abbas was naturally anxious to put his new weapon to the test. Accordingly, in 1603 he reopened hostilities with Turkey. His new army swiftly showed its mettle by the recapture of Tabriz, a success for which the Persian artillery was mainly responsible. His troops subsequently drove the Turks from Erivan and Kars, and in 1606 they inflicted a signal defeat on them at Sis, a place between the Lake of Urmia and the Turkish frontier. In a later campaign Shah Abbas wrested Baghdad from the Turks. As a result of these wars he succeeded in regaining all the territory which the Turks had seized. In consequence Persian prestige was greatly enhanced; the nation could feel that it could now meet the hereditary enemy on more than equal terms. Although no formal treaty of alliance was ever concluded between Persia and the Christian powers, the fact that the Ottoman Turks now had to contend with a brave and well-organized foe in their rear did much to curb Turkish activities in Europe.

The Genius of Shah Abbas.—The fame of Shah Abbas does not rest solely on his military exploits; it is also founded on his genius for administration, his tolerance in religious matters and his active encouragement of commerce and the arts. By these means he made his country once more a great power and welded the different peoples—Persians, Turks and Arabs—into a nation. Realizing the vital importance of communications, he improved the routes, building bridges and caravanserais and, above all, making them safe for travellers by his merciless suppression of brigandage. He did much to encourage trade not only in Persia but also with foreign countries, whose representatives he welcomed at his court. In religion Shah Abbas was an ardent Shi'ah, but he allowed Christian missionaries to enter his kingdom and establish missions and churches. As most of the holy cities of Islam were in the hands of the hated Sunnis, he urged his subjects to confine their pilgrimages to the shrines of the Imam Riza at Meshed and of his sister Fatima at Qum; he set them an example by performing the pilgrimage from Isfahan to Meshed on foot. Shah Abbas' most striking administrative act was his creation of a new capital at Isfahan. He transformed it from a provincial town into a city of magnificent buildings which before long rivalled even London in size. Among the important buildings erected by Shah Abbas were the majestic Masjid i-Shah, the smaller but exquisite mosque of Sheikh Lutfullah, the Ali Kapu and the Chihil Sutun.

Intercourse With Europe.—One of the most important events in Persian history was the rounding of the Cape of Good Hope by Bartholomeu Diaz de Novaes in 1487 and the subsequent establishment of direct intercourse by sea between Europe and the east. Greatest among the Portuguese captains was Alphonso d'Albuquerque who, with a squadron of six ships, captured the island emporium of Hormuz. Because of mutiny D'Albuquerque was unable to keep his conquest on this occasion, but eight years later he returned as viceroy in command of a powerful fleet and built the famous fort, which is almost as perfect today as at the date of its construction. Throughout the 16th century, the Portuguese, because of their sea power, dominated the Persian gulf, in spite of strong Turkish naval opposition, and monopolized its commerce, to the intense anger of the Persians.

The English appeared in eastern waters just a century later than the Portuguese. Their chief commodity was broadcloth, for which there was little demand in India, and it was consequently decided to open up relations with Persia, which was reported to have a cold climate. In view of the position of the Portuguese in the Persian gulf, it was decided to begin operations at Jask, and in 1616 a ship loaded with a trial cargo was dispatched to that port. The English were well received by Abbas. Apart from the hope that they might help him to expel the Portuguese, he was most anxious to export silk, which was a royal monopoly, by the Persian gulf instead of overland, thereby depriving the Turks of a large source of customs revenue.

The Portuguese viewed the arrival of the English with intense hostility. They attempted to capture the pioneer ship, but were just too late. However, when a second expedition appeared on the scene they were waiting off Jask and attacked the English. In spite of their superior force they were unable to capture the English ships and were completely defeated. The result of this action was most important. In 1622 the shah realized that his hoped-for chance of expelling the Portuguese had come, and the English were induced to co-operate. As the soil on the island of Hormuz was impregnated with salt, it produced neither food supplies nor fresh water, all of which had to be brought by boat from the neighbouring island of Qishm or the mainland. As a preliminary operation the English and Persians captured a Portuguese fort on Qishm Island and cut off supplies from there. The English ships then blockaded Hormuz and large numbers of Persian troops were landed on it. Although the Portuguese defended themselves bravely, their fleet made little or no attempt to help them, and they were forced to surrender after holding out for two months. This was the first, but by no means the last, manifestation of English sea power in the Persian gulf.

Decline of the Safawid Dynasty.—After the death of Shah Abbas in 1629 his descendants occupied the throne for nearly a century; but it was a period of decline, and as time went on only the veneration in which the dynasty was held prevented its fall. Because of the jealousy which Abbas had shown toward his sons, the princes of the blood, instead of being trained to arms, were immured in the harem under the tutelage of eunuchs. Shah Safi (1629–42) was a cruel tyrant who put to death his own relations of both sexes and executed most of the generals and councillors who had made the reign of his great predecessor so illustrious. The contemporary Turkish ruler was Murad IV, the last of the warrior sultans, who invaded Persia repeatedly, massacred the inhabitants of Hamadan, Tabriz and Baghdad and annexed the last-mentioned city. Under Shah Abbas II (1642–66), Persia recovered some of its glory, and the pomp and pageantry of the court dazzled European envoys and travellers. On Abbas' death, decline set in once more and became accentuated after the accession of Shah Sultan Husain in 1694. This monarch was humane, pious and meek, but he cared nothing for affairs of state and allowed the control to pass to the courtiers and eunuchs. During the Safawid period the province of Kandahar was a bone of contention between Persia and the Mogul rulers of India, with the result that it changed hands several times. When Shah Sultan Husain came to the throne it was in Persia's possession, but the Ghilzai Afghans, whose chief city it was, were intriguing with Delhi. On hearing this news, the shah sent a Georgian prince named Gurgin Khan as governor to Kandahar, together with a strong Persian garrison. Gurgin Khan at once arrested Mir Vais, the astute Ghilzai chief, and sent him under a strong guard to Isfahan. There he uon over the credulous shah with a story that Gurgin Khan was plotting to hand over Georgia to Peter the Great. The shah thereupon reinstated Mir Vais and allowed him to return to Kandahar, where he was soon able to arrange for the murder of Gurgin Khan and the massacre of his troops. Mir Vais was then virtually independent until his death in 1715.

Mir Vais's son Mahmud raided Persia in 1720, penetrating as far as Kerman, but he was defeated and driven back by a capable Persian general who mas later dismissed and disgraced. Two years

later Mahmud again invaded Persia; although he took Kerman, he failed to capture Yezd. Nevertheless, he marched boldly on Isfahan, halting at Gulnabad, a large village situated on level ground 12 mi. E. of the capital. There he found himself confronted with a Persian force of 50,000 men, well equipped and furnished with some heavy artillery. The Ghilzais, on the other hand, numbered only 8,000, with an equivalent number of Baluch and other tribesmen; their only cannon were *zanburaks* or light swivel guns mounted on camels. What the Afghans lacked in numbers, however, they more than made up for by their courage and impetuosity, while the Persians, long unused to war and commanded by incompetent and irresolute officers, were impressive only in appearance. The Persians gained an initial advantage in the battle that ensued, but their lack of training and the failure of their commanders to act in co-ordination with one another proved disastrous, and the whole force fled in headlong disorder from the field. The Afghans swiftly followed this victory by advancing on and closely investing the capital. During the siege that followed, Tahmasp, the heir apparent, escaped from the city with the object of raising a force to march to its relief, but the young man took no active steps to do this. Meanwhile the siege went on and, all supplies having been cut off, famine followed by pestilence soon claimed many victims. With its population decimated and with no hope of succour, the city surrendered in Oct. 1722 and Shah Sultan Husain abdicated in favour of Mahmud. Although the Safawid dynasty did not actually come to an end until Nadir Shah usurped the throne in 1736, it ceased actually to rule when the meek Husain surrendered.

The chaos caused by the Afghan invasion enabled both Russia and Turkey to seize large portions of Persian territory. Peter the Great, ever anxious to extend his power to the south and southeast, was first in the field, capturing Derbent in 1722; his forces later occupied Baku and the province of Gilan. Alarmed at these moves by Russia, the Turks crossed the frontier and annexed Georgia and Shirvan. They particularly coveted Baku, but found themselves forestalled by Peter. War between Russia and Turkey seemed imminent, but in 1724 a peaceful settlement was reached, whereby Russia kept the districts which it had already occupied and the three Caspian provinces, while Turkey recovered the western provinces that it had lost during the reign of Shah Abbas.

Mahmud was put to death in 1725 and was succeeded by his cousin Ashraf, who proved himself to be a capable ruler. Though he enjoyed great prestige among his fellow tribesmen, his position was one of great difficulty. He held Isfahan, Shiraz and southeast Persia, but could hardly be said to administer the country. Indeed the Afghans were totally lacking in the art of administration and, being Sunnis, were detested by the Persians. Prince Tahmasp was collecting a force in the north, while Russia and Turkey were determined to maintain their hold over the territories which they had seized. Ashraf dispatched an embassy to Constantinople to remonstrate with Turkey for combining with a Christian power against the Sunni Afghans. In spite of the feeling that this mission aroused in Constantinople, the Turks declared war on Ashraf and advanced on Isfahan. Ashraf defeated them, and by his studied moderation after his victory and by his appeal for unity among Sunnis, he succeeded in making peace on not unfavourable terms, being recognized by the sultan as shah of Persia. The Turks, however, refused to give up the provinces that they had occupied.

***Nadr* Kuli** Beg.—Ashraf was no sooner freed from the Turkish menace than he was confronted with another serious danger. Prince Tahmasp was at this juncture joined by the leader of a robber band named Nadr Kuli Beg, a soldier of genius who was destined not only to usurp the throne of Persia but also to achieve fame as the conqueror of India. Nadr Kuli Beg brought with him 5.000 of his Afshar tribesmen. Tahmasp had already collected about 3,000 Kajars under their chief Fath Ali Khan, and other recruits began to pour in. Nadr Kuli Beg. who could brook no rivals, speedily made away with the Kajar chief and persuaded Tahmasp to secure Khurasan before attacking the Ghilzai Afghans. This campaign was entirely successful, both Meshed and Herat being recaptured from the chiefs who had occupied them.

Meanwhile Ashraf, who was seriously alarmed at the national revival, determined to attack before the Persian army became too strong. The two armies met at Mihmandust near Damghan in 1729. The Afghans, whose morale was very high after their victory over the Turks, charged, but were met with heavy musketry and artillery fire by Nadr, who then advanced and drove the Afghans from the field. They stood again at Isfahan and at Shiraz, but were finally crushed, and the survivors were hunted across Persia to the desert, where the Baluchis intercepted and killed Ashraf.

The Afshar tribesman Nadr Kuli Beg, who was destined to restore the power and prestige of Persia, was born in a tent close to Muhammadabad in the district of Darragaz, in the province of Khurasan. In the summer his father inhabited the village of Kubkan, situated on the route between Kuchan and Muhammadabad. He died young, leaving his wife very poor. Four years later, Nadr Kuli Beg entered the service of the governor of Darragaz. The times were troubled and Nadr soon won a reputation for bravery; he so distinguished himself that his master gave him his daughter in marriage. Upon the governor's death Nadr succeeded to his post. Summoned to Meshed by Malik Mahmud, the ruler of Khurasan, he defeated a raiding force of Uzbegs, but, because he claimed what was considered to be an excessive reward, he was beaten and dismissed. He soon reappeared on the scene at the head of a body of robbers. But he aimed at higher things, captured Nishapur and occupied it in the name of Shah Tahmasp, whose service he entered.

Nadr fought three campaigns against the Turks at this period of his career. He lost one battle, but finally defeated the national enemy and recovered the western provinces of Persia. The Russian government, after the death of Peter the Great, decided to withdraw from Persia, and restored its Caspian provinces in 1732. Three years later, when war broke out between Russia and Turkey, Nadr secured Baku and Derbent from Russia by threatening to join the Turks unless these important towns were handed over. In 1732 Nadr deposed the feeble Tahmasp after he had, in Nadr's absence in Khurasan, waged a disastrous campaign against the Turks. He then placed the former shah's infant son Abbas on the throne and had himself appointed regent. By his wonderful leadership, the former robber had revived the military prowess of the Persians and had expelled the Afghans, Turks and Russians from their country.

In 1736 he had his reward, when the young Abbas was deposed and he himself was unanimously elected shah. Dropping the title of Tahmasp Kuli Khan, by which he had for some time been known, he changed his first name, Nadr, to Nadir and ruled as Nadir Shah. (P. M. S.; A. U. P.; H. A. R. G.; L. Lo.)

FROM NADIR SHAH TO THE REVOLUTION, 1736–1907

Nadir had settled accounts with Turkey and Russia, but the nation thirsted for vengeance on the Ghilzai Afghans, the recovery of whose country would restore to Persia all the territories ruled by Shah Abbas. Accordingly, in the year after his coronation, Nadir led a powerful army, 80,000 strong, toward Kandahar. The city was ruled by Husain, brother of Mahmud, the captor of Isfahan.

Being unable to meet Nadir in the field, Husain decided to defend the city, trusting to its great strength. Nadir, who had no heavy artillery, was thus reduced to a blockade. For nine months the siege continued without any appreciable progress being made, but in Jan. 1738 Nadir's troops stormed a commanding ridge, up which they hauled their cannon with great difficulty. Much damage was then done to the defenses, but the city nevertheless held out for another two months. Bearing in mind the Ghilzais' excellent fighting qualities and the prospect of further campaigns, Nadir treated them with such clemency that many of them enlisted in his army and served him loyally until his death.

***Invasion* of *India*, 1739.**—During the tedious months spent outside Kandahar, Nadir prepared his plans for a campaign in India, which was the natural sequel to the recovery of the cnstcrn provinces of Persia. The great Mogul dynasty had declined rapidly since the death of Aurangzeb, in 1707, and Mohammed Shah,

his degenerate descendant, "was never without a mistress in his arms and a glass in his hand." This despicable monarch and his effeminate troops were no match for virile Nadir and his warlike veterans. Treachery was also at work, and more than one Indian noble had opened up relations with the shah. With incredible folly, the Mogul court relied on the Ghilzais to repulse Nadir, and not only made no preparations for defense but treated with contempt his requests that no fugitives should be granted asylum across the frontier.

After the capture of Kandahar Nadir, whose prestige was much enhanced, marched northeast, following in the footsteps of Alexander the Great. After taking Kabul he marched on toward India. Traversing the mountains by the Tsatsobi pass, he attacked the Indian forces guarding the Khyber pass from the rear and routed them. By this time Mohammed Shah was thoroughly alarmed, but before either he or his councillors could really grasp the situation, Nadir had captured Peshawar and crossed the Indus at Attock.

One of the historical battlefields of India is at Karnal, 70 mi. N. of Delhi. Mohammed Shah formed a strongly entrenched camp there, and supinely awaited the invaders. Nadir, realizing the strength of this camp, decided to give battle if the Indians emerged and to march directly on Delhi if they remained inactive. While matters were in this state, Sa'adat Khan, the subahdar of Oudh, joined Mohammed Shah with 30,000 men. Hearing a report that the Persians were plundering his baggage train, Sa'adat Khan impetuously attacked them, but was lured into a trap, defeated and captured. The emperor's forces, advancing to Sa'adat Khan's assistance, then became involved with Nadir's army. In the ensuing battle Nadir was completely victorious and forced the Indians back to their camp with heavy loss; he then surrounded the camp and cut off all supplies.

Mohammed Shah, realizing that his troops would not fight again and that supplies would soon be exhausted, decided to surrender. Nadir treated him outwardly with respect but in reality made him and his nobles prisoners. In company with the luckless emperor, Nadir thereupon marched in triumph to Delhi, which he entered in March 1739. He then proceeded to strip the emperor and his people of their treasures, obtaining, it is said, booty to the value of 700,000,000 rupees. As the Indian historian Anand Ram remarked, "the accumulated wealth of 348 years changed owners in a moment."

Nadir remained for two months in Delhi. He put down with such severity a rising of the citizens against his troops that a "Nadir Shahi" is still synonymous there with a massacre. After this tragic event, Nadir demanded and obtained the hand of a granddaughter of Aurangzeb for his son Nasrullah. When, in accordance with Mogul etiquette, inquiries were made about Nasrullah's descent to the seventh generation, Nadir replied: "Tell them he is the son of Nadir Shah, the son of the sword, the grandson of the sword, and so on till they have a descent of 70 instead of 7 generations."

Knowing that he could not hold Delhi, Nadir restored it and the bulk of the empire to Mohammed Shah, but he annexed the provinces on the right bank of the Indus, which during the reign of Darius had formed part of the Persian empire. Thus, after a stay of less than a year in India, he returned to Persia with greater power, wealth and fame than any other Asiatic conqueror since Timur. It remains to add that he was the last great Asiatic conqueror.

***Campaign Against Bukhara and Khiva*, 1740.**—During the siege of Kandahar Nadir had dispatched his eldest son and heir against Balkh, whose ruler had promised help to the Ghilzai chief. Riza Kuli had proved himself worthy of the command, for his assault was so fierce and so continuous that the city was surrendered. The young prince had then crossed the Oxus and defeated a strong army of Uzbegs. Nadir, unwilling to attack Bukhara at this juncture, recalled his son and wrote to the amir of Bukhara that he had ordered Riza Kuli "not to disturb countries ruled by descendants of the Turkoman." After the Indian campaign the situation was entirely changed. Nadir had not forgotten the raids made on Khurasan by the Turkomans of Khiva, and he realized that a campaign against the two Uzbeg states would form a natural corollary to the conquest of northern India and would protect Khurasan against raids for many years to come. Finally, he expected rich spoils and little resistance. Large quantities of grain had been collected at Balkh and loaded into boats, and the expedition commenced its march down the Oxus to Charjui, where a bridge of boats was constructed. The amir of Bukhara, realizing that he could not resist Nadir's veterans, promptly submitted and proceeded to the Persian camp. There, at first, he was treated with disdain, but he was finally restored to the throne on condition that the Oxus should again constitute the boundary of Persia and that he should supply a contingent of troops for the Persian army The treaty, which was accompanied by the payment of huge sums of money, was cemented by a double alliance of marriage.

After Bukhara it was the turn of Khiva. Hearing of Nadir's approach, Ilbars, the khan of Khiva, set out to destroy the bridge of boats at Charjui, but Nadir forestalled him and routed his forces. Taking his supplies by boat down the Oxus, Nadir marched along the river bank in pursuit of the enemy, whom he decisively defeated near Khiva. Soon afterward Ilbars surrendered. As the khan had put to death the envoys whom Nadir had sent to him before the campaign, the conqueror executed him, together with 30 of his councillors. At Khiva Nadir found two Englishmen, members of the staff of Jonas Hanway, the intrepid merchant who attempted to trade with Persia and central Asia across Russia and left a most valuable account of the state of Persia at this period. Nadir treated the Englishmen with kindness, giving them passports and a promise of redress for their losses. One result of this campaign was the release of thousands of Persian and Russian slaves. Many of the former were settled in Nadir's homeland of Darragaz, some in a village which the shah founded near the site of his birthplace.

The conquests of Nadir were now finished. He had restored the boundaries of Persia and made them wider than those of the Safawid dynasty. He had made Persia once more famous as a great fighting power and he not only had released the inhabitants of Khurasan who were slaves but had ensured their safety in the future. Had he possessed any administrative capacity he could have restored prosperity to Persia, but success and wealth had spoiled his character and made him a miser, and the remaining years of his life are a record of ever-increasing avarice and cruelty, which made him detested by his subjects.

***Lesghian Campaign*, 1741–43.**—There is a Persian proverb that runs, "If any shah is a fool, let him march against the Lesghians." During the siege of Kandahar, Ibrahim Khan, Nadir's only brother, heard of his nephew's successes in Turkistan and wished to emulate them. He was rash enough to attack the Lesghians, but lost his life in so doing. Nadir, on his return from Turkistan, felt bound to avenge his brother and accordingly invaded Daghestan in 1741. At first all went well and the tribes inhabiting the foothill country submitted. The main bodies of the Lesghians, however, retreated to the densely wooded higher country, where conditions were ideal for defense and for surprise attacks. Consequently they defeated the Persians repeatedly. These reverses infuriated Nadir, but, despite his utmost efforts, the stubborn Daghestanis more than held their own and eventually forced him to retreat, baffled and sullen. At the end of the campaign, Nadir found himself with an exhausted and dispirited army and with his prestige much impaired.

Like Shah Abbas the Great, Nadir suffered from jealousy of his eldest son. While he was on his way to Daghestan, he was shot at from an ambush, and believed that the would-be assassin was in the pay of Riza Kuli Mirza. Though the prince was innocent, Nadir ordered him to be blinded, but bitterly repented when it was too late. Persians remember the remonstrance of the unfortunate prince: "It is not my eyes but those of Persia which you have put out."

The success of the Lesghians caused rebellions to break out in various parts of the empire, but they were suppressed with merciless severity. Nadir had unwisely attempted to reunite Islam by abolishing the Shi'ah sect and by substituting the Ja'fari, which he intended to be the fifth Sunni sect. At the time there was no open objection to the change by his subjects, who feared to oppose

him, but the following decision was given by the religious leaders of Turkey: "The new sect is contrary to the true belief, and it is permitted to kill the people of Persia." This decision was followed by the invasion of an enormous Turkish army, which was determined to avenge former defeats; but Nadir was as great a general as ever, and he inflicted a crushing defeat, capturing the whole of the artillery and military stores of the enemy. Negotiations for peace followed in which Nadir agreed to abandon his claims to found a new sect and released his prisoners. This was his last victory.

The Death of Nadir, 1747.—As the years passed Nadir put to death so many of his trusted officers, that finally he was attacked at night by members of his own bodyguard and killed, fighting to the end. Thus fell Nadir Shah, who, endowed with superb physique, a voice of thunder, dauntless courage and a genius for war, had hewn his way to the throne. Like Napoleon, with whom he may well be compared, success caused moral deterioration, and when he died the nation which he had saved from the Afghans, the Turks and the Russians received the news with intense relief, Had he died after the conquest of Khiva he mould have been the national hero for all time.

The assassination of Nadir Shah gave the signal for the breakup of his composite army. The Afghans under Ahmad Khan alone remained loyal, but, being unable to avenge his fallen leader, Ahmad marched off to Kandahar and, aided by the capture of a treasure convoy, founded the kingdom of Afghanistan, which included most of the Indian provinces situated on the right bank of the Indus. Throughout, he remained loyal to the family of Nadir and when, after desperate contests for power, Shahrukh, the son of ill-fated Riza Kuli. was set on the throne of Khurasan and then blinded, Ahmad Shah, as he had proclaimed himself, avenged Shahrukh and constituted Khurasan a separate kingdom for him under Afghan protection and suzerainty.

Fath Ali Khan of the Kajar tribe, who was killed by Nadir when he joined Tahmasp, had a son. Mohammed Husain Khan. After the death of Nadir Shah, he raised a force with which he successfully opposed Ahmad Shah and occupied the Caspian provinces. A second claimant was Karim Khan, a member of the Zand tribe of Fars. A man of humble extraction, he raised himself to power by sheer force of character and had a large following in south Persia. Finally there was Azad. an Afghan general, who was supreme in Azerbaijan. A curious triangular contest ensued in which each claimant at one period seemed to have won, but finally Mohammed Husain was defeated and killed and Azad surrendered, leaving Karim Khan supreme.

Karim Khan to Fath Ali Shah.—Karim Khan never aspired to the title of shah, but termed himself *vakil* or regent. He made Shiraz his capital and adorned it with many fine buildings. Under his kindly rule Persia gained a sorely needed rest and began to recover something of its ancient prosperity. Upon his death, however, there was the usual fight for power among the members of his family. Meanwhile Agha Mohammed Khan, the eunuch chief of the Kajar tribe, collected a force and, winning over to his side Hajji Ibrahim, the redoubtable vizier of the Zand monarch, finally defeated Lutf Ali, the heroic representative of the Zand dynasty, who was barbarously done to death by the cruel Kajar.

Agha Mohammed was a good soldier and, after the final defeat of his rival, decided to attack Heraclius of Georgia, who, upon the death of Nadir Shah, had declared the independence of his country and had annexed provinces up to the river Aras. He had also made a treaty with Russia, by the terms of which he was entitled to receive protection. Heraclius realized that he could not receive immediate help from Russia, yet he foolishly met the overwhelming Persian army in the field and was defeated. Tiflis was taken, the priests and infirm were massacred and the able-bodied of both sexes were enslaved. After Georgia, the shah turned his attention to Khurasan. The wretched Shahrukh was unable to offer any resistance, but Agha Mohammed required more than submission. He coveted with passion priceless jewels from Delhi which he knew were in the possession of the blind monarch, and set his torturers to work. Day by day some valuable gem was produced. Last of all the famous ruby of Aurangzeb was extracted and Shahrukh, worn out by the tortures, died cursing the Kajar eunuch. Shortly afterward, the tale of his cruelties was brought to an end by the hands of two of his body servants whom he had doomed to death but yet permitted to attend him. Thus, in 1797, after only three years' rule over the whole of Persia, died the founder of the Kajar dynasty, who was rightly detested by all classes.

Under his nephew, Fath Ali, Persia came within the orbit of European politics. The first step was taken by the British rulers in India. In 1798 Lord Wellesley received a letter from the amir of Kabul in which he stated his intention of making an expedition into India. This would have upset British policy and Wellesley sent a Persian, who was acting resident at Bushire, to induce the Persian court to put pressure on the amir. The task of the envoy was made easy by an Afghan demand for the cession of Khurasan, to which the young shah replied that he intended to restore the eastern boundaries of Persia as they were in Safawid days. He followed up this threat by dispatching a force to help two Afghan pretenders, with the result that the amir retired from Lahore to meet the threat in the west. The mission of the British agent was thus entirely successful and paved the way for an accredited British envoy, who was about to land on Persian soil.

Franco-British Rivalry in Persia.—The genius of Napoleon dominated his adversaries to such an extent that even his fantastic schemes caused them great alarm. Among these must be reckoned his plan of using the shah as an instrument for the invasion of India in co-operation with French and Russian troops. Accurate modern maps showing the barren nature of these countries have revealed the impracticability of the scheme, but in 1800 it was seriously considered by Napoleon and Paul of Russia. Indeed, Paul actually ordered the Don Cossacks to march on India. The movement was begun, without supply columns or maps, but it was stopped at the Volga upon the death of the tsar, which was fortunate for all concerned. The British, determined to forestall the French, instructed their agent, Capt. John Malcolm, to induce the shah to bring pressure on the amir of Kabul to counteract the designs of the French and to negotiate a political and commercial treaty. Malcolm's success was complete, and he speedily gained all his objects. Moreover, he established a high regard for British honour in Persia.

The British foolishly withdrew Malcolm and left no permanent representative at Tehran. Napoleon took advantage of the favourable position and in 1802 made definite overtures to Persia. These were followed in 1806 by the appearance at Tehran of a French envoy, who, in view of the fact that the emperor had declared war on Russia, offered to restore Georgia to Persia and to subsidize the shah, who in return was to join France in an invasion of India. Fath Ali was most unwilling to become the ally of a nation which had put its monarch to death. However, he could obtain no reply to his appeals from the British, who could not make up their minds what to do. Finally, therefore, he agreed to the French proposals. Fortune, however, favoured the British, since, by the time the Franco-Persian treaty had been signed, Napoleon had made peace with the tsar, and Persia lost all hope of recovering Georgia through his aid.

Outwardly a French mission held the field, and Malcolm, when he again reached Persia in 1810, was affronted. In spite of this, the situation was changing; the French mission was dismissed and Sir Harford Jones, representing the crown, as distinct from the governor general of Bengal, was given a magnificent reception. A new treaty was negotiated and in 1814 a definite treaty was signed, by the terms of which treaties or military co-operation with nations hostile to Great Britain was barred; Persia further pledged itself to use its influence aith the states of central Asia to adopt a similar policy. In return, Persia was granted a subsidy of £150,000 a year, which was to be stopped if it engaged in an aggressive war. This treaty dealt with the French peril after it had passed. On the other hand. it mas not realized by British statesmen that so far as Persia was concerned the annexation of Georgia and Karabagh by Russia had created an entirely new situation, that the treaty had not recognized the fact and was therefore likely to lead to trouble.

Struggle for Georgia.—Persia was bound to fight for Georgia,

and the campaigns that followed may be considered to fall into two distinct periods. The first ended with the defeat of Persia in 1812, peace being made in the following year by the treaty of Gulistan. Thirteen years later Persia again attempted to reconquer Georgia and its final defeat is recorded in the treaty of Turkmanchai (Turkman), which was signed in 1828. The Persian army was commanded by the heir apparent, who invariably lost his head on the battlefield and rendered the efforts of a handful of British instructors futile. The first campaign opened with the siege of Erivan by a Russian force, which was so harassed by the cutting of its lines of communication that the operation was abandoned. The campaign was ended in 1812 by a decisive action fought at Aslanduz. A small Russian column surprised the Persian army in broad daylight. The British officers had drawn up their men when Abbas Mirza in a panic ordered a hasty retreat, with the result that the force was annihilated.

After this disaster, the shah, who was also panic-stricken, agreed to abandon all claims to Georgia; he also ceded Derbent, Shirvan and Karabagh. Russia, at this very time, was at the crisis of its fate because of the invasion of Napoleon, and it is astonishing that Persia abandoned its possessions and made no further effort against such a sorely embarrassed enemy. As was to be expected, Persian opinion regarded the treaty of Gulistan as a national disgrace. It had been vaguely worded, so much so that the possession of three districts remained in dispute. Kegotiations were being carried on but before they were completed Russia occupied the areas. Persian opinion was deeply stirred, recruits poured in and the shah was forced by public opinion to break the treaty. At first the Persians carried all before them and occupied Shirvan and Talish in less than a month. But the Persians would not face Russian troops. In an action fought near Ganja, although the Persians were numerically superior, their cavalry fled, demoralized by artillery fire. The Russian infantry then advanced and swept the Persians off the field. Fath Ali was a miser; he refused to pay the troops in the winter and they perforce were disbanded. Realizing the position, a small Russian force marched on Tabriz and captured not only the city but also the entire artillery park of the Persian army. Thus ignominiously hostilities were ended. By the treaty of Turkmanchai, the Aras became the boundary of Persia. An indemnity was demanded and extraterritorial rights were included as well as a commercial treaty, by the terms of which there was a 5% tax on imports and exports. This treaty inaugurated a new era and became the basis on which other European nations conducted their intercourse with Persia. Great Britain recognized the changed position and, in view of the fact that Persia was the aggressor, declined to pay the subsidy. Persia was, however, in dire straits from its inability to pay the Russians, and it mas arranged that a single payment of £150,000 should be held to cancel all further claims on the subsidy.

Persia and Afghanistan. — Persia realized that its defeat by Russia was final. To salve its wounded pride, it decided to make strenuous efforts to recover Herat and the other provinces that now formed the state of Afghanistan. This trend of policy was viewed with apprehension by the British government, since Persia was under Russian influence and if Herat, Kabul and Kandahar were reconquered, Russian agents would be established close to the Punjab. Actually Persia's objective during this period was Herat, and Great Britain made strenuous and successful efforts to keep that province outside the influence of both Persia and Russia.

Abbas Mirza was more successful in eastern Persia than against Russia. He gradually reconquered Khurasan until Sarakhs alone held out, encouraged by the presence of the khan of Khiva. However the khan, alarmed by the surrender of Kuchan, retired, and Sarakhs was stormed, a feat which restored Persian prestige in central Asia. Shortly afterward, Abbas Mirza and then Fath Ali Shah died (1834).

Mohammed Shah was the son of Abbas Mirza and, when he had defeated various pretenders and established himself on the throne, it was clear that he was determined to capture Herat. He had already, during his father's lifetime, commanded a force which was besieging that city, but had hastened to Tehran to secure his nomination as heir apparent upon hearing the news of his father's death. At this period a second British military mission reached Tehran, but it was received with marked coldness by the young shah and was unable to serve any useful purpose. It is impossible to give any account of British policy in Afghanistan and we must confine ourselves to the question of Herat. In 1837 the shah opened his campaign, and the first prisoner that was captured was bayoneted in his presence. Yar Mohammed, the able vizier of the prince of Herat, had made every preparation for a siege. The fortifications had been repaired and strengthened; supplies in large quantities had been stored, and all villages within 12 mi. of the city had been burned. An English artillery officer, Eldred Pottinger, arrived on the scene and gave valuable help. In the spring of 1838 Sir John McNeill, the British envoy, reached the Persian camp and nearly persuaded the shah to break off the siege. Ho ever, at this juncture, the Russian envoy offered the services of a Russian officer. McNeill was consequently flouted and quitted the Persian camp. Shortly after his departure, the shah made his final effort. For six days the defenses were battered, but the general assault failed. The shah was utterly dejected, and when he received a communication from the British minister that his government would view the occupation of Herat as a hostile act, and that the island of Kharag had been seized by British troops, he agreed to British demands and broke off the siege. He died in 1848, leaving Persia on the verge of revolution and bankruptcy.

Nasr ed-Din (1848–96).—His son, Nasr ed-Din, began his reign well. He brought with him from Tabriz his adviser, Mirza Tski Khan, and appointed him his vizier. He was the most remarkable Persian of his generation, being not only capable and hard-working but also incorruptible. He set to work to abolish the sale of appointments and of justice; and the embezzlement of the soldiers' pay, the grant of pensions to favourites and many other abuses were all taken in hand. His reforms raised up a host of enemies, among them the mother of the shah, who persuaded her son that the vizier was too powerful, with the result that he was executed—a terrible blow to Persia. After this the shah, generally speaking, ruled in the bad old way, although he was a more enlightened ruler than his predecessor, partly as a result of his visits to Europe.

During the early part of Nasr ed-Din's reign, an inhabitant of Shiraz preached a new religion. He proclaimed himself the Bab or "gate" through which men might attain to knowledge of the 12th Imam (see BABIISM). The Bab was the son of a grocer, and when he attempted to convert his fellow townsmen he was considered to be a madman and was imprisoned. His followers, however, increased to such an extent that the shah finally ordered him to be executed at Tabriz. After his death the doctrine spread far and wide, causing risings and an attempt on the shah's life, which was met with pitiless persecutions. The Baha'i sect, an offshoot of the one founded by the Bab, still exists and counts many followers, not only in Persia but in the Levant and in America.

During the generation that followed its victories over Persia, Russia not only strengthened itself in that country by the creation of a naval base on the Persian island of Ashurada in Asterahad bay, but made great efforts to gain a footing in central Asia and in Afghanistan. It was probably at Russia's instigation that Nasr ed-Din determined to win renown by the capture of Herat. Yar Mohammed, the capable vizier, had died. leaving the province to his son, who was mentally deficient and whose first act was to open up negotiations with Persia. The British government thereupon imposed a treaty on Persia by the terms of which Persia promised not to send troops into the Herat province unless it was attacked from outside. The treaty caused intense irritation to Persia and was the main cause of relations being broken off between the two countries. Persia then gained possession of Herat through. an Afghan nominee in 1836, and there was intense delight throughout the country. But Great Britain had to be reckoned with. In addition to paying a subsidy to the amir, it declared war on Persia and landed an expeditionary force at Bushire. Under Sir James Outram, a march was made inland and a Persian force was defeated. The troops were then transferred to the mouth of the Karun river, where a second success was gained. Persia had already sued for peace, and by the terms of a treaty signed in Paris

in 1857 the shah agreed to evacuate Herat and to recognize the independence of Afghanistan. No indemnity or concessions were demanded.

Nasr ed-Din was fated to see the advance of Russia across central Asia until his northern frontiers were entirely enveloped. The khanates, as they were termed, were annexed one by one, until only the Turkoman was left. In 1881, after more than one failure, Mikhail Skobelev stormed the stronghold of the Tekke Turkomans at Geok-Tepe, the other tribes gradually submitted and Russia forced Persia to accept an unfavourable boundary that gave its new neighbour a stranglehold on Khurasan.

We must now turn to the advance of the Indian empire. Baluchistan had relapsed into anarchy at the end of the 18th century, and no immediate attempt would have been made to interfere with this state of affairs but for the fact that it was decided to construct a telegraph line from England across Persia to India. Negotiations were opened with Persia, with the result that a boundary was finally drawn between Persian and British Baluchistan. This latter province may be said to have been the creation of Sir Robert Sandeman, through whose exertions law and order were gradually introduced into a no man's land. From the Persian point of view these boundaries, mhich included the delimitation of its frontier with Turkey, completed its envelopment.

Constitutional Movement. — The desire for a constitution in Persia came relatively late. Persia was affected by the construction of telegraph lines and so forth, but national pride in its own perfection was also strong. The shah as a young man was in favour of progress, but the failure of the attempt at constitutional government in Turkey in 1876 frightened him, and his later policy tended toward keeping Persia free from dangerous new ideas. "I want ministers who do not know whether Brussels is a city or a cabbage," was his frank avowal, and although his point of view was selfish the event did prove that Persia was not ripe for the new order. Nasr ed-Din was assassinated in 1896. His successor, Muzaffar ed-Din, led Persia toward bankruptcy by borrowing large sums of money from Russia, which he wasted on his journeys to Europe and on his favourites. During his reign all fear of the shah passed away, and the tribes robbed with impunity on the caravan routes, inflicting serious losses on all classes.

The movement in favour of a new order was led by Jamal ed-Din, an agitator who gained considerable influence in Turkey and Persia during the last years of Nasr ed-Din. He was rather a Pan-Islamist than a constitutionalist (see PANISLAMISM), and vehemently denounced the corruption of the Persian vizier. Another moving spirit was Prince Malkom, a clever Armenian with a French education. He was the Persian minister in London and while holding this post quarrelled with the vizier over a lottery which the shah had sold to him but which the vizier wished to cancel. Prince Malkom published a paper in which he advocated a parliament for Persia, while he never ceased to denounce his enemy the vizier.

The weakening of the power of the shah encouraged the reformers, and in 1905 a definite movement began in favour of a constitution. It began with a protest against the vizier, who was held responsible for the costly journeys of the shah, for the corrupt government and for the disorder in the country. A number of merchants followed a time-honoured custom and took bast or sanctuary at a mosque in the capital, where they were joined by some mullahs. Driven from the mosque by orders of the vizier, they proceeded to the shrine of Shah Abdul Azim outside Tehran, where their numbers rapidly increased. In vain the shah intervened by sending his favourite to induce them to disperse. Finally the shah was obliged to dismiss the obnoxious vizier and to promise to convene an adalatkhana or "house of justice" — it is to be noted that there was no demand for a constitution at this juncture. Upon receiving the royal promise, the *bastis* returned to their homes and the shah took no steps to convene a house of justice. In 1906 the shah had a paralytic stroke and the vizier decided to take strong measures against the reformers. This led to the second Dart, which ended in the departure of the mujtahids or "doctors of the Divine Law" to Qum and the threat that they would lay the land under an interdict. Simultaneously thousands of citizens took *bast* at the British legation and declined to leave it until a national assembly had been granted by the dying shah. This was, at length, conceded by Muzaffar ed-Din, who opened the assembly in Oct. 1906 and died shortly afterward.

The Revolution. — Mohammed Ali, who succeeded his father, was an oriental despot of the worst type. He attempted to blind the reformers by twice pledging himself to adhere to the new constitution. However, he had no intention of keeping his solemn promises, for he resented any infringement of his absolute power to dispose of the revenues of Persia for his own purposes. The able vizier of Nasr ed-Din was recalled to office with secret instructions to overthrow the constitution. He set to work to gain the consent of the majority of the majlis, or national assembly, for the raising of a loan, for the shah had found the treasury empty and could not buy partisans without money. It seemed as if the vizier was achieving his purpose when he was assassinated. This act was glorified and the 40th day after the suicide of the assassin was observed as a national holiday. Public opinion forced the shah to appoint Nasir al-Mulk, who had been educated at Oxford, to be his vizier. This honest statesman realized that it was essential to restore the finances of Persia, but before he could carry through any of his reforms the shah, who had collected gangs of ruffians, called out his forces with the intention of closing the obnoxious *majlis* and of arresting its leaders. But he suddenly hesitated and stayed his hand. The majlis thereupon collected armed volunteers and sent telegrams to the provinces asking for support, which evoked a wave of enthusiasm.

The shah yielded to the popular feeling and sent a Koran to the assembly sealed with an oath that he would observe the constitution. This is the most solemn form of oath in Persia. Six months later, the shah bombarded the building in which the majlis sat, arresting some of the leaders and regaining control of the government for the time being. The answer to this outrage was a rising at Tabriz. In vain the shah dispatched troops to crush the rebellion. They merely blockaded the city, and in the spring of 1909 the Russians broke up the blockade in the interest of Russian subjects. The defense of Tabriz gave time for national forces to be organized at Resht and Isfahan. These forces combined and entered Tehran, whereupon the shah, who was in camp a few miles from the capital, fled and took refuge in the Russian legation. He was deposed by the victors and left Persia.

Thus, with little loss of life, the Persian revolution was successfully accomplished.

Anglo-Russian Agreement, 1907. — For a century there had been keen rivalry in Asia between Great Britain and Russia. The military party in Russia, which desired to approach ever nearer to India, was averse to any settlement with Great Britain, but the disasters of the war with Japan had a chastening effect. Moreover, both Russia and Great Britain were becoming alarmed at the growing might of Germany. Consequently the two powers concluded an agreement which was designed to settle all differences between them in regard to Tibet, Afghanistan and Persia. Here reference mill be made to the agreement only so far as it affected Persia. It began with a solemn declaration to respect the "strict independence and integrity of Persia," and then stipulated that each state bind itself to seek no concession of any kind in regions conterminous to the frontier of the other. To avoid misunderstandings, the commercial spheres were then defined. That of Russia included northern and central Persia, while Great Britain merely reserved the deserts of southeast Persia. It was a mistake not to have included the whole of south Persia, as there alone would commercial concessions be sought, and leaving it neutral was certain to lead to trouble. This was pointed out at the time, and the subsequent enormous development in oil proved that this view was correct. Persia naturally disliked the agreement. It had based its policy on the rivalry of its two neighbours and viewed with dismay the new order, by which, in its opinion, the two powers had agreed to dismember Persia. But the country was not in a position to protest against this threat of encroachment. It was soon clear that Russian officials considered that northern Persia had been made over to them and, when World War I broke out, they were gradually annexing it. The agreement was annulled both

by Great Britain and by Russia after the conclusion of World War I. (P.M. S.; A. U. P.; L. Lo.)

HISTORY OF THE PERIOD 1909–52

Constitutional Government. — The 35 years following 1909 were epoch-making in the history and evolution of Persia, and may be said to have begun with the accession of the boy king Sultan Ahmad Shah and the re-establishment of constitutional government.

The first cabinet of the new government included two patrician heroes of the revolution, the Sipahdar (to be known later as Sipah Salar) as prime minister and the veteran Bakhtiari chief Sardar Asad as minister of the interior; but they soon found themselves mere figureheads in the hands of the more extreme elements among the late revolutionaries, whose aim seemed to be to control the government without sharing its responsibilities. In these circumstances it was not long before the two ministers resigned their portfolios and took their seats in the *majlis* as ordinary deputies, a new cabinet being formed under the presidency of a well-known figure in Persian politics, Mustaufi al-Mamalik, with a sprinkling of the most able of the Young Persian element. Nevertheless, the first year of the revived constitution was marked by a continuation of cabinet crises and by the division of the *majlis* into a number of conflicting factions.

After the nationalist occupation of Tehran, Ephraim Khan, the military leader of the revolutionaries, promptly organized a vigorous police administration which gave the city immunity from those disorders which are so often experienced in such cases, and the lives and properties of foreigners were in no way molested. Nevertheless, on the plea that special measures were needed for the protection of their nationals, Russian troops were dispatched to Kazvin, and having succeeded in effecting a temporary occupation, they refused to withdraw, despite the earnest remonstrances of Great Britain, which advocated a policy of nonintervention in accordance with the spirit of the 1907 convention. The lack of administrative experience on the part of the personnel of the new regime soon made it apparent that the departments of the government could not be effectively reorganized without the assistance of foreign advisers, and when the subject came up for specific discussion Great Britain and Russia required that nationals of one or more of the minor powers should be engaged, failing which they must press for the appointment of their own nationals.

The deliberations in this connection extended into the new year (1911), and eventually it was decided that the United States should be engaged for the supervision of finances and Sweden for police and gendarmery. Action was taken accordingly, and in due course, in the following May, a U.S. citizen, Morgan Shuster, was engaged to serve as treasurer general for a period of three years, with a staff of four assistants, for the supervision, collection and disbursement of the revenues of Persia.

Hardly had they begun to work when, on June 17, the recently deposed Mohammed Ali Shah unexpectedly landed at Gumesh Tepe on the Caspian, bent on an attempt to recover the throne; while at the same time his brother, Salar ed-Dowleh, making a sudden appearance in Kurdistan, there too raised the standard of revolt, ostensibly on his brother's behalf. At first the menace to the capital from these two directions was undeniably serious, but the former shah's effort was conducted with that incapacity and indecision which had distinguished all his activities, and ended in a complete fiasco. The credit for this result was mainly attributable to the redoubtable Ephraim Khan and to Shuster's financial reforms which supplied his resources.

Meanwhile Shuster's financial plans had brought him into conflict with Russian interests. Finally the confiscation of the estates of the former shah's brother Shua as-Saltaneh (who, it was claimed, was in debt to the Russian bank) for the part he had played in his brother's abortive exploit was held to afford sufficient grounds for the presentation of an ultimatum to the Persian government, in which were included demands for an indemnity and for the dismissal of Shuster, failing which, it was announced, there would be an advance of Russian troops on Tehran. Great Britain made diplomatic protests at Tehran but they were of no avail and Russia persisted in its demands.

Relations With Russia and Great Britain. — National feeling was outraged by the abominations committed by the Russians at Tabriz, which were in the worst of the tsarist traditions. The independence, the very life of the nation, seemed at stake. Russian goods were boycotted (British goods also, in the south), and in a dramatic meeting the *majlis* refused to sanction compliance with the ultimatum. In view of the aggression of the Russians it was for many members an act of heroism and patriotism. Approximately 4,000 Russian troops at Kazvin and 2,000 more at Mazanderan threatened the capital, where Russian bribery and intrigue were already at work. An unprecedented demonstration by patriotic women of Tehran held the *majlis* firm to its decision. In the face of imminent disaster, the regent, Nasir al-Mulk, with the co-operation of the cabinet (which should have resigned on a vote of no confidence), effected a coup d'état on Dec. 24, dissolved the *majlis* and notified the Russians of compliance. The contracts with Shuster and his colleagues were terminated and Shuster left the country on Jan. 11, 1912. Affairs at the capital and throughout the country were in great confusion. Financial administration was carried on as well as could be in the circumstances by the Belgian customs administration, but no constructive improvement was possible.

British official consent to Russian policies, the ousting of Shuster and the defeat of Persia's hope for reorganization and a new era aroused resentment not only in the U.S. but in liberal circles in Britain and elsewhere. Though not denying the honesty, energy and ability of Shuster or the promising results he was accomplishing, the British government reported him as tactless and diplomatically inexperienced, but after World War I offered a more substantial justification for British policy in seeming to connive at the destruction of Persia's independence. Sir Edward Grey, the foreign minister, and the cabinet as well, were deeply anxious over the impending threat of Germany to world peace, and were convinced that there was little hope of successful resistance without a *rapprochement* with Russia and that such a vast stake excused compromise and injustice.

On the conclusion of the war, Persia was admitted as an original member of the League of Nations.

The British government negotiated a treaty with the cabinet of Vosuq ed-Dauleh on Aug. 19, 1919, using strong and unconventional pressure. The sum of $750,000 was somewhat irregularly advanced to three members of the cabinet to cover certain undesignated expenses. This treaty categorically reaffirmed the integrity and independence of Persia. But the subsequent provisions of the treaty were not consistent with this declaration and mould have reduced Persia to the status of a protectorate. They provided for British advisers, military and civil, to the Persian government, a substantial loan from Great Britain, co-operation with the British government for the improvement of communications (a provision that had in view the construction of a Persian railroad by British firms), and the revision of customs tariffs. Public opinion, educated by the Russian-British pressure for the defeat of the Shuster mission, rallied swiftly and brought irresistible pressure on the *majlis* to refuse ratification.

The Soviet Union, which already had been recognized by Persia, saw its opportunity of gaining Persian friendship and demonstrating the sincerity of its rejection of imperialistic policies by negotiating a treaty (initialled Jan. 16, 1921). This treaty renounced the old tsarist policy of force and aggression and guaranteed nonintervention in the affairs of Persia. All treaties that had been concluded between the tsarist regime and other powers in regard to Persia were denounced, a provision aimed especially at the Anglo-Russian convention of 1907. All concessions that had been granted to the Russian government or Russian subjects were cancelled. All loans and debts were likewise cancelled, and a cash balance in excess of $2,000,000 in the Imperial Bank of Russia was given to Persia. Railways, roads, ports and docks formerly Russian concessions reverted to Persia, the extraterritorial rights of Soviet citizens were abolished and Persians were allowed to have ships in the Caspian sea. It was expressly stipulated that none of the property returned to Persia could be alienated to any

other power. Meanwhile, the weakness and corruption of the cabinet and the irresponsibility and incompetence of the young shah stirred patriotic nationalists to hope and work for a drastic change. Saiyid Zia ad-Din, editor of an influential newspaper, the *Rad*, established contact with Riza Khan, then in command of the Cossack brigade. With 4,000 troops Riza Khan then marched on the capital from Kazvin, cutting communications as he went, and arrived in Tehran in the early morning of Feb. 22, 1921. The state offices were occupied and the government was taken over with hardly a shot. A new government was set up with Zia ad-Din as premier, but the real power resided in Riza Khan and Zia ad-Din a few months later retired to voluntary exile in Switzerland, where he remained until 1943 when he returned to Persia.

Four days after the coup d'état, the treaty with Russia was signed, and on the same day the Anglo-Persian treaty of 1919 was denounced and Persia started on a new regime — the regime of Riza Shah Pahlavi (*q.v.*).

Accession and Reforms of Riza Shah. — On the retirement of Zia ad-Din on April 3, 1921, Riza Khan, although officially only minister of war, actually controlled the government. He appointed Qavam as-Saltaneh prime minister. Almost his first task was to build up a dependable and efficient army. As this was impossible without regular pay, he insisted that certain branches of the ministry of finance be placed under his control as minister of war. He gradually converted the miscellaneous contingents into a disciplined force of 40,000 men, and then concentrated his efforts on the subjugation of the distant and semidependent tribes. His phenomenal success in this was soon reflected in the increased measure of security prevailing in the provinces and in the growth of the national revenues. In 1922, as the result of negotiations with the U.S. government, a strong financial mission arrived from the U.S. under the leadership of A. C. Millspaugh with the aim of reforming Persian finances.

In Oct. 1923 the shah left for Paris. Riza Khan appointed himself prime minister and summoned the *majlis*.

Late in 1924 Riza Khan reduced to submission Sheikh Khaz'al Khan, the semi-independent chief of Mohammerah (Khorramshahr), who had for years been greatly favoured by the British. On April 19, 1925, the sheikh was arrested by Persian troops and forthwith removed to Tehran, where he was detained as a political prisoner. He died in 1934.

In Feb. 1925 Riza Khan demanded from the *majlis* the grant of definite and comprehensive military powers withdrawable only by a vote of that body. His request having been granted, he became completely independent of the shah's authority, and six months later he formally asked for the crown of Persia. The change of ruler and dynasty was quietly effected, the deposition of the absent Sultan Ahmad Shah being executed by a simple declaration of the *majlis* on Oct. 31, 1925. A constituent assembly was then convened, which proceeded to elect Riza Khan Pahlavi shah of Persia, with right of succession to his heirs. On Dec. 15 the new shah took the oath to defend the constitution, and the following day he was publicly proclaimed amid much popular enthusiasm. A few weeks later his eldest son, Shahpur Mohammed Riza, was appointed crown prince. On April 25, 1926, the coronation took place.

The contracts of the members of Millspaugh's financial mission expired in Aug. 1927 and were not renewed. After a short interregnum, during which the financial administration was carried on by the Belgian customs staff, a German financial expert, Kurt Lindenblatt, was appointed (April 1928) to succeed Millspaugh, but with much reduced powers.

Following the example of Turkey and Afghanistan, in 1927 the shah gave notice to the powers concerned of his intended denunciation of all treaties in which extraterritorial rights (capitulations) were conferred. The abolition was formally put into effect on May 28, 1928. After difficult negotiations extending over several months, an agreement was reached in Nov. 1928 for the establishment of bases in Persian territory for the Imperial Airways service to India. At the League of Nations in Sept. 1928 Persia was elected to the council of the League. In 1929 Persia recognized the new state of Iraq.

During the period 1929–35, Persia's relations with foreign powers improved. Better relations with the U.S.S.R. were celebrated by a magnificent exhibition of Persian art in Leningrad and an International Congress for Iranian Art and Archaeology at the same time. The Anglo-Persian Oil company's D'Arcy concession of 1901, cancelled in 1932, was replaced by a new agreement in 1933 after reference to the League of Nations. The presence of British coaling stations at Basidu and Hanjam led to some friction, until these were removed in 1935 to the Bahrein Islands.

In Persia itself, Riza Shah, using his well-trained army with courage and ability, effectively subjugated and disarmed the tribesmen, a feat that was entirely beyond the power of the previous dynasty. More than this, the Kashgais and Bakhtiaris were put under the rule of military officers and their chiefs were either put in prison or accepted subordinate positions. The same policy was pursued with the smaller tribes. As the tribesmen were prevented from robbery, security of the roads was established. Nomadism was suppressed; transition to fixed habitations was sometimes cruelly enforced, but was later mitigated by generous allotments of land, houses and other facilities. The mullahs, like the nomad chiefs, lost their power for evil. Persia was really under military government.

The shah realized the importance of communications, and steady progress was made in road building under U.S. engineers. Even the poor began to travel, with the result that a wider outlook grew up. The postal services were radically improved, and the Junkers company inaugurated a regular service between Tehran and Baku, Baghdad, Shiraz and Meshed. Radio stations were also established and were available for public use. The construction of a railway line from the Caspian to the Persian gulf was eagerly desired by the progressive shah, whose enthusiasm infected the entire nation. U.S. engineers examined the various routes: and in the autumn of 1927 the shah inaugurated this great undertaking, which was carried out under tender by European and Persian contractors, with Italian and native labour, under the supervision of the Consortium Kampsax, a Swedo-Danish syndicate which took over the work in 1933. Of equal importance for the country was industrialization: textile, cement, sugar beet and other factories were established in various parts of the country. Many of them soon showed a profit and contributed to economic stability and a rising standard of living. Education was substantially reformed and improved and the proportion of literacy steadily rose. To the staff of the University of Tehran were united European experts of good standing. Medicine and hygiene showed a marked advance. The judiciary was remodelled along French lines. Civil offices were opened for marriages. Here, as in other reforms, the policy of Turkey was influential. Women were unveiled by a sudden and effective decree in 1935.

(P. Z. C.; A. T. W.; A. U. P.; L. Lo.)

Foreign Relations, 1938–41. — Persia viewed the onset of World War II with deep anxiety. Having suffered from the invasion of three armies — Turkish, Russian and British — in World War I, the country unanimously resolved to keep clear of all entanglements.

As late as 1939 the sympathies of the people were almost entirely with the Allies. The shah himself and some army officers, however, tended to favour Germany and Italy, partly because of the almost constitutional distrust of the U.S.S.R. and Great Britain and also because they were contemptuous of the timidity and confusion in Allied councils which culminated in the Munich agreement. The shah, resolute and forthright in all things, believing in swift, implacable decisions, was impressed by these same qualities in Mussolini and Hitler. German propaganda, moreover, was well organized, well financed, skilful and unscrupulous.

The U.S.S.R.'s accommodation with Germany, the indecision and ambiguity of Allied plans and the disastrous defeat of France convinced the shah, his officers and gradually the people that the democracies were doomed. The Germans meanwhile laid their plans well for their new *Drang nach Osten*, aiming at the Persian gulf and India.

Since 1935 Germany had held third place in Persian foreign trade, and by 1938 it had begun to make strenuous efforts not only to enlarge this trade but also to secure a dominant role in Persia's

internal economic development. Despite the memory of unethical procedures in the German part of the railway construction, and even more of the corruption and mismanagement by German officials of the National bank, the Germans were able by propaganda and infiltration to secure a commanding position in Persia. Within one year they tripled their exports of iron, urgently needed in Persia, and supplied textile machinery, radio equipment, military supplies (artillery and transport), agricultural machinery and other heavy industrial products; they built chemical, glass and hardware factories and provided first-class specialists at uneconomic rates to maintain technical services. Propaganda films were made available without payment, and generous contributions were given to charities. After the Allies occupied Syria and Iraq, Tehran became a centre for German intrigue for the whole near east, and the German legation was, according to Nazi custom, heavily overstaffed.

Much of this economic penetration was legitimate and in Persia's own interest, no different from what the U.S.S.R.. more naturally situated, had already accomplished; but much of it was part of the Nazi plans for world domination.

Made apprehensive by treachery to the Allied cause in both Syria and Iraq, and alarmed by the German advance against the U.S.S.R. with its threat to the Caucasus and ultimately Persia, the British and Soviets decided in 1941 that they could take no chances. Negotiations ineptly conducted through the Persian foreign office instead of by direct conversations with the shah, and the exaggeration in formal Allied communications of the number of German propagandists in Persia, created an overbold resistance on the part of the shah, and it was felt that his attempts to deny or dally with the problem could no longer be tolerated in view of the oncoming peril. That this threatened disaster quite as much to Persia as to the Allies, the Persians insufficiently understood.

The U.S.S.R. had reasonable justification for action under the terms of its treaty with Persia of 1921, which provided, on the one hand, that the U.S.S.R. should defend Persia from any invasion from the north, such as the Germans obviously contemplated, and on the other authorized the Russians to press for the expulsion from Persia of any foreign officials who were engaged in any action hostile to the U.S.S.R.; it even permitted the use of Persian territory to repel any invasion that might come from the south. The Soviets, acting under these provisions, and the British, under the necessity of self-preservation, simultaneously descended on Persia in Aug. 1941.

Foreign Occupation.——In a few hours British naval vessels had overcome the resistance of a few Persian coastal craft, an expeditionary force was landed in the gulf and another came up from Iraq through Kermanshah, rushing north to meet the oncoming Soviets south of Kazvin. The occupational zones were carefully delimited, the U.S.S.R. being responsible for the northern provinces, Azerbaijan, Gilan and Mazanderan and Great Britain for the rest.

The immediate consequence of this joint action by Great Britain and the U.S.S.R. was the abdication of Riza Shah in favour of his eldest son, Mohammed Riza, a young man of 22 who had been educated in Europe. The former shah was sent first to Mauritius and later to South Africa, where he died in July 1944.

The new shah immediately announced his intention of ruling as a constitutional monarch, which he described as "the best way," although it is now agreed that the first 12 years of his father's reign had provided the energy, discipline and control which had been essential for the renaissance of Persia. The transition to a fully democratic regime, which had been insufficiently prepared for, mas inevitably difficult, and there was much political rivalry and manoeuvring in Tehran.

On Jan. 29, 1942, Great Britain, the U.S.S.R. and Persia concluded a treaty of alliance, whereby the first two powers undertook to respect Persia's territorial integrity and sovereignty and to evacuate their forces within six months of the conclusion of hostilities with Germany and its allies. In Sept. 1943 Persia declared war on the Axis powers.

The trans-Persian railway proved to be of inestimable benefit to the Allies, who greatly increased its usefulness and capacity by constructing docks and supply centres in the south, building a branch line from Ahwaz to the port of Khorramshahr (Mohammerah) and importing many locomotives and additional rolling stock. The road system was also much improved. The result was that vast quantities of urgently needed war material were soon pouring across Persia to the U.S.S.R. The operations of the Anglo-Iranian Oil company in southern Persia were also of immense importance to the Allied cause, as they made available large supplies of aviation and motor gasoline, fuel oil and other products.

Although it was technically not an occupation, the presence of British and Soviet troops on Persian soil was most distressing to the inhabitants, who saw in it a physical renewal of the ancient threat of Great Britain and Russia to partition the country between them. A bad harvest and the diversion of transport facilities for Allied military purposes led to a serious food shortage in many parts of Persia in the minter of 1942–43. The situation was aggravated by the refusal of the U.S.S.R. to allow grain and rice to be sent from Azerbaijan to the other provinces in order to relieve conditions there. The spending by the Allied powers in Persia produced greatly increased income, especially in the middle and working classes; the cessation of importation resulted in the scarcity of certain consumer goods. The combination of these three factors led to destructive inflation, threatened the stability of the currency and multiplied the sufferings of the country. The price of food and other essential commodities soared in some instances to more than ten times their prewar levels.

At this juncture the young shah and Hussein Ala, the minister of court, as well as veteran liberals such as Furughi and Taqizadeh who had done much to create the modem Persia, turned to the United States. The Persian people, fearing both the Soviet Union and Great Britain, felt that the U.S. had no political axes to grind and had on occasion in the past rendered friendly and disinterested services. On the recommendation of the U.S. state department, A. C. Millspaugh was appointed treasurer general with wide powers, and Col. Norman Schwartzkopf was appointed to reorganize and direct the gendarmery. About 90 other U.S. experts in finance, agriculture, transport and other services were also employed.

Recovery was slow and necessarily took the disagreeable route of high taxation. Friction developed and was not helped by the sensational growth of a free press, for, released from the restraints of the former press law and government censorship, 40 to 50 new journals sprang up. Many were single sheets. improperly financed and run without experience, of small circulation and brief duration, but they added their quota to the confused situation.

In the meantime the U.S.S.R. had been strengthening its influence in the north. Rumours that it intended to secure a preponderant position there as well as direct access to the Persian gulf led the Soviet government to give repeatedly categorical assurances that it had no designs on Persian territory, a pledge that was reaffirmed and, moreover, jointly underwritten by both Great Britain and the U.S. at the Tehran conference, where, on Dec. 1, 1943, Winston Churchill, Franklin D. Roosevelt and Joseph Stalin jointly signed the declaration recognizing the territorial integrity, independence and sovereignty of Persia.

Notwithstanding this declaration, the U.S.S.R. continued to extend its influence in the north, supporting the left-wing Tudeh party and fostering the separatist tendencies of certain minority elements. In Sept. 1944 the Soviet government suddenly demanded an exclusive oil concession covering the northern provinces and applied such pressure that the prime minister, Mohammed Sa'id Maraghei, was forced to resign. This brusque behaviour produced a remarkable reaction in Persia, and the *majlis* passed a bill tabled by Mohammed Mossadegh (who was then a comparatively unknown deputy) forbidding the granting of oil concessions to any foreign interests during the war.

Postwar Developments.—When the war was over, Great Britain and the U.S. duly withdrew their forces from Persia though the U.S. had not been a party to the 1942 treaty. The U.S.S.R., on the other hand, disregarded its obligations and at first refused to evacuate the northern provinces. When the Soviet army finally withdrew it left behind agents who, late in 1945, started a move-

ment to make Azerbaijan secede from Persia and join the U.S.S.R. A puppet "democrat" regime was set up and carefully manipulated elections were held. In Dec. 1946, despite Soviet protests and threats, Ghavam-es-Saltaneh, the Persian prime minister, sent a force into Azerbaijan which overthrew this regime and restored Persian authority. Earlier that year, during a visit to Moscow, Ghavam had been forced to sign an agreement with the Soviet government to establish a joint Perso-Soviet company to exploit oil in northern Persia. This agreement proved so unpopular in Persia that in Oct. 1947 the *majlis* declared it null and void.

Late in 1948 the Anglo-Iranian Oil company (A.I.O.C.) and the Persian government opened negotiations for revising, in the latter's favour, the terms of the company's 1933 agreement, and a supplemental agreement was signed in July 1949 which increased the basic royalty rate and included other substantial financial advantages for Persia. The supplemental agreement was to come into force on ratification by the *majlis*. Later in 1949 the *majlis* passed an act implementing the seven-year plan, an ambitious project for raising the standard of living of the Persian people, to be financed largely by means of the A.I.O.C.'s royalties. Unfortunately the plan soon became moribund through the diversion into other channels of much of the money allocated to it, mismanagement and, finally, the cessation of royalty payments in 1951 because of the Anglo-Persian oil dispute.

Because of opposition by Mohammad Mossadegh, the bill to ratify the supplemental agreement was withdrawn from the *majlis* in Dec. 1950. When in Feb. 1951 the A.I.O.C. offered to conclude a 50-50 profit-sharing agreement, the campaign for the nationalization of the Persian oil industry was in full swing; this campaign coincided with a wave of intense nationalism in Persia. Gen. Ali Razmara, the prime minister. on being asked whether nationalization of the oil industry was practicable, consulted his experts who reported against it. On March 7, 1951, four days after he had submitted their reports to the *majlis,* he was assassinated.

Mossadegh became prime minister on April 30; three days later the act for the nationalization of the oil industry was passed by parliament and received the shah's assent. Protests by the A.I.O.C. and the British government proved unavailing, and no compromise could be reached. The A.I.O.C., after closing the oil fields and the Abadan refinery, was forced to withdraw its British staff from Persia in Oct. 1951. A subsequent offer by Pres. Harry S. Truman and Winston Churchill to resolve the deadlock was rejected (Aug. 1952), and on Oct. 22 the Persian government formally broke off diplomatic relations with Great Britain.

From April 1953 onward there was an open and often violent struggle for power rallying increasingly round General Fazlollah Zahedi, former minister of the interior in the Razmara and Mossadegh cabinets. His supporters accused the government of collusion with the Communist-led Tudeh party and the Soviet government. With considerable hesitation the shah signed a decree appointing Zahedi prime minister in place of Mossadegh. An attempt to arrest Mossadegh failed on Aug. 15 and for three days he appeared irresistible, while the Tudeh party openly demonstrated against the shah and in favour of a republic. The shah fled to Rome and Zahedi went into hiding. On Aug. 19 came another reversal, precipitated by mob action supported by the army. Mossadegh was overthrown and arrested, Zahedi took office and on Aug. 22 the shah returned to a frenzied welcome in Tehran. The coup was plainly welcomed by the western powers and sharply criticized by the U.S.S.R. The United States speedily answered Zahedi's appeal for funds with a first instalment of $45,000,000.

Zahedi's two most difficult decisions were to put Mossadegh on trial and to renew diplomatic relations with Great Britain. Charges of high treason were announced against the former premier who on Dec. 21 mas sentenced to three years' solitary confinement. By an ironical coincidence, the first members of the new British embassy reached Tehran on the same day.

In April 1954 a group of eight oil companies opened negotiations with Persia on the oil dispute and on Sept. 19 an agreement was signed at Tehran between Persia and an international oil consortium which included A.I.O.C. with a 40% interest. Despite Communist attempts to prevent it, the agreement was ratified by the parliament and received the shah's assent. The principal terms were that Persia should obtain 50% profit on all Persian oil exported: should pay the A.I.O.C. £25,000,000 in compensation over 10 years from 1957, free of interest; and that the agreement should stand for 25 years. At the option of the consortium it could be renewed under certain conditions for three periods of five years each.

This initiated a policy of increasing economic and political cooperation with the countries outside the Soviet bloc. Thus, Persia signed a commercial treaty with India in Dec. 1954, made contracts with British, French, West German, U.S., Danish and Belgian firms, signed a treaty of friendship with the Gnited States (Aug. 1955) and in Nov. 1955 defied Soviet protests by joining the Baghdad pact. Relations with the Soviet Union continued cordial. however: long-standing negotiations between the two countries reached a satisfactory conclusion in Dec. 1954 when the U.S.S.R. agreed to pay its war debt to Persia and to allow the mapping of the Persian-Soviet frontier (finally completed in April 1957).

Internally, affairs continued unsettled. In April 1955, Zahedi was replaced by Hussein Ala. A new aid agreement was signed with the United Nations in Feb. 1956. In April 1957 Hussein Ala was succeeded by Manouchehr Eghbal, a personal friend of the shah. Eghbal issued a decree ending martial law, which had been in force for 16 years, and declared his intention of encouraging a free press and free speech, of establishing a democratic two-party system and of allowing the formation of new political parties, except by Communists. In May the formation of a new People's party was announced: its leader was Assadollah Alam, former minister of labour.

(A. U. P.; L. Lo.)

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POPULATION

Racial Divisions.—In 1935 the name "Iran" was officially adopted for the country known as Persia for many hundreds of years, the intention of the shah being to stress the Indo-European origin of the inhabitants whose forebears had entered it from the central Asian steppes in the 2nd millennium B.C. Rut the people who are generally known as Persians are themselves of mixed and various race, and the country has important Turkish, Baluchi and Arab elements in addition to Kurds and Lurs, and minority communities of Armenians. Assyrians (Nestorian Christians), Georgians, Dravidian Brahuis and Afghan Hazaras of Mongolian origin.

Kurdish nationalism (embracing the Kurds of Turkey, Iraq, Syria and Persia) received some encouragement from the British after World War I and, persisting as an intellectual movement, later flared up in local revolt in Persia as elsewhere; the separatist tendencies of the Turkic people of the Azerbaijan province received Russian encouragement to rebel in 1945–46; and signs of hostility toward the Persian government have been shown by the Arabs of Khuzistan. But, generally speaking, there is little racial animosity and these outbreaks have usually been somewhat artificial if considered as expressions of racial consciousness. The great preponderance of Shi'ah Islam and the way of life prescribed by it form unifying factors transcending racial differences and the differences between tribesman, peasant and townsman and between the six estates—ulema (the learned), nobles, landowners, merchants, citizens and peasants—into which Persian society was traditionally divided. The religious minorities—Christian, Jewish and Zoroastrian—are too small to create a problem, but discrimination against them is by no means unknown.

The Kurdish tribes living on the northwestern borders from Urmia in the north to the plains of Kermanshah are nomadic, and until such movement was forbidden by Riza Shah some crossed into Iraq on their annual migration after the melting of the snows in search of fresh grazing for their flocks. The organization which such moves demand has kept alive the tribal system under the chiefs (agas), but mountain conditions have led to the breakup of the larger tribal units and there is little cohesion now among them. Among the settled Kurds the tribal system remains in

existence but the authority of the agas is usually less than among the nomads. The Lurs of the Pish-i-Kuh and Pusht-i-Kuh ranges on the western frontier south of Kermanshah were almost independent of the government under their own valis until Riza Shah brought them under control: he deported some sections to Khurasan. Their life resembles that of their northern Kurdish neighbours. The Rakhtiari, a large tribe of the southern Zagros, are akin to the Lurs. Their main divisions are the Haft Lang, mainly nomadic. and the Chahar Lang, mainly sedentary. The name "Bakhtiari" is properly confined to the ruling families and their retainers. The chiefs are among the most advanced among the tribes of Persia: in 1906 they took a leading part in the revolution which led to the grant of the constitution. They have latterly shown a keen business sense and for many years have been educated in Europe, and their daughters have received at least an elementary education. The women among the Kurds. Lurs and Bakhtiaris have considerably more freedom than do the women in the smaller towns and villages. They do not wear the veil and are not secluded from male company. In Rurdistan there is even a tradition of matriarchy. and tribes have been very successfully ruled by women. The Kashgai. a large tribe of Turkic origin. are neighhours of the Bakhtiari. with summer quarters extending over the highlands between Shiraz and Isfahan. In winter their flocks are found in the lowlands northwest and east of Shiraz. Riza Shah attempted the subjugation of the Kashgai but they soon reasserted themselves after his abdication.

A revolt of the tribe in 1946. when the leaders demanded autonomy on the pattern of that which the Azerbaijanis were expecting, was quelled. but the tribe remains an important political force.

The southern region of Rhuzistan (or Arabistan) is more akin to the delta lands of southern Iraq both in physical geography and in population. Some Lurs visit the northern fringes for winter pasture but the majority of the population is Arab and tribal, sedentary. seminomadic and nomadic. The principal tribes are the Al Kathir and the Bani Lam. who have a large branch in eastern Iraq, on the Tigris north of Amara. The sedentary and seminomadic tribesmen rear horned cattle and cultivate cereals or rice. Some also keep sheep or camels and own or work in date gardens.

In Khurasan bordering on the C.S.S.R. are the Turkmen tribes, and also some Kurdish and Baluchi tribes. There are few nomads since conditions are favourable for agriculture, and the tribal structure. though persisting, is gradually being replaced by that of the village community. Throughout the country there are many smaller tribal groups of varying racial origin. owing their present location to voluntary migration or to expulsion from an earlier home. They thus present a picture as confused as that of the detribalized elements of various racial origin among whom homogeneous blocks are even more rarely to be found. An exception is the Turkic community of Azerbaijan which has been settled for many centuries in more or less compact groups in the towns and villages of this province.

Whatever may have been the original population of Persia before the coming of the Aryan invaders. it was absorbed by them and by subsequent waves of conquering tribes whose blood has been mixed with that of the people of the plateau to a much greater extent than with that of the mountain tribes. Thus. among the Persian-speaking people there persists a widespread physical type on the border of the medium- and long-headed classifications for which the term "Iranian" has been reserved by some writers. Distinct from them are the short-headed Kurds, and the Lurs and Bakhtiaris, the Turki and Baluchis and the people found in southern Fars and Makran who speak a language of the Dravidian family.

Persian Society. — The basic industry of Persia is agriculture, and the life of the shepherd. peasant and landowner, whether tribal or settled, dictates conduct and customs and influences the moral outlook of the country dwellers and. through its impact upon them, that of the townsmen also. A notable feature of Persian society is its fluidity and individuality; though there are recognized classes. transition from one to another is easy; there is no caste system.

The townsmen and villagers as a rule lead a fairly easy life unless the local landowners and officials are especially tyrannous, for it is with them that the power lies upon which their living conditions depend.

The mullahs (priests) have little influence except in religious matters and in their guidance of public opinion. Absentee landlords are many. The towns are commercial rather than industrial and have a large class of shopkeepers and craftsmen — shopkeepers who are found grouped by trades in the bazaar. This pattern is found in all towns and villages, varying only in the wealth of the classes and the size of the community. The peasants and tribesmen live in houses or tents according to the climate of their district and to their way of life, settled or nomadic. The position of women is, on the whole, better in the tribes than in the settled communities. Their situation, too, has suffered from polygamy. easy divorce and *muta*, or temporary marriage. which is tolerated under the Shi'ah interpretation of Koranic law. Much was done under Riza Shah to destroy these old traditions, by permitting women to sue for divorce on certain grounds, by allowing them to hold property and by encouraging female education.

Numbers and Distribution. — In March 1953 the population of Persia was estimated at 20,477,672. Of this total 80% is rural. The largest proportion is found in the province (*ostan*) of Tehran (16.2%). The areas next in order of numbers of population are Gilan and the Elburz foothills to the west of Tehran, Azerbaijan and Khurasan, which however has a large area and thus lower density of population. The most densely populated districts (more than 100 per square mile) are a narrow belt along the Caspian coast; a district in the far northwest to the north of the Lake of Urmia, small areas round Meshed and on the Karun river near the southern oil fields. The principal cities and towns with their populations in round figures are: Tehran (the capital). 600.000 plus 400.000 in the suburbs and vicinity; Tabriz, 270,000; Meshed. 200.000; Isfahan. 200.000; Hamadan, 120,000; Shiraz. 110,000; Resht, 110,000; Kermanshah, 100,000; Qum (with Mahallat), 85,000; Kazvin, 80,000; Ardebil, 80,000; Arak (Sultanabad), 60,000; Kashan, 55,000; Urmia (Rizaiyeh), 50,000; Kerman, 50,000; Ahwaz, 50,000; Yezd. 50,000; Dizful, 48,000; Burujird, 48,000; Zenjan, 40.000; Babul (Barfurush), 40,000; Naragha, 35,000; Bushire, 25,000. The oil port of Abadan with Khorramshahr and the immediate vicinity has a population of 200,000.

Language. — The languages of Persia are: Persian, Kurdish, Luri. Turki. Baluchi and Arabic (see also IRANIAN LANGUAGES).

Persian (Farsi) is an Indo-European language based upon the Old and Middle Persian tongues which were introduced by invaders from the central Asian steppes east of the Caspian. After the conversion of Persia to Islam many Arabic words were introduced and a modified form of the Arabic script was adopted and is still used. In the written language some Arabic constructions also were adopted. There has been a tendency (as in Turkey) to expel Arabic words and forms, but devotion to the early literature. which contains them, hampers such efforts at Persianization. Dialects are spoken in certain parts of the country,

Kurdish is a language distinct from Persian although belonging to the Indo-European group. The principal dialects spoken in Persia are Gorani and that spoken by the Mukri Kurds of the northeastern district.

Luri, the language of Luristan, of the Bakhtiari and of some other tribes, has affinities with Old Persian, to which it is more nearly related than is Kurdish.

Turki.—The Azeri dialect of Turkish spoken in Azerbaijan is grammatically close to Xnatolian Turkish but the pronunciation is broader. It has more Persian and fewer Arabic words than the Turkish of Anatolia. Turkic spoken by the Turkmens of Khurasan is closer to eastern Turkish than to the Azeri dialect.

Baluchi is an Aryan language mixed with modern Persian.

Arabic is spoken by the Arab tribes of Khuzistan and along the coast of the gulf and of Makran, and by some sections of the Khamseh tribes of Fars.

Religion. — The state religion is Shi'ah Islam (see ISLAM) of the Ithna Xsharaya sect which recognizes 12 hereditary Imams.

There is also a Sunni minority. The Zoroastrians (known as gabrs) are relics of the followers of Zoroaster, whose doctrine was founded upon the ancient Mithraic faith; the majority of those who refused to accept Islam in the 7th century A.D. fled to India, where they formed the Parsee community. Jews have been in Persia since the time of the Babylonian captivity., The Christian churches are represented by Nestorians (Assyrians), Armenians (Gregorians and Catholics) and Protestants and Catholics who are Europeans or else converted Assyrians or Armenians.

Moslems.—The Shi'ahs were, in the past, strongly influenced by the mujtahids (doctors of the law), whose edicts affected political and other nonreligious affairs until the revolution of 1906 marked the beginning of a decline in their power. Riza Shah did much during his reign to break their authority, which was, in any case, founded on the superstitious awe of the ignorant rather than on profound religious belief, as the tendency to heterodoxy and agnosticism shows. "A host of heterodox sects born on Persian soil—Shi'ites, Sufis, Isma'ilis, philosophers—arose to vindicate the claim of Aryan thought to be free" (E. G. Browne, *A* Year Amongst the Persians).

Sunnis are found in scattered groups in various parts of Persia. The compact communities are the Kurds, the Baluchis and the Turkomans.

There are also some dissident sects: Sufis, the mystics whose teaching dates back to Abbasid times; the Ismailis, the direct forebears of the modern Ismailis whose head is the Aga Khan, who originated in a schism after the death of the sixth Iman (about A.D. 797) and afterward created the society of the Assassins (*q.v.*); the Ali Ilahis, an extreme sect found among the Kurdish tribes; and the Baha'is, who, in spite of the repression of 1850, still exist in Persia and have played an influential part in the reform movements. The numbers of these sects are small and no reliable statistics are available.

Zoroastrians are a small community (10,000–15,000) living principally in and around Yezd and Kerman. They are both urban and country people, successful as traders and famed as gardeners.

Jews.—In spite of legal equality, the Jews are regarded as foreigners and administrative posts are barred to them, though some have deserted the traditional business of moneylending and trade and have become doctors. Small Jewish communities are to be found in most towns. Some have left Persia for Israel and the total number in Persia in 1953 was about 40,000.

Christians.—The Armenians number about 120,000 and are both rural and urban. Peasants are most numerous in Azerbaijan and the largest town communities are found in Tabnz, Tehran and Isfahan, where the suburb of Julfa is almost exclusively Armenian.

The Assyrians are Nestorians or Uniate Catholics, known as Chaldaeans. Most of them live in the Urmia (Rizaiyeh) region of the northeast and are peasants or small traders, mechanics and motor drivers.

Catholic missionary work was begun early in the 17th century by the Carmelites, was suspended about 1780 but renewed in 1850 when the Lazarists opened a mission in Tabriz. Protestant activity dates from 1811. In 1829 an American mission was established at Urmia and was taken over later by the Presbyterians, who founded missions also in Tehran, Tabriz, Hamadan and Resht. The Church Missionary society began work at Isfahan in 1869. Until the time of Riza Shah the mission schools were tolerated, but the teaching of religion in all schools was forbidden in 1928 and the mission schools were absorbed into the state system. The hospital system was introduced to Persia by missionaries in the 1830s and hospitals, welfare centres and dispensaries continue to do most valuable work. Purely missionary activities meet with almost insuperable difficulties in Persia as in all Moslem countries.

Education.— Until the first reforms were introduced by Nasr ed-Din Shah (*q.v.*) in the middle of the 19th century, education, in the narrower sense, had been centred in the religious schools, the maktabs in the villages and towns and the *madressehs* or religious colleges which gave higher education in theological subjects, law and medicine. But Persia enjoyed the advantage of widespread and popular interest in its literary heritage so that, unlike other Moslem countries of the period, education, in spite of the illiteracy of the majority of the population, was founded not only upon the Koran but also upon the Persian classics, which are still widely known by recitation. In 1852 Nasr ed-Din Shah founded the Dar ul-Funun (College of Science) in Tehran and three years later established a ministry of science and arts, aiming rather to create a teaching body in the first instance than to modernize and extend primary education. A translation bureau was formed in 1862 to translate European works into Persian, and a royal library was founded in 1873, the year of the shah's first visit to Europe. He then decided to send a few young Persians of good family to France for military training at St. Cyr, for engineering at the École Polytechnique and to study law and medicine and modern art. But the development of the modern educational system more properly dates from 1897 when a "society for the establishment of national schools" (afterward known as the Anjuman-i-Ma'aruf, or Education council) was founded. Its efforts resulted in the opening of numerous elementary and secondary schools which with some foreign schools—notably the American Mission college which had been founded in Tehran in 1872, the Anglican Stuart Memorial college founded in Isfahan in 1904 and French Catholic schools—formed the basis upon which subsequent progress was made. The constitution of 1906 emphasized the importance of modern education and the freedom of all to study sciences, arts and crafts and to publish books, provided that religious laws were not transgressed. The establishment of schools at government expense and the regulation of compulsory education were recognized as a national responsibility. In 1911 a law was passed laying down the organization of a ministry of education which. with the Anjuman-i-Ma'aruf, had 128 primary schools, 2 secondary schools and 3 colleges under its supervision. The work of the ministry was considerably extended between 1911 and 1921 but the greatest impetus was given after the accession of Riza Shah in 1925, as Table I shows. After 1950 U.S. aid had a considerable influence in the development of education, particularly in the rural districts. In co-operation with the ministry of education an increase of about 1,600 teachers and 6,400 pupils had been effected by 1954.

TABLE I.—*Growth of* Educational Institutions

Year	Number of institutions			Number of students		
	Primary schools	Secondary schools and junior colleges	University faculties and higher schools	Primary schools	Secondary schools and junior colleges	University faculties and higher schools
1922 .	440	46	1	43,025	9,308	91
1932 .	1,186	156	3	141,103	13,120	692
1942 .	2,401	320	12	244,315	26,812	3,405
1947 .	3,229	314	18	386,266	37,866	6,257
1949 .	3,538	...	...	417,366	...	...
1950 .	8,612	308	...	756,683	44,585	3,624

The control of the educational system is centralized in the ministry of education, which has four directorates general dealing with (1) education proper; (2) administration, staff and finance; (3) fine arts (including painting, archaeology, the national library, museums, etc.) and (4) pious foundations (wakfs). There are in addition secretariats dealing with higher education and the theological sciences, a high education council and other bodies. There are also educational establishments under other ministries: certain technical schools under the ministry of national economy, a trade school under the ministry of labour, and institutes of hygiene under the ministry of health. There are also some private schools under general supervision but free to administer themselves, of which one of the most important was the Technical institute formerly run by the Anglo-Iranian Oil company at Abadan. This was taken over in 1951 by the National Iranian Oil company. Most of the higher technical colleges have been absorbed in the University of Tehran. In 1949 a program was introduced establishing a four-year minimum course for the primary schools; the secondary schools provide a five- or six-year course, the sixth year being specialized and intended to prepare a pupil for entry to a college or to the university. The University of Tehran, with 5,000 students, mas founded in 1934 and has faculties of arts (literature), law (including economics and political science), philoso-

phy and theology, medicine, engineering and science, together with certain colleges of faculty status: the Higher Teachers' Training college (literature and science) and the School of Fine Arts. The University of Tabriz has faculties of medicine and literature.

GOVERNMENT AND ADMINISTRATION

Constitution.—Up to 1906 the shah of Persia was an absolute monarch in the ancient tradition. He delegated wide powers to a grand vizier but was himself absolute in legislative, executive and judicial functions. The clergy (mullahs) exercised considerable temporal as well as spiritual power and played an important part in the events leading to the setting up of a national consultative assembly (majlis) by Muzaffar ed-Din Shah in 1906 and the grant of a formal constitution. Muzaffar died in 1907 and although his successor, Mohammed Ali, signed the constitution in its final form on Oct. 8, 1907, he soon attempted to suppress the majlzs and overthrow the constitution. An attempt on his life in 1908 was followed by a civil war in the provinces, and in 1909 Mohammed Ali Shah abdicated. His son Sultan Ahmad (a child of 12) was crowned shah with the head of the Kajar tribe as regent. A new majlis was elected and the constitution, differing little from that still in force in the early 1950s, was established. Sixteen years later Ahmad Shah was deposed after a precarious and unhappy reign during which the prestige of the government had reached a very low ebb. Riza Khan (see RIZA SHAH PAHLAVI), an officer of the Cossack brigade, led a coup d'état against the government in 1921 and became prime minister himself two years later. Meanwhile his vigorous action as minister of war had restored the authority of the central government and in 1925 he received dictatorial powers from the majlis and secured the deposition of Ahmad Shah. In Dec. 192 j he was elected shah and the sovereignty was vested in the Pahlavi dynasty. He abdicated in Sept. 1941 and was succeeded by his son, Shah Mohammed Riza Pahlavi.

The fundamental laws of the Persian constitution which were promulgated on Dec. 30, 1906, dealt seriatim with the constitution of the *majlis,* or national consultative assembly. the duties of the *majlis,* the proposal of measures on the part of the *majlis* and the conditions regulating the formation of the senate. A supplementary fundamental law was promulgated on Oct. 7, 1907, in which Islam, according to the Shi'ite Ja'fari doctrine, was prescribed as the official religion of Persia, which the shah must profess and foster. The doctors of the theological law (mujtahids) are its guardians and a committee of no fewer than five "mujtahids or other devout theologians." properly elected, may veto any law which infringes Islamic ordinance. This power seems to have remained a dead letter. The right of equality before the law, the guarantee of life. liberty, home and honour; the right to be tried in an appropriate tribunal; the liability only to penalties laid down by the laws; the right of property; the right to freedom of teaching; a free press; freedom of assembly and the secrecy of the post—all were set out at length. The powers of the state derived from the nation are defined as legislative, executive and judicial in such a way as to form a representative constitutional monarchy. The shah derives his power in trust from the people. These powers and those of the ntajlis are defined. The ministers are responsible to the majlis and the senate for all acts carried out in the name of the shah, and the shah's person is exempted from all responsibility. The appointment and dismissal of ministers is effected by royal decree, and it has become the practice, when a new prime minister is required, for the *majlis* to meet and agree on a name for submission to the shah; the shah appoints the person named and the latter selects his ministers for the shah's approval. If the *majlis* or the senate, by an absolute majority, declares itself dissatisfied with the cabinet or with one particular minister, that cabinet or minister shall resign. The number of deputies in the *majlis* was at first 162 but, after changes in 1909 and 1911, it was raised to 200 in 1957. In April 1949 a constituent assembly was formed to examine the draft of two new articles of the constitution, one of which gave the shah the right to dissolve either or both chambers while the other laid down the procedure for future amendments of the constitution of 1906. Under that constitution there was to have been a senate with 60 members, 30 elected and 30 nominated by the shah. No steps were taken, however, to create the senate until 1949, when the majlis passed a bill laying down the procedure for its election. This bill conformed generally to the articles of the fundamental law constituting the senate but stipulated that the internal regulations of the senate were to be approved by the senate itself (not by the majlis) and prescribed a system of two-stage election for the members. The first senate assembled in 1950. Laws may be initiated by the shah, by the cabinet, by the senate or by the majlis. Bills initiated by the cabinet are debated in the *majlis;* those proposed by the majlis are sent to the senate. The shah's signature is necessary before any bills can become law. Only the *majlis* has the right to enact and approve laws connected with revenue and expenditure. The supplementary law of 1907 provided for the establishment of provincial and departmental councils (*anjunmans*) but no steps had been taken to establish them by the mid-1950s. The cabinet comprises a prime minister with, usually, 11 or 12 ministers responsible for the following departments: foreign affairs; finance; interior; health; justice; war; agriculture; posts, telegraphs and telephones; labour; roads; national economy; education.

By 1957 the constitutional parliamentary system had had 50 years of trial in Persia but no truly independent parliament and cabinet had been established and no party system based on political principles had been developed.

From 1925 to 1941 Riza Shah ruled with absolute powers, ignoring the constitutional checks upon them, and all control of affairs passed out of the hands of the majlis. His successor respected the constitution but the amendments of 1957 strengthened his prerogatives.

Administration.— Until 1938 Persia was divided into 26 provinces. In that year a reorganization took place and ten large provinces (ostans) were created. These were divided into districts (*shahristans*). Further adjustments took place in 1946, when the *ostans* of Azerbaijan and Sub-Azerbaijan were merged, and in 1947, when Tehran, the capital of Persia, became an ostan. Baluchistan, with Sistan, continued to form a separate governorate. In 19j5 the administrative divisions were as follows:

Ostan	*Capital*	*Shahristans*
Tehran	Tehran	Tehran, Qum, Mahallat, Kazvin, Saveh, Demavend
Gilan	Resht	Zenjan, Arak, Resht, Fumen, Lahijan, Talesh, Bandar Pahlavi
Mazanderan	Sari	Shahsawar, Kashan, Semnan, Damgar Shahrud, Sari, Amul, Babul, Gurgan (Asterabad), Shahi, Dasht-i-Gurgan, Nanshahr
Azerbaijan	Tabriz	Tabriz, Ahar, Marand, Mianeh, Khalkhal, Ardebil, Maragha, Khoi, Urmia (Rizaiyeh), Mahabad, Maku
Kermanshah	Kermanshah	Eilam, Shahabad, Qasr-i-Shirin, Kermanshah, Sanandaj, Hamadan, Nahavand, Saqqiz, Malayer, Bijar
Khuzistan	Ahwaz	Khurammabad, Burujird, Dizful, Ahwaz, Gulpaigan, Dasht-i-Mishan, Shustar, Khorramshahr, Abadan, Behbehah
Fars	Shiraz	Shiraz, Kazerun, Firuzabad, Bushire, Fasa, Abadeh, Jahrum, Lar
Kerman and Mokran	Kerman	Kerman, Sirjan, Rafsinjan, Bam, Jiruft, Bandar Abbas
Khurasan	Meshed	Sabzavar, Birjand, Turbet-i-Haidari, Kashmir, Meshed, Nishapur, Guchan, Bujnurd, Gonabad, Firdans
Isfahan	Isfahan	Isfahan, Shahrikurd, Shahriza, Yezd, Daran, Nain
Baluchistan	Zahidan	Chahbar, Iranshahr, Sarawan, Zabul, Zahidan

Each ostan is administered by an *ostandar* (governor general), appointed by and directly responsible to the minister of the interior. He is assisted by a staff from other departments — health,

education, etc., appointed by their ministers. The shahristan is governed by a *farmandar;* further subdivisions are the bakhsh, consisting of a number of dehs (villages) and towns. Cities in the larger administrative divisions have their own municipality or town council administration under a mayor appointed by the minister of the interior. The Tehran council has 12 members; the town councils in first-class shahristans have 9 and the others 6. Members, who receive no salary, are elected for two years. Under the mayor they determine the kind and amount of the municipal taxes, study and approve the municipal budget (which must have the final approval of the minister of the interior) and supervise the financial affairs of the town. The administrative system, which is based on the prefectural system of France, is seen to be highly centralized. During the reign of Riza Shah this defect was accentuated and the withdrawal of his strong hand and the confusion inevitable during the period of Allied occupation resulted in a partial paralysis of the administration.

Justice. — Before the constitution of 1906 there existed in Persia two systems of law: the Sharia or Islamic religious law based on the Koran and administered by the clergy, and the common or customary law knoun as *urf,* which governed transactions not specifically covered by the Sharia. although, theoretically. the Islamic law applies to every act of man. (See ISLAMIC LAW.) In addition to these mere royal edicts. The Islamic law gradually became restricted to questions of personal status (marriage, inheritance, etc.), faith and morals. The *urf* represented local custom in matters such as water and grazing rights, landlord-tenant relations, etc The shah's edicts covered public administration, public security and taxation. The fundamental law of 1907 laid down the general principles of criminal and civil procedure. In 1912 a lan was passed setting up a judicial administration modelled upon European standards and in 1914 a system of commercial courts was established. Attempts to enforce these measures and to introduce reformed legal codes were successfully blocked by the action of the mullahs and it was not until Riza Shah came to power that modern systems were enforced The civil code, based upon the Sharia with adaptations from the French code. was adopted in 1928 and absorbed most of the functions of the Islamic law. The penal code, abolishing the principle of the *lex* talionis, was introduced in 1926 and is also based upon French law. The commercial code and the civil and criminal codes of procedure are also based on the French system. The most important change uas the authorization by the *majlis* in 1928 of the articles of the civil code which provided a uniform basis for the application of the modified Sharia law and thus eliminated the individual interpretations of the mujtahids. In 1931 the privileges of the teachers of Islam were further curtailed by a law requiring that all marriage contracts and acts of divorce be registered with a civic official. The law is administered by minor courts nhich sit in villages and small towns with a single magistrate and have jurisdiction in civil cases involving small sums and petty offenses. Appeal is to the district courts which correspond to the French courts of first instance and deal also with major misdemeanours and with the more important civil cases. The provincial high courts, to which lie appeals from the district courts, deal nith offenses classed as crimes and disputes between examining magistrates and public prosecutors of the district courts. The supreme court of cassation or appeal is in eight sections and hears appeals from the provincial courts or from special tribunals.

Police. — The police, some of whom carry firearms, are subject to the minister of the interior and are nominally under the local civil governors, though there is a chief of police in the larger towns.

Jurisdiction Over Foreigners. — A system similar to the regime of capitulations in Turkey was voluntarily conceded by a firman of Shah Abbas to Sir Anthony Sherley in 1600 to induce British merchants to enter Persia to trade. But although these privileges were extended to the nationals of other countries they nere not formally recognized until 1828. when, under the terms of the treaty of Turkmanchai. Russia obtained important commercial and diplomatic privileges. Russian consuls, with extra-territorial rights, could be appointed at will. Similar rights and privileges were later granted to other powers by virtue of most-favoured-nation clauses in other treaties. These privileges were renounced by the Russians in their treaty of 1921. In 1927 after the reformation of the judicial system (which was necessary to make it acceptable to foreigners) Riza Shah announced the formal abrogation of the capitulatory regime. to take effect within 12 months. The French government accepted at once. The British government objected on the ground that the rights which their nationals enjoyed were based on firmans issued by shahs of Persia before the signature of the treaty of Turkmanchai and on general international law. Eventually abolition was accepted as part of a settlement of various matters under dispute, and with the introduction of certain safeguards which applied to British subjects and to most other foreigners. These provisions may be briefly summarized as follows: (1) The rules of international law will be followed by the Persian government in all its relations with foreigners. (2) In all civil and commercial cases in which one of the parties is a foreigner, only written evidence will be admitted. (3) Foreigners are not to be tried by religious tribunals. (4) Foreigners will be sentenced to imprisonment only by a police court which designates imprisonment in lieu of a fine. Such imprisonment shall not exceed a week in duration. No sentence of corporal punishment shall be inflicted on foreigners. (5) No foreigner may be arrested or imprisoned without a warrant, save *flagrante delicto,* nor may he be kept imprisoned for more than 24 hours without being brought before a magistrate. No entry or search of foreigners' houses may be undertaken without a warrant. (6) A foreigner arrested shall have the right to communicate with and be visited by his consul. (7) Facilities for release on bail shall be granted save in cases of serious crime. (8) A foreigner sentenced to more than one month's imprisonment has the right to demand that he be kept in one of the prisons recognized to fulfil certain necessary hygienic conditions. (9) Trials are to be held in public save in very exceptional cases. (10) In matters of succession, divorce and personal status, non-Moslem British subjects shall have recourse to their own courts if they so wish. (11) Foreigners are not liable to civil arrest, except where there is a serious risk that distraint would not be effective and could not be otherwise assured.

Public Health. — In 1904, in accordance with a provision of the International Sanitary convention held in Paris during the previous year, a sanitary council was created. In 1925 the president of the council became the director of public health services, and in 1945 the ministry of health was established. Until 1911, when it became obligatory by law for all students of medicine to take a diploma of the Government Medical school, certificates to practice had been given to apprentices of Persian doctors and to assistants trained in foreign hospitals. This reform made possible a gradual expansion of the medical services. But in 1949 the 102 state hospitals and 37 private hospitals together still provided only one bed to rather more than 3,000 people. In addition there mere some foreign and mission hospitals and medical services, including those established by the Anglo-Iranian Oil company. Under the seven-year plan of 1947 it was proposed to divide the country into health districts, each representing a population of 50,000, and to subdivide so that one health centre would exist for every 12,500 inhabitants of the country. Private and voluntary agencies are the Imperial Social Services organization, which provides dispensaries in remote villages, and the Red Lion and Sun society.

DEFENSE

During the reign of Nadir Shah (1736–47) British, French, Italian and Austrian military missions in turn took a hand in the organization of the Persian army, but the Cossack brigade, founded in 1882, armed and trained on the Russian model and commanded by Russian officers, was the only efficient unit. In 1921 the Cossack brigade had a strength of about 14,000; the household troops about 20,000; the South Persia rifles, British-trained and equipped during World War I, about 6,000; and the Swedish-trained gendarmery (amnieh) about 12,000. When Riza Khan became minister of war in that year he immediately began to organize the army purely on Persian national lines, and his ability to secure

the downfall of the Kajar dynasty and to seize and retain power was a result of the new spirit with which he infused it. By 1939 the strength of the army had increased to 105,000 and it had considerable successes against the tribes. But it had to yield before the British and Russian forces when they entered Persia in 1941. A conscription law was introduced in 1925 prescribing two years' military service for all men over 21. Some details of this law were modified in 1938. The army, air force and navy are all controlled by the minister of war. The strength of the army in 1950 was about 100,000 and consisted of ten infantry divisions of varying strength, four independent infantry brigades and a mechanized brigade. The air force had in 1950 about 200 aircraft, training and operational. The navy, with 500 officers and men, had three gunboats, one frigate and a mine sweeper in the Persian gulf. Riza Shah established two officers' training schools in Tehran and military students nere sent, before World War II, to France and Germany for further military instruction. Small armament factories and arsenals were also established. The general staff is organized on the French pattern, and the chief of the general staff is directly responsible to the shah, who is the titular commander in chief. He has a military council to advise him.

The amnieh, or gendarmery, is responsible for security outside the towns and particularly on the roads. It was formerly under the ministry of war but responsibility was transferred to the ministry of the interior in 1941. It remains, however, a semimilitary organization, and from 1942 to 1948 was under the active control of a U.S. mission; after 1948 the functions of the mission became advisory.

The corruption, inefficiency and highhandedness of the force had made it extremely unpopular in the countryside and the efforts of the U.S. advisers did not appear to have been wholly successful in eradicating the traditional abuses. The strength of the gendarmery is somewhat more than 20,000.

ECONOMIC CONDITIONS

The Seven-Year Plan Organization. — In 1946 the government initiated a seven-year plan for the development of the country's economy and created a board which presented an outline plan which was approved by the *majlis* in Feb. 1949. A detailed project prepared by a U.S. firm in 1947 had not been adopted, and further recommendations submitted by another U.S. firm were presented to the government in Aug. 1949. Of an estimated total expenditure of $656,000,000, agriculture was to receive 25%, transport 23.8%, industries and mines 14.3%, petroleum development 4.8%, communications 3.6% and social welfare 28.6%. The whole of the revenue from the petroleum industry was earmarked for the plan, which went into effect in 1949. Progress was hampered by the cessation of oil revenues after the first two years and by the inability of the Bank Melli Iran to grant adequate loans in face of the other needs of the government.

With the resumption of oil output in 1954 the prospects were greatly improved and a new seven-year plan estimated to cost $930,000,000 was approved in March 1956. Under the main headings of expenditure, communications were allotted 32%, agriculture 26% and industry and mines 15%.

AGRICULTURE

Although Persia is primarily an agricultural country, the percentage of the whole area under cultivation at any one time is extremely small. In addition to the vast deserts and the land which lies fallow every year, very large cultivable but unused areas await development. Water is wasted, methods are out of date, landholdings are often uneconomical in size, and the system of land tenure gives little incentive to the cultivator.

The bulk of the land is held under three main types of ownership: (1) *khalisa* lands, which are public domains, sometimes leased in large blocks to wealthy persons who then often sublet; (2) *milkiat,* land held in full private ownership in accordance with Islamic law; (3) ***wakf,*** land held in trust either for groups of persons or for religious or educational purposes.

Tradition and these types of ownership favour absentee landlordism. It was estimated that the class holding 250 ac. (100 ha.) or more constituted 0.2% of the total rural families and landowners but held 33.8% of the total annually cultivated land. Crop sharing varies in different parts of the country but, in general, is based on the principle that there are five factors in production — land, water, seed, oxen and labour, the last including implements. Whoever provides one of these elements receives one-fifth of the crop. This system applies both to the crop-sharing peasants and to small landowners or communal owners working their own land, but not, of course, to leasehold or hired labour. It is modified by local custom and differs between summer and winter and between irrigated and rain-fed crops. In 1946 and 1952 decrees were issued by the government designed to modify this system so as to improve the peasants' lot, but the difficulty of applying them hampered their effectiveness. In 1951 the shah issued an edict for the sale of crown lands on long-term instalments to farmers occupying them. The area affected exceeded 800,000 ac. of cultivated or potentially cultivable land. In 1954 the government presented a bill to the *majlis* for the distribution of more than 10,000,000 ac. of state lands.

Water Supply. — It is estimated that, of the total cultivated area, about three-fifths is dry-farmed, two-fifths irrigated. Methods of irrigation are:

1. Kanats, water channels about 4,000 m. long which tap the water table underground at a level higher than that to be irrigated. The slope of the kanat is less than that of the surrounding land and the water is delivered by gravity. The kanat is the traditional Persian system of irrigation, though it is used also to a limited extent in Iraq and northern Syria.

2. River irrigation; brushwood dams are much used. They are renewed annually. Under the seven-year plan numerous projects were put in hand for irrigation from surface sources.

3. Wells with water wheels, used chiefly in the south; these usually consist of skin buckets worked by oxen.

4. Tube wells; plans for drilling 2,000–3,000 tube wells to irrigate about 600,000–700,000 ac. were part of the seven-year plan.

Important projects to increase the irrigated area were under way in the latter 1950s. A dam on the Karaj river, near Tehran: would store 200,000,000 cu.m. and would be used to supply drinking water to Tehran as well as for irrigation. It mas expected to be completed by 1960 and provide also 30,000 kw. of installed electric power. A dam on the Sapidrud river would irrigate 300,000 cu.m. and provide 80,000 kw. of power. Several smaller works were either projected or were under construction.

Farming Methods. — The implements used in farming are primitive; an iron-tipped wooden plow drawn by oxen, donkeys or small mules, and occasionally a small wooden drag or roller to break the clods. Seeding, planting and reaping are done by hand. A light mattock, a long-handled spade and a sickle are the tools used. Threshing is done by drawing a wooden frame fitted with rollers and blades over the grain, usually in a circle; winnowing, by tossing the grain and chaff into the air with a fork.

Crops. — Cereals. — In order of importance the cereal crops grown are wheat, barley and rice. The most important wheat-growing districts are the Urmia plains in Azerbaijan, the Kuchan-Meshed plains in northern Khurasan, and areas in the Kermanshah, Isfahan, Fars and Kerman districts. Wheat is usually sown in the autumn and harvested in the spring, either as an irrigated or rain-fed crop; in the valleys and plains between the mountains it is more usually an irrigated crop sown in the spring and harvested in summer. The average yield is low — less than 1,000 lb. per acre, as against about 2,000 lb. in Great Britain — although in especially favoured regions more than 1,800 lb. per acre has been recorded. Barley is grown in the same areas as wheat and in the same may but is harvested a little earlier. The yield is somewhat higher than that of wheat. Rice is the principal crop of the Caspian provinces, where the climate?unsuitable for wheat, is very favourable for rice cultivation. It is grown elsewhere on a small scale wherever there is sufficient water. The fields are plowed in winter or early spring and flooded at the end of April. The seed is sown in May and the crop is harvested in August or September. The average yield is somewhat more than 1,000 lb. of husked rice per acre. Small quantities of millet (or sorghumj and some maize are grown.

Vegetables.—Beans, French beans, lentils, onions, tomatoes, carrots. peas, cucumbers and, in fact, most vegetables found in temperate and subtropical climates are grown both as summer and winter crops, generally irrigated. Potatoes were introduced at the beginning of the 19th century by Sir John Malcolm. There is no reliable estimate of the average vegetable crop.

Fruits and Nuts.—There is an exportable surplus of raisins, almonds and apricots; excellent peaches, apples, cherries, figs, dates, olives. oranges, lemons, grapes and melons are also grown. Nuts are found in many districts, the pistachios and walnuts being particularly good. Citrus fruits are grown at Shiraz and on the Caspian coast, the estimated crop being about 100,000 metric tons a year. Melons and watermelons are grown in most districts; the Isfahan melon is particularly celebrated. There are many varieties of grape and wine is made in many parts of the country. Dates are a staple food on the Persian gulf and Makran coast. The production of noncitrus fruits has been estimated at more than 1,000,000 tons a year, and between 4,000 and 8,000 tons of dried apricots, nearly 40,000 tons of raisins, 4,000 tons of pistachios and 6,000 tons of shelled almonds are produced annually.

Industrial Crops.—Cotton is the most important of the industrial crops. It is grown by irrigation in many parts of the country and particularly in Azerbaijan, Tehran, Mazanderan, Khurasan, Kermanshah, Fars and Khuzistan. It is estimated that the total production of ginned cotton in 1952 was about 20,000 metric tons, a somewhat lower output than before World War II. Three types are grown—Filistani, a long-staple cotton; American short staple; and a local short staple, which is hardier than the other two. Silk is produced by the breeding of silkworms in the Caspian coast area. Sugar beets, the growing of which was encouraged by Riza Shah, are an important crop. They are grown mainly in Khurdsan, near Meshed; round Tehran; and in the Kermanshah and Shiraz areas. Cane sugar is an old but neglected crop. Jute is indigenous to Mazanderan but the production is small. Tea is a comparatively recent introduction; plantations were developed in Lahijan and the area rose after 1932 from about 700 ac. to 24,000 ac. in the early 1950s. Production is about 7,000 tons. Tobacco is extensively grown. The crop is all purchased by the government and processed by the tobacco monopoly. The figure for production (1,000 lb. per acre) appears to be high. The cultivation of the opium poppy has been much restricted and in 1946–47 its cultivation was prohibited; the order. honever, was not enforced. Gum tragacanth is collected in the hill country from Kerman to Kermanshah; gum arabic near Shiraz and elsewhere.

TABLE II.—*Agricultural Production*
(In thousands of metric tons)

Crop	1934–38	1952	1953	1954	1956
Wheat	1,869	2,041	2,245	2,800	2,300
Barley	793	840	820	1,066	800
Rice	423	420	500	659	350
Cottonseed	69	70	86	....	....
Cotton (ginned)	34	36	43	63	60
Tea	0.6	4	4	4	6
Tobacco	1.F	13	18	....	....

Livestock.—The most important livestock are sheep and goats, which are not only the principal means of subsistence for the nomadic tribesmen but the chief suppliers of milk and meat to the peasants, who derive most of their cash income from the sale of animal products. Wool is the raw material of the carpet industry, lambskins from the karakul flocks are an important export, and tribal tents are made from goats' hair. Though sheep and goats are found everywhere the largest numbers are raised by the tribes who depend on the seasonal vegetation in the mountain pastures. Good natural grazing land is uncommon and it is probable that the country is overstocked and that controlled grazing and the growing of special grazing crops will be necessary if serious soil erosion, already threatened, is to be checked. Cattle are of increasing importance because of the rising consumption of milk and milk products in the towns. The general quality of dairy cows is low, but in Sarab (Azerbaijan) and Gulpaigan two good breeds have been produced. With help from the U.S. Technical Cooperation mission an extensive livestock improvement program was laid down at mid-century. Oxen are largely used for draught purposes. Horses are of three types: the Turkoman in the north, the Arab in the south and a cross between the two which is the common Persian breed. Mules and asses are of greater importance for transport purposes. Mules (chiefly bred in the southeast, in Luristan, Kurdistan and the Bakhtiari country) are not large but can carry 350 lb. or even more at a good pace 30 mi. in a day. The donkeys are also sturdy and can carry up to 200 lb. Both are used to draw plows and for other similar work. Camels are still widely employed in the waterless areas of central and southeastern Persia. Poultry are found in nearly every village and particularly in the north where they are of increasing importance as food for the peasants and in the dependent urban areas.

TABLE 111.—Livestock
(In thousands of head)

Livestock	1937	1946	1947–48	1948–49	1950	1954
Sheep	14,011	13,000	12,900	11,000	16,000	21,650
Goats	...	...	...	...	7,000	9,728
Cattle	2,920	2,100	2,500	2,100	2,654	3,155
Asses	1,180	1,309	1,290	1,000	1,150	1,300
Horses	305	350	340	310	383	450
Mules	52	50	48	42	50	93
Camels	...	...	...	...	75	100

Forests.—It is estimated that 44,000,000 ac. or about 11% of the total area of Persia is forest land, which may be divided into four main groups. The most important, though not the largest (8,000,000 ac.), is the Caspian forest, extending along the Caspian coast and the seaward slopes of the Elburz chain to northeastern Azerbaijan. About half consists of dense forest of high quality. In the whole area it has been estimated that there is a growing stock of 315,000,000 cu.m. of timber. The varieties found are walnut, Siberian elm, boxwood, oak, beech, hornbeam, elm, maple and others. The second group comprises the oak-tree forests of the Zagros mountains, stretching from Kurdistan in the northwest through Luristan to eastern Fars and covering about 25,000,000 ac. Only about one-tenth of this is dense and productive forest; the remainder is open forest of low grade. The dominant tree is the Persian oak, but ash, maple, wild pistachio, almond and other fruit trees are found. In the limestone forests of the northeast, from Bujnurd to the southeastern slopes of the Elburz, the principal tree is the juniper but small maples and hawthorn are also found. From Khurasan to Kerman and northern Fars is a scattered group of pistachio forests in which wild (inediblej almonds also are found. In addition to these four, other important groups are the small subtropical forests in the Persian gulf-Makran area and desertic forests of scrub round the Dasht-i-Kavir and the Dasht-i-Lut. Much damage has resulted from grazing sheep and goats, from charcoal burning and other human depredations. A forestry organization was established in 1949 whose functions are forest administration, including education and research; establishment of forest and timber industries; demarcation and survey; and the purchase of waste lands for reafforestation.

Fisheries.—Although several thousand persons are engaged in the fishing industry in the Persian gulf, the industry was quite unorganized and no data were available in 1957. Much of the fish caught is consumed fresh in the coastal areas but there is an appreciable export trade in dried and salted fish to Iraq, India and Arabia. The fishing on the southern coast of the Caspian sea with the two bays of Pahlavi and Gurgan was from 1928 to 1952 in the hands of the Société Mahie Iran, a joint Persian-Soviet concern. In Jan. 1953 Persia refused to renew the concession.

In 1956 a company was formed with two-thirds capital from the seven-year plan organization and one-third from Japanese interests to exploit the Persian gulf fisheries.

INDUSTRY

Out of a population of more than 18,000,000 the number of industrial workers in the late 1950s was about 150,000 plus an estimated 200.000 engaged in the carpet industry, in hand-loom weaving and in the hand production of hosiery and knitwear. Thus,

although a great impetus was given to the development of industry by Riza Shah, whose aim was to make Persia self-sufficient in some measure, industry is still less important than agriculture. Although most modern industry is artificial, in the sense that it was deliberately created by the government, it depends in the main upon indigenous raw materials and was able from the first to draw upon some existing technical skill. Most of the industries started by Riza Shah were grouped under the Industrial and Mining bank, which was. in effect, a holding corporation and an industrial bank which controlled more than 100 factories and a number of mines. This bank was liquidated in 1949 and all its industries with their assets and liabilities mere taken over by the seven-year plan administration and reorganized into groups under specialized corporations. There were also a few industrial plants outside the seven-year plan administration but owned by the government, as well as some private industries.

Textiles. — In 1948, when the government owned two cotton textile plants at Behshahr in Mazanderan and at Shahi, there were 200,000 spindles and 2,240 power looms in the country. Private enterprise raised these totals to 276,000 spindles and 3,360 looms by 1954. The government then had under construction another plant with 10,000 spindles and 340 looms and had ordered two more plants totalling 60,000 spindles. The government looms produced 19,700,000 m. of cotton fabrics in 1953–54. The total production increased from an estimated 70,000,000 m. in 1948 to about 110,000,000 m. in 1953, of which more than a third was produced on hand looms. Cotton yarn production rose from 11,000–12,000 tons to 18,000–20,000 tons in the same period. There were privately-owned factories at Isfahan (10,000 workers) Tabriz, Meshed, Shiraz and elsewhere. Woollen textile plants were all privately owned; they comprised 26,130 spindles and 460 power looms and produced annually about 2,700 tons of yarn, over 2,000,000 in. of cloth and 500,000 blankets. The government-owned jute factory at Shahi produced jute bags, mats, ropes, etc., from raw material partly locally produced and partly imported from India. A second plant was ordered in 1953. The Silk Industry corporation was established under the seven-year plan to encourage the production of natural silk on the Caspian coast, thus reviving an industry which had flourished in the 17th and 18th centuries. At Resht there was a breeding station and a silk-reeling plant which could handle about 250 tons of cocoons a year; there was also a silk-reeling and weaving plant at Chalus. The total capacity was estimated at about 1,000,000 m. of fabric and 30,000 pr. of stockings annually but actual production in 1949–50 was only about half this amount.

Carpets. — Although the demands of the export trade caused some reduction in the artistic standard of Persian carpets, this deterioration applied mainly to the "factories" established by the foreign dealers. In them the carpets were still hand-woven but the design was modified to suit the country of import, the weave was usually looser and the nap was left longer than in the finer products. Carpets of the finest design, colour and texture were still made by the tribes and in the traditional centres of manufacture, the districts of Tabriz, Hamadan, Bijar, Senna, Sultanabad, Kashan, Shiraz and Kerman. World demand had fallen and the industry was no longer so important in the Persian economy as in 1925–26 when 10,000 metric tons of carpets were exported. In 1949 the export was 3,536 metric tons but production and the quantity exported showed some increase between 1949 and 1955.

Food Processing. — In 1954 the government owned nine rice-cleaning plants, and there were a number which were privately owned. The Tea corporation owned six plants of which the largest was at Lahijan. Their ouput, with that of privately-owned plants,' increased from 850 tons in 1938–39 to 4,000 tons in 1952–53. Sugar refining was government owned; production increased from 20,000 metric tons in 1945–46 to 110,000 metric tons in 1954–55. Two additional plants: with a daily capacity of 700 tons of sugar beet, were under construction. Cane sugar was produced at a factory at Varamin. Flour milling was all in private hands; there were about 50 large mills and a great number of village mills, many of them water-driven.

Cement. — The Building Materials corporation owned a cement plant near Tehran which was working much below capacity in the early 1950s. In 1953 and 1954 two additional cement plants were being built to increase the total capacity from 300 to 800 tons a day. There was a refractory brick factory at Aminabad.

Electricity. — In 1954 generating capacity was about 125,000 kw., excluding 72,000 kw. in the southern oil fields. Under the seven-year plan an increase of 400,000 kw. in capacity was planned for the early 1960s, by the harnessing of water power (of which the total potential was estimated at 2,500,000 kw.) and the installation of thermic plants.

Mining. — A mining law of 1952 reserved exploitation of deposits of hydrocarbons and radioactive materials to the state; other categories of minerals could be developed either by the government or by private enterprise. Great impetus was given to the mining industry by exploration carried out under the seven-year plan. Red oxide, sulphur, salt, copper, chromite, lead and iron ores amounting to about 86,000 tons (with a value of 253,000,000 rials) were exported in 1953–54; in 1938–39 the only export was 6,000 tons of red oxide. Among other projects was one to develop the iron deposits at Shamsabad and the coal in Kerman.

Other Industries. — By the mid-1950s other industrial establishments included an army munitions plant near Tehran which comprised a group of factories including both chemical works and machine shops. Some government ammunition plants had also been converted to make a variety of nonmilitary articles. The glass industry flourished under private ownership. Tanneries, soap and oil-extraction plants, a match industry which filled local demand and exported to neighbouring countries, cardboard and paper factories were also working. Craft industries, for which Persia has been renowned for many centuries, continued to exist: the cotton printing of Isfahan; the pottery, mosaic, faience and tilework of Isfahan and Tehran; the repoussé and carved silverwork of Shiraz, Zenjan and Isfahan; the wood carving of Abadeh and Gulpaigan. In spite of the influence toward commercialization which the import of foreign, machine-made goods had upon these national industries, the creative instinct and pride of craftsmanship were by no means extinct.

Oil.—Eratosthenes of Alexandria (c. 276–*c.* 194 B.C.) appears to have been the first to mention petroleum or its allied products in the region of the Persian gulf (Sir Arnold Wilson, *The* Persian *Gulf* [1928]) and later travellers recorded its existence in Persia. The first project for its exploitation dates from 1896 when the shah granted a concession for a small area in the province of Mazanderan to a Persian. This was acquired by a Georgian adventurer named Khostaria in 1916. Meanwhile William D'Arcy in 1901 obtained a concession covering 480,000 sq.mi. which was afterward transferred to the Anglo-Persian (Anglo-Iranian) Oil company (A.I.O.C.). This concession was cancelled by the shah in 1932 but a new concession covering 100,000 sq.mi. in southwestern Persia was signed in 1933 with a period of 60 years. In 1944 the Persian government decided to postpone consideration of all further oil concessions until after the war. A written promise was given by the Persian prime minister to the Soviet government in 1946 to introduce a bill permitting the formation of a Soviet-Persian oil company to exploit the resources of northern Persia, but the bill was rejected in 1947 by the *majlis*. The movement against the foreign exploitation of Persian oil was then directed against the Anglo-Iranian Oil company, a supplemental agreement which would have given additional benefits to Persia was rejected and the 1933 concession was cancelled in 1951, in spite of a clause in it which stipulated that arbitration should be sought in case of any dispute between the company and the government. A bill for the nationalization of the oil industry was brought in and passed and the National Iranian Oil company was set up to take over the A.I.O.C.'s interests. All British employees of the company were withdrawn in Sept. 1951.

Under the earlier A.I.O.C. concession the royalties to the Persian government varied within fairly wide limits. During the nine years ending in 1928 they averaged £708,000. In 1929 they were £1,437,000, in 1930 £1,288,000, but in 1931 they dropped to £306,872, an amount which the Persian government would not accept; this led to the cancellation of the concession and its replace-

ment by that of 1933. The revenues of the Persian government from this source from 1933 to 1949 are shown in Table IV.

TABLE IV.—*Revenue* to the Persian Government From *the* Anglo-Iranian *Oil* Company
(In thousands of pounds sterling)

Year	Revenue	Year	Revenue
1933	1,785	1944	4,464
1934	2,159	1945	5,623
1935	2,192	1946	7,130
1936	2,828	1947	7,104
1937	3,444	1948	9,172
1938	3,307	1949	13,489
1939–43	20,271	1950	14,000

The output of crude oil rose from 83,000 metric tons in 1913 to 7,200,000 metric tons in 1933. During the war years it dropped to 6,705,000 metric tons (1941) but in 1949 reached 27,247,933 metric tons.

Under the National Iranian Oil company's administration production and refining were greatly reduced and exports practically ceased. In Oct. 1954, an international consortium of eight oil companies reached an agreement with the government which promised the revival of the industry (see History above). The output of crude oil during 1955 was 15,780,000 metric tons and, under the agreement, was to be about 71,000,000 tons during the first three years. In 1955 the N.I.O.C. signed contracts with a British and French firm for a 10-in. products pipeline from the southern oilfields to Tehran (920 km.).

COMMUNICATIONS

Railways. — Until 1927 when work on the new railway system was begun, no railway construction had been undertaken except a five-mile line from Tehran to the shrine of Abdul Azim which was completed in 1887 and an extension of the Russian system from Julfa to Tabriz built in 1916. (This finally became Persian property in 1935.) Riza Shah decided for political and economic reasons to create a railway system which would comprise four main lines: (1) a north-south line from Bandar Shah on the Caspian through Tehran to Bandar Shahpur on the Persian gulf; (2) a northwest line from Tehran to Tabriz to connect with the Russian line to Julfa; (3) a northeast line to link Tehran with Meshed with possible extensions beyond; (4) a southeast line from Qum to Kerman. Work on the trans-Iranian (north-south) was begun in 1927 in two sections and the line was opened for traffic in 1938. The length of the northern section (Tehran to Bandar Shah) is 286 mi.; that of the southern (Tehran to Bandar Shahpur) is 574 mi. Of the northnest line to Tabriz only the section to Mianeh (272 mi.) had been completed in 1952.

The northeast line to Meshed was completed in 1957 and, although the newly laid track was then said to be defective, some service was inaugurated. The southeast line had been completed from Qum to Kashan (61 mi.). The gauge of these lines is 4 ft. 8½ in.; steam and diesel locomotives are used. The gauge of the Tabriz-Julfa line (91 mi.) is 5 ft.

Roads. — The important land routes which passed through Persia linking east with west in ancient times fell into decay with the opening of the seas to navigation. The Safawid shahs restored the road system in the north and west during the 16th and 17th centuries but it was not maintained, and natural obstacles and tribal unrest made travel in Persia a precarious and dangerous undertaking. These conditions persisted until World War I when roads fit for light motor traffic were built by the Russian and British armies in the northwest, southwest and east. When Riza Shah came to power. however, there were still only two main routes suitable for motor traffic (Tehran to the Iraq border at Qasr-i-Shirin and Tehran to Shiraz) totalling less than 1,200 mi. and indifferently surfaced. As a part of his policy of centralization and tribal control Riza Shah initiated a plan of road construction in which appreciable progress had been made by 1939. During World War II the important supply routes uere further developed and improved by the occupying forces, although there was some deterioration afterward. Under the seven-year plan, however, a scheme was started which aimed to reconstruct or build by linking existing sections six principal north-south and six principal east-west roads connecting the main cities of Persia and aggregating nearly 8,000 mi.

Inland Waterways. — The only navigable river of importance is the Karun, which is navigable by light-draught vessels between Khorramshahr and Ahwaz (112 mi.), below which are rapids which are negotiable only with difficulty during the low-water season (August to November).. Above Ahwaz it is navigable again almost to Shustar. The river mas used by vessels of the Anglo-Iranian Oil company and there was a separate service from Khorramshahr to Ahwaz operated by a British company.

Seaports. — Khorramshahr (Mohammerah) is the principal port at the head of the Persian gulf. It is situated on the north bank of the Shatt-al-Arab at its confluence with the Karun. A jetty built in 1938 was extended in 1942 to provide berthing space for six or seven ships. The depth of the channel is from 2½ to 3 fathoms. A branch of the railway connects the port with Ahwaz. The port of Bandar Shahpur was erected after the construction of the railway by the reclamation of a mud flat in the Khor Musa about 45 mi. from the sea. It was designed by Riza Shah to give an all-Persian outlet for the railway, the Shatt-al-Arab being in Iraqi territory. There are two jetties with a capacity for berthing five ships. Abadan on the Shatt-al-Arab was the principal oil port of the Anglo-Iranian Oil company. Bandar Mashur on an extension of the Khor Musa is also an oil port of importance. Bushire is an ancient port about 140 mi. S. of the mouth of the Shatt-al-Arab. It was formerly the principal point of entry for the Isfahan and Shiraz areas but has lost much of its trade. Ships anchor from three to seven miles offshore and cargo is discharged by lighter. Other Persian gulf ports frequented by trading dhows and pearling vessels are Lingeh, Jask and Charbar.

Bandar Pahlavi (formerly Enzeli) was the principal Caspian port for many years but it is now not greatly used. Bandar Shah was built in 1926 as the terminal of the railway but both this port and Nawshahr are subject to much silting. All Caspian ports were extensively used during World War II.

Civil Airports. — The principal airports are at Tehran (Mehrabad) and Abadan, where runways suitable for large four-engined aircraft are available. There are smaller aerodromes at all the principal towns. The main international air lines have services to Tehran. The Iranian Airways company maintains a system of internal air services as well as services to Pakistan and middle east countries.

Posts and Telecommunications. — These are administered by the ministry of posts, telegraphs and telephones (P.T.T.). The telegraph line from Tabriz through Tehran to Bushire was formerly part of the Indo-European system which connected London and India. The line now forms part of the national system of about 11,000 mi. which covers most of the country. Outlying districts are being brought into the network by the use of small radio sets. Long-distance telephone land lines were constructed by the Allied armies and later taken over by the government. They link Tehran with the southwest oil field area, the main ports in the Persian gulf and Iraq. One follows the trans-Iranian railway through Qum and Ahwaz, to Bandar Shahpur, Khorramshahr and thence to Basra; the other follows the main highway through Kazvin, Hamadan and Kermanshah to Baghdad. There is no national radiotelephonic network but international communication by telephone is available from Tehran to most parts of Europe and the British Isles and, by relay through Berne, Switz., with the United States. There is also a point-to-point service with Karachi, Pak. Radiotelegraphic communication is available to all parts of the world. Radio broadcasting is operated and maintained by the ministry of P.T.T.; programs are handled by the department of propaganda and information.

Postal services are under the general post office department of the ministry of P.T.T.; mail is distributed by private motor-truck contractors to places not directly served by the railway. Horse-mounted couriers deliver mail to villages off the main roads. An internal air mail is operated by the Aero club and serves the principal cities.

FINANCE

Currency and Weights and Measures.—The legal monetary unit is the rial. the nominal equivalent of the older kran, which it superseded under a law of March 1932. The rial, which is subdivided into roo dinars, has a value of 0.07322382 g. of gold. One hundred rials make a pahlavi, the equivalent of £1 sterling in gold. In 1944 silver coinage was authorized and 1-, 2-, 5- and 10-rial pieces were issued. There are also notes for j, 10, 20, 50, roo, 500 and 1,000 rials issued by the Bank Melli Iran. The equivalents of the old and the new currency are 1 shahi = j dinars; 1 kran = 1 rial; 10 tomans = 1 pahlavi. A sum of 10 rials is in common usage still referred to as a *toman*, the equivalent in the old currency of 10 krans.

The metric system of weights and measures has been officially adopted but in the country districts old local standards still prevail.

The old short linear measure was the gereh, equalling just over 2.j in. or a little more than 6.35 cm. Sixteen gereh made one zar or gaz. somewhat over 41 in. The unit for long distances was the farsakh, which was the distance a laden horse or mule would cover in one hour; on level ground one farsakh equalled about $3\frac{1}{2}$ mi. or j.6 km. but it varied in different parts of Persia. One farsakh is today considered to be equal to 6 km.

Measures of area on the old system varied considerably. The major measure was the jarib, equalling 1,067 square zar and therefore equalling rather more than 1,000 sq.m. or $\frac{1}{4}$ ac.

The standard older weights were: 1 kharvar = about 650 lb. or 300 kg. (a donkey load) = 100 man; 1 man = about 6.5 lb. or 3 kg. (but very variable) = 40 seer; 1 seer = 16 miskal.

Banking.- he banking system was introduced into Persia in 1888 when the New Oriental Banking corporation of India opened branches in the principal towns. In the following year a concession for the establishment of a state bank was granted to an English group under Baron Julius de Reuter which took over the business of the New Oriental Banking corporation. The Imperial Bank of Persia, thus formed, had the right of issuing bank notes in the Persian currency to a total value of £800,000. Its name was changed to the British Bank of Iran and the Middle East in 1949. In 1952 all branches in Persia were closed down.

A Russian bank, a subsidiary of the Russian State bank, was also founded in 1889 but this Persian branch, with all its assets and liabilities. was transferred by the Soviet government to Persia in 1921 and became the Bank-i-Iran. In 192j a new Soviet bank, the Russo-Persian, was established to help trade between the two countries.

In 1930 the right to issue notes was transferred from the Imperial Bank of Persia to the Persian National bank, the Bank Melli Iran. which had been founded in 1927, with capital derived from the value of crown jewels and domains and other government assets including the Bank-i-Iran. In 1950 the bank had 81 branches and 32 sub-branches and the pawnbroking office had 11 branches. In 1943 the issue department of the bank and its accounts were separated from the banking department. In 1932 the Bank Melli was authorized to issue notes up to an amount of 90,000,000 rials plus an additional 250,000,000 rials in notes of large denominations (1,000 rials). Further increases were authorized in 1934, 1936 and in July 1951. At the end of 1949–50 the bank had slightly more than 111 tons of gold worth 4,032,000,000 rials in the issue department and exchange amounting to 1.718,000,000 rials. Monetary reserves in the banking department amounted in 1950 to about 460,000,000 rials in gold and more than 2,000,000,000 rials in exchange. The law of 1932 required that reserves of gold and silver, whether in the form of coins or bullion, together with convertible foreign exchange, should be held equal to the whole amount of the notes issued and the nickel coins in circulation. In 1934 at least 60% of the notes issued were to be covered by gold or silver coins and bullion. In 1940 the value of the crown jewels was counted to make up the deficit when an increase in the note issue mas authorized. Increases after that date were rapid but from 1944 to 1950 100% ratio of reserve to notes issued was maintained. A new note cover bill was passed in July 1954. The compulsory cover for the note issue was lowered from 43.8% to 40%; $87\frac{1}{2}$% of the cover to be gold and $12\frac{1}{2}$% foreign exchange convertible into gold.

Other banks are the Agricultural bank and the Building bank, which branched off from the Bank Melli in 1930, and the Mortgage Bank of Iran, which was founded in 192j under the name of the Bank Pahlavi, in which are deposited army pension funds. The first privately owned bank, the Bank Bazargani Iran (the Commercial Bank of Iran), was registered in 1950. In Dec. 1946 it was decreed that all banks carrying on business in Persia must deposit at least 15% of their sight deposits and 6% of their time deposits with the Bank Melli. In 1949 another decree required the foreign banks operating in Persia to deposit at least 55% of all their deposits with the Bank Melli and, at any time the remainder of their deposits exceed 225% of their capital and reserves in Persia, all excess deposits must be deposited with the Bank Melli. A new banking law was passed in 19jj involving increased supervision by the Banks Supervisory board but foreign banks were allowed to operate on the same condition as Persian banks if given prior approval.

Taxation and Revenue.—Until 1899 there was a system of tax farming which led to many irregularities and abuses, and although this was abolished then it was not until 1906 when the constitution was set up that any real improvements were made. A ministry of finance was created and a U.S. mission introduced reforms. They were followed by a Belgian mission and in 1911 Morgan Shuster, with American assistants, attempted further reorganization as treasurer general. After less than a year in office he was succeeded by a Belgian who remained until 1918. In 1922 A. C. Millspaugh, another U.S. citizen? was appointed and remained until 1927. During his term of office considerable order was brought into the tax system; antiquated and inequitable taxes were abolished and new taxes introduced; the revenues were increased and a deficit was turned into a handsome balance. In 1943 Millspaugh returned with a large staff but, following a disagreement with the government, he resigned in 1945.

The bulk of the revenue is derived from indirect taxes (because of their ease of collection). In the financial year March 1954–March 1955 out of a total revenue of 9,511,000,000 rials only 10.2% (976,000,000 rials) came from direct taxation. The total expenditure was 13,500,000,000 rials (£50,000,000) the deficit being met largely from U.S. aid.

Up to the year 1941–42 great efforts were made to balance the budget, and loans from the Bank Melli were confined to those necessary for financing development and productive projects. The disruption caused by the war caused a fall in revenue and an increase in expenditure so that the government debt to the bank which in March 1940 was 1,986,000,000 rials had increased to about 4,936,000,000 rials by March 1946. In March 1954 it had reached over 17,000,000,000 rials owing partly to the loss of the oil revenue.

Actual figures of revenue and expenditure for selected years between 1939 and 1957 are given in Table V.

TABLE V.—*Revenue end Expenditure*
(In millions of rials)

Year	Revenue	Expenditure	Year	Revenue	Expenditure
1939–40. .	1,920	1,829	1951–52. .	8,000	10,000
1945–46. .	4,978	4,932	1954–55. .	9,511	13,500
1948–49. .	7,532	7,614	1956–57. .	15,000	19,000

Items of expenditure for the years 1945–46 and 1950–51 are shown in Table VI.

TABLE VI.—*Items of Expenditure, 1945–46, 1950–51 and 1955–56*
(In millions of rials)

Government department	1945–46		1950–51		1955–56	
	Expenditure	Percent of total	Estimated expenditure	Percent of total	Estimated expenditure	Percent of total
War . .	1,487	30	2,799	24.4	4,500	30
Interior .	1,037	21	1,137			10
Health .	178	3.6	300	9.9	156*	3.5
Education .	508	10	1,182	10.2	2,[illegible]†	14.3

*Excluding gendarmerie, 728,000,000 rials.
†Excluding Tehran university, 189,000,000 rials

TRADE

Internal Trade.— Because of lack of transport, storage and credit facilities there is no easy flow of commodities between producers or importers and consumers, and there is always a great divergence between wholesale and retail prices. In towns the bazaar, both a wholesale and retail institution, is the principal point of assembly, storage and breaking of bulk. It is departmentalized to a striking degree. retailers specializing in one kind of goods concentrating in one section oi it. In Tehran department stores are beginning to appear. In villages a few shops or peddlers supply the needs of a scattered population in sugar, tea, cotton piece goods, kerosene. cigarettes, etc.

Foreign Trade.— The basic law regulating foreign trade is the Foreign Trade State Monopoly act of 1932 as amended by acts of 1941 and 1942. By it control of foreign trade is vested in the government which can (1) itself engage in the import or export of certain goods; (2) grant a monopoly for the import or export of certain goods to a particular private or public agency; (3) allow the public to engage in public trade subject to certain regulations. Partly as a consequence of these regulations merchants either establish themselves in Tehran or have agencies there. Under a law of 1942 chambers of commerce operate in Tehran and in provincial centres where the volume of trade justifies their existence.

Before the Russian Revolution Persia was, economically. largely dependent upon Russia. which took 69% of Persia's exports and sent 58% of its imports. The violent change in Russia's attitude toward Persia aiter the revolution combined with the world economic situation of the 1920s brought Persia almost to bankruptcy. but a series oi new agreements with Russia. the development of the Anglo-Iranian Oil company, and improved internal communications and internal security imposed by Riza Shah's rule helped to stabilize the situation.

Measures of control. also. were introduced which enabled the country to maintain a precarious but favourable balance of trade in the decade preceding World War II.

The principal articles of export are: fruit and dried fruit. skins and hides, wool and hair, casings, cotton, gums, carpets and petroleum products; of import: sugar. tea, coffee and cocoa, paper and cardboard. silk, cotton and woollen textiles, iron and steel, copper and brass (manufactured), machinery and machine tools, electrical appliances, motor vehicles, rubber tires. Table VII shows the value of imports and exports at five-year intervals from 1900 to 1949.

TABLE VII.—*Imports and Exports, 1900–55*
(In thousands of rials)

Year	Imports	Exports	Year	Imports	Exports
1900	355,380	147,323	1934	648,792	513,747
1909	442,129	254,736	1939	612,164	803,888
1914	499,323	558,060	1944	2,956,789	792,066
1919	629,793	971,572	1949	6,784,541	1,720,848
1924	715,824	213,545	1954	15,991,000	8,660,000
1929	841,000	487,000	1955	23,973,000	8,020,000

Table VIII gives the relative share of individual countries in the import and export trade with Persia, excluding duty-free imports (by the Anglo-Iranian Oil company, government departments, etc.) and the value of oil exported by the A.I.O.C. or fish exported by the Caspian sea fisheries.

TABLE VIII.—*Direction of Trade, June 1937–38, March 1946–47 and March 1954–55*
In percentages)

Country	Imports			Exports		
	1937–38	1946–47	1954–55	1937–38	1946–47	1954–55
U.S.S.R.	32.5	23.2	7.4	35.0	21.3	14.1
United States	8.6	23.2	20.1	8.2	18.5	12.4
United Kingdom	8.2	17.9	10.0	6.2	12.5	7.9
India	7.7	15.2	7.8	4.7	14.2	2.0
France	1.8	1.1	2.8	1.4	6.6	10.5
Belgium	3.0	0.6	...	0.4	1.0	...
Germany	25.5	0.5	18.1*	29.7	...	17.8*
Other countries	12.7	18.3	33.8†	14.4	25.9	35.3‡

*German Federal Republic
†Including 8.6% from Japan
‡Including 2.1% to Japan

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PERSIA, CAMPAIGNS IN, a series of military operations in World War I whose primary purpose was to protect India. At the outbreak of the war Persia declared its neutrality, but there is no doubt that Germany had prepared plans for attacking India across Persia. using the Turkish army. Germany also hoped to embarrass Russia and Great Britain by forcing Persia into the war on its side. Ii Persia would come in, the claim that Islam was on the side of the Central Powers might have brought in Afghanistan. Before Turkey declared war, however, the government of India took the precaution of sending troops to the Bahrein Islands. After the outbreak of hostilities, this force defeated the Turks and occupied Basra, thus protecting the refineries of the Anglo-Persian Oil Company. Ltd. The battles between the Allied and Turkish forces swayed back and forth until the Russian collapse in 1917. After that. the British, who had recruited a native iorce to restore order in south Persia. defeated the Turks and moved into western Persia in order to provide further protection for India. Thereafter, the British troops were used to quell internal striie in Persia until a stable government could be restored in the summer of 1918.

See also WORLD WAR I; PERSIA.

PERSIAN ART. Pictorial art flourished in Persia beiore Islam. ior although no traces of frescoes or illuminations have come down to posterity from the Sassanian period (*c.* A.D. 224–651), it is known from other evidence that that great age of Iranian culture included painting among its many creative activities. Ernst Herzield traced to Sassanian models the motifs (dancing girls. huntresses. animal figures, floral decorations of various kinds) of the fragments of ornamental wall paintings which came to light in the course of excavations made at the caliph's palace at Samarra (9th century). At about the same time illumination must have come into favour at Baghdad, probably through the Manichees. Some knowledge of their book painting was gained through the discoveries made by Sir A. Stein and by the German expeditions to Turfan.

PAINTING AND CALLIGRAPHY

The Persian contribution to painting and calligraphy began in the Moslem era. and the form in which it first appeared was that of book production. The share of Persia in the development of this art in the Islamic countries dates from beiore the beginning of the Abbasid period (750). Toward the end of the 7th century in the two oldest centres of culture in Iraq — Basra and Kufa — beautiiul Koran manuscripts in Kufic execnted on parchment were common, though at first they had no extraneous decoration. but produced their effect solely by the heavy lapidary style of the archaic character. In the 8th and 9th centuries this branch of Islamic art reached its first period of splendour under the powerful stimulus imparted by the caliphs of Baghdad; and the masters of the Kufic who flourished at that time (*c.* 800) include not only a number of Arabs, but also the Persian Khoshnam of Basra. More important. however. was the part played by calligraphers of Iranian origin in the development of the various forms of the *naskhi,* the round correspondence character. a-hich early began to take a dominant place beside the vertical script. The inventor of the decorative *thuluth,* which derived from this. is said to have been Ibrahim Segzi of Sijistan, and his pupil Ustad Ahwal Segzi has the reputation of having been the first. under the caliph Ma'mun. to elaborate and discuss rules of calligraphy. He in turn was the teacher of the celebrated Ibn Moqla. who brought the *naskhi* into general use in place oi the Kufic and is regarded as the

greatest authority on all the principles of the art. Ibn Moqla's school produced, among other famous pupils, Ibn al-Bawwab, Hasan al-Sirafi (d. 979), who was of Mazdaic origin, and the Buyid prince Fana-Khusru (d. 982), reputed to be a descendant of the Sassanian kings.

The Baghdad School.—The first extant works of the Baghdad school of painting date only from the 12th century, when the Seljuk period had already begun, but in their content and their artistic tendencies they go back unmistakably to older traditions, and continue with little change until the middle of the 13th century. They include scientific treatises (by Dioscorides, Galen and others) translated from the Greek by Nestorian scholars or based on ancient models, with explanatory illustrations; Arabic versions of the Bidpai fables (Kalila va Dimna) which were imported from India; and the anecdotes of Hariri, then in great favour, in which the bold jests and witty conceits of Abu Sa'id of Serruj were illustrated. These three types of text were all equally well adapted to direct the artist to the study of nature and to emphasize the importance of problems of composition and colour, and the works of this school are veritably astonishing in their wealth of colour shading and their forcible depiction of their subjects. To what extent Persian masters are represented is not exactly known; but the circumstance that the *minai* pottery of Rayy (Rhages) (*c.* 1200) borrowed the Baghdad style of painting suggests that the whole tendency had already spread from Mesopotamia to centres in Iran.

As early as about the 10th century, paper had supplanted parchment, not only in secular works but also in copies of the Koran and other religious texts, its manufacture having gradually spread from Samarkand to all the countries of Islam. Ornamental decoration of manuscripts, from which for religious reasons figures were excluded, also made continual strides, and soon the craft of the illuminators and gilders began to break away from that of the calligraphers and painters and to develop on its own lines. Kufic was now no longer used except in chapter headings and title pages; elsewhere the script employed was either one of the many variants of *naskhi,* or a decorative script representing a more graceful and stylistic development of the vertical character.

The Ilkhan Period.—The Mongol invasion in the 13th century proved unexpectedly fortunate for the art of book production in western Asia. Hulagu and his successors not only took pains to promote it in every possible way, but also brought it into contact with the highly developed painting of the far east, and directed it toward new subjects, with the important effect of immensely enlarging the painters' outlook. The main tendency was now to the pictorial representation of historic events and legendary episodes, in world histories conceived on a large scale like Rashid al-din's and the principal result of acquaintance with the works of the Chinese masters of the Sung period was to enhance the feeling for landscape. In manuscripts of the early 14th century the strong foreign stimuli are seen combining with older traditions, and in course of time there developed a new Persian-Mongol style of painting which reached a high standard in the two capitals of the Ilkhans, Baghdad and Tabriz. The profane texts were now no longer in Arabic, but generally in Persian, and the whole art of miniature painting was soon iranized when the great national epic of Firdausi and other poems, such as those of Nizami and Khwadju Kirmani, became increasingly common in illustrated and often sumptuous copies. New and effective uses were found for devices of composition, and, moreover, the arrangement of the verses in vertical columns, which could be broken up wherever desired, made possible a much more intimate and aesthetically satisfying conjunction of picture and text than had been known previously. Heroic scenes from the *Shah-Nama,* sentimental themes from *Khosrau and Shirin, Laila and Majnun,* etc., were then for the first time expressed in characteristic forms.

Of Arabic texts there were at this period mainly the cosmography of Qazwini and a few astronomical treatises, which seem to have been produced with loving care in western Turkestan. To the Baghdad school of calligraphy belongs the credit of developing, about 1300, the lapidary style of the Kufic Korans into the round writing, and bringing this to the ripest degree of ornamental beauty in majestic variants. In the production of the magnificent Korans of the age of the Ilkhans, with their large size and their few and incomparably imposing lines of script in black and gold, Persian masters were in first line concerned; and they carried to Tabriz and Samarkand the new principles for the decoration of the holy book, especially the rich arabesque illumination.

The Timurid Schools.—When Timur altered the whole political complexion of western Asia, a highly productive centre arose at his capital of Samarkand. His chief secretary, Amir Mohammed Badr ud-din, gained a reputation as a master of all forms of writing, and two of the great emperor's grandsons, Ibrahim Mirza and Baisonqur Mirza, were famous calligraphers. At Timur's court there came into favour, through the stimulus of far eastern models, the separate sheet bearing a light ink sketch, sometimes with some touches in gold and colour, to be pasted on cardboard and collected in albums. The traditional miniature illustration in body colour found in this period a new and prosperous evolution in the schools of Herat and Shiraz.

Baisonqur Mirza, who unfortunately met with an early death in 1434, earned much honour by founding at Herat an academy in connection with his library; for years it employed 40 calligraphers, besides numerous illuminators and painters. In this academy the Persian texts were no longer written in *naskhi,* but in *nastaliq,* an offshoot of the old cursive character, invented by the celebrated Mir Ali of Tabriz. All the 40 masters of Herat were directly or indirectly his pupils, and toward the end of the century the style of calligraphy invented by him found its most splendid representative in Sultan Ali of Meshed (d. 1513), the protégé of the famous poet and minister Mir Ali Shir Newai and friend of the great poet, Jami.

The preference that painters displayed for subjects drawn from the national literature, and the enthusiasm with which they steeped themselves in the magic of their native countryside, give to Persian painting of this period a romantic note which often chimes with the atmospheres found in contemporary western Gothic. In the east, however, the purely decorative and impersonal character of the pictures continued, and Shiraz rivaled with Herat in the same line, but using a colour scheme of its own.

It was at this time that the harmony between picture and text reached the highest imaginable degree of perfection, and the leaves of the extant manuscripts are astonishing in the skill with which the painters fitted their subjects into spaces allotted to them quite arbitrarily by the calligraphers. Meanwhile at the beginning of the 14th century the backgrounds were still carefully coloured red or yellow; subsequently a rich blue became general, and it was not until the end of the period that a gold background came into favour. The incidental landscape is generally of a steppelike character; jagged rocks, isolated trees, and little brooks rippling among stones and bordered by growing flowers, are the essential features of almost all open-air scenes, and only occasionally is the mysterious atmosphere of the forest or the luxuriance of a flower garden depicted. The highly effective motif of a tree in blossom, which is often used in smaller pictures, is obviously taken from Chinese models of the Ming period. Under the Timurids direct contact with the far east became increasingly frequent.

Behzad of Herat.—An undeniable weakness of Timurid painting lies in the diagrammatical conventionalizing of the figures, the spiritless treatment of the heads, and the absence of expression in the movements. In this respect no progress can be seen throughout the whole development of the art, which in other directions is so astonishing; and the appearance of a completely revolutionary personality was needed before a change could be brought about and new paths indicated. This personality was found in the genius Behzad of Herat, who is rightly honoured as the greatest master of Persian painting. Behzad understood how, even in his most populous compositions, to differentiate every single figure in countenance and bearing; his palette was extraordinarily rich, especially in warm, full tones, and this enabled him to individualize his portraits by the employment of numerous colour nuances for costumes and even for flesh. He was also a reformer in the treatment of landscape, which appears more naturalistic in his pages than in those of his forerunners, and in the choice of subject a markedly

realistic note is likewise seen. Moreover, it was he who revolted against the dictation of the calligraphers, and admitted no text at all, or only a few lines of verse in one corner, in the pages he illustrated; even a number of double-page miniatures by his masterly hand can be seen.

Behzad, who was born before 1450 and died after 1520, represents the zenith of the Timurid and the opening of the Safawid period in Persian painting. He was head of the Herat academy until 1506, when Shah Ismail took him to Tabriz, made him his chief librarian, and covered him with honours. Only a few extant works are indisputably by his hand. Both in Herat and in Tabriz he had many pupils, who carried his style far and wide in Persia, western Turkestan and India; and even in the 16th century his name was already so famous that his art was imitated on every side, while later on pages of the most various origins were furnished with his signature to enhance their value.

The Tabriz School.—The next generation of painters in Tabriz is dominated by the highly gifted Sultan Mohammed, who exercised a commanding influence in the whole field of art at the court of Shah Tahmasp. In collaboration with other masters he illustrated de luxe editions of the Persian epics, several of which have come down to posterity; but for the most part he preferred genre subjects and portraits, which were produced as single sheets and were designed to be bound in volumes together with specimens of the handwriting of famous calligraphers. He opened new fields of activity to the painters by bringing lacquer bindings into fashion, and also by inducing them to design patterns for textiles and knotted carpets to be made at the royal factories. Some of the studies for the celebrated hunting and animal rugs of the 16th century were made in his studio, as were also a few velvets and silk brocades with figure subjects.

From the end of the 15th century an immense impetus had been given to Koran decoration at Tabriz. It was here that the picturesque division of the title pages into star- or medallion-shaped fields and borders with a reciprocal pattern or a cartouche design was devised, and this again brought about a revolution in the style of Persian carpetmaking. The ornament grew richer and more complicated; to the arabesque were added slender floral twines in a profusion of lines, palmettes, rosettes and cloud patterns.

In Behzad's time Shah Mahmud of Nishapur came to eminence as a master of the *taliq* script and later Mir Ali of Tabriz, "the royal scribe" (d. 1559). Many other calligraphers and illuminators heard the call of the Ottoman rulers and founded a school of book decoration at Constantinople, which adhered closely to the tradition of Tabriz; they were accompanied by painters like Shah Quli and Wali Jan.

The Isfahan School.—Late in the 16th century, when all the artistic forces of Persia were once more being concentrated at the new capital, Isfahan, under the powerful impulse communicated by Shah Abbas the Great, there arose also in Isfahan a new and important centre for the art of book production in all its various forms. Mir Imad al-Husni (d. 1618) and Riza 'Abbasi competed in calligraphy for the royal favour, while others sought to attract attention by animal figures ingeniously constructed out of pious mottoes and similar jests, or by a perfect mastery of the *skikasta,* a complic'ated script so full of flourishes as to verge on illegibility. In painting there is a link with the schools of Herat and Tabriz in the person of Ustad Mohammedi, who was undoubtedly the first to put his observations of nature on to paper in the purest ink-wash technique without any reference to a text. His successor as head of the painters' guild at Isfahan was Riza 'Abbasi, whose signature, genuine or doubtful, is frequently met with; it is still not established beyond dispute whether this artist is identical with Xga Riza, who is thought to be of an older generation. Be that as it may, it was he who filled the albums of Persian and Indian collectors with his gay, sure-handed colour sketches and drawings in red chalk on the most everyday subjects, and with carefully executed pages in rich colour; and he ultimately became so much admired as almost to overshadow, for a time, the fame of Behzad. He likewise gave a new impulse to the illustration of manuscripts, and his elegant, fashionable style gained him a great influence in the other decorative arts also; wall paintings, figural tiles and lacquered doors in the garden palaces of Isfahan clearly show the mark of his atelier. Riza's best pupil, and his bosom friend, was Mu'in, one of whose extant works is a portrait of his master. The style created by the latter was still a living force at the end of the 17th century, when Shah Abbas II's effort for an assimilation to European painting had already failed, as is shown by the fact that of the young artists he sent to Rome only Mohammed Zaman gained some reputation.

In the 18th century European paintings and engravings were slavishly copied, and Nadir Shah's expeditions to India introduced transitory influences of the Mogul school. At the beginning of the 19th century an enormous impetus was given to lacquer painting, though only as an ordinary bazaar industry, and decoration also took the form of large canvases. Since the end of the 19th century the growing interest for Persian miniatures has called into existence a considerable number of workshops for the production of fakes, where single pages and even complete manuscripts are concocted in the style of any old master or period. This somewhat questionable development has at least the advantage of maintaining some contact with the masterpieces of the past. (E. K.)

ARCHITECTURE, CERAMICS, TEXTILES, METALWORK

As with painting and calligraphy, a certain strain of decorative skill dating from the Islamic conquest permeates all other forms of Islamic art generally known as Persian, but pre-Islamic influences are not absent, and such Sassanian motives as twinned animals facing each other appear constantly.

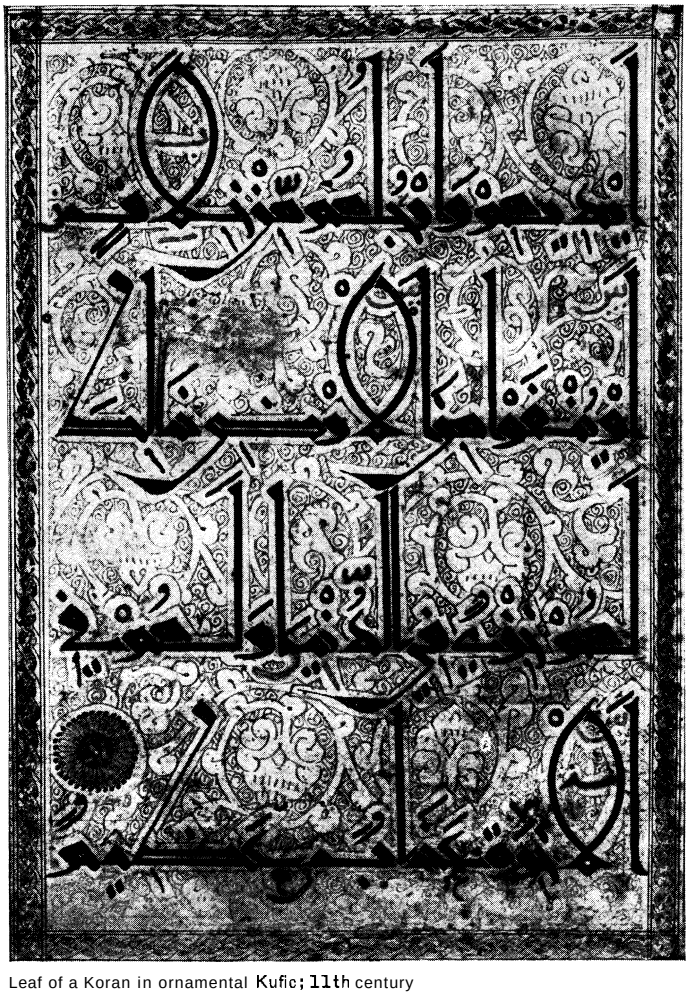
Architecture.—In architecture, the love of barrel-vaulted porches can be traced directly to Sassanian palaces and were the chief motives of the great mosques where they were flanked by twin minarets in the design of which appears that emphasis on height which is universally Persian. A second characteristic was the use of a dome with two shells, the outer onion-shaped and supported on a high drum, and the swelling slight in early examples but more pronounced later. Daring ingenuity of construction marks all these vaults and domes. The stalactite *(see* STALACTITE WORK) corbels, elaborate intersections of curved surfaces, delicate groined lines and scalloped forms display great skill and differ widely from similar Islamic buildings elsewhere.

The progress of architecture from the Seljuk domination continues to a rich climax in the 16th and 17th centuries.

During the 18th century there developed rich and delicate wooden construction including slim columns, intricate cornices treated with lavish carving and inlays used frequently in the exquisite formal gardens so important to Persian life. The Moslem love of surface ornament led to dominance of plane surfaces covered with tiles so that walls, vaults, domes and minarets glowed with blue-greens and turquoise, rose and yellow. In no other style has applied colour become such an integral part of architectural design. *(See* ISLAMIC ARCHITECTURE; TILE.)

Ceramics.—Springing from the most ancient Mesopotamian development of pottery Persian ceramics developed in about the 13th century into one of the most exquisite of all arts. The pottery body was coarse because of the available clay but the glazes were developed to a high degree of perfection and the coloration, especially the blues ranging from turquoise to cobalt, became world famous. Sassanian, Parthian and Byzantine influences lent vigour and charm. By the 14th century floral ornament became more important and the designs were freer and less formal. Vases were decorated in low relief and covered with monochrome blue glaze. During the 16th century the Chinese influence made itself felt and became strong in the 17th century not only in design but in methods of manufacture and at the same time Persian influences were felt in China. Tiles were of course an important phase of the ceramic industry. *(See* POTTERY AND PORCELAIN: *Persia* and *the Near East;* MOSAIC.)

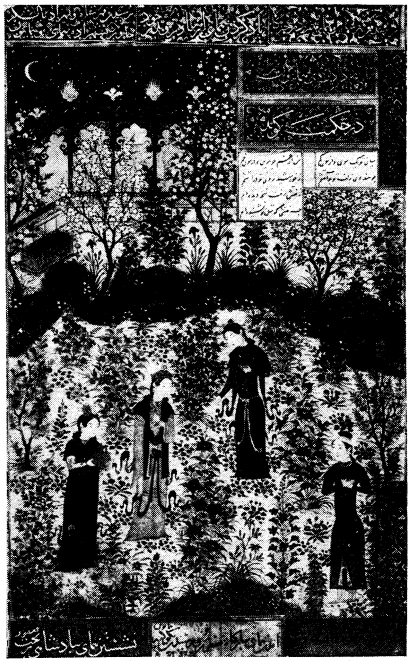
Textiles.—Church treasuries throughout Europe reserve textiles that are obviously of Asiatic origin showing the same Sassanian and Byzantine influences felt in Persian ceramics. Lions, eagles and imaginary beasts enclosed in geometric patterns form the decoration on a material of woven silk and sometimes gold and silver. Prior to the 13th century these textiles came from different parts



Leaf of a Koran in ornamental Kufic; 11th century

Painting showing the building of a mosque. By Behzâd of Herat; end of the 15th century. Walters Art gallery, Baltimore, Md.

Painting of rural life. By Mir Sayid Ali; 16th century. Fogg museum, Cambridge, Mass.

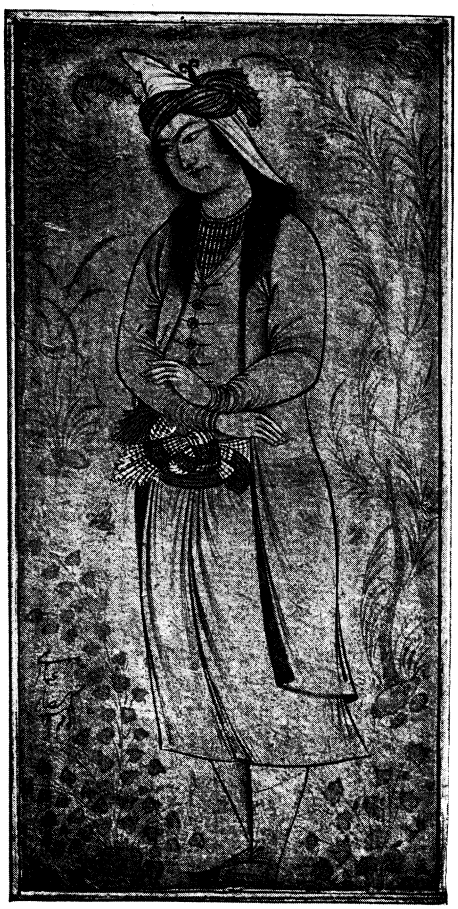


Humay and Humayan in the Imperial garden at Peking. Herat school; about 1450

EXAMPLES OF PERSIAN ART, 11TH TO 16TH CENTURIES

BY COURTESY OF (TOP LEFT) EHEMALS STAATLICHE MUSEEN BERLIN, ISLAMISCHE ABTEILUNG, (BOTTOM LEFT) FOGG ART MUSEUM, HARVARD UNIVERSITY, (FORMER LOUIS CARTIER COLLECTION); PHOTOGRAPHS, (TOP RIGHT, BOTTOM RIGHT) F. BRUCKMANN

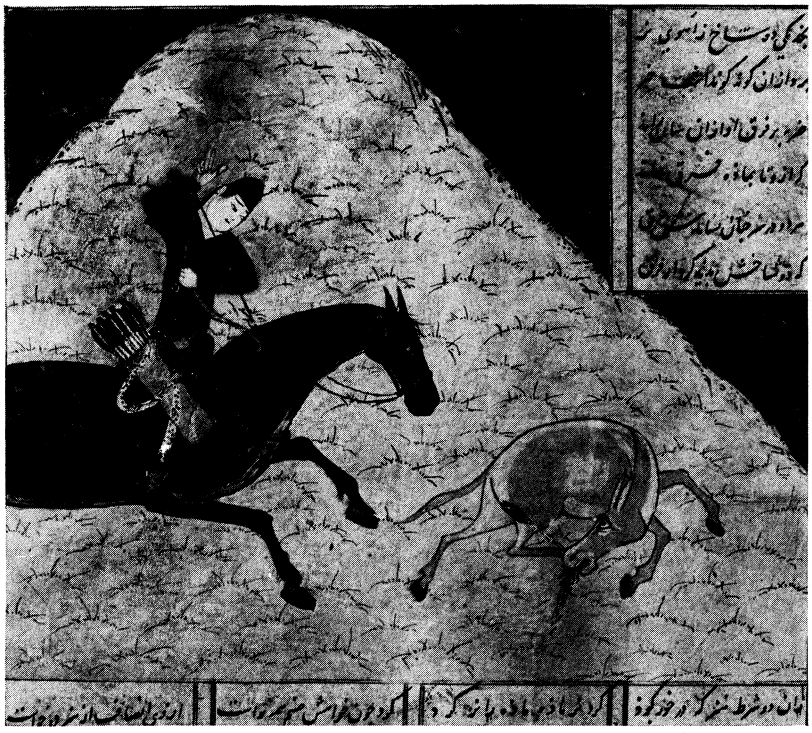
PERSIAN ART



Portrait of a young man. By Rizâ Abbâsi, Isfahan; late 16th century

Gazelles, from a bestiary dated 1298

Scene from a Shahnameh manuscript, Tabriz; *c.* 1330–40



Bahram Gur hunting. From a Persian anthology made for the Library of Baisonqur; dated 1420

Calligraphy in nastaliq. By Imad al-Husni; 16th century

EXAMPLES OF PERSIAN ART, 13TH TO 16TH CENTURIES

BY COURTESY OF (TOP LEFT, BOTTOM LEFT) THE ISLAMISCHES MUSEUM, BERLIN. (TOP RIGHT) PIERPONT MORGAN LIBRARY, N.Y.; PHOTOGRAPH, (CENTRE) A. C. COOPER LTD.

of the Islamic world but later from Turkey and Persia, the Turkish development appearing in conventionalized ornament and the Persian from the 18th century onward showing greater complexity in formality and realism, and influenced eventually by Chinese elements as a result of the Mongol domination.

Rugs are the most important of Persian textiles, the best of them, which date from the 16th and 17th centuries, displaying amazing delicacy in technique and great decorative skill in design with rich soft colours marvelously adapted to the texture. *(See* EMBROIDERY; TEXTILES; RUGS AND CARPETS; BROCADE.)

Metalwork.—The Persians were aesthetic craftsmen in metal and their delicate inlaying of silver and gold into copper and steel of intricate geometric and naturalistic ornament shows decorative genius and the greatest of technical facility. The motives in this work were similar to those used in ceramics and textiles.

A rinceau or branching scroll ornamented with sharp pointed spearlike leaves was widely used. Much of this artistry was employed, of course, in the decoration of arms and armour and although there is a definite resemblance between the work of Turkey and Persia, the Persian far surpasses with its richness and delicacy. *See* METALWORK, DECORATIVE; SILVERSMITHS' AND GOLDSMITHS' WORK; *see* also references under "Persian Art" in the Index volume. (T. F. H.; X.)

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PERSIAN BERRIES are the seed-bearing fruit of species of *Rhamnus* which are, or were, cultivated in France, Spain, Italy, the Levant and Persia.

The Persian berry proper is derived from R. *amygdalinus,* R. *saxatilis* and *R. oleoides.* The berry, gathered when unripe, has a greenish-yellow colour, but when older it is black and gives an inferior result in dyeing. Though their use declined. Persian Berries were still employed in modern times by calico printers for the production of "steam" orange, olive and green effects. In dyeing property they closely resemble quercitron bark and contain, as their main constituent, xanthorhamnin, $C_{34}H_{42}O_{20}$, a glucoside of rhamnetin. $C_{16}H_{12}O_7$. (A. G. P.)

PERSIAN GULF. The Persian gulf (as here described) is the shallow trough which extends 500 mi. from the Shatt-al-Arab in a southeasterly direction to the Musandam peninsula in Oman. There the Hormuz strait separates it from the Gulf of Oman. But "the gulf" is a term frequently used to include all the waters of the approaches (the Gulf of Oman and the Hormuz strait) as well as of the Persian gulf itself and. indeed, historically it is impossible to differentiate between them. The breadth of the Persian gulf varies from 50 mi. at the entrance, the Hormuz strait, to 140 mi. at the head and 200 mi. at its widest part. On either side lie the Persian and Arabian plateaus. the former nearer to the coast and with a quick rise through a series of limestone ranges. On the western side the rise is much more gradual to the central uplands of the Arabian peninsula.

In the Persian gulf the depth of water rarely exceeds 50 fathoms and, generally speaking, increases more rapidly from the Iranian than from the Arabian shore; on the pearl banks. which occupg about one-third of the area, the depth is less than 20 fathoms. At the head the 20-fathom line lies about jo mi. from the entrances to the rivers. Near Ras Musandam, however. a depth of 100 fathoms is reached. Off the Arabian coast, and especially north of Bahrain, a white clayey bottom is found; on the pearl banks it is sand, coral or rock. Off the Iranian coast it is generally mud.

The shores vary in character from the precipitous and rugged cliffs of the Musandam peninsula, with its broken outline, caverns and small sandy beaches, to the marshes and mud flats at the head of the gulf. Between these southern and northern limits on the Arabian side the shores are, in general, low and sandy with reefs and shoals extending up to jo mi. from the coast. On the Trucial coast there are narrow creeks and shallow lagoons with low, rocky islands sometimes surrounded by coral reefs.

There are many shoals, islets and reefs of? the shore of the Qatar peninsula; from its western base (Dohat as-Salwa) the coast trends toward the northwest, forming the western shore of the Bahrain gulf, with several small bays and low, sandy headlands. From Qatif, at the northern end of the Bahrain gulf, to the entrance to Kuwait bay the coast is low and sandy with reefs extending more than 20 mi. from the shore. The head of the gulf is formed by the deltas of the Shatt-al-Arab, the Karun, the Khor Musa and the Hindian; it consists of mud flats, swamps, and marshy plains. The Iranian shore from Ras Bahrgan (a headland formed by the delta of the Hindian) sweeps to the northeast for 30 mi. and then turns southeastward. It is low and sandy almost to Bushire where there is a swampy stretch north of the town. South of Bushire the coast is fringed by mountain ranges which sometimes leave a strip of plain only one or two miles in width; wide bays are formed where valleys open between the mountains and there are stretches of marsh and mud flats.

From Lingeh to Bandar Abbas (96 mi.) the coast has an east-northeasterly trend. crossing the ends of several mountain ranges and the valleys between them. There are mangrove swamps and mud islands in the western half of the Clerence strait, which separates Qishm (q v.) island from the mainland, and on the mainland opposite. Bandar Abbas, on the coast. lies in a bare, sandy, littoral plain backed by mountains rising to the peak of Kuh-i-Ginau (7.783 ft.) 17 mi north-northwest of the town. From Bandar Abbas to Minab the coast is fringed by mud flats and is low and swampy. The Minab river waters a fertile district of orchards and date groves. Southeast of the river the coast forms the shore of the Gulf of Oman. A coastal road runs from Bushire to Lingeh and a dry-weather track thence to Bandar Abbas. (K. C. B.)

Geology.—The Persian gulf and its continuation, the alluvial plain of Mesopotamia, together form a depressed zone lying between the stable tableland of Arabia and the folded ranges of southwestern Iran, the so-called Zagros system. It is a shallow sea. nowhere with depths of more than 60 fathoms, and is in no sense a "rift valley" such as the Red sea. The rocks forming its shores are of recent or young Tertiary age and are mostly sandstones, marls, limestones and gypsum. Locally Eocene and Upper Cretaceous limestones are exposed. and the Hormuz series, in part Cambrian, appears associated with intrusive salt bodies. Relics of raised beaches up to 150 ft. above sea level are locally preserved.

The strike of the folds throughout the length of the Iranian coast is parallel to the shore line. A number of anticlinal structures form prominent ranges. such as Kuh-i-Bang. Kuh-i-Mund, Shahin Kuh. The greatest folding movement is of late Pliocene age. The marked swing of the strike between Lingeh, Bandar Abbas and Jask shows the influence of Oman which projected as a buttress toward the advancing fold waves of the Zagros system.

The headland of Oman, the Ru'us al-Jibal. consists of massive limestones of Permian to Lower Cretaceous age. These were strongly folded in middle Cretaceous time and the complex played a passive part during the later Pliocene folding of Iran. The inlets in the Ru'us al-Jibal are drowned valleys indicating a relative depression of the land of about 1.500 ft.

The Arabian coast of the gulf is mostly very flat and featureless. Between Kuuait and Qatif it is composed of an extended sheet of horizontal or very gently folded calcareous sandstones and limestones probahly of Pliocene to Pleistocene age. Bahrein island and Qatar peninsula are elongated domes exposing Eocene

limestones and marls. The water of the copious springs of Bahrein and of the wells of Qatar is artesian.

The numerous islands of the eastern half of the gulf are formed of intrusive salt plugs. Salt is only exposed in a few islands, Qishm, Henjam, Hormuz, etc., but its presence under the other islands may be assumed. On the Iranian mainland there are a great number of these plugs, which in some cases built great salt mountains rising to nearly 4,000 ft. above the surrounding plain, as at Kuh-i-Namak in Borazjan (Dashtistan). The salt masses are 4 to 6 mi. in diameter and appear as intrusions.

(P. Z. C.)

Minerals.--On the Arabian side of the gulf, other than oil, minerals do not exist in significant quantities. In Oman some coal of poor quality has been found and copper exists in the mountains of the interior. Red ochre exists in several islands (notably Hormuz and Abu Musa) and is profitably worked. Salt is found in unlimited quantities on many islands, particularly Hormuz and Qishm, and large amounts are exported. Iron, as haematite and pyrites, is widely scattered in the Hormuz series. Sulphur has been worked near Lingeh on the Iranian coast. Gypsum of good quality is widely distributed.

Tides.—Great variations occur in the type of tide, the diurnal type being usual in the south and semidiurnal in the north. The rise of the spring tides varies between 6 ft. at Bushire and Bahrein and 11 ft. at Kuwait and Bandar Abbas. The tidal streams everywhere in the Persian gulf are erratic and the information about them is unreliable.

The Arabian Coast.—The promontory which terminates in Ras Musandam is known as Ru'us al-Jibal (the mountain tops) and forms part of the territory of the sultan of Muscat and Oman and dependencies (Gwadar and Dhofar) whose frontier on the eastern side is at Ras Sha'am. Southwestward of this point the coast is known as the Trucial coast (formerly the Pirate coast) and is occupied by a number of independent sheikhdoms, Ras al-Khaimah, Umm al-Qaiwain, Ajman, Sharja, Dubai and Abu Dhabi, whose rulers have been in treaty relations with the British government since 1892. The small territory of the sheikh of Fujairah on the eastern shore of the peninsula became independent of Sharja in 1901 but its ruler was not recognized as independent until 1952 when he accepted the same engagements as the Trucial coast sheikhs. Sharja, which formerly included what are now the independent sheikhdoms of Ras al-Khaimah and Fujairah, was until recent times the largest and most important town on the coast; its place has now been taken by Dubai. A British political agency was established at Sharja about 1823; it was transferred to Dubai in 1954.

Before 1835 there was no restriction on war at sea between the sheikhs but in that year they were induced by the British authorities to sign a maritime truce for six months to cover the pearling season. It was renewed annually until 1843 when, the benefits having become manifest to all, it was prolonged for ten years. In 1853 a treaty of peace in perpetuity was concluded which accepted British intervention in case of aggression by sea, but it has been British policy not to interfere in the quarrels of the sheikhs on the mainland. They have been left also to administer their territories in their own manner. In 1892 an "exclusive" agreement was signed by which the sheikhs bound themselves not to enter into relations with any other government than the British without the latter's consent and similarly not to grant concessions. In return British good offices were promised in the event of unprovoked aggression.

The Qatar peninsula forms a sheikhdom which has been in relations with Great Britain since 1882, but it was not until 1916 that they were put on the same footing as those of the Trucial sheikhdoms. The southern frontier of Qatar extends from the Khor al-Odaid (which is claimed by Abu Dhabi) to a point north of Salwa. which is in Saudi territory (neither this frontier nor the landward frontier of the Trucial sheikhdoms and Oman, where they march with Saudi Arabia, had been defined in 1954 in spite of attempts to reach agreement dating back 20 years). There begins the western shore of the gulf containing the Bahrein Islands which terminates at Qatif.

The Bahrein group of islands is ruled by a sheikh whose relations with the British government are governed by a series of agreements dating back to 1880 and containing provisions similar to or identical with those binding the Trucial sheikhs. The headquarters of the British political resident is in Bahrein, to which it was transferred from Bushire in 1946.

The coast of the extensive Hasa province, in which lie the valuable oil fields of Saudi Arabia, stretches for about 300 mi. from Salwa to the southern boundary of a neutral zone in which Saudi Arabia and Kuwait share the rights. This zone, which extends about 70 mi. inland, has a coastline 50 mi. long. Kuwait harbour, which stands on the southern shore of a deep bay, gave the place importance before the discovery of oil in 1938. Late in the 19th century the ruler, who enjoyed semiautonomy under the Turkish empire, frequently requested British protection. This was finally agreed and a treaty of friendship was concluded in 1899. A British political agency has been established in Kuwait since 1904 and relations with the British government are similar to those of other gulf sheikhdoms. Between Kuwait and Iran is a narrow corridor giving Iraq access to the gulf.

The Iranian Coast.—From the Shatt-al-Arab the northern and eastern coasts of the gulf are Iranian territory, which extends to the small port of Gwatar on the shore of the Gulf of Oman. The inhabitants are either Iranians or Arabs who, by domicile and intermarriage, have lost nearly all their racial and most of their social characteristics but retain a dialect of Arabic as their mother tongue.

Islands.—The islands lying off the Arabian coast to the east of the Qatar peninsula belong to Abu Dhabi, with the exception of Sini which was occupied by Persia in 1887, the Tamb Islands which belong to Ras al-Khaimah, and Abu Musa which belongs to Sharja. The ownership of some of the islands and shoals between Bahrein and the mainland is claimed by Saudi Arabia but the question was unsettled at the end of 1954. Saudi claims to islands off Kuwait and the neutral zone have also been made. All the islands off the Iranian coast are Iranian, except those already mentioned, and Iran has claimed ownership of the Tamb Islands and of Abu Musa.

Climate.—From the earliest times the climate of the gulf has been denounced by travellers of every nationality, and residents have gained some gloomy satisfaction from recording daily temperatures in their letters and reports; but modern housing and amenities have done much to make it more bearable and less unhealthful.

Temperatures vary as follows:

	Mean (° F.)	Minimum (° F.)	Maximum (° F.)
Kuwait	55 (Jan.) to 94 (Aug.)	36 (Dec., Jan.)	117 (June, Aug.)
Khorramshahr	55 (Jan.) to 93 (Aug.)	30 (Jan.)	120 (July)
Bushire	57 (Jan.) to 91 (Aug.)	32 (Jan.)	115 (Aug.)
Bahrein	61 (Jan.) to 92 (Aug.)	41 (Jan.)	103 (July, Aug.)
Jask	67 (Jan.) to 91 (July)	42 (Jan.)	113 (June)

Relative humidity is high everywhere, reaching 84% at Bushire and 80% at Bahrein. Rainfall is considerably higher on the Iranian than on the Arabian coast; mean annual values, calculated over varying periods give: Kuwait, 4.8 in.; Khorramshahr, 8.4 in.; Bushire, 10.9 in.; Bahrein, 2.9 in.; and Jask, 4.7 in. The number of days of rainfall vary from an annual average of 21 days at Khorramshahr to 7 days in the southern part of the gulf.

The prevailing wind is the northwester known as the shamal; it varies in direction from north to north-northwest on the Arabian coast and from northwest at the head on the Iranian side to west-northwest, west and southwest at the southern entrance of the gulf. Squally shamals of short duration occur in winter; in summer they may rise to gale force and last for a week. The southeasterly or easterly wind known as the qaus and the southwesterly (the *suhaili*), which usually follows it, are feared by the natives, as the latter blows directly into nearly all the otherwise sheltered anchorages.

Vegetation.—Throughout the islands and coastal fringes of the gulf vegetation is exceedingly sparse and varies considerably in amount and in its incidence according to the extent of the winter rains and the nature of the country. The most conspicuous family

of indigenous plants is the Chenopodiaceae of which at least three species are found. All are eaten by camels. "Harm" (*Zygophyllum album*) and "shanan" (*Suueda sp.*) grow abundantly on the Trucial coast and varieties of the acacia are widespread. The date palm flourishes in Oman and in Hasa. and the quality of the dates from these tno districts is especially esteemed. From the Shatt-al-Arab in southern Iraq dates are exported in large quantities. They are also grown in Bahrein and on the Trucial coast and in small quantities on oases in the hinterland. Extensive fertile patches on which agriculture is possible are found near Bandar Abbas and on the Mund river in Laristan, on the Batina coastal strip on the Gulf of Oman, and in Hofufin Hasa. Elsewhere small quantities of cereals, vegetables and citrus fruits are grown where conditions are favourable.

Livestock. — Although fast losing its former importance as a means of transport, the camel is still bred extensively on the Arabian coast, and the Omani strains are famous for speed and for comfort.

Other domestic animals are the horse and the ass; flocks of sheep and goats are kept. Many of the islands are almost entirely barren, but some wild goats, black and gray partridges and pigeons are found in hilly districts and some gazelle on the plains. Gazelle, hares, the lesser bustard (houbara) and sand grouse also are found on the mainland. The animals on the Arabian coast are distinguished for their very light coloration.

Fish.—About 200 varieties of fish are known to exist in the gulf including the seer (Scomberomorus commersonii), known there as the surmai, and mullet, seabass, members of the horse-mackerel family, the Indian shad, several species of sea perch and sea bream, and varieties of the sardine; sharks abound including the harmless Rhineodon. or whale shark, the largest of all fishes. There are many kinds of brilliant reef fishes; rays and sting rays are also found including the giant devil ray which has been reported to attain a span of 24 ft. Porpoises and swordfish are common, and the narnhal is sometimes seen. Sharks are caught with hook and harpoon, and the flesh is dried and exported to the interior; the dried fins and tails go to China and the oil is locally used for smearing boats. The edible fish are mostly caught by trap or stake net or from small boats. Dried fish is the staple diet in Makran, the land known to the ancients as that of the ichthyophagi. There is a modest export trade in dried and salted fish to India and Iraq The Iranian government started a sardine-canning factory at Bandar Abbas, but it ceased production before 1945.

The **Pearling** Industry. — The Great Pearl bank is situated in the waters of the great bight between Sharja and the north of the Qatar peninsula and southwest of a line from this point to Jazirat Abu Ali off the Arabian coast. Pearls are also found in small quantities off the Iranian coast north of Lingeh and near Kharag Island.

Average depths are from 10 to 15 fathoms. but in places they reach 20 fathoms or more. The majority of the pearling fleet is based on the Trucial coast where the oil industry had not by 1955 yet offered more alternative employment. The principal season for the fishery is during the four months May to August with the first ten days of September. Within the main area more than zoo banks are knoan where the average depth is about 8 fathoms and the extreme 14 fathoms. The longest time a diver can remain under water is about one and a half minutes, but few exceed one minute. Although the industry has declined enormously since the introduction of the culture pearl, it is still of some importance. No reliable figures exist enabling a comparison between present and past trading to be made.

Lights and Buoys. — The government of India established about 1912 an efficient system of lighting and buoying, which was maintained after World War I by the Basra Port directorate which after 192j levied a charge on vessels entering the Shatt-al-Arab to meet the cost. This administration continued until 1948 when it was taken over by the British ministry of transport. For financial reasons responsibility was transferred in 1950 to a nonprofit-making company. the Persian Gulf Lighting service, with a board of management in London. The Iranian government has more than once since 1929 shown a disposition to assert its authority by assuming responsibility for lighting and buoying the Iranian. coast and islands.

Currency. — In Iranian ports the Iranian currency alone is legal. The Indian rupee is in general use in Kuwait, Bahrein, Qatar and the Trucial coast, but in the interior and in Muscat only the Maria Theresa dollar is accepted.

The British Bank of the Middle East (formerly the Imperial Bank of Iran) has branches in Bahrein. Kuwait, Qatar, Dubai, Sharja. Abu Dhabi and Muscat; the Eastern bank has branches in Bahrein and Qatar. In Kuwait. a Kuwait National bank was formed in 1952 with a board of Kuwaiti merchants and a British manager.

Posts. — The postal services which were formerly administered by the India government came under the British general post office in Kuwait, Bahrein and Dubai after India became independent in 1947. In Doha (Qatar) the postal service mas under the British political officer. British stamps, surcharged, being used except for the internal post in Bahrein for which the ruler issues his own.

Telecommunications. — Bahrein has radio and radio telephone communications with London, New York, Kuwait, Doha and Muscat. There are radio stations at Sharja and Dubai.

Internal telephone systems have been installed in Bahrein, Kuwait and Doha.

Air Services. — Scheduled services to Kuwait and Bahrein are (mid-1950s) provided by B.O.A.C.. Middle East Airlines, Cyprus Airways, Iraqi Airways; to Kuwait, also by Misrair, Iranian Airways, Air Liban. Syrian Airways and Kuwait National Airways; Bahrein. Qatar and Sharja are served also by the Gulf Aviation company.

Shipping. — Apart from the tankers that serve the Iranian and Arabian oil fields, eight shipping lines have regular services to the gulf calling at Kuwait, Bahrein, Khorramshahr and southern Iranian ports.

Economy. — The prosperity of the sheikhdoms was transformed by the discovery and exploitation of oil which, directly and indirectly, affords the main source of revenue. Oil was not yet in production on the Trucial coast at the beginning of 1955, but strikes at Bahrein (1934), Kuwait (1946) and Qatar (1949) and the refinery at Bahrein, processing large quantities of crude oil from the Saudi Arabian fields on the mainland, had already brought wealth in which less fortunate neighbours shared to some extent. Kuwait, with a revenue of about £55,000,000 in 1953, was by far the richest of these states; Qatar, formerly dependent on a desert economy, had a revenue of £6,500,000 in 1953/54 and Bahrein, where the access of wealth was less spectacular, about £4,000,000 in the same year.

Trade of Kuwait and ***Bahrein***
(In thousands of pounds sterling)

	Imports		Exports	
	1926	1953		1953
Kuwait	448	22,350*		22,500*
Bahrein	1,622	14,525*	1,155	7,253*

*Excludes imports and exports by the oil companies and the governments.

Trade figures for Qatar are not available. Dubai, importing goods to the value of about £2,500,000 in 1953, does trade not only with the interior but with southern Iranian ports.

The main articles imported are clothing. textiles, household goods, tea, coffee, sugar, rice, flour and other foodstuffs, motor vehicles and spare parts, building materials and luxury goods of all kinds.

HISTORY

The history of the gulf before the 4th century B.C. is based on scraps of evidence provided by inscriptions. and on deduction from other records of a much later date. It appears to be certain, however. that from the very earliest times the Arabian shores of the gulf, the southwestern plains of Persia and the Sumerian territories of Ur were inhabited by a Semitic people.

There is evidence that a seafaring race lived in "Magan" (which

may be synonymous with Oman) about 2600 B.C., and that communication betneen India and southern Iraq existed at an even earlier period. The Babylonians (7th century B.C.) certainly navigated the waters of the gulf and may have traded direct with India. For our first certain record we are indebted to Nearchus, the admiral of Alexander the Great, who brought his fleet from India at the end of Alexander's successful campaign in 326 B.C. Writers of this period indicate the existence of maritime trade between the gulf and the far east.

Eratosthenes (c. 276–*c.* 194 B.C.) and other writers describe Gerrha, "a city five miles in circumference." on the Arabian coast opposite Bahrein as an important centre of trade in spices and other products of southern Arabia which were carried by land to Mecca, Medina and Petra and by land or sea to Babylon. Bahrein was even then famous for its pearls. Later the Persian gulf route seems to have suffered a decline and trade from the east was carried through the Red sea. Gerrha, however, remained important until the days of Pliny (A.D. 23–79). About A.D. 116 the Romans under Trajan reached the gulf but left no mark there.

Moslem Conquests. — From that time records are scanty until after the rise of Islam in the 7th century, when the Arab conquests brought Persia and the whole of the western coast of the gulf, including Oman, under Moslem rule.

By the middle of the 9th century Siraf, on the Dashti coast, had become the most prosperous port, and it was visited by Chinese trading vessels. Basra, too, with its suburb Ubulla, was a centre of Arab sea trade. The stories of the voyages of Sindbad the Sailor are evidently based on records of Arab travel in the 9th and 10th centuries.

Hormuz became the most prosperous trading centre some time in the 14th century. Indigo was then an important export and the country on the mainland (the Minab district) was rich in wheat, barley, rice and sugar. Mineral products were gold, silver, copper, iron, cinnabar and salt. Marco Polo (end of the 13th century) had visited the island and described its immense trade with India. The Arabs held this trade until the coming of the Portuguese early in the 16th century.

The Portuguese. — The emergence of the two stable empires of Turkey and Persia at the end of the 15th century had restored the security of the land routes through Mesopotamia which had been destroyed by the Mongol invasions. But by 1515 Alphonso d'Albuquerque had secured Hormuz, closed the gulf to other shipping and diverted almost all the Indian and far eastern trade, for nhich Hormuz was the entrepôt, around the Cape of Good Hope. Throughout the 16th century the Portuguese held control in the waters of the gulf, and all trade with Basra and other ports, including Muscat. passed through Hormuz. But their ruthlessness and greed made them many enemies and, about the middle of the century, their supremacy was disputed by the Turks. Toward the end of it both Dutch and English adventurers began to consider the commercial possibilities of the east.

The Dutch and the English. — English interest in eastern trade was small during the middle ages, and merchants dealt through Venice which held a monopoly in business with the Levant. But this declined after the, capture of Constantinople by the Turks (1453) and was extinguished after the discovery of the Cape route. Antwerp then superseded Venice as the entrepôt of eastern commerce and the minds of the Dutch, who were forced to trade via Lisbon, turned toward direct communication with the east. In 1602 a number of rival companies was combined in the Dutch East India company which consolidated victories already gained over the Portuguese in India.

In 1592 the English Levant company extended its interests to the Indian ocean, and in 1600 the East India company was formed. Fourteen years later, the possibilities of trade with Persia being perceived, a firman was obtained from Shah Abbas and Jask was selected as the most suitable port in the gulf. The Portuguese opposed the project violently, but their behaviour having aroused the hostility of the shah he launched an expedition against Hormuz in which English help, unwillingly given in response to his threats and promises, enabled him to expel the Portuguese from Hormuz in 1622.

Gombrun on the mainland became the port of Persia and was renamed Bandar Abbas. For a century and a half it remained the principal trading centre of the East India company on the shores of the gulf. During the whole of this period the English company had to contend with the commercial rivalry of the Dutch, who did not finally abandon the struggle until 1766 when their last foothold, on Kharag Island. was destroyed by the Persians.

There is evidence that pirates from the coast of Oman harried shipping as early as the 9th century. and they probably remained a constant menace. In the 17th century they were certainly active and in 1698 the English, the Dutch and the French reached an agreement to share the policing of the waters of the Red sea, the Persian gulf and the approaches to India. But this arrangement appears to have been stillborn and the responsibility was gradually assumed by the English alone.

In 1763 the shah granted a firman to the East India company in which the English agent was described as "Governor-General for the English nation in the Gulf of Persia"—a reflection of the change in the company's status in India and of their commercial supremacy in the gulf—and a virtually exclusive liberty of trade was given. Their factory was established at Bushire in the same year. During this century, however, as a result of a series of revolutions and internal chaos, Persia ceased to be the predominant state of the gulf region. Bahrein was lost to the Utub Arabs from Kuwait, and a new force appeared in the sultan of Muscat who established himself on the Persian coast soon after his seizure of power in 1793. In 1798 the company reached an agreement with the sultan which was the beginning of a close political liaison which developed as time went on.

Thus the active hostility of the Portuguese and the Dutch, the depredations of Arab and other pirates, the decay of Persian authority with its resultant lack of a predominant power in the region, and the threat from France, against which the agreement with Muscat was specifically directed, together forced upon the agents of the company the assumption of political and administrative control in the gulf which was developed in a more positive form in the 19th century.

The 19th Century. — The intrigues of the French and the aggression of Russia had, on the whole, an adverse effect on British relations with Persia. On the Arabian coast the rise of the Wahhabis in Nejd and their advance to the shores of the gulf in 1800 introduced a new and disturbing factor there. Their defeat and expulsion by an Egyptian army in 1818 was regarded with even greater concern by the British authorities. But the Wahhabis recovered their lost power and were back on the coast in 1830; their precarious hold there was not finally lost until 1869. During their periods of ascendancy the Wahhabis occupied the oasis of Baraimi (Buraimi) on the western borders of Oman from which they launched ferocious attacks on the sultan's dominions and levied tribute upon them. They also encouraged the piratical activities of the Juwasim of Sharja, who became such a menace to shipping that British expeditions were sent from India to destroy their strongholds in 1809 and 1819. In 1820 a general treaty of peace was signed by all the sheikhs of the coast and by the sheikh of Bahrein. This treaty prohibited "plunder and piracy" at sea but was no bar to regular hostilities between the signatories. A treaty of perpetual peace in 1853 put an end to piracy as a regular calling in the gulf, and the "Pirate coast" became the Trucial coast. By agreements concluded between 1838 and 1856 the sheikhs gave undertakings to prohibit the use of their ships for the carriage of slaves and gave consent to the seizure and confiscation by British ships of any vessels found to be contravening their orders in this matter. The British government thus voluntarily assumed responsibility for putting a stop to this traffic as far as it was possible to do so at sea, having gradually been forced by the course of events to undertake the policing of the gulf in the interests of all users. British intervention was. however, confined to maritime affairs even during operations in support of the sultan of Muscat in his long struggle with the Wahhabis and the Juwasim. Military forces were landed to deal with pirates at their bases, but they never penetrated inland, and the British government steadfastly refused to become involved in the

internal affairs of the sheikhdoms or the sultanate or in their squabbles among themselves, so long as these did not threaten the peace at sea. Thus boundaries between the sheikhdoms, at no time clearly defined, fluctuated, and their landward frontiers depended rather upon the limits of the grazing grounds of the tribes owing their allegiance than upon any recognized line. The Wahhabis, during their years of power, levied tribute and exercised military control of varying extent from the Baraimi oasis until they were finally expelled in 1869.

In the waters of the gulf and on its eastern shore Persian authority was still negligible. In 1869 an exclusive agreement was concluded between the Trucial sheikhs and Great Britain by which the sheikhs undertook neither to enter into agreements with nor to make concessions to any other government. This alarmed the Turks who then sought to strengthen their position at the head of the gulf. Hasa was occupied in 1871 and a small detachment of troops was established at Doha on the east side of the Qatar peninsula. Kuwait, though virtually independent, was regarded both by the Turks and the British as under the exclusive influence of the Porte. The use of Kuwait as a regular port of call by British steamers, which began about this time, made the Turks fear a diminution of the trade of Basra, and they made a feeble attempt to establish a firmer position there.

Sheikh Mubarak, who became the ruler in 1896, repeatedly sought British protection. Russian attempts to obtain a railway concession linking the Mediterranean with the Persian gulf (which might have resulted in Russia's gaining territorial rights in Kuwait) caused the British government in 1899 to enter into an agreement with the sheikh similar in scope to the exclusive agreement mentioned above.

20th Century.—The Russians who attempted to gain a footing at the head of the gulf were followed by the Germans. who obtained a concession for an extension of the Anatolian railway to Baghdad and Basra in 1903. By an agreement with Turkey in 1913 Great Britain gained representation on the board of the railway and the right to control any extension south of Basra. By the same agreement Kuwait was recognized as an autonomous *qaza* of Turkey, and the Turkish government accepted the validity of the agreements between the sheikh and Great Britain. Turkey also abandoned all pretensions to sovereignty over Bahrein, Qatar, Muscat and the Trucial coast and recognized the British right to continue their time-honoured work of policing, lighting and buoying the waters of the gulf. The limit of Turkish authority was defined by a straight line roughly marking the southern boundary of the province of Nejd which included the coastal district of Hasa. Meanwhile Abd ul-'Aziz ibn Sa'ud had reconquered the Wahhabi capital, Riyadh; in 1902, and drove the Turks out of Hasa in 1913, thus bringing the Wahhabi power to the coast again. He was warned, however, that no attempt to interfere with Qatar or the Trucial sheikhdoms would be countenanced by the British government, and in treaties concluded later with Great Britain he formally agreed "to maintain friendly and peaceful relations" with them and with Kuwait and Bahrein.

The importance of the gulf to Great Britain was enhanced by the discovery of oil in the Persian province of Arabistan (Khuzistan) by a British concessionaire in 1907, and Abadan became the oil port on which British naval squadrons in the Indian ocean relied for fuel during World War I. Basra was occupied in 1914 to cover the oil fields, and the Mesopotamian campaign followed. Elsewhere in the gulf the mar brought no immediate changes.

The reappearance of the Wahhabi power on the coast, however, and Ibn Sa'ud's unwillingness to be restricted by a formula more precise than that quoted above aroused some misgiving, particularly as the landward frontiers of Qatar, the Trucial sheikhdoms and Muscat had never been defined. Negotiations with Ibn Sa'ud about these frontiers, initiated in the early 1930s. had failed, and in 1955 the questions of the frontier with Abu Dhabi and that of the ownership of the Baraimi oasis were referred ta arbitration.

Except for the inevitable shortage of foodstuffs and consumer goods, World War II hardly touched the gulf. The move of the headquarters of the British political resident from Bushire to Bahrein which had been decided upon several years earlier took place in 1946, but no other administrative changes took place until, as a result of the constitutional changes in India, the responsibility for gulf affairs was taken over by the British foreign office from the government of India in 1917.

Some modification in British policy occurred after that date. Efforts were made to encourage methods of sound administration and justice and to improve education and health services by the appointment of British advisers without, however, affecting the internal independence of the rulers. In 1950 a small force known as the Trucial Oman levies, paid from British funds, was established with headquarters at Sharja to assist in the maintenance of internal security. After the arrival in 1952 of a Saudi amir at Baraimi over which Ibn Sa'ud claimed rights, on the grounds of the Wahhabi occupation which was terminated in 1869, the duties became extended to include the protection of the Trucial sheikhdoms against external aggression.

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PERSIAN LANGUAGE: see IRANIAN LANGUAGES.

PERSIAN LITERATURE. The term Persian literature is used to describe those productions written in the Persian language as it emerged, much transformed in grammar and vocabulary, some three centuries after the Arab conquest of Iran in the mid-7th century A.D., when Islam had displaced Zoroastrianism as the predominant religion of the country. This literary language, commonly called modern Persian, later spread into Afghanistan, Turkey and above all Moslem India, giving rise to significant subsidiary literatures in those lands. The growth of a literature in modern Persian mas gradual, and few documents have survived to illustrate its earliest phase. Arabic had supplanted the national language as the prestige literary medium and many Persians made important contributions to Arabic literature, even centuries after the rebirth of Persian letters. The first specimens of modern Persian are in verse; prose literature appears more than a century later.

POETRY

Earliest Period.—The beginnings of Persian poetry are associated with the rise of the partially independent Persian dynasties which sprang up in the eastern provinces with the weakening of the central administration of the caliphate. The earliest name mentioned by Persian literary historians is that of 'Abbas of Marv, who is stated to have composed in A.D. 800 a panegyric in honour of Harun al-Rashid's son al-Ma'mun. The fragments of this poem quoted in the anthologies are now regarded as spurious; but the Arab geographer Ibn Khurdadhbih (*c.* A.D. 836) cites a Persian verse by a certain Abu Taqi al-'Xbbas ibn Tarkhan which looks genuine, and possibly this al-'Abbas is to be identified with 'Abbas of Marv. Clusters of poets gathered at the courts of the Tahirids (A.D. 821–873) and the Saffarids (A.D. 878–900), flattering their princely patrons in the language best known to them, but though their names are known their talents cannot be estimated, so little of their output having survived.

The unification of the eastern provinces under the Samanids (A.D. 875–999) provided employment and scope for many Persian poets, some of whom were patronized by the princes of other contemporary dynasties—the Buwaihids (A.D. 932–1055), Ziyarids (A.D. 928–1042) and Farighunids (A.D. 980–1010). The advent of the Samanid dynasty ushered in, indeed, a veritable renaissance of Persian letters. Proud of their Persian blood, they welcomed to their twin capitals Bukhara and Samarkand many scholars and poets. Nasr II (913–943) was immortalized by his favourite encomiast Rudagi (*q.v.*), the first truly great poet of Islamic Persia. It is possible to trace in the surviving fragments of these early

poems most of the literary forms which developed later. The qasida or formal ode, used especially in panegyric, and the ghazal or lyric, found suitable for poems of love and wine, stem directly from Arabic literature, which lent the Persians most of their prosodic patterns. The *mathnavi* or rhyming couplet, employed in epic and didactic poetry, was also known to the Arabs, though despised by them, but the *ruba'i* or quatrain, the shortest of all Persian poetic forms, universally famous through the verse of Omar Khayyam and his translator Edward FitzGerald (*qq.v.*) and popular with all Persian poets and men of letters, was unknown to them.

The Epic.—With Persian princes once more on the throne of Persian kingdoms, memories were revived of the ancient glory of pre-Islamic Iran as recounted in the Pahlavi writings. Nuh II (976–997) ordered his laureate Daqiqi to put into Persian verse the *Khvatay-namak* ("Book of Kings"), and the poet set to mork upon this congenial task but had not progressed very far when he died in the prime of life. The great undertaking was carried forward by Firdausi (*q.v.*), who brought it to a triumphant conclusion by 1010. His *Shah-nama,* though spurned at first by the Ghaznavid Mahmud (998–1030) who had overthrown the Samanids, soon won universal popularity as the national epic of Iran; repeatedly copied in fine and exquisitely illustrated manuscripts, it continued to be recited by professional rhapsodes down to modern times. Other poets soon sought to emulate the success of Firdausi; none came anywhere near to equaling his achievement, though numerous epics on heroic and romantic themes have been preserved. The nearest rival to Firdausi is Nizami (*q.v.*) who died about 1202; he composed five epic poems on a variety of topics, including the legendary exploits of Alexander the Great, the life of the Sassanian emperor Bahram Gur and the Bedouin romance of Laila and Majnun. Asadi completed in 1066 a heroic epic on the loves and wars of Rustam's ancestor Garshasp. A little earlier Fakhr al-Din As'ad Gurgani wrote his charming *Vis u Ramin,* later put into Georgian, a poem based on a Sassanian story which strongly resembles the legend of Tristan and Iseult. In due course the epic was pressed into service as a handmaid of historiography. Thus, Hamd Allah Mustaufi. otherwise famous as a historian and a geographer, having produced a revised edition of the *Shah-nama,* proceeded to compose the *Zafar-nama,* a gigantic poem reviewing the course of events from the birth of Mohammed down to the year 1331. The exploits of Timur, and later of the Safavids. were duly made into epics, while it is interesting to mention one of the last ambitious projects of this genre—the *Jarj-nama* composed in honour of George III by a Persian living in India, telling the political history of that country from its discovery by the Portuguese up to the British conquest of Poona in 1817. The Koranic story of Joseph and Potiphar's wife inspired a succession of poets: the first of the series is even attributed to Firdausi's old age, but the ascription has been hotly contested by modern scholars. while the finest treatment was that of Jami (*q.v.*), who gave a mystical interpretation to the tale.

Panegyric.—Panegyric, which forms an important branch of all eastern literatures, is less apt to interest the average western reader, but Persian qasidas merit the attention of all Persian students for the mastery of language and expression displayed by the best-known practitioners. This important genre, already perfected in Arabic especially by al-Mutanabbi (*q.v.*), could be as lucrative to the poet as it was pleasing to his patron; the richer and more powerful the prince, the more numerous his train of encomiasts. Sultan Mahmud of Ghazni created the congenial atmosphere for Farrukhi, Minuchihri, Asadi and 'Unsuri to display their virtuosity; their artful productions paved the way for the court poets of the Seljuk Sultan Sanjar (1118–57)—Mu'izzi, the "prince of poets"; Adib Sabir; and, most highly esteemed of all qasida writers, Auhad al-Din Anvari (*q.v.*), whose elegy describing the sufferings of his countrymen while Sanjar was held captive by invading Ghuzz tribesmen has been brilliantly translated into English as The *Tears* of Khorassan first by William Kirkpatrick and then by E. H. Palmer. Contemporary with Anvari was his greatest rival Khaqani (*q.v.*), court poet to the Shirvanshah of northwestern Persia. Khaqani, being erudite in most branches of Islamic learning and a supreme master of Persian lexicography, composed in a forbiddingly obscure style and thus endeared himself to the later crop of commentators. Indeed it was held to be far from a fault in the panegyrist to write obscurely; rather it highly flattered his patron to be supposed equal to understanding the learned references of his poet. Every succeeding dynasty attracted and rewarded its circle of panegyrists, and all the Mogul emperors of India liked to have their exploits celebrated in Persian verse. Nor has the panegyric by any means vanished, though its themes tend to be national and party-political rather than personal. In general, though the lengthy passages of servile flattery make tedious reading in the countless products of the classical age, many qasidas contain vivid and beautiful descriptions of natural scenery and great occasions which more than atone for the stretches of boring bombast.

Didactic and Mystical Poetry.—The origins of didactic poetry, ever popular in a country abounding in proverbs, saws and maxims, may be traced back to Firdausi and his times. Abu Shakur of Balkh, favourite of the Samanid Nuh I (943–954), wrote a didactic poem called *Afarin-nama* of which only fragments have survived, but sufficient to establish it as the parent of such famous works as the *Bustan* of Sa'di (*q.v.*); while Firdausi's *Shah-nama* abounds in sententious wisdom pithily expressed. Religious and mystical poetry was a natural outgrowth of moralizing didactic; the Isma'ili Nasir-i Khusrau (*q.v.*) composed an abundance of ethical and religious poems, while the mystics Abu Sa'id ibn Abi 'l-Khair (d. 1049) and 'Abd Allah Ansari (d. 1089) employed the quatrain to express mystical ideas. The first great mystical epic, the Hadiqat *al-haqiqa,* was composed in 1130 by Sana'i of Ghazni, who thus set a fashion which many later poets followed; he wrote a number of shorter epics as well. all of a religious character, and many odes and lyrics containing passages of great mystical insight and beauty. His immediate successor Farid ud-din 'Attar wrote numerous epics on religious and mystical themes, the most famous being the *Mantiq ut-tair* which FitzGerald abridged into his *Bird-Parliament;* mention may also be made of his *Ilahi-nama* and *Asrar-nama,* in which mystical teaching is illustrated by lively and well-told anecdotes. 'Attar in addition composed many odes and quatrains, and in prose an extensive and valuable book of memoirs of the saints. After Sana'i and 'Attar came Jalal-ud-din Rumi (*q.v.*), who died in 1273 having passed most of his life in Konya; his *Mathnawi i ma'nawi,* which draws upon his predecessors, is by far the greatest mork of its kind, while in his lyrics and quatrains he reached astonishing heights of pure poetry entitling him to be ranked with the world's great mystical poets. His contemporary Sa'di (*q.v.*), who has always been the most popular moralizing poet of Persia (though in his lyrics he displays a higher poetic gift), will always live by his *Bustan* and *Gulistan*—the latter a graceful miscellany of rhymed prose interspersed with passages in verse. Jami's Baharistan and Qa'ani's *Parishan* are among the books written in emulation of the *Gulistan,* which has been translated into many languages.

Lyric Poetry.—While the *ghazal* played a minor part in Arabic literature because of the greater popularity of the qasida, Persian poets from Rudaki onward showed increasing fondness for the shorter poem. By Sana'i's time the convention of the *takhallus* (the poet's pen name signed in the concluding couplet) had been established and remained thereafter the distinguishing mark of the lyric. Whereas the qasida sometimes ran to as many as 100 or more couplets in monorhyme, the *ghazal* seldom exceeded 12 and settled down to an average of seven. This art form was brought to perfection by Hafiz (*q.v.*) in the 14th century, but it was practised thereafter by almost all the Persian poets including those of India and has continued to be popular in modern times.

End of the Classical Period.—Contemporary with Hafiz were 'Ubaid i Zakani (d. 1370), the most talented satirist of Persia, Ibn Yamin (d. 1368), admired for his occasional verse, Khvaju of Kirman (d. 1352), who composed romantic *mathnavis* in emulation of Nizami, and Salman i Savaji (d. 1378), panegyrist to the Jala'irid rulers of Baghdad. The golden age of Persian poetry came to an end with the Timurids, and Jami (*q.v.;* 1414–92) is generally regarded as the last of the classics; he distinguished himself in

all branches and was also a notable prose writer. The Safavids, who gave a powerful impulse to painting and architecture. found poetry in a slow decline, though every generation brought its crop of imitators; the outstanding authors are Sa'ib of Tabriz (d. 1677), laureate to 'Abbas II, and, in the 18th century, Hatif of Isfahan (d. c. 1784). Under the Qajar dynasty (19th century) lived Qa'ani of Shiraz (d. 1853), considered by some the most brilliant and melodious of all the poets of Persia, though rather indifferent in his choice of subjects.

Persian Poetry in India. — The extension of Moslem rule in India gave rise to an Indian school of Persian poetry, founded by Amir Khusrau (d. 1325) who lived at the court of the Khilji kings of Delhi and composed brilliantly and extensively in all genres. Thereafter all the Mogul emperors had their laureates, such as Faidi (d. 1590). 'Urfi (d. 1590), Nau'i (d. 1610) and many others. These poets refined and complicated the familiar conceits to such a point that "Indian poetry" became synonymous with obscurity and artificiality.

PROSE

The foundations of Persian prose, as of poetry, were laid in the time of the Samanid dynasty. In 963 Bal'ami, vizier of Mansur I, published an abridged translation of the famous annals of Tabari (*q.v.*). About the same time a band of theologians from Transoxiana made a Persian version of Tabari's other great work, his commentary on the Koran, thus proving that Persian was a fit medium for sacred as well as profane writing. Mansur I also commissioned the first Persian book on medicine, the pharmacopoeia of Abu Mansur Muvaffaq of Herat. The application of Persian to philosophy and science, which involved the coining of an extensive and subtle technical vocabulary, ranks among the outstanding achievements of Abu 'Ali ibn Sina or Avicenna (*q.v.*) whose formative years were passed at the Samanid court.

The Two Styles. — The two translations of Tabari mentioned above set a norm of simple and pure Persian style which has seldom been surpassed. A more artificial type of prose, under the influence of the *saj'* ("rhyming prose") of the Arabs, was introduced by Hamid al-Din of Balkh whose Maqamat, composed in 1156 in imitation of the Maqamat of al-Hariri (*q.v.*), proved that Persian was fully equal to all the complications of scholastic Arabic. The "battle of the styles" continued to be fought out down the succeeding centuries; the taste of the Mongol conquerors encouraged involved and bombastic prose, satiation with which caused a reaction toward archaic simplicity. This polarity has continued to characterize prose writing ever since.

History. — Of all branches of prose writing, history has always been the most popular and every dynasty of kings and princes has had its circle of professional chroniclers. The anonymous history of Sistan, composed in the middle of the 11th century, was quickly followed by the history of the Ghaznavids by Baihaqi (d. 1077) in 30 volumes (only a sixth has survived). The Seljuk dynasty found a notable historiographer in Ravandi whose massive *Rahat al-sudur* was written c. 1203. The famous vizier Nizam al-Mulk (d. 1092) left a political testament called *Siyasat-nama* which has great importance as a historical source; as a guide to rulers it belongs to the same tradition, going back to Sassanian days, as the *Qabus-nama*, "Mirror of Princes," composed in 1082 by Prince Kai-Ka'us of the Ziyarid house. The advent of the Mongols ushered in a golden age of historiography. 'Ata Malik Juvaini's *Tarikh i* Jahan-gusha, completed in 1260, is a masterpiece of majestic prose and has great historical value, for its author held high office under the Mongols whose conquests he celebrated. Juzjani was another personal witness of the Mongol invasion, and his *Tabaqat* i Nasiri is especially interesting for its account of the events which occurred in Afghanistan and India. The history of Vassaf, completed in 1312, continues the authentic record of this critical period, but its usefulness is somewhat marred by its inflated style. Along with regional and dynastic histories. Persia has produced a number of universal histories on the grand scale, and the most valuable of these was written during the Mongol period: the *Jami'* al-tawnrikh of Rashid al-Din Fadlullah (*q.v.*), who drew upon Chinese and European as well as Islamic sources. The output of histories large and small continued undiminished through the ensuing centuries, and mention may be made here only of a few outstanding works. The career of Timur i Lang (Tamerlane) and the exploits of his successors in the 15th century are told by Sharaf al-Din 'Ali Yazdi and 'Abd al-Razzaq Samarqandi. Mirkhwand (Mirkhond, *q.v.*), who died in 1498, laboured for many years upon his elephantine history of the world, the *Raudat al-safa'*, much used by early European historians of Islam. Khwandamir (Khondamir), his grandson, abridged this massive work and also compiled the *Habib* al-siyar tracing the emergence of the Safavid dynasty. The life and times of 'Abbas the Great (*q.v.*) were described by Iskandar Munshi, and later Nadir Shah, Karim Khan Zand and the Qajars had their own chroniclers. Many local and provincial histories of great value also exist; while Moslem India yielded a rich crop of general and special works, most of which were described and partly translated in the eight volumes of Sir H. M. Elliot's Hzstory of India (1867–78).

This extensive historical literature is supplemented by many biographical works, particularly of poets, such as the *Lubab al-*albab of Muhammad 'Aufi (d. 1232) who also compiled a valuable encyclopaedia of stories; the Tadlzkirat al-shu'ara' of Daulatshah, completed in 1487; and the *Atash-kada* of Lutf 'Ali Beg (d. 1781). Nur Allah Shushtari (executed in 1610) composed an important biographical dictionary of mystics and Shi'ite martyrs, and Jami's Nafahat *al-uns* contains valuable notices of the leading Sufis down to his times.

Geography. — Many of the Arabic-writing geographers of the 9th and 10th centuries were Persian, and the oldest geography in the Persian language is the anonymous *Hudud al-'alam*, written toward the close of the 10th century. Nasir i Khusrau, famous otherwise as poet and theologian, left a curious travelogue (*Safar-*nama) of his journey (1046–52) from Merv across Persia. Mesopotamia and Palestine to Egypt and back to Balkh. Of special importance is the geography of the Mongol period which forms a part of the *Nuzhat* al-qulub, a cosmographical work completed in 1430 by Hamd Allah Mustaufi who also compiled an important history, the Tarikh i *guzida*. Toward 1420 Hafiz i Abru finished and dedicated to Shahrukh his untitled geography in which certain Persian provinces are described along with an epitome of their histories. Many valuable additions to Mustaufi are found in Amin Ahmad Razi's Haft *iqlim* (completed in 1594), an encyclopaedia of geography and biography. In the 19th century the impact of western knowledge stimulated the writing of new universal and local geographies, and the diaries of the shah Nasr-ed-Din (*q.v.*) recording his visits abroad are both entertaining and informative.

Theology and Mysticism. — Arabic was in general preferred by Persians writing on theology, but many important books were also composed in Persian. Nasir i Khusrau wrote extensively on Isma'ili ideas, as did Nasir al-Din Tusi (1201–1274) during his Isma'ili period; he is best known in Persia for his ethical manual Akhlaq *i* Nasiri. The first Persian handbook of Sufism was composed toward 1050 by Hujviri of Ghazni; 'Abd Allah Ansari of Herat (d. 1089) wrote down his *Munajat* or private litanies in charming rhymed prose interspersed with poetry. Mohammed Ghazali whose main output in the fields of jurisprudence, theology and mysticism was in Arabic, enriched Persian literature with his *Kimiya i* sa'adat on the mystical life and doctrine. His brother Ahmad Ghazali (d. 1126) wrote a beautiful essay on the theme of the Lover and the Beloved. and Suhravardi Maqtul (executed in 1191) composed a series of mystical allegories in Persian in addition to his many Arabic books. These are but a few titles out of a very extensive literature, including in the 19th century, the writings of the Babis and Baha'is.

THE MODERN PERIOD

In the 19th and the first half of the 20th century western thought and the demand for social and constitutional reform had their effect on Persian literature. The first signs of a new spirit may be traced back as far as Qa'im-Maqam Farahani (d. 1835), a vigorous stylist in prose and verse. and Amir Kabir (d. 1852). The idea of the novel as an instrument of social criticism sprang from Hajji Baba (1824) by James Morier (*q.v.*), which when first

translated into Persian (by Ahmad i Kirmani, Calcutta, 1905) passed muster for some time as an original composition. It was under the influence of this work that Zain al- 'Abidin (d. 1910) wrote his searing *Siyahat-namah i Ibrahim Beg.* Translations of foreign romances, such as the works of Alexander Dumas, Jules Verne and Jurji Zaidan, stimulated the growth of the historical novel celebrating the splendour of ancient and medieval Iran; mention may be made of the *Dastan i Shams u Tughra* of Mohammed Baqir Khusravi (1909), the *Ishq u sultanat* of Musa Nathri (1919) and the *Dam-gustaran* of San 'ati-zada (1920–25). The first successful experiment with the short story was made by Jamalzada in his *Yaki bud yaki nabud* (published in Berlin, 1922); his lead was followed by many writers, of whom the most noted are Mohammed Hijazi (b. 1900, who also composed plays, essays and novels), Buzurg 'Alavi (b. 1908), Sadiq Chubak, Jalal Al i Ahmad and above all Sadiq Hidayat (d. 1951). The last-named author, who was a learned antiquarian and folklorist, came into great prominence as the inventor of the "new style" which brought into literature many words and idioms previously current only in colloquial speech. His most famous novel *Bufi kur (The Blind Owl)*, translated into English and French, attracted wide interest. The followers of this fashion were generally left wing in politics, and their writings provoked much controversy.

The work of the first modernist poets, such as Adib i Pishavari (d. 1930), Adib al-Mamalik (d. 1917) and Iraj-Mirza (d. 1926), although important, was overshadowed by that of later writers. The earliest revolutionary poet was 'Ishqi, murdered in 1924; the latest was Lahuti (d. 1957), who spent the latter half of his life in the U.S.S.R. The most eminent of the "conservative" poets mere Malik al-Shu'ara, mentioned above, and the remarkable woman writer Parvin i I'tisami (d. 1941). Though Sir Mohammed Iqbal (d. 1938) was an Indian, his Persian poetry has been accepted into the canon of the national literature. Many poets rose to prominence after World War II, among them Parviz Natel Khanlari (b. 1914, editor of the literary magazine *Sztkhan),* Mohammed Hussein Shahriyar (b. 1904), Gulchin, Fereydun Tavallali (b. 1917) and Yasimi. Their work exhibited the increasing influence of western contemporary styles.

The extent of the modern renaissance of Persian letters is strikingly shown by the remarkable advance in book production. Not only were the Persian classics being edited in a scholarly manner—and much credit for this belongs to Mirza Mohammed of Qazvin—but a constant flow of original writings came from the presses in elegant and attractive print. The output was all the more astonishing since the reading public was still severely restricted by the low literacy figures, which, however, progressively rose as new schools and colleges were built.

The Press.—An important part in the modern literary movement has been played by the press, which has provided a forum for political and sociological discussion, for new literary criticism and for poetry on political and other new themes. The first Persian newspaper in Teheran appeared in the reign of Fath 'Ali Shah (1797–1835). Certain organs founded abroad by exiles or expatriates exercised real political influence during the long years of struggle for a modern constitution; Istanbul, Calcutta, Cairo, Paris, London and Berlin all contributed at various times and in various ways. After the revolution of 1905–08 newspapers proliferated in Persia itself, and the number of titles runs into hundreds; the competition of wireless did not sensibly diminish the flow.

From the purely literary standpoint, the press rendered the language more pliant, simple and popular. Daily papers revealed the talents of 'Xli Akbar Dakhau (d. 1956), good poet and excellent reporter imitating in his satires the humorous speech of the bazaars; the poet laureate Malik al-Shu'ara' Bahar (d. 1951); and many others. Magazines, especially those devoted to literature and social comment, were also produced in great numbers, some fugitive and some more firmly established; through this medium many essayists and writers of short stories first appeared before the public. The Persian press had by the mid-20th century become as competent and influential as that of any comparable country.

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(V. F. M.; A. J. Ay.)

PERSIGNY, JEAN GILBERT VICTOR FIALIN, Duc de (1808–1872), French statesman, was born at Saint-German Lespinasse (Loire) on Jan. 11, 1808, the son of a receiver of taxes. A strong Bonapartist, he planned the attempt on Strasbourg in 1836 and that on Boulogne in 1840; he took a prominent part in securing the election of Louis Napoleon to the presidency.

Persigny plotted the restoration of the empire, and was a devoted servant of Napoleon III. He succeeded Morny as minister of the interior in January 1852, and later became senator. He resigned office in 1854, being appointed next year to the London embassy, uhich he occupied (but for a short interval, 1858–59) until 1860. when he resumed the portfolio of the interior. The growing influence of Rouher caused his resignation in 1863, when he received a dukedom. He tried in vain to see Napoleon before his taking command in 1870, and the breach was widened when both were in exile. Persigny died at Nice, Jan. 11, 1872.

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PERSIMMON, the English name for the trees and fruit of the botanical genera *Diospyrus.* The oriental persimmon *D. kaki* is an important fruit in China and Japan where it is known as kaki. It was introduced into France and other Mediterranean countries in the 19th century and grown to a limited extent there. Introduced into the United States a little later, it is grown commercially on a small scale in California. It is grown throughout the gulf states of the U.S., mainly in home gardens. The fruit is 2 to 3 in. or more in diameter, yellow to red in colour, somewhat resembling a tomato in appearance. The trees will tolerate winter temperatures only to about 0° F.

The native American persimmon *D. virginiana* is a small tree, occasionally up to 40 ft. in height, and is native from the gulf states north to central Pennsylvania and Illinois and from the Atlantic coast west to the prairies. The fruit is 1 to 2 in. in diameter, usually rather flattened, and dark red to maroon in colour. Most fruits contain several rather large, flattened seeds. Until soft ripe, the persimmon is extremely astringent. When the flesh has become fully soft, the astringency disappears and the fruit develops a rich flavour. Considerable quantities are gathered from the wild and utilized. **A** number of superior kinds have been named and propagated to a limited extent, but are not grown commercially. (J. R. Mag.)

PERSIS (mod. Fars; *q.v.*), the southwestern part of Iran (Persia), named from the inhabitants, the Iranian people of the Pārsa (Fars); their name was pronounced by the Ionians *Persai,* with change from a to e, and this form has become dominant in Greek and in the modern European languages. The natural features of Persis are described very exactly by Nearchus, the admiral of Alexander the Great (preserved by Arrian *Indic.* 40 and Strabo xv, 727). The country is divided into three parts, of very different character and climate: the coast is sandy and very hot, without much vegetation except date palms; it has no good harbours, and the climate is very unwholesome; the population is

scanty. About 50 mi. from the coast rise the chains of the mountains, through which some steep passes lead into the interior valleys (called κοίλη Περσίς, Strabo, xv, 729), which lie about 5,000 ft. above the sea. There the climate is temperate, the country watered by many rivers and lakes. the soil fertile, the vegetation rich, the cattle numerous. These regions, which were thickly populated, form the real Persis of history. "This land Persis." says Darius, in an inscription at Persepolis. "which Ahuramazda has given to me, which is beautiful and rich in horses and men, according to the will of. Ahuramazda and myself it trembles before no enemy." The third part is the north, which belongs to the central plateau, still much higher, and therefore rough and very cold in the winter. Toward the northwest it borders on the Median district of Paraetacene (about Isfahan); toward the north and northeast it soon passes into the great desert, of which only the oasis of Yezd (*q.v.*) (*Isatichai* in Ptolem, vi, 4, 2) is inhabitable. In the east, Persis proper is separated by a desert (Laristan) from the fertile province of Carmania (Kerman), a mountainous region inhabited by a Persian tribe. To Carmania belonged also the coast. with the islands and harbours of Hormuz and Bandar Abbas. In the west Persis borders on the mountains and plains of Elam or Susiana. For the ancient topography *cf.* Tomaschek. "Beiträge zur historischen Topographie von Persien," in *Sitzungsber.* der Wiener Akademie, *phil. Cl.* cii, cviii, cxxi.

The Persians are not mentioned in history before the time of Cyrus; the attempt to identify them with the Parsua, a district in the Zagros chains south of Lake Urmia, often mentioned by the Assyrians, has been argued. Herodotus i, 125, gives a list of Persian tribes: the Pasargadae (at Murghab), Maraphii, Maspii, Panthialaei (in western Carmania), Derusiaei, Germanii (*i.e.,* the Carmanians) are husbandmen. the Dahae (*i.e.,* the "enemies.!' a general name of the rapacious nomads, used also for the Turanian tribes), Mardi. Dropici, Sagartii (called by Darius Asagarta, in the central desert; cf. Herod. vii, 85) are nomads. The kings of the Pasargadae, from the clan of the Achaemenidae. had become kings of the Elamitic district Anshan (probably in 596, *cf.* CYRUS). When. in 553, Cyrus, king of Anshan, rebelled against Astyages, the Maraphians and Maspians joined with the Pasargadae; after his victory over Astyages all the Persian tribes acknowledged him, and he took the title of "king of Persia." But from then only the inhabitants of Persia proper were considered as the rulers of the empire, and remained therefore in the organization of Darius free from taxes (Herod. iii. 97). Carmania. with the Sagartians, the Utians (called by Darius *Yautiya*), and other tribes, formed a satrapy and paid tribute (Herod. iii, 93); the later authors therefore always distinguished between Carmania and Persis. Names of other Persian tribes, partly of doubtful authority. are given by Strabo xv, 727,[1] and Ptolem, vi, 4 and 8.

The Persians of Cyrus (see PERSIA: History) were a vigorous race of husbandmen. living in a healthful climate, accustomed to hardship. brave and upright. Many stories in Herodotus (especially ix, 122) point the contrast between their simple life and the effeminate nations of the civilized countries of Asia. They were firmly attached to the pure creed of Zoroaster (cf. Herod. i, 131 sqq. and the inscriptions of Darius).

When Darius had killed the usurper Smerdis and gained the crown, a new usurper. Vahyazdata, who likewise pretended to be Smerdis, the son of Cyrus, rose in Yautiya, but was defeated in two battles by Darius's generals and put to death (Behistun inscription). Cyrus had built his capital with his palace and tomb, in Pasargadae (*q.v.*). Darius founded a new city about 30 mi. farther south on the left bank of the Pulwar, near its confluence with the Kur, with a large terrace, on which his magnificent palace and that of his son Xerxes were built. As Pasargadae was named after the tribe in whose district it lay, so the new capital is by the Persians and Greeks simply called "the Persians"; later authors call it Persepolis (*q.v.*), "the Persian city."

Both in Persepolis and Pasargadae large masses of gold and silver from the tribute of the subject nations were treasured. as in Susa and Ecbatana. Rut Persis lies too far off from the centre of the Asiatic world to be the seat of government. Like Arabia and similar countries. it could exercise a great momentary influence in history and produce a sudden change throughout the world; but afterward it would sink into local insignificance. So the Persian kings fixed their residence at Susa, which is always considered as the capital of the empire (therefore Aeschylus wrongly considers it as a Persian town and places the tomb of Darius there). After the reign of Xerxes. Persis and Persepolis were used only for special, mostly ceremonial, occasions and certain palaces in Persepolis remained in part unfinished. But the national feeling of the Persians remained strong. When Alexander had won the victory of Arbela. and occupied Babylon and Susa, he met (in the spring of 330) with strong resistance in Persia, where the satrap Ariobarzanes tried to stop his progress at the "Persian gates," the pass leading up to Persepolis. There Alexander set fire to the cedar roof of the palace of Xerxes as a symbol that the Greek war of revenge against the Persians had come to an end. Our best information tells us that he soon had the fire extinguished (Plut. *Alex.* 38); the story of Thais is a pure fiction, and we may well believe that he repented the damage he had done (Arrian. vi. 30, 1).

Alexander had planned to amalgamate the former rulers of the world with his Macedonians; but his death was followed by a Macedonian reaction. Peucestas, the new satrap of Persis, followed the example of Alexander, and thus gained a strong hold on his subjects (Diod. xix. 48); nor did Seleucus. to whom the dominion of the east ultimately passed (from 311 onwards), disdain the aid of the Persians; he is the only one among the Diadochi who retained his Persian wife, Apame, daughter of Spitamenes. Seleucus and his son Antiochus I Soter tried to introduce Hellenism into Persis. Of Greek towns which they founded there we know Alexandria in Carmania (Plin. vi 107; Ptol. vi 8, 14; Ammian. Marc. 23, 6, 49), Laodiceia in the east of Persis (Plin. 6, 115), Stasis, "a Persian town on a great rock, which Antiochus, the son of Seleucus, possessed" (Steph. Byz. *s.v.*), Xntiochia in Persis, founded apparently by Seleucus I and peopled by Antiochus I with immigrants called together from all Greece, as we learn from a *psephisma* passed by "boule and demos" of this town in 206 in honour of Magnesia on the Maeander. But at the same time we find in the centre of Persis in the district of Istakhr (the town which succeeded Persepolis) a local dynasty with Persian names (Bagadates I, Vahuberz, Artakhshatr, Autophradates I), and the still unexplained title Fratadara. On their coins in Aramaean Pehlevi which begin about 250 B.C., they have Persian features and wear the headdress of the satraps; on the reverse is the fire altar with the image of Ahuramazda hovering above it and the standard of the empire. They must have been recognized as vassals by the Seleucids; but a story preserved by Polyaenus (vii 30) narrates how one of them, Oborzos (Vahuberz), allured 3,000 settlers (evidently Greek settlers) into a fertile plain and annihilated them at night. Another story (Polyaenus vii 39) relates how, in the same way, a general of Seleucus (evidently Seleucus II 247–225) destroyed 3.000 Persian rebels with his Macedonian and Thracian troops. Thus the Seleucid supremacy was restored, but the dynasty of the Fratadaras was suffered to continue. When in 221 Molon, the satrap of Media, rebelled against Antiochus III, his brother Alexander, satrap of Persis, joined him, but they were defeated and killed by the king. Persis remained a part of the Seleucid empire down to Antiochus IV Epiphanes, who at the end of his reign restored once more the authority of the empire in Babylonia, Susiana and Persis; perhaps a battle, in which the satrap Numenius of Mesene (southern Babylonia) defeated the Persians on the shore of Carmania on sea and land (Plin. vi 152), belongs to this time. But after the death of Antiochus IV (164) the Seleucid empire began to dissolve. While the central provinces, Media and northern Babylonia, were conquered by the Parthians, Mesene, Elymais and Persis made themselves independent.

Persis never became a part of the empire of the Arsacids, although her kings recognized their supremacy when they were

[1] To the Pateiskhoreis belongs the lance-bearer of Darius, "Gobryas (Gaubaruva) the Pâtishuvari," mentioned in his tomb inscription they occur also in an inscription of Esarhaddon as Patushara, east of Media, 'in Choarene at the Caspian gates; the Kyrtii are the Kurds.

strong (Strabo xv 728, 736). From the *Periplus of the Erythraean Sea* (33–37) we learn that their authority extended over the shores of Carmania and the opposite coasts of Arabia. On their coins they now wear Parthian dress and have the title of king (written *malkâ*, pronounced *shdh*). Among their names we find Darayav (Darius), probably the founder of a town, Darabjird, in southern Persia, his son Artaxerxes (according to a fragment of Isidore of Charax in Lucian, *Macrob.* **15**, murdered by his brother Gosithres at the age of 93 years), Narses, Manucihr and others. From the traditions about Ardashir I we know that at his time there were different petty kingdoms and usurpers in Persis; the principal dynasty is by Tabari called Bāzrangi. The coins demonstrate that Hellenism had become quite extinct in Persis, while the old historical and mythical traditions and the Zoroastrian religion were supreme. It is highly probable that at this time the true form of Zoroastrianism and the sacred writings were preserved only in Persis, whereas everywhere else (in Parthia, in the Indo-Scythian kingdoms of the east and in the great propagandist movement in Armenia, Syria and Asia Minor, where it developed into Mithraism) it degenerated and was mixed with other cults and ideas. So the revival of Zoroastrianism came from Persis When Ardashir I the son of a king of Istakhr began to subdue the other Persian dynasts and in A.D. 224 defeated and slew the Parthian king, Artabanus, his aim was religious as well as political. The new Sassanid empire which he founded enforced the restored religion of Zoroaster (Zarathushtra) on the whole of Iran.

The new capital of Persis was Istakhr on the Pulwar, about 9 mi. above Persepolis, now Hajjiabād, where already the predecessors of Ardashir I had resided. It was a great city under the Sassanids, of which some ruins are extant and was important also in early Islamic times. But it shared the fate of its predecessor; when the empire was founded the Sassanids transferred their headquarters to Ctesiphon. (ED. M.; X.)

PERSIUS (in full, AULES PERSIUS FLACCUS) (A.D. 34–62), Latin poet whose satires, written under the influence of Stoic philosophy, reach a higher moral tone than any other work of their kind in classical Latin literature and are also remarkable for the author's individual use of language. According to the *Life* attached to his poems in the manuscripts, Persius was born at Volaterrae in Etruria (hence his Etruscan name Aules, often latinized as Aulus), of a family of equestrian rank. Having lost his father when he was about six years old and his stepfather a few years later, he went to Rome at the age of 12 to study under Remmius Palaemon and the rhetorician Verginius Flavus. At the age of 16 he began a close friendship with the Stoic philosopher L. Annaeus Cornutus, whose pupil Lucan was also to show himself to be a generous admirer of all that Persius wrote. Another friend from his early youth was the lyric poet Caesius Bassus, and his friendship with Thrasea Paetus (whose wife Arria was a relative of his) lasted for some ten years. Later he met the younger Seneca, but was not attracted by his mind.

His reading of the tenth book of Lucilius revealed to Persius his vocation, and he began to write his own book of satires. He wrote slowly, however, and left his book unfinished at his premature death. Cornutus then suppressed all that Persius had written except the book of satires, in which he made some slight alterations before handing it over to Bassus for editing. On publication, it had an immediate success.

Persius is said to have been gentle in disposition, girlishly modest, good-looking and affectionately devoted to his mother, sister and aunt. To his mother and sister he left a considerable fortune.

The six satires, which amount only to 650 lines, are composed in hexameters; but what appears as a prologue, in which the poet ironically asserts that he writes to earn his bread, not because he is inspired, is in choliambics.

The first satire, which censures the literary tastes of the day as reflecting the decadence of national morals (this theme is not unlike that of Seneca in *Epistulae morales*, 114), contains a vivid description of a poet reciting his own work, a scathing account of literary conversation at a dinner party and an interesting passage deriding specimens of bland mythological writing and languishing style. Here Persius writes real satire, treating what he himself has seen with understanding. whereas the remaining five satires in his book are in fact philosophical discussions on themes often handled by Seneca. Satire ii discusses what we may justly ask from the gods; satire iii, those who live wrongly though they know the right and those who have not been enlightened by philosophy; satire iv, the necessity of self-knowledge for public men (*cf.* Plato. *Alcibiades I*); satire v, the Stoic doctrine of freedom (introduced by friendly allusions to the teaching of Cornutus); and satire vi, the proper use of money.

In earnestness and moral purpose Persius rises far above the political rancour or good-natured persiflage of the earlier Roman satirists on the one hand and the rhetorical indignation that Juvenal was later to display on the other. He seems, as it were, a forerunner of the great Christian apologists. His thought, however, is often very difficult to follow. and the meaning of his powerful expressions is sometimes far from clear. He seeks brevity at all costs, and he is clumsy in his management of dialogue so that it is often hard to know where one speaker is supposed to leave off and another to begin. Frequently his metaphors are strained and his colloquialisms jarring. He takes not only characters but also whole phrases, thoughts and situations from Horace, despite his great difference from Horace in ideals, temperament and technique.

Yet Persius can write with natural simplicity and genuine eloquence (as in ii, 61–75; iii, 23–43; and v, 26–29) and occasionally has passages memorable for their realism or for their metaphor: for instance, *nescit quid perdat et alto Demersus summa rursus non bullit in unda* (iii, 33–34: "he does not know what he is losing and, drowned in the depths, sends not a bubble back to the surface") or *dum veteres avias tibi de pulmone revello* (v, 92: ". . . while I pluck your old grandmother's notions from your breast").

The *Life* states that before the publication of the book of satires some lines were removed from the end so that it should appear to have been completed; this may mean that an unfinished sentence or paragraph had to be omitted. Cornutus is also said to have suppressed an offensive allusion to the emperor Nero's literary taste, changing the original *auriculas asini Mida rex habet* ("King Midas has ass's ears") to *auriculas asini quis non habet?* ("Who has not ass's ears?"; i. 121).

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PERSON, OFFENCES AGAINST THE. This expression is used in English law to classify crimes involving some form of assault or personal violence or physical injury, *i.e.*, offencesaffecting the life, liberty or safety of an individual: but it is also extended to certain offences which cannot technically be described as assaults, such as criminal libel. The bulk of the offences thus classified, so far as their definition or punishment depends upon statute law, are included in the Offences Against the Person Act 1861, in the Criminal Law Amendment Acts, and in the Children Act 1908. The classification in these statutes is not scientific. The particular offences dealt with by the acts above named are discussed under their appropriate titles, *e.g.*, abortion,

assault, bigamy, homicide, rape, etc. In the Indian penal code most of the offences above referred to fall under the head "offences against the human body." In his *Digest* of *the* ***Criminal Law*** Sir James Stephen includes most of these offences under the title "offences against the person, the conjugal and parental rights and the reputation of individuals."

United States.—In the United States, such crimes as fall under the classification of offences against the person in England, are crimes by common law or statutes in the different States, but sometimes without any such general classification in the statutes.

PERSONAL ACCIDENT INSURANCE: **see** CASUALTY INSURANCE.

PERSONALITY. In defining personality the psychologist employs the two indispensable ideas of integration and uniqueness. While the various other concepts and principles of psychology refer to one or another segment of behaviour, personality invariably signifies, for one thing, the functinning of the whole person, and, for another, the unique organization of the individual that distinguishes him from his fellows. In accounting for a personality it therefore becomes essential to know how the person, in expressing his needs and his social relationships, functions as a recognizable unity with distinctive traits, drives, attitudes and habits which enable or prevent his attaining an adequate adjustment to his environment and to himself.

In the early 19th century James Ward in England stressed the individualistic orientation of the psychology of personality; in Germany, Wilhelm Stern adopted a similar standpoint in his personalistic approach. In conventional psychology textbooks personality is placed at the top of the conceptual hierarchy: the lower-order concepts lead systematically to "personality" as the most complex and inclusive.

There is a point of view, dating from about 1950, according to which personal experience is only one aspect of psychology; other aspects refer to other levels of behaviour. From this standpoint "psychology" would have to be replaced by the collective phrase "behavioural sciences" or, more simply, by the single term "humanics." Thus a reflex action, such as the blink of the eyelid in response to a sudden visual stimulus. would be regarded as behaviour at the physiological or neurological level, whereas a marked like or dislike of some other person, say a brother or sister, would fall directly within the domain of "personality" (more strictly. psychodynamics or idiodynamics; *see* below).

There is no unanimity of thought regarding personality in subhuman organisms, though, on the whole, psychologists tend to reserve the term, with or without sufficient justification, for the human species. Character (q v.), as distinguished from personality, usually involves moral and other normative judgments. It is therefore used only sparingly in U.S. psychology, although in European writing the term often is equated with "personality." Values, like any other data, are for the scientist a part of nature. Good and bad (as qualifiers of character, etc.) are always to be designated as belonging to a specific ethical frame of reference, not necessarily that of the observer or his social group.

Observation *v.* Explanation.—To find one's way in this area of scientific research one must keep constantly in mind the difference between observation and explanation. There are, on the one hand, data observed and reported and, on the other, concepts or theories set forth for explanatory purposes. While the concepts usually are presented as derived from observed data. as often as not the particular data selected for observation reflect the observer's theoretical bias. Progress in this field is a matter of gradually achieving, through continuous experimentation, a core of concepts that can be generally accepted and a related set of observational methods. In the process of attaining this end. hypothetical constructs must be freely entertained; otherwise it would not be possible to draw broad and significant inferences from a limited number of observations. At the same time techniques for gathering data must be fully exploited and new methods constantly devised. Only in this way will a body of agreed-upon theory be achieved eventually. Hence in this account the methods of observing personality will first be described, followed by a survey of personality theory.

METHODS OF OBSERVATION

Methods of observation may be conveniently divided into subjective, objective and projective. In brief, the subjective methods aim to evaluate what has been called opinion behaviour—what the subject believes about himself or others; the objective methods stress overt behaviour—the gross verbal, physical and social responses made unself-consciously in adaptive situations; the projective methods tap the implicit (unconscious) aspects of personality—those motor, perceptual and dynamic sets or trends that enter into the subject's every response, particularly affective or emotional ones. These three approaches are not, however, as mutually exclusive as the abbreviated exposition below may seem to imply. In actual practice they overlap. In expert application, for purposes of clinical diagnosis or experimental research, their overlapping in the given case reflects the unique organization of the subject's personality.

Subjective Methods.—In the subjective methods the subject himself discloses what he knows about himself. He makes himself an object of observation and reports his finding to the psychologist. Among the techniques used here are: the autobiography, elements of the life or case history, some types of interview and the so-called inventory method in which the subject reports about himself on a standardized questionnaire or check list. That these self-reports have the advantage of direct relevance and broad scope—who should know better than the person himself or have access to more facts about him than he does?—is readily appreciated; but these advantages are obviously counterbalanced by conscious or unconscious deception of self and others. It is therefore essential to include in such subjective methods control or stabilizing devices that help to identify at least the more obvious deceptive reports.

Objective Methods.—The objective methods of observation depend not upon the subject's own statements about himself but upon his overt behaviour as revealed to others who serve as examiners, observers or judges. Here are included not only verbal behaviour but physiological responses (blood pressure, heart rate, etc.), which may be recorded by special instruments, and adaptive or expressive physical or social responses (*e.g.*, intelligence tests). Objective observations may be made in the natural state (*e.g.*, the interview) by attending less to what the subject says about himself and more to his nonverbal, adaptive responses such as his stance, the amount rather than the content of his verbalization, nervous manifestations such as fidgeting, etc. Again, miniature life situations may be created in the laboratory for the single individual or for small groups that interact with each other under conditions defined by the investigator. Sometimes such observations are made through one-way observation screens or mirrors, and cinematic records of these observations may be obtained. Microphones may also be used to record verbal responses.

As will be noted, even in such objective methods of observation as those just described the verbal response of the subject may still play an important part. The difference between these records and the self-reports mentioned among the subjective methods lies in the treatment of the obtained data. In the objective approaches the verbal behaviour of the person is not necessarily construed at its face value. Instead it is treated much like any other behaviour; *e.g.*, movements of the limbs or of the internal organs. In such a frame of reference the verbal output of the subject is analyzed quite apart from his own conscious intent to communicate information about himself. The subject has merely behaved in a certain way under the given stimulating conditions. The quantity, form and content of his utterances may then be submitted to measurement and analysis. In the second quarter of the 20th century new techniques for the systematic analysis of verbal behaviour were contributed by a group of specialists devoted to the fields of semantics and information theory. (*See* also SEMANTICS; INFORMATION THEORY.)

Projective Methods.—The projective methods of appraising personality differ from both the subjective and the objective by approaching personality indirectly. Neither the person himself nor the examiner takes the subject as an object of direct observation; instead the subject is requested to behave in an offhand man-

ner—merely to exercise his imagination, to let himself go without self-criticisms or adaptive intent. In other words, he is encouraged to "project" himself and thus to reveal the implicit or unconscious content of his personality. The earliest of the projective methods employed on a systematic basis was that of word association, introduced by Francis Galton in 1879. Stimulus material is provided by individual words to which the subject responds with the very first word that comes to his mind as he hears the stimulus (see also ASSOCIATION, MENTAL). Sigmund Freud modified Galton's word association method into the free association technique for analyzing dreams, etc., as an aid to psychotherapy and personality research. Here the person responds to his own previous responses, *e.g.,* images from his own reported fantasies or dreams. In the ink blot method of Hermann Rorschach the subject is asked to tell what the blots look like to him. Responses provide clues to the subject's usual perceptual approach to real objects in terms of his habits, interests, needs and abilities. Another projective method is the Thematic Apperception test, in which the subject is invited to tell stories in response to pictures that he is shown. Finally may be mentioned the Rosenzweig Picture-Frustration study. Cartoonlike drawings that portray a series of everyday frustrating social situations serve as the stimuli for the subject, who is asked to supply (in the blank caption box above the head of the frustrated person) the first verbal response that comes to mind. As will readily be seen, all these projective techniques encourage the person to respond in terms of his own bias, with a minimum of external stimulation, since their common aim is to assay that bias. The methods of assessing personality are discussed in detail in PSYCHOLOGICAL TESTS AND MEASUREMENTS: Tests of Personality and Temperament.

STRUCTURE OF PERSONALITY

Observational methods having thus been surveyed, it is now in order to consider representative concepts that have been used for purposes of explanation or prediction. These range from the physiological or organic to the phenomenological or purely psychological.

PERSONALITY TYPES

The concept of personality type makes two assumptions: (1) that personalities are divisible into two or more groups each of which excludes the other and (2) that in each type are to be found certain mutually dependent and interrelated traits or patterns of response that can be inferred from each other. This theory has an obvious appeal because of its simplicity. As a result of experience and experiment, however, the view, while still having its adherents, is rarely entertained in its simple form. Even as abstractions personality types have a very limited usefulness and often contribute more to prejudice and to hasty generalization than to sober judgment or real knowledge.

Humoural Types, **Temperament** and the Endocrines.—Historically, type theories go back to Galen with his four humours—blood, phlegm, choler (yellow bile) and melancholy (black bile)—from which the four temperaments—sanguine, phlegmatic, choleric and melancholic—were derived. While this essentially pre-Socratic humoural psychology was long ago abandoned, the words denoting the four types have been absorbed into occidental language. Moreover, the essential idea that bodily disposition, or perhaps even predisposition, determines difference in temperament still has its exponents. The humours themselves have been replaced by the secretions of the endocrine glands.

Personality is an organismic unity, embracing both physiological and psychological manifestations. Biological maladjustments can lead to serious disturbances in the mental and emotional life of the person, and, conversely, mental upsets can disturb physiological functioning. Both the autonomic nervous system and the endocrine glands participate in such control. For example, overactivity of the thyroid gland results in nervousness, irritability and insomnia, in addition to the usual physical symptoms. Underactivity of the thyroid will bring about sluggishness, apparent mental deficiency, indifference to emotional stimuli, and so on. Again, the endocrine secretions of the sex glands have much to do with typical masculinity and feminity of personality as well as physique. Boys showing emotional and recreational interests below those typical of their chronological age have increased markedly in maturity upon receiving injections of male hormone. The pituitary, parathyroids and adrenals also affect personality traits (see also ENDOCRINE GLANDS). Various studies have attempted to relate phases of blood chemistry, such as acid-base balance, calcium-potassium ratio and sugar tolerance, to personality variables. While some of the experiments have returned encouraging results, none can be said conclusively to have proved a correlation between the physical and the psychological measurements. It must be emphasized that the positive findings with respect to endocrine glands relate mainly to instances in which glandular function was distinctly above or below normal. Interpretations of normal personality trends in terms of endocrine function must in the 1960s be regarded as highly speculative. A similar restriction applies to the data with respect to autonomic nervous system function.

Morphological or Physical Types.—A second chief theory of types depends upon the conformation of the human body—of its component parts or tissues. These morphological or physical types are then regarded as giving rise to, or being correlated with, types of personality. This theory is found in general terms as early as Hippocrates in Greece. In the 19th century a notable contribution was made in France by L. Rostan, who distinguished digestive, muscular and cerebral types. Around 1885 A. de Giovanni founded his school of clinical anthropology in Padua. His pupil G. Viola, utilizing the earlier work of the German Friedrich W. Beneke, and Viola's pupil S. Naccarati conducted detailed anthropometric studies with specified indexes for measuring the dimensions of physique and relating them to each other. The German psychiatrist. Ernst Kretschmer (*q.v.*) at about the same time nas led by his work with mental patients to develop a threefold physical classification: pyknic. asthenic and athletic. The pyknic is characterized by a broad trunk and relatively short limbs, round face. usually with a tendency to gain weight in middle age; the asthenic has a narrow trunk, shoulders and hips, long limbs, long narrow face and is generally lean; the athletic has broad shoulders and trunk, narrower hips, well-proportioned limbs and good muscular development. Kretschmer found a marked predominance of the cyclothymic temperament among pyknics; *i.e.,* they tended toward extremes of gaiety and depression. By contrast the asthenics were introverted, shy. serious and ranging in temperament from hypersensitive to phlegmatic and dull. This latter pattern he called schizothymic. The athletic physique was found to be intermediate in temperament. Kretschmer's views were attacked on the grounds, first, that it is impossible to classify most persons in any of his three physical groupings with any degree of accuracy and, second, that there are too many exceptions to the expected temperamental relationships when physical classification seems fairlv definite.

A considerable improvement on Kretschmer's work appeared in the research of W. H. Sheldon. In his approach the arbitrary classification of individuals into physical types was replaced by three ratings (on a seven-step scale) on three extreme physical patterns: the ectomorphic (resembling Kretschmer's asthenic), the mesomorphic (athletic) and the endomorphic (pyknic). Sheldon next reported three patterns of temperament (cerebrotonic, somatotonic and viscerotonic) and found that the physical and temperamental types agreed in a rather large proportion of cases. While this quantitative development might be expected to appeal to psychologists, Sheldon's conclusions have not been fully confirmed and have been looked upon with some doubt.

Psychological Types.—It was in psychiatry and philosophy that the third chief doctrine of types first emerged. As representative in the 20th century, the views of C. G. Jung and E. Spranger may be cited. Jung coined the terms introversion and extraversion to describe what he considered to be contrasting types.

Introversion was characterized as directing attention and interest inward, with a tendency to excessive daydreaming and introspection and to careful balancing of considerations before reaching a decision. Extraversion was characterized by outgoing-

ness in attention and interest, responsiveness to external stimuli, especially other persons, and impulsiveness. Recognizing that the postulation of only two types failed to do justice to the rich variety of observable patterns, Jung subdivided introverts and extraverts according to the relative dominance of four psychological functions — sensation, thinking, feeling and intuition. But subsequent research has placed most persons somewhere between the type extremes. The theory is useful mostly in calling attention to certain poles of personality and in providing a framework for noting certain trends.

Another widely influential type theory was that of E. Spranger. He began by emphasizing the "dominant value direction" of the individual and held that for purposes of analysis it was convenient to assume the existence of pure or ideal types, one corresponding to each of six major values: theoretical, economic, aesthetic, social, political and religious. This classification was developed into a scale of values by Gordon W. Allport, P. E. Vernon and Gardner Lindzey whereby, as in Sheldon's advance over Kretschmer, the subject is assigned a rating for each of the values.

Types, Traits and Factors

As is now apparent, the concept of types has a limited validity. Its two basic assumptions do not gain strong confirmation from empirical studies. These indicate that a "normal distribution," ranging from one extreme to the other, is likely to be found for any one trait associated with a supposed type, whereas the type concept assumes a piling up of subjects at the two extremes (bimodally). Again, while certain traits are found clustered together interdependently as the type concept implies, the organization is not always of one sort. The peculiar way in which each person has organized the traits of the so-called typed has not been taken into account.

For these reasons there has been a gradual shift from interest in types to interest in traits, singly and in their interrelationships. One of the most influential trait theories in the second quarter of the 20th century was that of G. W. Allport, who defined the trait as a psychophysical disposition acquired in the course of experience on the basis of a biological *Anlage*. Allport described traits as arranged in a hierarchy in the individual, some having a cardinal importance in relation to other subordinate ones. He strongly insisted on the existence of individual and even unique traits that might be found in only one person but still demanded to be included in any system of personality. He likewise stressed the individualized organization (congruence) of traits in every person —a view that contrasts with the universalized organization of traits in the type concept. This emphasis on individuality, adapted by Allport from Stern's personalistic psychology, was opposed by him to the exclusive interest of academic, experimental psychology in the generalized or average man. Following Wilhelm Windelband, Allport therefore wished to add the idiographic orientation to the nomothetic (universalized) orientation of general psychology. An almost simultaneous approach to traits developed in England, where Charles Spearman's work on human abilities, including intelligence, was applied to the field of personality. Important contributions were made there by Cyril Burt and later by Hans Eysenck, and by L. L. Thurstone, R. B. Cattell and J. P. Guilford in the United States.

Factor analysis is essentially a method of statistics, a branch of mathematics, employed for the systematic reduction of raw scores, obtained from a variety of tests, to a minimum number of basic elements. These latter are disclosed through the study of correlations between test scores. As applied to personality, the method begins with the administration of many tests to a group of subjects whose scores are then correlated. The correlation coefficients are next scrutinized to reveal which of the tests are presumably tapping similar or identical factors. Once the factor analysis has been completed it is possible to devise "pure factor tests" based not only on the crude knowledge that gave rise to the initial tests but on the refined knowledge disclosed by the factorial studies. It has been contended that factor analysis does not deliver what it claims: the factors derived by the method are held to depend too heavily on the original selection of tests, which are, of course, only a selection from a limitless number of possibilities; and, again, the factors themselves, once derived, have an uncertain psychological significance which is dubiously aided by the use of letters to designate them or by the arbitrary assignment of trait names that it is hard to justify on psychological, grounds. Moreover, the various exponents of factor analysis employ somewhat different mathematical procedures, especially in the critical last phases and, accordingly, bring forth different sets of factors among which it is no easier to choose than among more a priori personality theories. Finally, it has been argued, by Allport and others, that factor analysis does not allow for individuality; the technique radically assumes that all persons reflect a common mold.

To supplement the conventional method of factor analysis, in which scores on a group of subjects are correlated with each other test by test, an inverse method of factor analysis was introduced by Burt and developed by William Stephenson. In it persons, each of whom has achieved a variety of test scores, are correlated with each other. Such person-to-person correlation is, in a sense, a new expression of the earlier typologies, here reapproached on a more empirical — a sophisticated statistical — basis. Moreover, inverse factor analysis has been used not only for relating the several test scores of an individual subject obtained at any given stage, but, taking into account the variability of personality in time, it has been used to compare the assemblage of scores received at one time with those acquired at another. These novel efforts in the use of factor analysis to study individuality are, however, still controversial as to method and meaning.

BIOLOGICAL AND CULTURAL DYNAMICS

The concepts or inferred variables thus far considered refer primarily to the structure of personality — the patterns or other modes of organization that account for the several forms of behaviour that are recognizably personal. In contrast to this approach is one that stresses dynamics; *i.e.*, the forces or drives that direct the personality toward various ends and that secondarily may become attached to certain structures or patterns of function.

Psychoanalytic Theory

This dynamic orientation is, again, a very ancient one; classical writers, like Plutarch, who devoted themselves to biography or morals implicitly used some sort of dynamic theory of personality, and the same is even more obviously true of the great poets, dramatists and novelists of nearly every age. But the 20th century understanding of personality dynamics received fresh vigour and acquired a theoretical formulation from the writings of the psychologist Sigmund Freud, the founder of psychoanalysis. His interest in the raw, often fantastic data of experience in the individual case led Freud to explore not only dreams but other wayward and seemingly haphazard behaviour, such as slips of the tongue. Thus he developed the theory that both dreams and these other "lawless" or accidental acts were, like neurotic symptoms, the product of psychic determinism at an unconscious level. The concept of the unconscious became for him the basic one. Just as during sleep, when the ego is not on the alert, the nonconscious forces of personality come into obvious play, so, he asserted, they are present also in the waking state and at every weak point — in fatigue, emotional states and conflict — break through the conventional mask worn by the conscious ego. Much energy is expended by the ego to keep these untamed and unwanted elements of personality from gaining access to consciousness. It was, in fact. in the study of these mechanisms of ego-defense in the neuroses, particularly hysteria, that Freud first came to grips with the unconscious forces of personality *(see* also Ego; Defense Mechanisms). A few years later these initial studies were followed by his masterpiece *The Interpretation of Dreams* (1900). In psychoanalytic therapy the aim is to circumvent the ego-defenses by the method of free association in the presence of an analyst who permits and, in fact, encourages the patient to disregard in that setting the conventional social ameni-

ties. This therapy is a kind of re-education of the personality in which the repressed becomes expressed, the unconscious conscieus and the disintegrated integrated. While beginning with the neuroses and with dreams, Freud soon went on to apply the same methods of study and the same concepts to the history of civilization, to the various products of culture—religion, art, literature. etc.—and to the social practices of modern life. The influence of this theory of personality has been considerable, partly, no doubt, because it is itself a reflection of the period of social conflict and tension that contributed to its birth.

Freud based his study of personality on his medical background and hence tended to present his views as biological generalizations with universal application for homo sapiens wherever found. The unconscious drives of which he wrote and which he discovered in his patients were to him universal instincts modified, to be sure, by family upbringing and social education, but nonetheless rooted in the biology of man. The paradox is that, as compared with other psychiatrists of his time, Freud made much more of environmental factors than they and tended to oppose, by his insistence on psychotherapy, their fatalism. But subsequent criticism has tended to emphasize Freud's implicit belief in the fatalism of the' unconscious itself and of its inevitable repetition—as in the classical Oedipus Rex of Sophocles. which Freud invoked in naming the oedipus complex. True, the environment has power, it has an effectiveness in Freud's theories; infants can be fixated, adolescents are subjected to intolerable conflicts, etc., and neurosis results. But these influences of the culture are largely negative: they can misshape the personality by deflecting it from the biological goals to which it naturally strives. The positive shaping forces of the culture were scarcely considered in Freud's theories. He was alert to the negative features of religion, which he considered a group neurosis; of art, which he analyzed as a compromise expression of conflict in the artist's personality, etc. The more positive aspects of these cultural phenomena were neglected or ignored by him.

It became the major emphasis in the so-called neo-Freudian schools of Karen Horney, Harry Stack Sullivan (*qq.v.*) and Erich Fromm to compensate for Freud's overemphasis on universal biological forces in personality. In fact, many of Freud's concepts, particularly those concerned with sexuality, were repudiated or radically revised by them. The formative influences of culture have been studied and the findings of social anthropology (*q.v.*) have been invoked to support this newer orientation by showing that different cultures produce different effects on the personalities that develop within them. A healthful ferment has been added to the orthodox Freudian view. (See also PSYCHOANALYSIS.)

Social Influences on Personality

At this point it is in order to interrupt the exposition of the various concepts offered to explain personality by introducing a summary of general conclusions concerning the role of social influence in the formation and functioning of personality. One such conclusion concerns the importance of infancy in determining basic adult reactions. The child's first experience with any class of stimuli must inevitably have disproportionate significance for his future development. Foremost among such patterns are those concerned with attitudes of security and insecurity. If the child feels wanted, loved and understood, he will tend to be secure in social situations outside the home. Rejection in the family situaticn engenders insecurity and either withdrawal or hostility subsequently. If, again, the child learns to bow to firm authnrity in the home, his attitude toward firm governmental authority may become submissive. If, on the other hand, he is subjected to excessive or to inconsistent discipline and so rebels, he is likely to carry over similar rebellious attitudes into his relations with school teachers. employers and government.

The family is important in molding personality not only because so many parent-child relationships are prototypes of adult situations, but also because the child there unconsciously assimilates many attitudes and social expectations. Children are extraordinarily sensitive to vocal inflection, facial expression and other muscle tensions of which adults may be quite unaware. Sarcastic remarks about labour unions, Negroes, people who are too aggressive and those who are not ambitious enough have their effects on the child listener. The division of society into men v. women, bosses v. workers, leaders v. followers becomes sacrosanct to him and he develops a rigid concept of how people ought to act when they assume a certain role. Moreover, parents impose standards of behaviour by threats or punishment. Much of this learning goes on before the acquisition of language; *i.e.*, it is unconscious and deeply implanted. Sexual experimentation for example, is normal to young children, but severe punishment may cause the child not only to abandon habits of sexual play but also to forget (repress) that he ever thought of such acts.

The school system has a strong influence on the growing child's personality. Occasional arbitrary discipline. overrigid work assignments and the necessity for treating diverse individuals alike in crowded classes are examples of undesirable practices Good teachers, on the other hand, may become models whom the child will imitate. The content of education is also significant. Narrow, nationalistic, prejudiced teaching in history and social studies not only misleads the child but gives him an outlet for repressed hostility that tends to fixate his manner of thinking on a low level. Finally, the competitive system of grading, with its emphasis on invidious personal comparisons, is open to criticism.

Economic conditions have been shown to have a significant effect on the personalities of both children and adults. Poverty, for example, tends on the whole to distort personality development. The alleged beneficial effects of hardship have. for moralistic reasons, been largely overrated. To note this point is not to suggest that maladjusted personalities are never found in the upper economic brackets; obviously they are. But on a percentage basis the child in a better-class home has a better chance of reaching maturity with a well-balanced personality.

Values, ethics and character standards are all functions of social influence. With respect to these complex variables the child at birth appears to be a blank slate. Potentially he may be molded to satisfy his biological need for security by selfishly protecting his interests in the face of competition, or he may learn to gain the very same end by altruistically sharing aith and receiving from others. His later view of human nature and ethics will follow as a rationalization fitted, as verbalization becomes possible, to justify the unconsciously learned patterns of social behaviour. One thus sees that ideas of right and wrong, beliefs as to the proper ways of behaving socially, or gaining one's ends, etc., come originally from behaviour patterns that have been inculcated or have been acquired from observation and imitation of those in closest contact with the growing child. The improvement of the intimate environment and the education of children is therefore held to be one of the chief avenues for developing more mature personalities.

Experimental Psychodynamics

The cultural critique of Freud within psychoanalysis itself was supplemented by a critique on grounds of scientific method from the ranks'of academic psychology. Since Freud's findings were largely based on his clinical work with neurotic patients, it was reasonable to ask whether his concepts would stand up under experimental scrutiny, At the same time opportunity might be taken to probe the general applicability of Freud's theories to normal persons. (Freud himself regarded his theory as a psychology of the normal and the abnormal indiscriminately.) What resulted was not, however, merely a critique of Freud: it reflected the autochthonous conceptual orientation of the research centres that performed the experimental work and led to a development that may be conveniently called experimental psychodynamics. In most of these investigations the aim was to study personality with a dynamic theoretical basis borrowed from or based on the insights of Freud but intended to offer new and more rigorous concepts for handling the same psychological data.

Carl Jung (*q.v.*), who was for a time a close associate of Freud, conducted what may be regarded as the earliest studies in experimental psychoanalysis, presented in his book on the word associa-

tion method (1906). But the first concerted program of this sort was conceived and conducted at the Harvard Psychological clinic about 25 years later. In that laboratory, beginning around 1930. Rosenzweig instituted an experimental program devoted to the clarification of psychoanalytic principles such as repression. This work led to a set of concepts under the heading of frustration theory that took frustration as a key concept for analyzing personality dynamics. The program of research resulted in the construction of the Picture-Frustration study, mentioned above. By combining detailed investigations of biography and projective methodology with frustration theory, this view was later broadened to include growth and creativity in its theory of personality. Henry A. Murray, in another departure, formulated a theory of personality in which the concept of need was made pivotal. In collaboration with Christiana D. Morgan he developed the Thematic Apperception test, cited above. Through the use of a wide variety of experiments. tests and interviews, supplemented by a diagnostic council of the principal investigators who all worked with the same subjects, the effort was made both to fathom personality dynamics in the momentary cross section and to reconstruct in selected instances the longitudinal life history. The result appeared in Explorations in Personality (1938).

At the Yale Institute of Human Relations a research program was pursued with a different ground of conceptualization. Behaviourism (*q.v.*) was the point of view there prevalent, and concepts of learning (*q.v.*) theory played the crucial role in the work of this group (Clark Hull, John Dollard, Neal Miller, Robert Sears and O. H. Mowrer). An interpretation of aggression as instigated by frustration was formulated and published (1939); the process of psychotherapy, including psychoanalysis, was reconceptualized with the principles of learning as a basis (1950). More fundamental even were the numerous studies of animal behaviour (*q.v.*), especially of the white rat, in controlled situations with dynamic significance (*e.g.*, fear, anxiety, conflict), some of which mere planned as analogues of human psychodynamic principles (*e.g.*, regression). In soviet psychology, nhich historically initiated the behaviouristic approach, this emphasis is carried to an exclusive consideration of social conditioning, on the one hand, and organic, physiological function, on the other, the dynamic theories of psychoanalysis and of existentialism (see below) being completely rejected. One here sees how personality theory is, in part, an expression of cultural forces. From the soviet standpoint, psychoanalysis, and even more so existentialism, rationalizes the unhealthy individualism of capitalistic culture.

Self-Realization and the Self-Concept

A fruitful source of concepts for understanding personality has been psychotherapy (*q.v.*). While other psychologists, as above noted. worked with psychodiagnostic devices (*e.g.*, projective methods) or attempted to unravel motivation through experiments in the animal laboratory, a third group utilized the interaction of therapist and patient with actual human problems posed for solution. Freud was, of course, the pioneer in this field of work in his special domain of psychoanalysis, but in psychology proper Carl Rogers led the way. Beginning with a minimum of theory, Rogers recorded and studied therapeutic interviews of neurotic or merely troubled clients in an effort to discover objectively what changes occurred and how they were effected. By systematic exploration of this kind he was eventually led to a view of personality in which the so-called self-concept was pivotal and in which self-realization in the process of normal and abnormal development came under close scrutiny. Rogers was led to the theory that the individual normally has a drive toward self-development nhich when impeded by conflict leads to symptoms of disorder. The opportunity to review these blocks to growth in a permissive therapeutic situation proved an important means toward overcoming them, quite apart from any theoretical interpretation of the behaviour such as that given in Freudian psychoanalysis. The relationship between therapist and client was in itself salutarv.

This conceptualization of the therapy of the neurotic in terms of autonomous growth was reinforced from other directions. For example, the neurologist Kurt Goldstein. first in Germany and later in the United States, studied cases of brain injury by inquiring in each instance how the individual adapted to his defect and managed somehow to cope or come to terms with it. Even in such grave situations, the capacity of the human organism for self-correction was shown to be remarkable. according to Goldstein's findings. Abraham Maslow, working at the other extreme with normal and gifted persons, tried to throw light on the process of self-actualization. What, he asked, contributes in fortunate cases to successful self-expression and what, on the other hand, defeats such an outcome? From these diverse directions contributions have been made to a better understanding of the dynamics of frustration, gron th and creativity.

In the theory of personality that Rogers gradually achieved from his investigations of psychotherapy, the concept of the self played a leading part. Moreover, he was concerned less with his onn concept of the subject's self than with the subject's self-concept. Changes in psychotherapy were interpreted as changes in this self-concept—in the way the client (or patient) modified his view of himself. The so-called real environment—if we leave aside that part of it nhich, as a minimum requirement for life, supplies the biological necessities—is important from the psychological standpoint only in the measure that and in the way that it is filtered through the subject's perception of it and of himself in relation to it. For this reason, the therapist in seeking to change personality works very largely with the client's own concept of himself, nhich, of course, in turn involves his feelings of relationship with others.

It is thus appropriate to consider. at least briefly, this concept of self. It is inferred by the psychologist that the new-born infant has no conception of himself. It is only in the course of the first pear or tno of life that the sense of personal identity is acquired. The baby's earliest interest in his own mirror image, for example, is often regarded as pointing to the dawn of this awareness. But there are, of course, many ramifications and dimensions of the subject's self-identity. and attempts have been made to trace the changes in the self-concept (or sense of identity) from infancy through childhood and adolescence to maturity and after. Closely connected with the achievement of a stable self-concept is the degree of security that the person has achieved by virtue of earlier experience. If in the earliest months of life the child has been made to feel secure, he more readily develops a stable sense of his own identity which stands him in good stead in bringing to fruition the potentialities of his personality and in utilizing the opportunities of his environment. It has been demonstrated. for example, that the image which the person has of his own body—the body image—is an important nucleus of his conception of self. If the body image is defective by virtue of a "real" or imagined crippling, an element of permanent instability may enter the self-concept. But, of course, the current secure or insecure situation in nhich the person has to exist is likewise important in reinforcing or impairing the sense of identity. One dimension of this influence is the feeling of hope or hopelessness that may affect the self-concept in profound ways.

This approach to personality via the self-concept seems to many psychologists to refer back to older philosophical speculations; *e.g.*, those of German idealism. To some extent this criticism is doubtless valid. and it has led many investigators to avoid this form of personality theory and to prefer a more behaviouristic variety. But it should not be overlooked that in the hands of the. psychologist the self-concept is rarely treated as a thing-in-itself. As mentioned above, the records of therapeutic interviews and the products of projective techniques are employed as data to which appeal is made before interpretations are given about the self-concept in the specific case. The psychologist never accepts a pure introspection as final; he treats subjective reports like other phenomena of nature—as data for analysis to support the explanatory concepts he employs.

Phenomenology and Idiodynamics

The point of view of Rogers has been sometimes designated "phenomenological"—a term that gained currency beginning with

G. Husserl (see PHENOMENOLOGY). Starting as a branch of epistemology, European phenomenology strongly influenced developments in experimental psychology, particularly the studies of perception that gave birth to the German school of Gestalt psychology. While various theoreticians have given different interpretations to phenomenology, all have agreed in using the term to denote a discipline devoted to the analysis of immediate experience. As such, this discipline challenges the common-sense concept of the real world, the external environment as conceived by the biologist, and attempts to examine systematically the subject's knowledge of his world as an interdependent aspect of his self-knowledge. Rogers in his psychotherapeutic studies was little influenced by the more technical aspects of philosophical phenomenology. These are more clearly discernible in the approach of "existential psychiatry." This orientation, dating from the second quarter of the 20th century, concerned itself initially with experiences of the schizophrenic and other mental patients, but its avowed implications extend to all the data of personality.

Among the Gestalt psychologists, Kurt Lewin made important experimental and theoretical contributions which belong in the frame work of phenomenology. He generally ignored the remote history of the individual and subordinated it to the analysis of the momentary psychological situation. This cross section was analyzed with the aid of "field theory" in concepts adapted from the physical and mathematical sciences (vector analysis and topology; *qq.v*). Lewin's aim was the prediction of specific behaviour that uent beyond the statistical or actuarial objective. He maintained that psychology must posit and work within a different space from that employed by the physicist — a psychological or "hodological" space with properties of its own. Though purporting to bear directly on problems of personality dynamics, Lewin's work had more immediate influence on social psychology (group dynamics) than on the psychology of the individual.

A last conceptual approach that belongs under the general heading of phenomenology is idiodynamics. In this view the personality is conceived as an idioverse — an individual universe of psychological events (experiences) — which can be categorized and analyzed to show temporal and motivational consistencies. The universal norms of general psychology and the group norms of cultural anthropology here give way to individual norms in terms of which the personality operates and is to be understood. But this view has been advanced as but one approach to a composite science of psychology; as a complement to the several other dimensions of a complete analysis of personality.

INTEGRATION OF CONCEPTS

The foregoing survey of concepts, ranging from the organic to the strictly psychological (subjective, phenomenological), may be interpreted in one of two ways: (1) as indicating, if taken at face value, the broad gamut of competing diversity in the field of personality theory; (2) as portraying the multidimensional nature of personality (and of psychology) which, of necessity, approaches the person — the human organism — at diverse but complementary levels or axes. On this latter view a composite set of levels must be plotted in a complete chart of personality; each level provides working concepts for specific problems related to it. See also under such related subjects as ADJUSTMENT (IN PSYCHOLOGY); MOTIVATION, etc.

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(S. RG.)

PERSONAL PROPERTY, one branch of the main division of the common law of property, the other being "real property." The division of property into real and personal represents in a great measure the division into immovable and movable, incidentally recognized in Roman law and generally adopted since.

Personal estate is divided in English law into chattels real and chattels personal; the latter are again divided into choses in possession and choses in action (see CHATTEL).

Interest in personal property may be either absolute or qualified.

There are several cases in which. by statute or otherwise, property is taken out of the class of real or personal to which it seems naturally to belong. By the operation of the equitable doctrine of conversion money directed to be employed in the purchase of land, or land directed to be turned into money, is in general regarded as that species of property into which it is directed to be converted. An example of property prima facie real which is treated as personal is an estate *pur autre vie*, which, since 14 Geo. II, *c.* 20, s. 9, 1740–41 (now replaced by the Wills act 1837, s. 6) is distributable as personal property in the absence of a special occupant. Examples of property prima facie personal which is treated as real are fixtures, heirlooms, such as deeds and family portraits. (See further LAW OF SUCCESSION.)

The terms heritable and movable of Scots law in a general sense correspond with the real and personal of English law. Movable or personal property is, in Scots law, subdivided into corporeal and incorporeal movables. Corporeal or physical things, not being land or attached to land, are movable property. Incorporeal things, or rights, are said to form movable property when they do not affect land, and are not similar to rights affecting land in having a tract of future time. By the Titles to Land Consolidation (Scotland) act 1868, s. 117, heritable securities are movable as far as regards the succession of the creditor, unless executors are expressly excluded. They still, however, remain heritable *quoad fiscum*, as between husband and wife, in computing legitim, and as far as regards the succession of the debtor. Annuities, as having *tractum futuri temporis*, are heritable, and an obligation to pay them falls upon the heir of the deceased. At common law an obligation to pay money was, after the term of payment, considered heritable in the person of the creditor as having a tract of future time. Bonds containing such obligations, except where the creditor's executors are excluded, are now movables in the creditor's succession.

See the Scots act of 1661, cap. 32 and the Conveyancy (Scotland) act 1924, s. 22 (1).

The law in the United States agrees in most respects with that of England. Chattels real include all estates in land less than freehold. Legislation in some states has, however, made terms for years and estates *pur autre vie* real property. Title deeds are generally regarded as personalty inasmuch as their importance is less than in England, due to the Land Registration acts. Shares in some of the early American corporations were, like New River shares in England, made real estate by statute, as in the case of the Cape Sable company in Maryland (Schouler, *Law of Personal Property*, i). Otherwise, shares of stock, like other choses in action, are regarded as personalty.

PERSONATION, in English and American lam, a form of fraud consisting in a false representation by one person (by words or conduct) that he is another person living or dead. It is not an offense by the common law unless the representation is made on oath under circumstances constituting the offense of perjury, or unless the representation if not made on oath is made under circumstances amounting to a common-law cheat. See also FRAUD; ELECTORAL SYSTEMS.

PERSPECTIVE is the method used in drawing to portray three dimensions on a two-dimensional surface.

History. — Artists have been experimenting since the Stone Age in their attempts to express a feeling of space and solidity. A reindeer herd was etched on a fragment of bone 15,000 years ago, and the illusion of distance was created by showing the legs and antlers as if seen beyond the fully sketched animals of the foreground. The artist of ancient Egypt discovered that his main perspective problem was showing a single important object in the necessary three dimensions. This he expressed in his own way by drauing a combination of plan and side view. A Pharaoh carrying a circular tray of sacrificial offerings was drawn in this manner.

The top view of the tray is shown in half by means of a semicircle. On this half-tray is the sacrificial food as it would appear when viewed from above. This stylized method of expressing a third dimension persisted in Egyptian drawing for 3,000 years.

In America, northwest Indian artists developed a unique method of showing the front view together with both the left and right sides of a person or an animal. The creature was drawn as if it were split down the back and then flattened out like a hide. Each side of the head and body thus became a profile facing the other.

Chinese artists created landscapes that had excellent feeling of distance and space by skillfully arranging the natural contours of land; water and foliage. When buildings were drawn it was necessary to show the parallel horizontal lines of the construction. Isometric drawing was used. Isometric drawing is a simulation of perspective drawing wherein parallel lines are drawn parallel, instead of converging as in true perspective. Often foliage was used in the drawing to crop these lines before they extended far enough to cause the building to appear warped. These isometric arrangements made an attractive pattern of interposing line.

The early European artist used a perspective which was an individual interpretation of what he saw rather than a fixed mechanical method. It was not until the first half of the 15th century that the Italian painters made perspective drawing an exact science by the use of the horizon line and the vanishing point.

At the beginning of the Italian Renaissance the mathematical laws of perspective were discovered by a Florentine architect, Filippo Brunelleschi (1377–1446), who worked out some of the fundamental principles. Masaccio (1401–*c.* 1428) began using the method and within a short period brought about an entirely new approach in painting. A style was soon developed using configurations of architectural exteriors and interiors as the background for religious paintings. This gave the new science the opportunity to expand freely. One of Brunelleschi's contemporaries Paolo Uccello (1397–1475) compiled these principles into book form and in doing so became the original authority in the field of perspective projection.

In modern times, perspective has an important part in the work of artists as well as in idea presentations of architects, engineers, landscape specialists and industrial designers. It furnishes an opportunity to view the finished product long before it is begun.

Technique. — The simplest perspective drawing that can be made is a single horizontal line across the paper (fig. 1**[A]**). The word horizontal in itself suggests the natural horizon (*i.e.*, the distant line where the earth or sea apparently meet the sky). By drawing this horizontal line the artist has created the illusion of space and distance as far as the eye can see. A sailboat added and a few clouds above the line complete a picture of the sea in the distance meeting the sky. If the sails of the boat shut from view a segment of the horizon, this places the horizon farther in the distance than the boat, as in fig. 1(B).

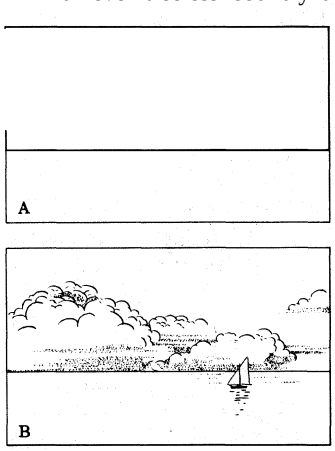

FIG. 1. — THE SIMPLEST PERSPECTIVE DRAWING (SEE TEXT FOR FURTHER EXPLANATION)

In a level treeless country a distant mountain range may be seen beyond the horizon (fig. 2[A]). The curve of the earth's surface is so gradual that it gives the impression of being flat. Yet mountains can be seen beyond this curvature. The superstructure of ships at sea can be sighted long before the hull is seen. A distant island appears to rise out of the sea as it is approached. The horizon therefore is seen as a continuous line between the observer and distant objects. This line is curved. but the curvature is so slight it is usually ignored in drawing.

The colours of distant objects are softened by the atmosphere into bluish tones. This atmospheric colour effect in itself creates an impression of distance and is called aerial perspective.

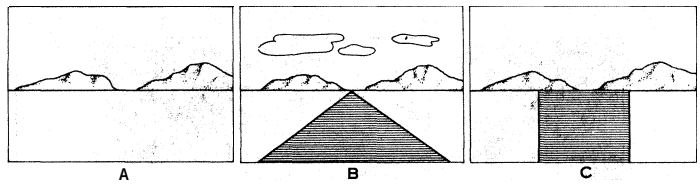

FIG. 2. — A HIGHWAY ACROSS LEVEL COUNTRY

A highway built across the plain may be drawn as two straight lines meeting at a point on the horizon (fig. 2[B]). These lines represent the two curbs which are uniformly parallel throughout their lengths. Why are the curbs drawn as converging lines rather than parallel lines, as in fig. 2(C)?

Fig. 3 shows the top view of a person standing in the centre of the highway. For him to see both curbs near his feet his eyes must take in a wide area at the section marked AA. Twenty feet beyond, at section BB, he sees the same width but it appears considerably narrower than at **AA.** As he looks beyond to CC it appears still narrower and when he looks as far as he can in the distance, to the horizon line, he sees that the width has narrowed to a mere point. Beyond this point no more highway is visible. This point is called the vanishing point.

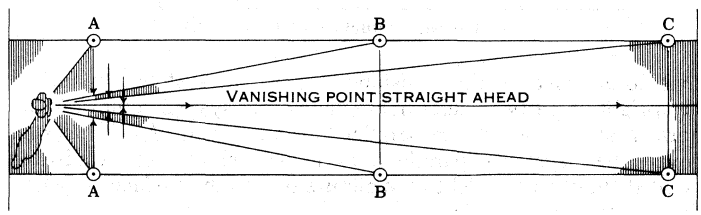

FIG. 3. — AS DISTANCE INCREASES, THE HIGHWAY DIMINISHES IN BREADTH

The side view of the same situation is shown in fig. 4. The person must look down in order to see the highway near his feet **at** section A. To look at B, the section 20 ft. beyond A, it will be necessary to raise his eyes. This is also true for section C, and so on, until he is looking straight ahead along a line that is level with his eyes. He is then looking directly at the vanishing point of the highway. Fig. 5 illustrates how level highway appears to rise to eye level at the horizon.

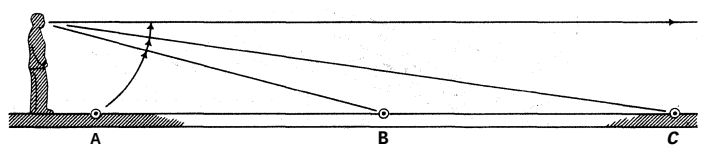

FIG. 4. — THE HIGHWAY APPEARS TO RISE

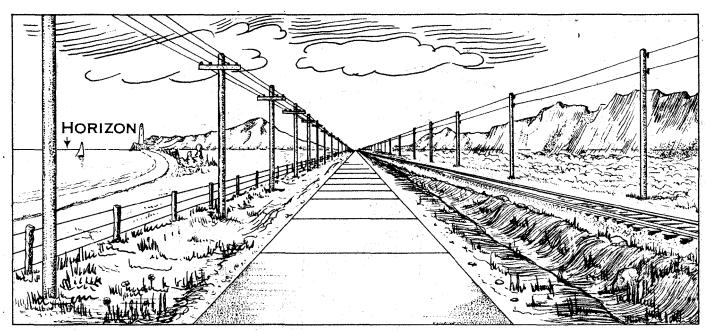

FIG. 5. — PARALLEL LINES MEET AT THE HORIZON

Two conclusions may be drawn: (1) The natural horizon and the artist's eye level are at the same height. This is true whether he is lying on the ground or sketching from an airplane. The horizon seems to rise to meet the eye level. (2) The vanishing point of a system of horizontal parallel lines is always on the horizon line. There can be systems of parallel lines in a picture

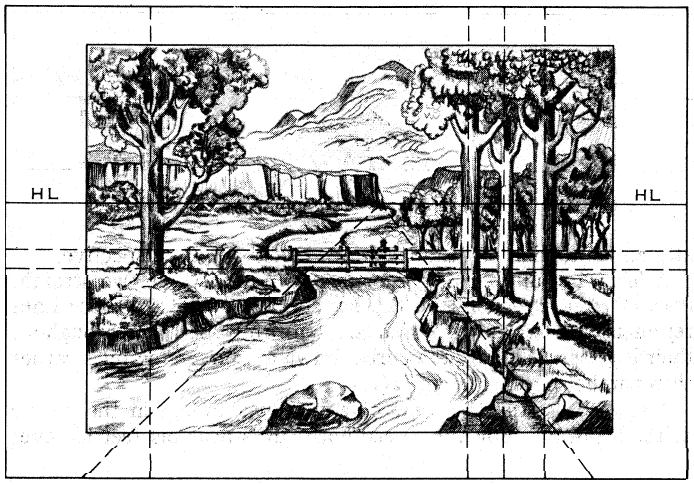

FIG. 6. — THE PERSPECTIVE OF NATURE

that do not meet at the vanishing point. One system is made up of upright or perpendicular lines. The other system comprises the horizontal lines which are parallel to the horizon. A general rule covers these systems. parallel lines do not converge to a vanishing point if they are parallel to the picture plane (the surface on which the picture is executed).

In nature (see fig. 6) there are very few square corners but man's most common form of construction is the box. Houses and furniture. books and skyscrapers. all are modifications of box designs. A solution for most perspective problems may be derived from a proper understanding of the box. The drawing of curved forms,

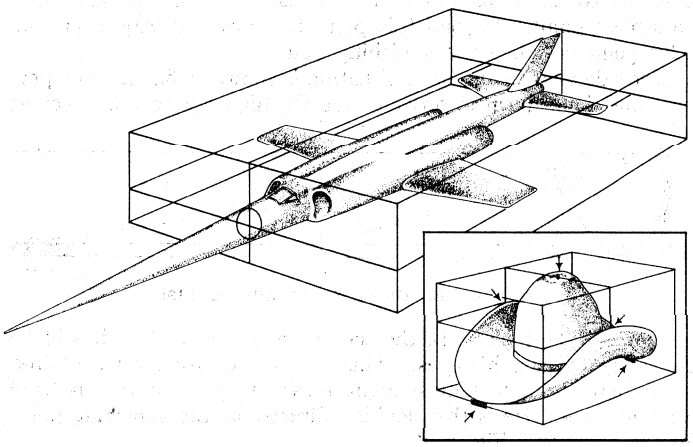

FIG. 7. — CURVED SHAPES FIT INTO BOXES

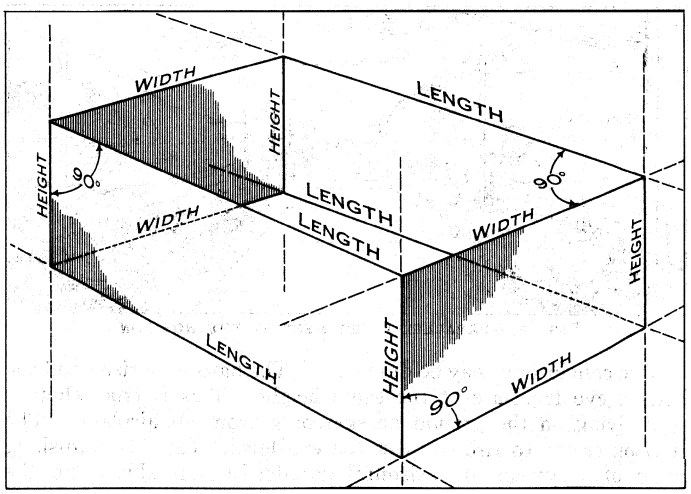

FIG. 8. — THE CONSIDERATION OF PERSPECTIVE IN A BOX

such as shoes, hats, automobiles and airplanes, becomes simplified when these objects are fitted into boxes (fig. 7).

The box has two upright sides, a top, a bottom and two ends—six planes in all (fig. 8). There are 8 corners where 3 planes meet at right angles to one another and 12 edges where 2 planes join. These 12 edges or intersections of the planes are represented in the drawing as lines which will be referred to in groups of four: length lines, width lines and height lines.

One-Point Perspective. — To draw a box in one-point perspective, two lines may be drawn converging at a horizon line. as in the case of the highway (fig. 2). Let a section represent the bot-

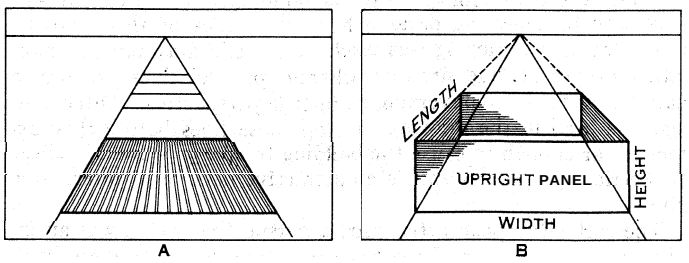

FIG. 9. — PERSPECTIVE AS SHOWN ON A HIGHWAY AND A BOX

tom of the box (fig. 9[A]). Upright end panels can be placed on the section lines (fig. 9[B]). The top and the sides can be represented by drawing two upper length lines from the top corners of the near panel to the vanishing point. The height of the far end panel is determined by the intersection of the length lines with the verticals or height lines.

The entire projection may be inverted so that the vanishing point is below the object depicted. as in Masaccio's "Trinity" at S. Maria Novella, Florence. In Florence 70 years later Leonardo da Vinci (1452–1519) painted his famous "Last Supper" using the one-point perspective. All the perspective lines of the room lead to the vanishing point at the head of Christ

Two-Point Perspective. — If the box is rotated slightly the vanishing point of the length lines will move along the horizon

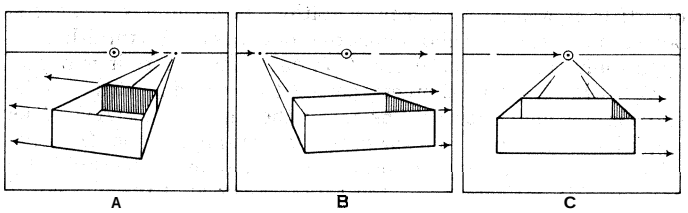

FIG. 10. — POSITION DETERMINES VANISHING POINTS

accordingly (fig. 10[A]), until it passes out of the picture, although it will still remain on the horizon line. As the width lines move they are no longer parallel to the plane of the picture and it is necessary to establish a vanishing point for them. This point is also on the horizon line (fig. 10[B]). In two-point perspective there are two vanishing points: one for the width lines and one for the length lines. If the box is rotated farther until the newly established point coincides with the central position of the original vanishing point, the length lines will be parallel to the picture plane, and the box is again in the position of one-point perspective, having been rotated 90° (fig. 10[C]). The distance between the vanishing points in two-point perspective is governed by a simple ratio. In order to understand this it is necessary to become further acquainted with the use of the picture plane. (*See* fig. 11.)

Perspective Projection. — The picture plane is represented as an upright transparent surface. The artist stands facing it on a level plane called the

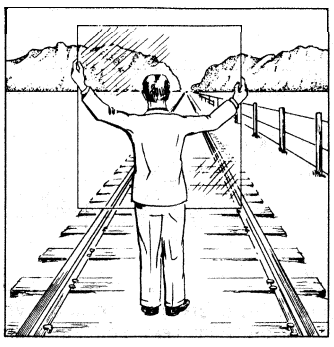

FIG. 11. — THE PICTURE PLANE

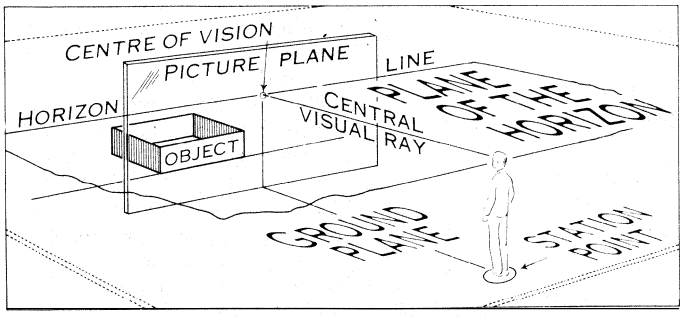

FIG. 12.— THE PERSPECTIVE ARRANGEMENT

ground plane. He looks through the picture plane at the object, also resting on the ground plane (fig. 12). In this instance, the object he wishes to draw is the box. The ground line (GL) is the line where the picture plane rests on the ground. The artist stands on the station point (SP) and sees the scene before him from an eye level viewpoint, called the eye. When he looks directly at the picture plane (along a line perpendicular to it) he is looking along a line called the central visual ray (CVR) which lies on a plane called the plane of the horizon.

Everything that can be seen above this plane is said to be above eye level; everything seen below this plane is below eye level. The central visual ray intersects the picture plane at a point called the centre of vision (CV). (See fig. 13.) A horizontal line drawn through this point is the horizon of the picture. It is the line where the plane of the horizon intersects the picture plane. If the

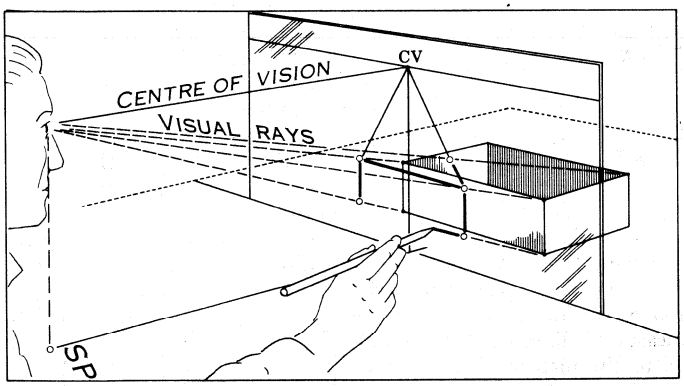

FIG. 13.— THE USE OF THE PICTURE PLANE

artist is seated, the horizon is lowered; if he views the object from a stepladder. the horizon raises accordingly. The object also may be raised and the picture plane may be moved closer to the artist or back against the object. These arrangements allow a great deal of freedom.

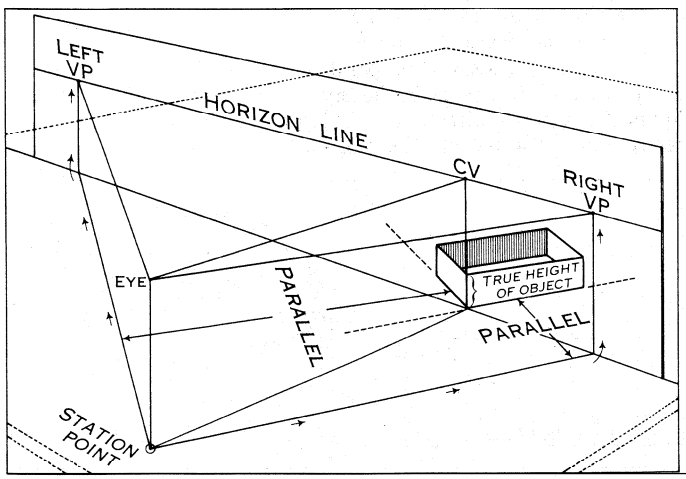

FIG. 14.— LOCATING VANISHING POINTS

According to theory the artist can now locate all the necessary points and lines of the object and draw them where the visual rays (VR) show them on the picture plane. The centre of vision becomes the vanishing point of a drawing in one-point perspective.

The two-point perspective arrangement can be made by rotating the object (fig. 14) to the desired view. For convenience the picture plane is placed against the corner of the object. By doing this the height is actually on the picture plane in true measurement. In this way the process of projection is made simpler and easier to visualize.

The station point is chosen at any desired distance from the object and the view from any desired height above the ground. When the eye height is established, two lines from the eye are extended parallel to the two sides of the box. The two lines form a right angle and each meets the picture plane on the horizon line. The points where they intersect the horizon line are the left vanishing point (LVP) and right vanishing point (RVP). The same points can be reached by drawing the two lines on the ground from the station point to the picture plane and then up to the horizon line (indicated by arrows. fig. 14). Then it is necessary to get all this arrangement flattened down onto one sheet of paper. The picture plane may be visualized as being moved toward the station point (fig. 15[A]). The ground line remains in the new position but the plane is folded down (fig. 15[B]) so that it is lying on the ground (fig. 15[C]). The top edge of the picture plane is ignored. The plane remains in its original position touching this trace (fig. 15[C]).

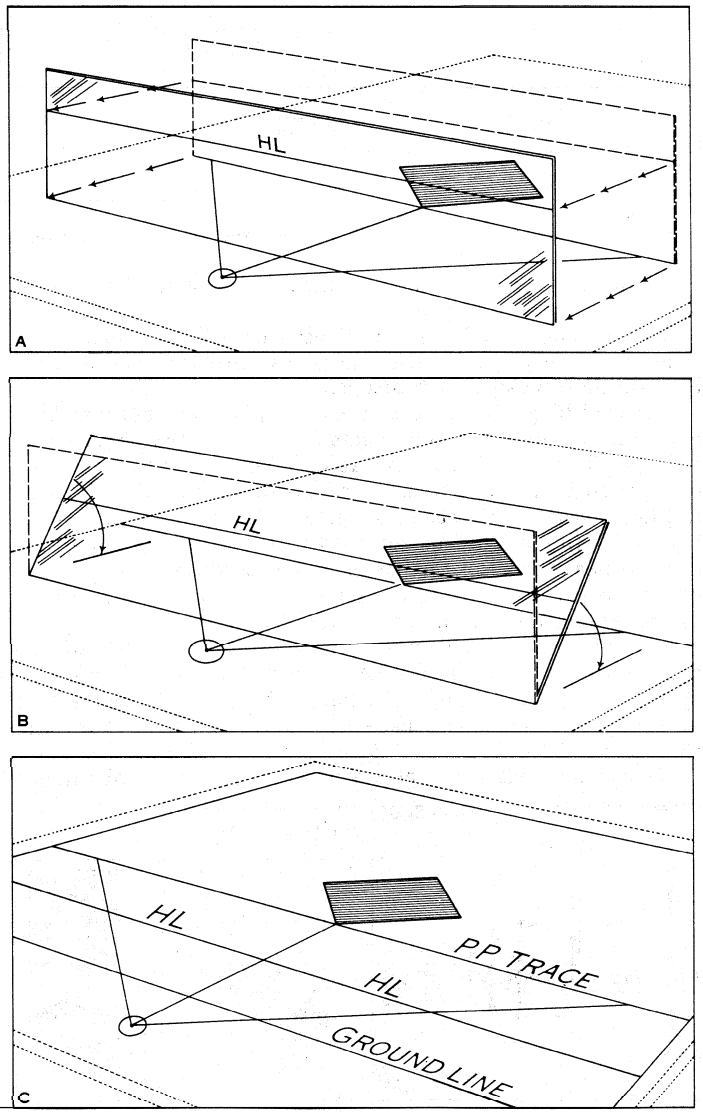

FIG. 15.— TWO-DIMENSIONAL ARRANGEMENT

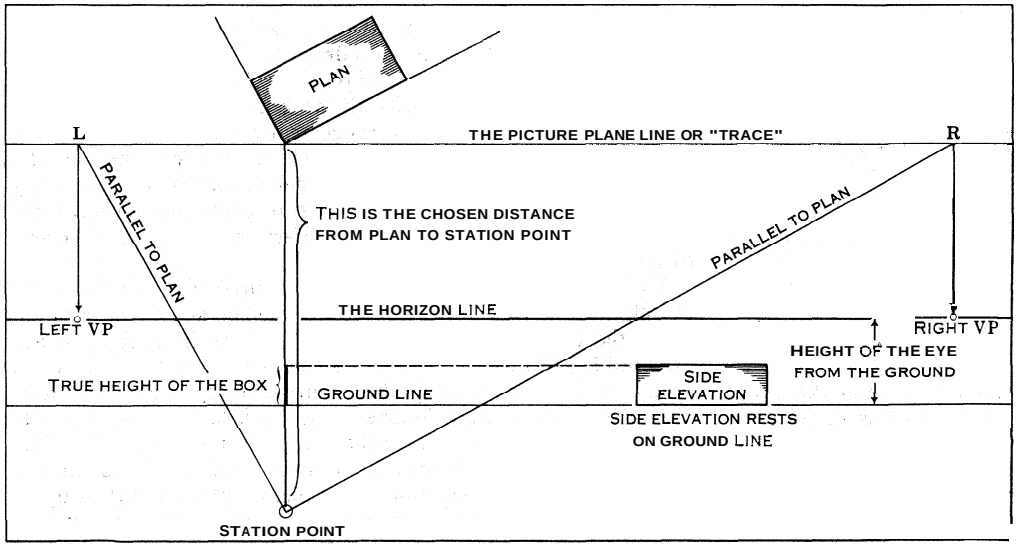

FIG. 16. — COMPLETE PERSPECTIVE ARRANGEMENT

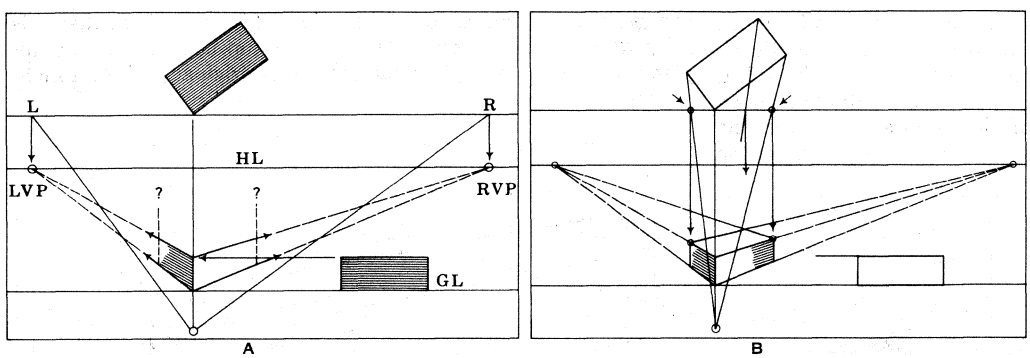

FIG. 17. — PERSPECTIVE PROJECTION

All three-dimensional units can then be translated into a two-dimensional surface (fig. 16).

This method is called the architect's or office method. It is found to be adaptable to most perspective problems and it is the basis for most perspective projections.

The vanishing point is located by dropping perpendicular lines from the previously located points L and R to the horizon (fig. 17[A]). The side elevation is placed so that it rests on the ground line. A horizontal line from the top of this elevation to the central line gives the true height of the box. Lines from the top and bottom of this height line extended to the vanishing points will give the near corner of the box in true perspective, with the sides of the box extending to the vanishing points. It is then necessary to find where the sides of the box actually end.

A line is drawn from the station point to the right-hand corner of the plan. It intersects the picture plane at a point indicated by the arrow (fig. 17[B]). A line is drawn to the left corner in the same manner. The space between the two arrows measures the extent of the box as it would be seen on the picture plane. Perpendicular lines from these arrows drawn downward through the sides of the box cut the sides off at the correct place. The perspective picture is completed by drawing lines to the vanishing points from the established corners of the box.

Division of Space. — If a line divided into equal parts is drawn in perspective, the parts become smaller as they recede (fig. 18). The simplest division is two equal parts. A square, rectangle or line may be divided into halves by the use of intersecting diagonals (fig. 19).

The point of intersection becomes the central point and a line drawn through this point parallel to the sides is the line of division.

When the rectangle is drawn in perspective this method of dividing still holds true; the true centre is the point where the diagonals intersect.

These divisions in turn may be subdivided into quarters and then into eighths and sixteenths, if desired.

When the space cannot conveniently be subdivided into halves, another method may be used. To divide a rectangle into three equal parts with vertical lines (fig. 20), it should be first divided by length lines into three parts.

A diagonal is then drawn. If the vertical lines are drawn where the diagonal intersects the length lines the correct spacing is obtained.

Fig. 21 is an example of a façade with seven columns drawn in perspective. Irregular divisions also can be projected in the same manner. These methods follow the principle of dividing measurable lines (*i.e.*, lines parallel to the picture plane) and of translating these measurements into corresponding divisions on the receding perspective line.

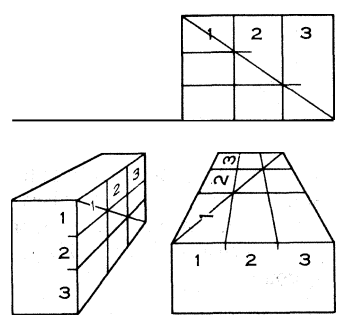

FIG. 20.—SUBDIVISIONS

There is another method of subdivision in perspective in which a high or low vanishing point is used. It can be understood by drawing a fence in which all the posts lean at the same angle along the line of the fence (fig. 22). The posts will be parallel to one another and will all point to a vanishing point in the sky (or below the horizon if leaning in the opposite direction). This point will be somewhere directly above (or below) the vanishing point of the fence. To

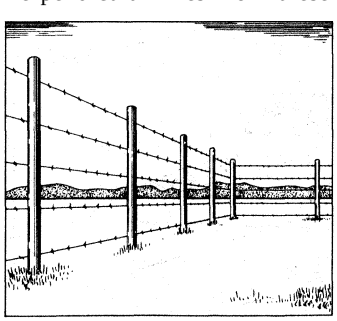

FIG. 18. — EQUAL SPACING

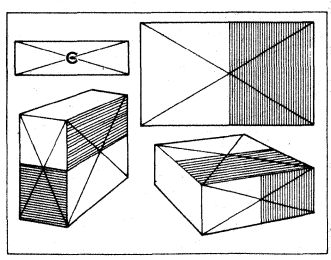

FIG. 19. — HALVES AND CENTRES

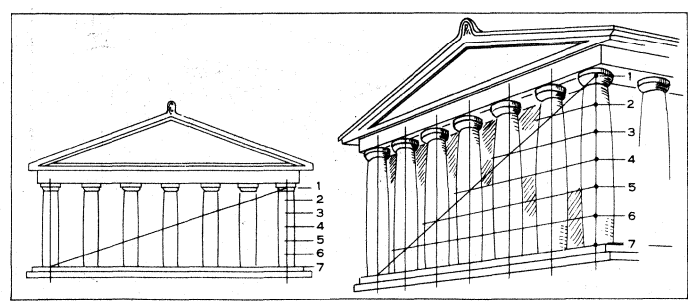

FIG. 21. — FACADE IN PERSPECTIVE

verify this, tilt the posts more and more until they finally lie end to end on the ground. It will be found that their vanishing point has moved down in a perpendicular line until it is the same as the vanishing point of the original fence. Using the draftsman terminology. this perpendicular line on which the vanishing points fall is the vanishing trace of the vertical plane of the fence. An axiom applied to this form of projection is that parallel lines in a plane have their vanishing points in the vanishing trace of the plane.

If the diagonal drawn between the first two posts is extended to

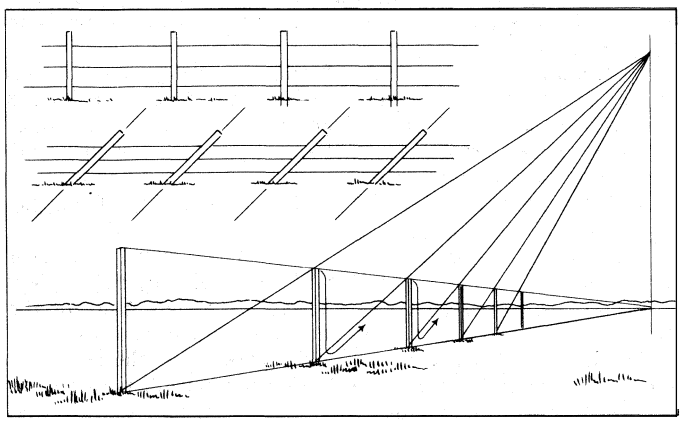

FIG. 22.— CONTINUOUS SPACING

intersect the vanishing trace, the successive posts can be located by the use of this point of intersection as the common vanishing point of all the diagonals.

Perspective projection is a growing science which has not been fully developed. A number of methods other than here shown are in use; each has its advantages.

See also DRAWING (TECHNIQUES OF); DRAWING, ENGINEERING; DESCRIPTIVE GEOMETRY; RENDERING, ARCHITECTURAL.

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PERSPIRATION. Perspiration is an inclusive term referring to any water. either in vapour or visible form, which is given off by the normal skin. There are two sources: the epidermis and the sweat glands. The average adult loses about 500 g. of water vapour via the transepidermal route every 24 hours. This type of water loss is called insensible perspiration and involves no chemicals besides water. The mechanism of loss is obscure, but it would appear that the water loss, which is constant, is associated with the growth and aging process of the epidermal cells as they form keratin.

Only factors affecting the epidermal cells have an influence on the rate of epidermal water loss.

The common usage of the word perspiration disregards the above vapour loss and relates it solely to the secretion from the eccrine sweat glands. These glands are distributed over the entire skin surface of man. Totaling approximately 2,000,000 in number, they show marked regional differences in density. The palm and sole may present over 2,500 per square inch, whereas the back may have fewer than 500 per square inch. Each gland is a simple coiled tubular unit. The secretory coil is deep in the dermis and from it the sweat duct extends up through the dermis and epidermis.

The sweat pore is not visible except on the palms and soles. The glands provide surface water for evaporative cooling of the body under heat stress, 540 cal. being lost per litre of sweat evaporated. In cool environments the glands remain entirely at rest.

However, once the skin temperature or body temperature becomes elevated. many of the glands are instantly stimulated to secrete. This stimulation is caused by autonomic nerves which are under control of the thennoregulatory centre of the hypothalamus of the brain. In areas which have been denervated (*e.g.,* by sympathectomy, or by neural changes in leprosy) sweating does not take place. The total sweat rate may range from zero to 2,000 g. per hour. Often sweating rates are excessive since only the sweat which evaporates cools the body. Eccrine sweat is about 99% water, the chief solute being sodium chloride. The more efficiently the gland functions. the lower the salt content is. Very little salt is present in the sweat of acclimatized persons, so that a normal person rarely needs salt supplementation of his normal diet despite high sweating rates. Similarly vitamin supplementation is unnecessary since only trace amounts are lost. Eccrine sweating of the palms. soles and to a certain extent elsewhere is under a different neural control, reflecting emotional tension rather than thermal stress; *e.g.,* the cold sweat of shock or motion sickness.

Closure of the sweat pores with subsequent extravasation of trapped sweat into the skin is the cause of prickly heat, a common summer ailment.

Apocrine sweat is a second type formed in human skin. It arises from apocrine sweat glands, most of which are in the armpits and appear at puberty as an offshoot of the hair follicles. Very small amounts of sweat are continuously formed and stored in these glands, later to be expelled in response to emotional rather than thermal stimuli.

The expulsive force is provided for by a sheath of muscular tissue enveloping the glands. Apocrine sweat is a whitish odourless liquid which contains considerably more solid material than eccrine sweat. Surface bacteria of the skin act on the lipid content of this sweat to form odorous unsaturated fatty acids, thus accounting for the distinctive "underarm odour." In rare instances apocrine sweat may contain unusually large quantities of pigment, a condition called chromidrosis. Such reddish-brown sweat is normally produced by the apocrine sweat glands of the hippopotamus.

See also ANIMAL HEAT; SKIN. (W. B. SY.)

PERTAB (PARTAB) **SINGH,** SIR (1844–1922), maharaja of Idar, Indian soldier and statesman, belonging to the Rahtor Rajputs of the Jodha class, was born in 1844, the son of Maharaja Takht Singh, ruler of Marwar (or Jodhpur). In 1878 and again in 1879 he was chief minister of Jodhpur. In the following year he accompanied the British mission to Afghanistan, and on his return he carried out many reforms and administered Jodhpur with remarkable success. He visited England to take part in the celebration of the 1887 Jubilee of Queen Victoria's reign. He served on the staffs of Sir William Lockhart and General Elles in the Tirah and Mohmand expeditions in 1897–98, was slightly wounded, was mentioned in dispatches, and promoted to the rank of full colonel.

When it was decided to send a force from India to China in 1900 to relieve the foreign embassies besieged in Peking, Sir Pertab Singh at once offered the services of the Jodhpur Lancers, and himself accompanied them. From Queen Victoria he received the honour of knighthood and Order of the Bath and the Star of India; from King Edward VII the distinction of aide-de-camp; and the University of Cambridge gave him the degree of LL.D. From his own state of Jodhpur he obtained the title of Maharaja-Dhiraj.

In 1901 he succeeded to the rulership of the state of Idar.

He relinquished his position as maharaja of Idar in 1911 in favour of his adopted son Daolat Singh, in order to resume the regency of Jodhpur which he had previously held on the death of his brother in 1895, but this time for his grandnephew Summair Singh, then 13 years of age. When World War I broke out Sir Pertab, though he had reached the age of 70, went to France for service in the field with his young ward, then only 16, and commanded the Jodhpur Lancers. In the later stages of the war he served with them in Egypt and Palestine.

Sir Summair Singh died in 1918, two years after receiving ruling powers, and Sir Pertab again became regent, assisted by a

council. Sir Pertab Singh died on Sept. 4, 1922.

PERTH, EARLS AND DUKES OF. The Scottish title of earl of Perth was bestowed upon James, 4th Lord Drummond (d. 1611), in 1605. His ancestor Sir John Drummond (d. 1519) had been created Lord Drummond in 1488.

James, 4th earl and 1st duke of Perth (1648–1716), opposed the duke of Lauderdale, and after his retirement in 1680 James was one of the committee of seven which managed Scottish affairs. He was made justice-general and extraordinary lord of session in 1682, and was lord chancellor of Scotland from 1684 to 1688. As a convert to Roman Catholicism after the death of Charles II, he stood high in the favour of James VII and II. Perth, who is credited with the introduction of the thumbscrew, was very unpopular with the Scottish people, and during the Revolution of 1688–89 he was imprisoned at Stirling. Released from captivity in 1693 he joined James VII at St. Germain, and was made duke of Perth, a titular dignity only.

His son JAMES (1675–1720) and his grandson JAMES (1713–1746) fought for the Stuarts. The titular dukedom became extinct in 1760.

The 1st duke's brother, JOHN (c. 1649–1714), earl of Melfort, rose to favour under Charles II about the same time as his brother; like him, too, he became Roman Catholic in 1686. In 1684 he was made secretary of state for Scotland; in 1686 he was created earl of Melfort by James VII, and during his reign he took a leading part in Scottish affairs.

He died in Paris on Jan. 25, 1715.

GEORGE (1807–1902), nominally 6th earl of Melfort, in 1853 obtained a reversal of the various attainders, and his own recognition as earl of Perth and Melfort.

The succeeding earl (the 15th) was his kinsman, William Huntly Drummond, Viscount Strathallan (1871–1937), who was in turn succeeded by his half-brother, Sir James Eric Drummond.

PERTH, the capital of Western Australia, is situated in the southwest of the state on ground rising 200 ft. from the right bank of the Swan river about 12 mi. N.E. from its mouth where lies its port, Fremantle (*q.v.*). Established in 1829, Perth was constituted a city in 1856. The population of the city in 1954 was 97,350; that of the metropolitan area with suburbs (including Fremantle) was 348,647, 54.5% of the total population of the state.

BY COURTESY OF WESTERN AUSTRALIA TOURIST & PUBLICITY BUREAU

ST. GEORGE'S TERRACE IN PERTH. THE COMMERCIAL, BANKING AND PROFESSIONAL STREET OF THE CITY

Besides being the political and administrative centre, Perth, with Fremantle, is by far the most important centre for trade, commerce, banking, etc., in the state. Its first newspaper was founded in 1831. It is the terminus and departure port for the principal railway routes of a hinterland stretching far inland and its airport became international in 1952. There are regular air services to and from Johannesburg and Singapore.

The climate is of the Mediterranean type, warm to hot and sunny, with occasional hot winds from inland, and winter rains. The average annual temperatures range from 73.5° F. to 55.5° F., with some days over 100° F.; the mean daily hours of sunshine average 7.8 and the rainfall 34.9 in. falling during 122 days, mainly from May to October inclusive.

Though many of the streets are still narrow, the city has been largely rebuilt and the metropolitan area now extends more than 20 mi. east and west along the northern side of the river, though the southern side also is being increasingly occupied. Perth contains some of the finest terraces, avenues and buildings in Australia (*e.g.*, St. George's terrace and Forrest place). The public buildings include two cathedrals, government house, the houses of parliament, the university (established in 1913), the observatory, a branch of the royal mint and a hospital begun in 1939, the first part of which was opened in 1948. A new causeway over the Swan was opened in 1952.

The city owns about 5,700 ac. of lands devoted to parks, recreation grounds, etc., and including the beautiful King's park (1,018 ac.) overlooking the city and river from the west. The water supply is derived from artesian bores (450 to 2,000 ft.) and, chiefly, from the Darling ranges.

The largest reservoir, Canning dam, has a capacity of 20,550,000,000 gal.

PERTH, a city, royal and large burgh and county town of Perthshire, Scot., about 22 mi. W.S.W. of Dundee by road. Pop. (1961) 41,199. Area 6.1 sq.mi. It is on the right bank of the Tay, between the meadows of the North Inch and those of the South Inch, both laid out as public parks. On the left bank of the river (crossed by three bridges) Kinnoull hill rises 729 ft. The Perth bridge, which crosses the Tay just below North Inch, has nine arches and was built by John Smeaton in 1766–71. The city has long been famous for its dye works. Other industries include whisky blending, the making of glassware (and particularly of gauge glasses), jute, carpet and linen manufacture. Perth is the centre of a prosperous agricultural area, with sales which attract buyers from all parts of the world.

Notwithstanding the importance of Perth in former times (it was the capital of Scotland until *c.* 1452), almost the sole relic of the past is the church of St. John the Baptist. The original building is believed to have been erected in the time of Columba, but the present choir was built c. 1440 and the nave *c.* 1490. In 1598 the church was divided into two churches and a third was inserted between them in the 18th century, but under Sir Robert Lorimer the whole was restored to its original form as a World War I memorial (1925–28). There, in 1559, John Knox preached his famous sermon in denunciation of idolatry, as a result of which the Dominican, Carthusian, Franciscan and Carmelite friaries were destroyed. The castle, palace and fortress have also disappeared. The tombstone of James I and his queen, who, though the king was murdered in the Dominican, were buried in the Carthusian monastery (destroyed in 1559), was afternard removed to St. John's church.

During the period between the beginning of the 12th century and the reign of James II many of the Scottish parliaments were held in a building (demolished in 1818) where the Freemasons' hall now stands. The supposed house of Catherine Glover, the "Fair Maid of Perth," still stands in Curfew Row. James VI's hospital, founded in 1569 on the site of the Carthusian monastery, was converted into workmen's dwellings. A 19th-century replica of the Mercat (market) cross, which in 1668 replaced one destroyed by Oliver Cromwell, stands opposite the city hall.

Public buildings include St. Ninian's Episcopal cathedral (1850–90); the city chambers; the county buildings (1808–20); the art gallery and museum (1935), which incorporates as its principal feature the Marshall memorial (1824) and contains the museum of the Black Watch, the collections of the Literary and Antiquarian society and the Perthshire natural history museum; and the Sandeman public library, founded by a bequest of Professor Sandeman of Owens college, Manchester. The general (convict) prison for Scotland was originally erected in 1812 as a depot for French prisoners.

Northwest of the city are the military barracks (1793–94). The burgh grammar school, supposed to date from the 12th century, was amalgamated with the Perth academy (1807) and Sharp's institute (1860).

History.—During the time that it was occupied by the Romans, a period estimated at 320 years. the city was called Victoria: its present name probably derives from the Celtic Abertha ("at the mouth of the Tay"). On the conversion of the original Pictish inhabitants and the dedication of the first church to St. John the Baptist, the town was designated St. Johnstoun, and it continued to be known indifferently by this name and that of Perth down to the 17th century. Perth is stated to have been a burgh in 1106 and was made a royal burgh by William the Lion in 1210.

During the Scottish Wars of Independence its fortifications were strengthened by Edward I (1298). Robert Bruce several times ineffectually attempted to seize it, but in 1311 he succeeded in scaling the walls during a night attack. This was the fourth and most brilliant of the seven sieges which the city sustained. Taken by Edward III in 1335, it was recaptured in 1339. In 1396 the combat between the Clan Chattan and the Clan Quhele, described in Sir Walter Scott's *Fair Maid of Perth,* took place on the North Inch in the presence of Robert III and his queen, Annabella Drummond.

The Dominican friary (Blackfriars) was the scene of the murder of James I by Sir Robert Graham, instigated by Walter, earl of Atholl, in 1437 In consequence Perth lost its status as capital, in which it had succeeded to Scone, and the parliament courts were transferred to Edinburgh in 1482.

Gowrie house (on the site now occupied by the county buildings) was the scene of the mysterious "Gowrie conspiracy" against James VI in 1600. The town was taken by the marquess of Montrose in 1644, by Cromwell in 1651, and was occupied by Viscount Dundee in 1689.

In 1715 the Old Pretender was proclaimed king at the Mercat cross, and the chevalier himself appeared in the city in the following January, only to leave it precipitately on the approach of the earl of Argyll.

PERTH, ARTICLES OF, a series of five articles on rites, authorized by a general assembly of the Scottish church at Perth, Scot., in 1618. The articles. approved by the Scottish parliament in 1621, were passed at the insistence of James I, who used them as a point in his campaign to bring the independent Church of Scotland under royal influence.

They required kneeling at communion; the observance of Easter and Christmas; confirmation by bishops; communion at home for the dying and child baptism on the first Sunday after birth.

See also JAMES I.

PERTH AMBOY, a city in Middlesex county, N.J., U.S., at the mouth of the Raritan river, on Raritan bay and Staten Island sound, 29 mi. S.W. of New York city.

It is strategically located on the fringe of the two major metropolitan areas of the east, Philadelphia and New York. Connecting these areas with the city are an elaborate highway system, four rail lines and a harbour for ocean-going ships.

Local industry is well diversified and produces steel, nonferrous metals, petroleum products, building materials, chemicals, paints, lead, printing and electrical goods, clothing, food products and cigars.

Despite its industrialization the city stresses residential living and supports numerous parks and recreation and play areas. Public utilities (electricity and water) are municipally owned.

Perth Amboy was settled in the late 17th century and from 1684 to 1702 was the capital of the colony of East Jersey. The original name, Amboy, is of Indian origin. Later Perth was added in honour of an early proprietor, the earl of Perth. A city charter. one of the first in New Jersey, was granted in 1718. The last royal governor of the colony, Benjamin Franklin's son William, resided in the city in the governor's house (Westminster house, erected in 1764), which is one of a number of colonial buildings still standing.

The city was occupied by the British in 1776–77 and later evacuated when Gen. George Washington's troops seized northern New Jersey.

For comparative population figures *see* table in NEW JERSEY. *Population.* (W. L CA)

PERTHES, FRIEDRICH CHRISTOPH (1172–1843), German publisher. nephew of Johann Georg Perthes (*q.v.*), was born at Rudolstadt, on April 21, 1772. In Hamburg, where he settled in 1793 as an assistant to the bookseller B. G. Hoffmann, he started in 1796 his own bookselling business. and in 1798 he entered into partnership with his brother-in-law Johann Besser.

In 1810–11 Perthes issued *Das deutsche Museum,* to which many of the foremost publicists of Germany contributed. In 1821 he transferred his business in Hamburg to his partner and went to Gotha, where he established what ultimately became one of the first publishing houses in Germany.

As a result of his initiation, the Union of German Booksellers in Leipzig was founded in 182 j. When the foundation stone of the building of the union was laid in 1834, he was made an honorary freeman of Leipzig. Perthes died at Gotha May 18, 1843.

His *Life* was written by his son, Rlemens Theodor Perthes (1809–1867), professor of law in the University of Bonn and author of *Das deutsche Stnatsleben vor der Revolution* (1845) and *Das Herbergwesen der Handwerksgesellen* (1856).

PERTHES, JOHANN GEORG JUSTUS (1749–1816), German publisher, was born at Rudolstadt on Sept. 11, 1749 In 1785 he founded at Gotha the business that for many years bore his name (Justus Perthes). In this he was joined in 1814 by his son Wilhelm (1793–1853). On the death of Justus at Gotha on May 2, 1816, Wilhelm took entire control of the firm. He laid the foundation of the geographical branch of the business by publishing the *Hand-atlas* (1817–23) of Adolf Stieler. The business passed to his son Bernard Wilhelm Perthes (1821–57), who was then associated with August Petermann and Bruno Hassenstein (1839–1902); and subsequently to his son Bernard (1857–1919).

The firm published the *Almanach de Gotha,* a statistical. historical and genealogical annual (in French) of the various countries of the world; and the elaborate *Geographisches Jahrbuch,* produced under the editorship of Ernst Behm (1830–84), on whose death it was continued under that of Hermann Wagner.

A new edition of Stieler's atlas (ed. by H. Haack) was published in 1925.

PERTHSHIRE, an inland county of Scotland, bounded north by the counties of Inverness and Aberdeen; east by the county of Angus; southeast by the Firth of Tay and the counties of Fife and Kinross; south by the counties of Clackmannan and Stirling; southwest by the counties of Stirling and Dunbarton; west by the county of Argyll and northwest by the county of Inverness. It is the fourth largest county in Scotland, its land area being 2,493.4 sq.mi. Pop. (1961) 127,018. By far the greater part is mountainous and, including those on the borders of Inverness-shire and Argyllshire, there are at least 50 mountains exceeding 3,000 ft. in height. The most familiar are Ben Lawers (3,984 ft.) near Loch Tay, Ben More (3,843) east of Crianlarich, Ben Lui (3,708) on the Argyllshire border, Schiehallion (3,547) southeast of Loch Rannoch, Ben Vannoch (or Bein Mhannach; 3,125) west of Loch Lyon, and Ben Chonzie (3,048) near the head of Glen Almond. Four of the many hills of lesser altitude have been made famous by Sir Walter Scott's *The Lady of the* Lake—Ben Ledi (2,873), Uam Var (or Bheag; c. 1,600) near Callander, Ben Venue (2,393) and Ben A'an (1,326). The Ochil hills divide Perthshire from the counties of Clackmannan, Kinross and Fife.

The chief river is the Tay, which rises on the Argyllshire border and discharges into the North sea off Buddon Ness, after a course of 120 mi., being thus the longest river in Scotland. Its headwaters are the Fillan and Dochart, and among its affluents are, on the right, the Bran, Almond and Earn, and, on the left, the Lpon, Tummel rising in Argyllshire and receiving the Garry on its left, and Isla. The Earn flows out of Loch Earn and enters the Firth of Tay 6½ mi. below Perth. The Forth, the principal natural boundary of the county on the south, properly belongs to Stirlingshire, in which it rises, but its leading left-hand affluents are Perthshire rivers, namely the Teith, the Goodie, issuing from the Lake of Menteith, and the Allan, rising in the Ochils near Sheriffmuir. All the lochs are narrow, scarcely one exceeding a mile in width. Loch Ericht, belonging partly to Inverness-shire. is about 15 mi. long. Loch Tay (14½ mi.). situated about the centre,

is the largest in the county. In the south are the series of lochs which *The Lady of the Lake* has rendered famous—Loch Vennachar (4½ mi.), Loch Achray (1¼ mi.), Loch Katrine (about 8 mi.); to the west of Aberfoyle is Loch Ard (3 mi.) and to the east Lake of Menteith (1½ mi.). Nearly all the glens possess striking natural features, among them, from south to north, being Glens Artney, Almond, Dochart, Ogle, Lochay, Lyon, Garry, Shee, Bruar and Tilt; the Trossachs, Killiecrankie, Birnam and Leny are among the loveliest passes in the Highlands. The low-lying country is represented mainly by Strathmore, Strathallan, Strathearn, Strathbraan, Strathtay and Strathfillan, but more particularly by the fertile alluvial belts of the Carse of Gowrie, a raised marine platform on the northern shore of the Firth of Tay, and the Carse of Stirling.

History.—In 83 Agricola explored the lands beyond the Forth and in the following year penetrated to the Grampians. The growing lawlessness of the southern Picts and their frequent raids in the more settled country in the south later compelled the attention of the emperor Severus. But though he led a strong army to the shores of the Moray firth, he was unable effectually to subdue the tribesmen. There were several Roman forts in the county such as those at Bochastle, Dalginross, Bertha, Fendoch and Gourdie as well as a legionary fortress at Inchtuthil; along the Earn there were many signal stations.

When the Romans finally withdrew from Britain, the Picts established their capital first at Abernethy and then at Forteviot. Abernethy was the centre of the Celtic church after the conversion of the natives by Ninian, Palladius and other missionaries in the 5th and 6th centuries. On the burning of Forteviot by the Norsemen in the 8th century, the seat of Pictish government was removed to Scone. In the latter half of the 9th century, Dunkeld—to which Kenneth MacAlpin had brought some of the relics of Columba from Iona—became the scene of monastic activity.

The Danes periodically harried the land, but suffered a crushing defeat at Luncarty in 961. In 1054 Macbeth was defeated at Dunsinane by Siward, earl of Northumberland, who had invaded Scotland in the interest of his kinsman, Duncan's son, who, on the death of the usurper three years later, ascended the throne as Malcolm III. With Malcolm's accession the Celtic rule of the monarchy of Scone came to an end. Perth became the capital at the beginning of the 12th century and remained the capital until 1452; from that time the history of the county is merged in that of the county town, with the exception of such isolated incidents as the removal of the coronation stone from Scone to Westminster in 1296, the defeat of Robert Bruce at Methven in 1306, the battle of Dupplin Moor in 1332, the victory of Viscount Dundee at Killiecrankie in 1689 and the indecisive contest at Sheriffmuir in 1715. Among non-Roman archaeological remains are the hill fort on Dunsinane; the ship barrow of the Vikings at Rattray; weems (or earth houses) in the parishes of Monzie, Alyth and Bendochy; standing stones near Pitlochry; and an extraordinary assemblage of sculptured stones at Meigle.

Agriculture, Industries and Communications.—The arable land is chiefly in the drier regions of the east and southeast, the soil for the most part being fertile. Light soils prevail in the lower undulating districts; clay and alluvial land occur in the Carse of Gowrie, the Carse of Stirling and the lower reach of Strathearn below and above Bridge of Earn. The best heavy carse land is rich, and produces heavy crops of wheat, potatoes, sugar beet, beans, timothy and silage crops. The principal cereal crop in Perthshire is oats—extending to 11,000 ac. in the mid-1950s. Wheat occupied about 6,300 ac. and barley more than 10,000. The county exports a big tonnage of seed potatoes, over 20,800 ac. being under this crop in the mid-1950s. Turnips and swedes occupied 16,200 ac. and sugar beet 1,660. The county specializes in the growing of small fruit, being the main raspberry-growing county in Scotland.

There are many herds of pedigree livestock, particularly of the Shorthorn and Aberdeen Angus beef breeds. On the hills Blackface sheep are carried, and on many of the foothill farms herds of breeding beef cows are now established.

The rivers and lochs abound with good salmon and trout. Hardly any of the streams have suffered pollution from industries.

The deer forests, of which the largest four cover about 90,000 ac., are frequented by red and roe deer, and on the extensive moors and in the woods are found grouse, pheasants, partridge, capercaillie, woodcock, ptarmigan and hares. The ancient Caledonian forest has practically disappeared from the county except the Black wood of Rannoch (of native Scots pine) and oak woods in the valleys which used to be cut as coppice for tanning bark. Large-scale afforestation with European larch was carried out by the dukes of Atholl from the end of the 18th century. Forestry has been and is an important part of the economy of many estates in the county. From 1921 through the 1950s the Forestry commission planted over 30,000 ac., mainly with conifers, in almost 20 forests including the Queen Elizabeth National Forest park near Aberfoyle. There is a training school for foresters at Pitlochry. The census of woodlands of 1947–49 gave a total woodland acreage of 150,372, about 9½% of the total land area.

In the valley of the Tummel river is the greatest hydroelectric power development in Scotland. The Tummel and its tributaries are harnessed in six hydroelectric stations with an installed capacity in the latter 1950s of about 240,000 kw. and an average annual production of 600,000,000 units of electricity; further developments were expected to add another four small stations and increase the total estimated annual output of the valley to 660,000,000 units. In the Breadalbane district lying between Loch Earn, Loch Tay and Glen Lyon, eight power stations were planned with a total capacity of 118,500 kw. and an estimated average annual output of 384,000,000 units of electricity. The first section of this group went into operation in Dec. 1955. This is the Lawers scheme, which has a 30,000-kw. generating station at Finlarig on the shores of Loch Tay. This station is fed from Lochan na Lairige, a loch on the high pass between Loch Tay and Glen Lyon where a dam was built. The turbine operated in the latter 1950s under a gross head of 1,362 ft., the highest head of the North of Scotland Hydro-Electric board's stations.

Dyeing and bleaching works are in Perth and its vicinity. Flax and jute mills are at Blairgowrie and Rattray and cotton mills at Stanley, Deanston and Perth. Woollens, linen, jute and tartan are woven at Dunblane, Alyth, Auchterarder, Aberfeldy and Pitlochry. Whisky is distilled at Pitlochry, Aberfeldy and Blackford, while Perth is a centre for blending and bottling. Tay fishing, especially salmon, is famous.

The British railways main line to Aberdeen enters the county near Dunblane and runs in a northeasterly direction via Perth. At Perth a line runs eastward to Dundee. The Stirling to Oban line crosses the county from Dunblane to Tyndrum. The main line to Inverness runs northward from Perth. On the east side the line from Edinburgh Waverley runs via Kinross to Perth. The West Highland line to Mallaig skirts the west of the county.

Population and Administration.—The population in 1951 was 128,029 and Gaelic and English were spoken by 2,318 persons, of whom one spoke Gaelic only. The city and royal burgh of Perth (40,487) is the only large burgh. There are 11 small burghs: Aberfeldy (1,528), Abernethy (676), Alyth (2,071), Auchterarder (royal burgh, 2,435), Blairgowrie and Rattray (5,379), Callander (1,728), Coupar-Angus (2,175), Crieff (5,477), Doune (834), Dunblane (2,985), Pitlochry (2,383). There are five county districts.

With Angus the county forms the sheriffdom of Perth and Angus, with a sheriff substitute presiding at Perth and Dunblane. For parliamentary purposes it was divided into the Perth and Western divisions (the latter including Kinross), each returning one member. There are secondary schools at Perth, Crieff, Blairgowrie, Aberfeldy and Callander. Trinity college in Glenalmond and Strathallan are well-known boys' schools.

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PERTINAX, PUBLIUS HELVIUS (A.D. 126–193), Roman emperor, the son of a charcoal burner, was born at Alba Pompeia in Liguria. From being a teacher of grammar he rose

through many important offices, both civil and military, to the consulate, which he held twice. Chosen, at an advanced age and against his will, on Jan. 1, 193, to succeed Commodus, he was himself assassinated in a mutiny of the soldiers, on March 28, 193.

PERTZ, GEORG HEINRICH (1795–1876), German historian, the first general editor of the *Monumenta Germaniae historic* for which he laid down the determining principles. Pertz was born in Hanover, March 28, 1795, and was a pupil of A. H. L. Heeren at Gottingen. In 1823 he became secretary of the archives in Hanover, in 1827 royal archivist and in 1842 chief librarian in Berlin. In 1832 Pertz founded the *Hannoverische Zeitung* to promote Baron von Stein's ideas; he also sat in the Hanoverian second chamber. His enduring work, however, was done on the *Monumenta Germaniae.* This owed its inception to Stein but behind it lay a scholarly need, a new pride in the German past and a romantic interest in the middle ages. In 1819 the work was begun under the auspices of the newly founded Gesellschaft für altere deutsche Geschichtskunde, supported by funds from both Prussia and Austria. Stein invited Pertz to help in 1819 and he journeyed through Europe examining manuscripts and making many finds. In 1823 Stein entrusted him with the 'general direction of the work, which was to be a critical edition of writings on German affairs (*Scriptores, Leges, Diplomata, Epistolae* and *Antiquitates)* from *c.* 500–1500. The first two volumes (Carolingian narrative sources), largely Pertz's work, came out in 1826 and 1829 and by 1873, when he was superseded, more than 20 volumes had appeared. Pertz also wrote a life of Stein (6 vol., 1849–55) but his gift was for research rather than for creative work and his biographies had less merit than his editions. He died in Munich. Oct. 7, 1876.

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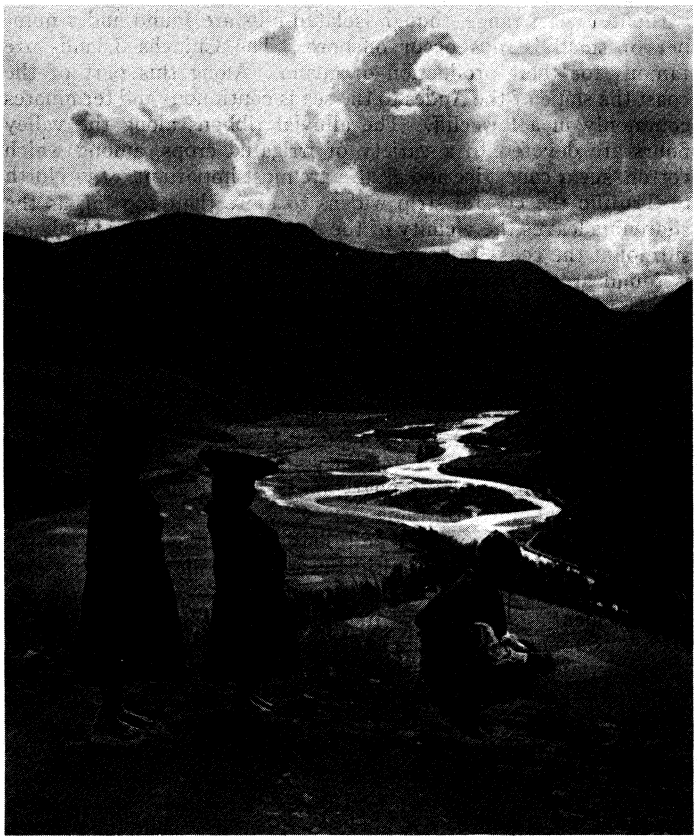
PERU, a republic on the western side of South America. Its area is estimated officially to be 496,222 sq mi., which makes it the third largest South American country. following Brazil and Argentina. Along the Pacific ocean it extends in a general southeasterly direction from 3° 16' S. to 18° 21' S., with a seacoast of about 1,400 mi.. but east of the Andes it reaches north to the equator. Peruvian territory borders on Ecuador and Colombia on the north, Brazil and Bolivia on the east and Chile on the south. Often in the past the territorial interests of these neighbouring countries conflicted with that of Peru, and lengthy negotiations resulted. Indistinctly defined boundaries were of little importance so long as all the territories involved had colonial status. The establishment of sovereign states, however, changed the situation fundamentally. Such factors as contradictory royal decrees, as well as the lack of accurate geographic knowledge of the areas concerned and the later economic development of certain previously unimportant frontier zones, combined to make the problem of modern boundary delimitation a complex one indeed. The frontier between Spanish and Portuguese interests along the upper Amazon, determined by the treaty of San Ildefonso in 1777, was revised by a treaty between Peru and Brazil in 1851 and further modified in 1909 by a treaty which involved Bolivia in addition to Peru and Brazil. While Peru has settled most of its frontier problems with Brazil amicably, violence has marked the boundary disputes with its Spanish-speaking neighbours, culminating in open warfare in the case of Chile and Ecuador.

The more-than-a-century-old frontier dispute with Ecuador was terminated in 1942 by a settlement on the whole favourable to Peru. In the west it retained the areas around Tumbes and Jaén which Ecuador had claimed, while in the east it was confirmed in its rights of possession to those parts of Ecuador's former claim containing navigable affluents of the Marañón and the Amazon. Despite the official settlement, however, the frontier zone remains a potential trouble spot, while Ecuador continues to clamour for access to the important waterways. In the north Peru's common boundary with Colombia follows the Putumayo river to the edge of the Leticia Trapezium, Colombia's southernmost extension, and around it to the south and east to the confluence of the Yavari (Javari) and the Amazon. The boundary then leads up the Yavari to its source, south along the water parting between the Ccayali and the Yurua, and then irregularly to the southeast to the confluence of the Heath and the Madre de Dios. It ascends the Heath in a southerly direction to its source, continuing by an irregular line to the shore of Lake Titicaca, crossing the lake in a southeasterly direction to the Desaguadero, and thence southwest to Chile's northernmost point at 17° 30′ S. The boundary with Chile, after 46 years of bitter dispute, was finally settled in 1929, largely through the mediation of the United States. The line was drawn from the Pacific to the Bolivian border parallel to and 10 km. N. of the Arica-La Paz railway.

Physical Characteristics. — The tremendous mountain system known as the Cordillera de los Andes forms the backbone of Peru. It trends roughly north-northwest and south-southeast, and divides the country longitudinally into three sharply contrasted regions: (1) the coastal zone, a dry strip from 10 to 100 mi. wide; (2) the sierra, a series of great mountain chains with their associated mountain knots, high plateaus and deep valleys; and (3) the montaña, the hot, moist low country to the north and northeast beyond



BY COURTESY OF UNESCO "COURIER"

PERUVIAN CHILDREN OVERLOOKING THE VALLEY OF THE VILCANOTA RIVER NEAR CUZCO

the mountains, consisting in part of slopes and foothills and in part of true Amazonian lowland.

With the exception of a small area near the Ecuadorean boundary. the entire coastal strip is a desert. It is crossed by about 50 streams, most of them intermittent and all of them exceedingly variable in rate of flow. Only about ten of them regularly reach the sea throughout the year. These stream valleys with their rich alluvial soils and their water for irrigation are the site of most of Peru's commercial agriculture and of the densest population clusters. The sierra is approximately 250 mi. wide in the south, narrowing to about 150 mi. in the north. It contains a number of distinct mountain chains, in part parallel to one another or stepped, trending in general with the coast line. On the east is the Cordillera Oriental, on the west the Cordillera Occidental. the main watershed. No other mountains are continuously so lofty (some more than 20,000 ft.) near a coast which drops off to such abyssal depths (20,000 ft. and more). Much of the area between the

mountain chains is occupied by plateau surfaces of gentle to moderate relief known as puna, varying in elevation from more than 13,000 ft. in the south to less than 10,000 ft. in the north. Longitudinal valleys with their tributaries create a gigantic maze of ramifying wild gorges.

Between sierra and montafia lies a transitional zone, the ceja de la montafia ("eyebrow of the montaiia"). The contrast between sierra and montafia on the east, in topography, climate and vegetation, is one of the most abrupt and spectacular on earth. The sierra is dry and cold. The montafia is covered with dense tropical forest, long impenetrable except for rivers and a few short trails to gold and rubber camps.

Coastal Zone.—The littoral of Peru may be conveniently divided into three sections: (1) The southern coast from the Paracas peninsula (about 14° S.) almost to the Chilean border has in large part the aspect of a high wall. This steep escarpment is the seaward aspect of a coast range that exceeds 3,000 ft. in elevation and has a width of 15 to 30 mi. Behind it lies a rocky, dissected surface which rises gradually toward the Andean foothills. (2) The central section irom Paracas to Trujillo (about 8° S.) is without a coast range, though isolated hills are found and a number of small islands occur offshore. The Chincha Islands are famous for their production of guano. Along this part of the coast the slope of the Andes to the sea is continuous and terminates commonly in a low cliff. The alluvial ribbons along the valley floors are devoted to a variety of irrigated crops, among which cotton, sugar cane, rice and alfalfa are most important. (3) North of Trujillo the coastal strip widens to more than 100 mi. as the shore line leaves the vicinity of the Andes. Three minor highlands surmount the coastal plain, and an extensive region of sand dunes is found around Sechura (5° 36' S.). Although of considerable actual and greater potential importance as an agricultural district, the area is most noted for its long-continued production of petroleum from several fields around Talara (4° 35' S.).

Sierra.—The southern Cordillera Oriental, a grandiose wilderness of craggy peaks and ridges, mostly snow covered, loses its high mountain character north of Cerro de Pasco; the extensive puna has no parallel in the north, and the volcanic cones of the Cordillera Occidental, so marked a topographical feature in the south, are entirely absent north of Lima.

Sections of the sierra may be briefly summarized as follows: In southern Peru the puna or altiplano is overshadowed on the east by the Cordillera Oriental (Real) and on the west by the Cordillera Occidental. It is a vast intermontane basin, roughly 500 by 100 mi., sloping gently to the south, very high, cold and dry. Upon it, ranges of low hills alternate with alluvial tracts, salt swamps and many lakes, the largest of which is Titicaca. At an altitude of 12,507 ft., Lake Titicaca is 125 by 35 mi., with an average depth of 100 ft. (maximum about 892 ft.). Well-defined on the east, the bordering scarps of this great tectonic depression are concealed on the west by thick lava flows. Near the lake, crops of barley, quinua (quinoa) and potatoes are grown, while the western part of the plain is pastoral, covered with grass and occasional stretches of bushy growth. Puno is the only large town. Seen from the western slopes of the Cordillera Occidental, the even sky line of the lava plateau is broken by a series of volcanic peaks, some eroded, some symmetrical. They are isolated, snow capped, dormant or extinct, 19,000 to 20,000 ft. in height (Coropuna, 21,696 ft.). Earthquakes are frequent throughout this area. The bordering scarps of the altiplano converge on the north at the Nudo de Vilcanota (14° 26' S.). In the valley of the Huatanay, 11,207 ft. high, is the ancient city of Cuzco. In this beautiful, luxuriant valley enclosed by mountains the Incas founded their great empire. Between 12° and 14° S. the heart of the sierra is a wilderness of gorges with cliffed sides, some more than 6,000 ft. deep. Into these it is usually impossible to descend. The valley of the Apurímac is spectacular, its highly coloured walls with tufts of cactus reaching from fever-ridden floor to snowy peaks. Between 10° and 12° S. the puna is called the Pampa of Junin. It has many lakes, the largest of which is Lake Junin (Chinchaicocha), 14 by 6 mi., altitude 13,560 ft. From it the Mantaro flows south across the plain—a deep, silent, swift-flowing stream. The chief activities on this plain are mining and pastoral, the only crops, potatoes and quinua. North of the Pampa of Junin is the Cordillera de Huayhuash, as the Nudo de Cerro de Pasco is now called, a desolate mining region. North of this, the western chain is divided in two, Cordillera Negra, toward the west, and Cordillera Blanca, so called because of its snowcaps. The latter (8° 43' and 9° 53′ S.) is about 100 mi. long, its average height 15,000 ft. and its highest peak, Huascarán (22,205 ft.), a laccolith of granodiorite. Inhabitants are few, Indians living on slopes and valley moraines in small groups of huts like animal burrows. The Cordillera Negra (8° 43' S. and 10° 11′ S.) is about 110 mi. long and about 14,000 ft. high (maximum 14.764 ft.). The bare, dark gray rocks and even sky line contrast with the sharp peaks of the Cordillera Blanca. It is an unbroken wall without practicable passes. Between the two ranges lies the fertile valley of the Huaraz (Huarás), averaging 25 mi. in width, one of the most thickly settled parts of the sierra. The river flows north through a series of basins each with its town—Recuay, Huaraz, Yungay, Caraz, Huaylas—strung like beads upon a thread, responding to the presence of good soil, water and favourable climate. Temperate-zone crops are raised in the upper reaches of the valley and tropical in the lower, known as the Callejón de Huaylas. At 8° 40' S. the Huaraz, now called Santa, cuts the Cordillera Negra at right angles and crosses the desert to the Pacific. Two great rivers, the Marañón and Huallaga, rise on the northern slopes of the Cordillera de Huayhuash. The valley of the Marañón, 500 mi. long (4° 30′–10° 20′ S.), and for most of that distance more than a mile deep, is east of the Cordillera Blanca and parallel to it. In the rainy season the Marañón is impassable. It cuts the Cordillera Oriental at the Pongo de Manseriche (4° 25' S.) and flows toward the Atlantic. The valley of the Huallaga, farther east than the Marañón, is more open and populated. Huánuco, in the upper valley, communicates by a good road with Cerro de Pasco. The Huallaga cuts the eastern chain at the Pongo de Aguirre (6° 30' S.). North of 8° S. the cordilleras gradually subside. There are no more snowy peaks. The plateau levels commonly lie at 7,000 to 9,000 ft. above the sea. The ancient town of Cajamarca is the agricultural centre of the northern sierra.

Throughout the length of the Peruvian Andes there are 27 practicable passes, most of them more than 12,000 ft. high. The highest in use, between Antabamba and Cotahuasi, is 17,400 ft. above sea level, whereas the lowest, the Porculla pass in the far north near Piura and Olmos, is only 7,072 ft. high.

Montaña.—This area, which covers more than half of the nation's territory, is virtually unexplored. Yet its economic possibilities are very great and its vast timber, mineral and possible petroleum resources will benefit the national economy when an improved system of transportation makes the region accessible. Except for a series of mule trails, an automobile road, opened in 1943 to connect Lima via Huánuco with Tingo Maria on the Huallaga and with Pucallpa on the Ucayali, provides the only contact by land between the coastal area and the montafia proper. From Pucallpa a three-day trip downstream by boat gives access to Iquitos, the chief centre of Peruvian Amazonia.

A project of the utmost importance for the opening up of the montafia zone was launched in 1953 when the U.S. Le Tourneau interests reached an agreement with the Peruvian government according to which they undertook to clear and develop approximately 1,000,000 ad. of jungle in the Pachitea river region. This project involved the construction of a stretch of road to connect with one of the existing east-west highways.

Climate.—The three major climatic controls in Peru are latitude, the ocean and relief. The latter, in its twin aspects of elevation and exposure, is the most important. Climatic change is far more rapid from east to west than from north to south. A few hours of ascent from the west coast will bring a change from a temperate marine desert climate to a very cold, brilliantly illuminated tropical highland. A similar ascent from the equatorial lowland up the eastern border valleys brings even more rapid contrasts. Rainfall. which is heavy in the east, increases to a certain height, then decreases from east to west across the sierra. Easterly winds sweep across the warm lowlands of Amazonia, filled

with moisture. Confronted by the Andes, they are forced to rise, undergo adiabatic cooling, and heavy rains result. The annual rainfall on the low eastern slopes probably exceeds 150 in. Swollen streams give rise to the world's greatest river system. Along the Pacific coast the Humboldt or Peru current flows northward, bringing cool water both from higher latitudes and from the depths of the sea. Prevailing south and southwest winds, cooled by the ocean and saturated with moisture, rise over the coast and the Andean foothills and produce widespread fogs (*garúas*) and low stratus clouds, which are especially characteristic of the southern coast in winter. Occasional violent summer rains causing widespread damage occur at irregular intervals, especially along the northern coast. They are correlated with as yet unexplained changes in the part of the Humboldt current which veers out to sea and allows a broad belt of warm water from the equatorial countercurrent to flow south along the shore.

Climatic provinces are distinguished chiefly by variations in rainfall. From east to west, montafia and ceja de la *montaña* (the higher eastern slopes) have precipitation throughout the year, heaviest in summer. Sierra rainfall, confined to summer, diminishes both in quantity and in length of season toward the south. The rainfall of the higher western slopes resembles that of the sierra, the amount of precipitation diminishing with altitude.

1. The immediate coast zone, though desert, has a cool, damp climate with small annual and diurnal variability. Mean annual temperatures at the north average about 10° F. wanner than those at the south (Paita 75° F., Mollendo 65° F.). The western slopes below 4,000–6,000 ft., though averaging about the same, have greater diurnal ranges of temperature. This uniformity, interrupted by no storms and no sudden changes of temperature, is very monotonous, especially since the skies, as far north as 8° S., are covered with clouds during more than half the year, though the total annual rainfall is less than two inches.

2. The summer rain zone is an extremely complex province. It includes, besides the western slopes above the rainless zone already described, the summit region at about 15,000 ft., desolate, high plateaus. intermontane basins and deep canyons, whose climates range from equatorial to frigid. Climates in Peru depend primarily on altitude; deep valleys are tropical to semitropical, depending on depth, valley trend, slope and exposure. Mean annual puna temperature averages about 50° F., with greater diurnal than annual range. With an average relative humidity of 50%, the mean annual rainfall is 2j in. in the south, where it is confined to summer, reaching 40 in. in the north, where precipitation occurs in spring, summer and autumn, overlapping the equatorial rainfall type. Snowfall occurs south of about 7° S. above 12,000 to 13,000 ft. Because of aridity the snow line is very high. Heat in deep sierra valleys is so great and rainfall so slight that often the narrow floors are semidesert; while 4,000 to 6,000 ft. above those same floors rainfall may exceed 80 in. Similarly, high-level basin stations have less rainfall than surrounding mountains and irrigation is often necessary.

3. Maximum rainfall is on the eastern slopes between 4,000 and 8,000 ft. elevation. Rainfall may be different on opposite sides of a single valley, so that the eastern walls may be grassy, the western, forest-covered. The mean annual temperature is about 72° to 75° F., with a negligible range.

4. Constant evaporation takes place above the great Amazonian wilderness (the area of which equals half that of Europe) and this moisture is precipitated, to be once more vaporized and condensed. Excessively high relative humidity is maintained throughout the year, so high that salt dissolves and matches will not ignite unless kept in airtight boxes. Rainfall averages considerably more than 100 in., with winter minimum. The mean annual temperature probably averages 78° F., with a range of 3" F.

Hydrography. — The cordillera supplies three systems of drainage. The first flows toward the Pacific, the largest of these streams (Santa) is the only one to cross the Cordillera Occidental. The second flows toward the Atlantic, including such vast tributaries of the Amazon as the Marañón, Huallaga, Mantaro and Apurimac. These quick-flowing streams pass through narrow pongos (gateways) and then join the sluggish jungle streams of Amazonia, whose branches spread out over half a continent before reaching the Atlantic, nearly 3,000 mi. a ay. The third is that of Lake Titicaca, an inland system complete in itself, fed by perpetual snow. The Desaguadero river, a shallow stream, empties into Lake Aullagas (Poopó), thence into a series of salares (salt swamps) to the south, where its waters eventually evaporate.

(H. J. Bn.; M.T. Bi.; K.L.L.)

Vegetation. — The division of the territory into three contrasting regions applies logically to Peru's plant life:

1. Costa, mostly a narrow, dry stretch of coastal plain, consists of desert and semidesert types of vegetation. Species of *Capparis*, associated with algarroba (Prosopis *chilensis*), various other trees and shrubs, grasses, numerous herbaceous annuals and some tuberous plants predominate. Other types of habitats, such as wet sea cliffs, brushy riverbanks and seashore formations, add diversity to the area, while northnard, principally in the department of Tumbes, a green parklike landscape, with many kinds of trees and shrubs, columnar cacti and small annual grasses, occurs.

2. Sierra, a diversified region embracing the western slopes, high Andean regions and valleys lying between the main Andean chain, varies in width from 1jo to 250 mi. In southern Peru the western slopes of the Andes are marked by a shrubby zone of Franseria and *tola* (*Lepidophyllum*) with altitudinal belts of desert at the lowest elevations to columnar cacti higher up, finally to *tola* heath from 11,500 to 12,000 ft. Northward the flora of the western Andean slopes is richer because of the less arid climate. In central and southeastern Peru between 11,500 and approximately 12,200 ft., above the limit of agriculture, the puna zone predominates. Most of the *puna* plants consist of perennial herbs, characterized by such rosette and cushion plants as *Werneria, Azorella* and Distichia; the treelike bromeliad, Puya raimondii, occurs there. Farther north exists the Jalca, whose extensive essentially treeless paramos correspond to the *puna* formation with similar types of plants. South of 11° lat. in the inter-Andean valleys, with their moister climate, there are more shrubs, especially on the higher slopes where many shrubs hold their leaves all year instead of shedding them periodically as on the lower slopes affected by a drier climate. In the inter-Andean Huallaga river section, with dry climate, occur various columnar cacti, pepper tree (Schinus *molle*), *Fourcroya* and many other kinds, depending upon the altitude. To the north in the inter-Andean valley of the Marañón river the increased humidity effects a corresponding change in vegetation, ranging from treeless or grass steppes and cacti on the upper slopes to sparsely forested formations in the lower and main portion of the valley.

3. Montana, or eastern slopes, embrace an area of dense forest, which begins at the tree line on the eastern slopes of the Andes and continues eastward into the tropical lowlands of the interior. There is encountered the richest and most luxuriant display of plant life. The lower tropical part, the montafia proper, extends up to approximately 5,500 ft., about the limit of tropical agriculture. Vegetable ivory (Phytelephas), cabinet woods, dyes, medicinal and fibre plants grow in this area. On the more elevated part of the eastern slopes, the ceja, between 5,500 and 11,000 ft. altitude, the predominant vegetation consists principally of trees and shrubs with firm, leathery, evergreen foliage, a response to the cooler climate. There occur an abundance of tree ferns, members of the heath (Ericaceae) and sunflower (Compositae) families, and such genera as barberry (Berberis), *Fuchsia, Vallea* and *Calceolaria*. In this area, likewise, abound many epiphytic flowering plants and ferns. (J. A. Sk.)

Fauna. — The fauna, too, divides naturally into that of the coast, of the high Andes and of the Amazonian lowland. There is little life on the coast except for vast numbers of sea birds, which feed in the teeming waters of the Humboldt current. The Andes are the principal home of the American cameloids, the domestic llama and alpaca and the wild vicuña. Rodents include. the rabbit-sized mountain *vizcacha* and, formerly, the chinchilla (now more abundant as an introduced form in North America than in its native region). The montane condor descends to the seacoast for carrion. The life of the tropical lowland is that of the Amazon basin in general. (See Amazon: Vegetation and Fauna.) (X.)

HISTORY

Ruins of vast edifices at Tiahuanaco just south of Lake Titicaca, at Cuzco and at Ollantaytambo appear to have been erected by sovereigns with unlimited command of labour. Of their origin nothing is known, for they are entirely unlike the later Inca structures. Settlement of the Cuzco valley by the Incas or "people of the sun" probably took place in the 13th century. They already possessed a considerable civilization, and an empire dating from the victories of Pachacutec Inca about a century prior to Huayna Cápac, the Great Inca, who died in 1526, one year before Francisco Pizarro first appeared. The consolidated empire extended from the Ancasmayo river north to Quito to the Maule in Chile. (See INCA.)

In March 1526 a contract for the conquest of Peru was signed by Pizarro, Diego de Almagro and Hernando de Luque. In 1527 Pizarro landed at Tumbes. The next year he went to Spain, and in 1531 returned to Tumbes with his brothers. The civil war between Huáscar and Atahuallpa, sons of Huayna Cápac, had been fought out in the meanwhile, and the victorious Atahuallpa was at Cajamarca, whither Pizarro with 183 men made his way. On Nov. 15, 1532, after a friendly welcome from the Inca, Pizarro treacherously seized him. In Feb. 1533 Almagro arrived with reinforcements. In spite of fulfilling an agreement to provide a vast ransom in gold and silver, the Inca Atahuallpa was murdered on Aug. 29, 1533; in November Pizarro entered Cuzco. He allowed Manco, the legitimate son of Huayna Cápac, to be solemnly crowned. Almagro then undertook an expedition to Chile, and Pizarro founded the "City of the Kings" (Lima) on Jan. 18, 1535. A dispute arose between Francisco, Juan and Gonzalo Pizarro and Almagro as to the limits of their respective jurisdictions; Almagro was defeated near Cuzco in 1538 and executed. His adherents recognized his young half-caste son, a gallant youth generally known as Almagro the Lad, as his successor. Bitterly discontented, they conspired at Lima and assassinated Francisco Pizarro on June 26, 1541. Meanwhile, Vaca de Castro had been sent out as governor by Charles V. On Sept. 16,1542, he defeated Almagro the Lad and beheaded him at Cuzco.

Civil Wars.—The "New Laws" code was enacted in 1542 whereby grants of estates (encomiendas), on which the inhabitants were bound to pay tribute and give personal service, reverted to the crown on the death of the holder. Blasco Núñez Vela was sent out in 1544 as first viceroy of Peru to enforce the New Laws. Their promulgation aroused a storm among the conquerors. Gonzalo Pizarro rebelled and entered Lima on Oct. 28, 1544. The viceroy fled to Quito, but was followed and killed in Jan. 1546. The New Laws were revoked. Pedro de la Gasca, first president of the court of justice of Peru, arrived in 1547, and in April 1548 defeated and executed Gonzalo Pizarro near Cuzco. La Gasca made a redistribution of encorniendas to the loyal conquerors, which caused great discontent, and left Peru before his scheme was made public in Jan. 1550. Don Andrés Hurtado de Mendoza, marquess of Cañete, entered Lima as viceroy on July 6, 1555, and ruled with an iron hand for six years. All leaders in former disturbances were sent to Spain. Magistrates were ordered to execute all turbulent individuals. Unemployed persons were sent on distant expeditions, The viceroy came to an agreement with Sayri Túpac, son and successor of the Inca Manco, and granted him a pension. Schools and towns were founded, wheat, vines, olives and European domestic animals introduced. From this time there was a succession of viceroys until 1824. The splendour of their entourage was unexcelled. Meanwhile, in the sierra, Indians were being exterminated in an extravaganza of destruction.

Viceroyalty.—Don Francisco de Toledo (viceroy 1569–81), fearing that the little court of the Inca Tupac Amaru might prove rebellious, beheaded the last of the Incas at Cuzco in the year 1571. Toledo's Libro de *Tasas* fixed taxes on the Indians, exempting all under 18 and over 50, and imposed, in addition to the tribute, the mita, or forced labour in mines and farms.

The Spanish authorities, although desiring to protect the people, were unable to restrain distant officials and the country was depopulated by the illegal methods of enforcing the mita. Moreover. the colonies suffered from the strict trade monopoly of Spain and from the arbitrary proceedings of the Inquisition. Between 1581 and 1776, 59 heretics were burned at Lima. and there were 29 autos-da-fé. In 1780, Tupac Amaru II. a descendant of the Incas, rose in bloody revolt. He was brutally executed the following year, and the rebellion was finally crushed in 1783.

Peru Independent.—Meanwhile the Creoles (American-born Spaniards) had long been shut out from all important official positions. Peru was still the centre of Spanish power in South America, though New Granada (Colombia) in 1740 and Rio de la Plata (Argentina) in 1776 had been created independent viceroyalties. As military strength was concentrated at Lima, the more distant provinces, Chile and Buenos Aires, were first to declare themselves independent, in 1818 and 1816. But destruction of the viceroy's power in Lima was essential to their continued independent existence. A fleet fitted out at Valparaiso, commanded by Thomas Cochrane, later 10th earl of Dundonald, convoyed the Argentine and Chilean army under command of the Argentine general, José de San Martin (*q.v.*), to the coast of Peru in Sept. 1820. San Martin was enthusiastically received, and after the viceroy had withdrawn, the independence of Peru was proclaimed at Lima (July 28, 1821). The young republic honoured San Martin by giving him the title of protector.

Though Lima was now in patriot hands, strong viceregal forces remained in the interior. To discuss united action in eliminating this last stronghold, Simón Bolivar (*q.v.*), the man who had triumphantly swept Spanish colonial power from the northern sector of South America. met with San Martin at Guayaquil. Ecuador, in July 1822. Two months later San Martin resigned his protectorate and left the country, the government falling successively to the congress, Pres. José de la Riva Agüero, and then to Bolivar. In two memorable battles, at Junin on Aug. 6, 1824, under Bolivar's command and at Ayacucho on Dec. g, 1824, under that of the Colombian general Antonio José de Sucre, the Spanish forces were decisively defeated. Spanish power in Peru (and in South America) was at an end. Upper Peru was given the name of Bolivia, in honour of the liberator, and declared an independent republic in 182 j. Bolivar ruled Peru with absolute powers until Sept. 1826.

Early Presidents.—Gen. José de la Mar, who commanded the Peruvians at Ayacucho, was elected president in Aug. 1827, but was deposed and Gen. Agustin Gamarra, chief of staff in the patriot army at Ayacucho, was elected third president in Aug. 1829. From 1829 to 1844 Peru painfully experimented with independence. The officers who fought at Ayacucho were all-powerful and settled political differences by the sword. Three men during that period are conspicuous: the generals Agustin Gamarra, Felipe Santiago Salaverry and Andrés Santa Cruz. Gamarra never accommodated himself to constitutional usages, but attached to himself many loyal and devoted friends. Born at Lima of pure Basque descent, Salaverry joined the patriot army before he was 15 and displayed audacious valour in many a hard-fought battle. Andrés Santa Cruz was an Indian, his mother a lady of high rank, and he was very proud of his descent. Unsuccessful as a general in the field, he nevertheless possessed remarkable administrative ability and for nearly three years (1836–39) realized his dream of a Peru-Bolivian confederation. But the strong-handed intervention of Chile on the ground of assistance rendered to rebels ended in the defeat and overthrow of Santa Cruz. After this, except for the administrations of Gen. Ramon Castilla (1845–51 and 1855–62), revolution succeeded revolution for the spoils of office. In 1849 regular payment of interest on the public debt was begun, steam lines were established along the Pacific coast and a railway was built from Lima to Callao. A dispute with Spain, arising from indemnity claims for injuries to Spanish subjects, precipitated actual war in 1864, when Spain suddenly seized the Chincha Islands. In the naval war which ensued, Peru received active aid from Chile and support from Ecuador and Bolivia. Actual hostilities ended with a heavy Spanish bombardment of Callao in May 1866, but a formal truce was not mdde until 1871, followed eight years later by a treaty of peace. In 1868 Col. José Balta became president. With the vast sums of money raised from guano and nitrate deposits at his disposal, he began the construction of public works. principally railways, on a gigantic scale. He was succeeded in 1872 by Manuel

Pardo, the country's first civilian president, an honest and enlightened individual who was sincerely concerned with promoting education and literature and with carrying out governmental reforms. Yet the reckless expenditures on the part of his predecessor doomed Pardo's best endeavours to failure, and the country was all but bankrupt when Gen. Mariano Prado took over the reins in 1876.

War **of the** Pacific.—Peru and Bolivia, alarmed at continued Chilean encroachments in the desert of Atacama, signed on Feb. 6, 1873, a treaty of defensive alliance. On Feb. 14, 1879, Chile, in the course of a dispute over Bolivia's right under treaty to levy an export tax on nitrates, occupied the Bolivian port of Antofagasta, and on April 5 declared war on Peru (see PACIFIC, WAR OF THE). When President Prado went abroad to secure aid, Nicolás de Piérola usurped his power and had himself elected president in 1879. Several attempts on the part of the United States to mediate in the dispute failed. Chile refused to deal with President Piérola, but sanctioned a provisional government set up in 1861 under Francisco Garcia Calderon. When the latter, however, failed to meet Chile's demands. he was exiled. The occupation of Lima by Chilean forces continued for almost three years and serious harm resulted to the city and its cultural institutions. The university was looted and the National Library destroyed. Finally, Gen. Miguel Iglesias, who favoured accepting the Chilean terms, was elected president, and on Oct. 20, 1883, a treaty of peace was signed at Ancón. Chilean soldiers, however, were not withdrawn from Peruvian territory until 1884 when the treaty was ratified. The chief conditions imposed by Chile were: unconditional cession in perpetuity of Peru's nitrate province of Tarapacá; possession for a period of ten years of the provinces of Tacna and Arica, after which time a plebiscite should decide whether the territory was to remain under Chilean rule or should revert to Peru. As Iglesias' name was linked to these harsh peace terms, his presidency was short lived and he was forced out of office in 1885.

(M.T. Bl.; K.L.L.; X.)

Peru After 1883.—Economically, politically and culturally, Peru was slow to recover from the conflict. For the remaining years until the turn of the century the presidency was occupied chiefly by military men. In the field of international affairs, the border dispute with Ecuador flared up once again, while the failure on the part of Chile to honour the agreement by holding a plebiscite in Tacna and Arica in 1894 opened old wounds in Peru's leadership and population. A final settlement of the vexing problem was not reached until 1929 when a treaty concluded with the aid of the United States assigned Tacna to Peru and Arica to Chile, imposing compensatory payments upon the latter.

Nicolás de Piérola who took power in 1895 initiated a system of reforms designed to lead the country along the road of recovery. His plans for building up the national economy included the exploration of some of the country's virtually untapped rubber and petroleum resources in the eastern jungle regions. Among the men who held the presidency during the next 25 years, most of whom ruled the country without excessive regard for democratic principles, Augusto B. Leguia should be mentioned. He started his first four years of office in 1908 with certain reforms but in 1919 revealed increasingly authoritarian methods. His attempt to serve for a third term was foiled in 1930 by a rebellion which broke out at Arequipa under Gen. Luis M. Sanchez Cerro. Elected president in Oct. 1931 Sánchez Cerro met with considerable internal opposition and frequently had to resort to emergency powers. His severest critics belonged to Apra (Alianza Popular Revolucionaria Americana), a political party and social group which advocated a pro-Indianist, anti-imperialist doctrine.

The ideological groundwork for Apra had been laid by the writer and intellectual Manuel González Prada (1844–1918) whose analysis of the causes of Peru's defeat in the disastrous War of the Pacific and its subsequent decadence led him to radical conclusions. His work was carried on by two prominent disciples: José Carlos Mariitegui, and especially Victor Raúl Haya de la Torre who. while exiled from Peru in 1923, created the Apra movement in Mexico and remained its leader. Mariátegui, a brilliant economist and historian who ideologically stood further left than Haya de la Torre, eventually parted company with his former associate and unsuccessfully challenged his leadership. Mariátegui died in 1930. Haya de la Torre proposed to achieve national reforms by uniting students and labour, "intellectual and manual" workers. He was jailed in 1932 and his party was outlawed for plotting against the government. One year later President Sánchez Cerro was assassinated, and Gen. Oscar R. Benavides was appointed by congress to complete the unfinished presidential term. In 1934 Peru returned to Colombia the Leticia Trapezium occupied by Peruvian forces in 1932 in violation of an existing treaty.

In 1936 congress, rather than face the possible electoral triumph of an Apra-backed presidential candidate, challenged the legality of the elections, entrusting Benavides with absolute powers and the mandate to continue in office. Benavides retired in 1939 and was succeeded by Manuel Prado y Ugarteche, the first civilian in a decade to fill the nation's highest post. Peru, though declaring strict neutrality at the outbreak of World War II, soon espoused the Allied cause and opposed the axis, and even the Apristas overcame their anti-U.S. bias in a reappraisal of their position prompted by world developments.

Free elections held in June 1945 returned a coalition government which was headed by José Luis Bustamante y Rivero. In this coalition, called the Democratic front, in which they held three cabinet posts, the Apristas at first wielded considerable power which reflected a substantial increase in popular support. The three Apra members relinquished their cabinet posts, however, and the party temporarily lost support when President Bustamante was overthrown in 1948 and Gen. Manuel A. Odria came to power. Once again Apra, which since 1944 had been known as the People's party, was outlawed and Haya de la Torre was forced in 1949 to seek refuge in Colombia's embassy in Lima. Peru demanded his surrender as a common criminal, while Colombia regarded him as a political refugee and therefore entitled to asylum. The matter was submitted to the International Court of Justice for arbitration. The decision of the tribunal did not clarify the issue entirely, and Haya de la Torre remained in the Colombian embassy until direct negotiations between Peru and Colombia finally resulted in his departure for Mexico at the beginning of April 1954. Odria, elected for a six-year term in 1950, at once turned his attention to economic reconstruction. and at the close of the year Peru's trading balance was active for the first time since 1946. In 1951 Peru signed the General Agreement on Tariffs and Trade. Government projects envisaged irrigation schemes and a new road-building plan, including one which would help develop the eastern slopes. In 1952 Peru banned exports of strategic materials to Russia and its satellites and in March 1953, imports from the same countries, giving as a reason for this measure an unfavourable balance of trade with the areas concerned. The five economic and cultural agreements which Odria concluded with Pres. Getúlio Vargas of Brazil and which were made public in Aug. 1953 were interpreted in many quarters as designed to counterbalance Argentina's growing hemispheric influence. Budget and trade deficits in 1954 were controlled with the aid of sizable U.S. loans from the Chase National bank, the U.S. government and the International Monetary fund. During 1954 the century-old border dispute with Ecuador, which was thought to have been settled at Rio de Janeiro in 1942, flared up once again. There were charges and countercharges; minor clashes along the common boundary and a verbal exchange at the Caracas conference, hut no lasting settlement was reached. In November Panamanian whaling vessels were impounded by Peruvian coast guards for violating the terms of an agreement between Peru. Ecuador and Chile which. while allowing each other's operations in any sector of a zoo-mi. strip from the shore. banned outsiders from it. Once more a formal protest by Ecuador in 1955 accusing Peru of aggressive designs, this time before the Council of American States, proved unfounded when investigated.

Odria. who had ruled eight years with absolute powers but who had undoubtedly benefited the country by his liberal economic policies, relaxed his political controls somewhat during his final year, authorizing free elections to be held on June 17, 1956. Women, were given the vote for the first time in the nation's history. In a three-way contest which saw Hernando de Lavalle, the candidate

supported by Odria, trailing the other t o by a wide margin, Manuel Prado y Ugarteche, president from 1939 to 1945, was again elected to the country's highest office.

POPULATION AND SOCIAL CONDITIONS

Population. — By 1953 there had been an estimated increase of more than 2,000,000 in population since the official census of 1940, which showed a total of 7,023,111 inhabitants. Ten years later, on Dec. 31, 1950, this figure had risen to 8,605,549, reaching at the end of 1953 a total of 9,125,750. In considering these figures it must be borne in mind, of course, that the number of persons covered by actual census methods was approximately 10% lower and that the balance was computed from census omissions and the inhabitants of the eastern jungle regions. In 1940, for instance, inhabitants counted by census were 6,207,967, while census omissions amounted to 465,144 and the jungle population was calculated at 350,000. Most of the country's economic life is concentrated along the coast where the most densely populated areas are located and where slightly more than one-third of the country's population can be found. According to ethnic origin, roughly 46% of Peru's population is of pure Indian stock, 53% is either white or mestizo, while the dark and yellow races (the latter chiefly Chinese and Japanese) contribute about 1%.

Several million Indians of Quechua stock, constituting by far the majority of Peru's Indian population, live in the highlands, while roughly 500,000 of the Aymara group live in an area of which Lake Titicaca is the centre, and a few hundred thousand of a more primitive tribe inhabit the eastern zone.

In contrast with the Indians of Mexico who share actively and prominently in national affairs, the Peruvian sierra Indian leads a relatively isolated existence perpetuating his languages, customs and rituals. Some cultivate their own land, while others work as labourers. The village has retained its traditional closely knit character and, though individual ownership of the soil has become the rule, the community will collectively defend its interests in case of emergency. The Indians build their own homes, usually plain adobe huts with thatched roofs, and make their clothing out of rough homespun for which chiefly sheep and llama wools are utilized. Mainly such traditional subsistence plants as potatoes, quinua and oca are groan by time-honoured methods of agriculture. Native languages and rituals still play important roles, though bilingualism is on the increase and Catholicism has long been accepted as the official religion.

Between 10% and 15% of the population is white, chiefly of Spanish stock. These share with the mestizo element the control of Peru's political and economic fortunes. Slaves brought in under colonial rule account largely for the small number of Negroes found today exclusively in the coastal zone. Chinese immigration received its strongest impetus by the arrival of labourers who reached Peru between 1849 and 1874, whereas Japanese colonies are a 20th-century phenomenon. Germans, Italians, Spaniards, British and North Americans have enriched the national mosaic.

Cities. — Table I shows departments and capital cities, along with their population figures according to the census of 1940 and the official estimates for Dec. 31, 1953.

Unlike Mexico City, Bogotb (Colombia), and other capitals established on the sites of old Indian strongholds, Lima was chosen by the Spaniards to be Peru's capital city rather than Cuzco, the ancient centre of the Inca empire, located in the Andes. The founding of Lima shortly after the feast of the Epiphany gave it its alternate name, "City of the Kings."

Lima and its seaport of Callao are the two most important centres. Official estimates at the end of 1953 placed their respective population figures at 964,800 and 108,600. The country's population is densest in this area, which is regarded as the political, economic and cultural hub of the nation. Lima and Callao were the only departments to increase their populations by more than 50% during the period covered by Table I; other increases as a rule did not go beyond 25%. Third comes Arequipa (103,422), distributing centre for southern Peru, followed by Cuzco (59 918), victim of a violent earthquake in 1950 which damaged four-fifths of the city. Trujillo (50,930), Chiclayo (43,000) and Piura (26,400) in the northern sector of the coastal zone figure prominently in the country's agriculture, chiefly as producers of Peru's main export crops, cotton and sugar.

Iquitos (45,200), important Amazon river port and trading point, stands out in the tropical jungle of eastern Peru. Grouped in a crescent around the departments of Lima and Callao are Ica, Huancavelica, Huancayo. Cerro de Pasco, Hubnuco and Huaraz,

TABLE I.—*Population of Peru by* Departments

Department	Capital	Census 1940, adjusted	Population est., end of 1953
Amazonas	Chachapoyas	89,560	112,754
Ancash	Huaraz	465,135	582,366
Apurimac	Abancay	280,213	350,836
Arequipa	Arequipa	270,996	339,206
Ayacucho	Ayacucho	414,208	519,225
Cajamarca	Cajamarca	568,118	712,139
Callao	Callao	84,438	128,987
Cuzco	Cuzco	565,458	708,701
Huancavelica	Huancavelica	265,557	332,486
Huánuco	Huánuco	276,833	347,335
Ica	Ica	144,547	180,978
Junín	Huancayo	500,161*	480,418
La Libertad	Trujillo	404,024	505,852
Lambayeque	Chiclayo	199,660	249,982
Lima	Lima	849,171	1,362,100
Loreto	Iquitos	321,341	406,485
Madre de Dios	Puerto Maldonado	25,212	32,189
Moquegua	Moquegua	35,709	44,708
Pasco	Cerro de Pasco	*	147,046
Piura	Piura	431,487	540,237
Puno	Puno	646,385	809,509
San Martin	Moyobambs	120,913	152,010
Tacna	Tacna	37,512	46,966
Tumbes	Tumbes	26,473	33,145
		7,023,111	9,125,750

*The figure quoted for Junfn included, at the time of the 1940 census, the population of Pasco which was then one of Junín's provinces. The Departamento de Pasco was established on Nov. 27, 1944.

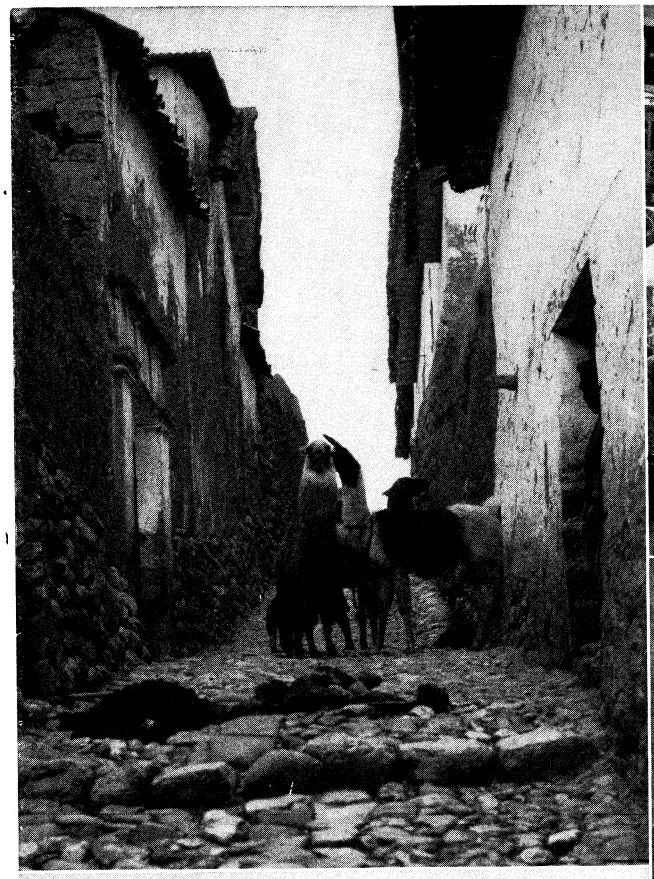
guarding the land approaches to the capital. Structurally and architecturally Peruvian cities have largely preserved their colonial flavour. A central plaza contains public and religious buildings, streets follow a rectangular arrangement and most houses adhere to a colonial style with central patios, tile roofs and wrought-iron grills and balconies.

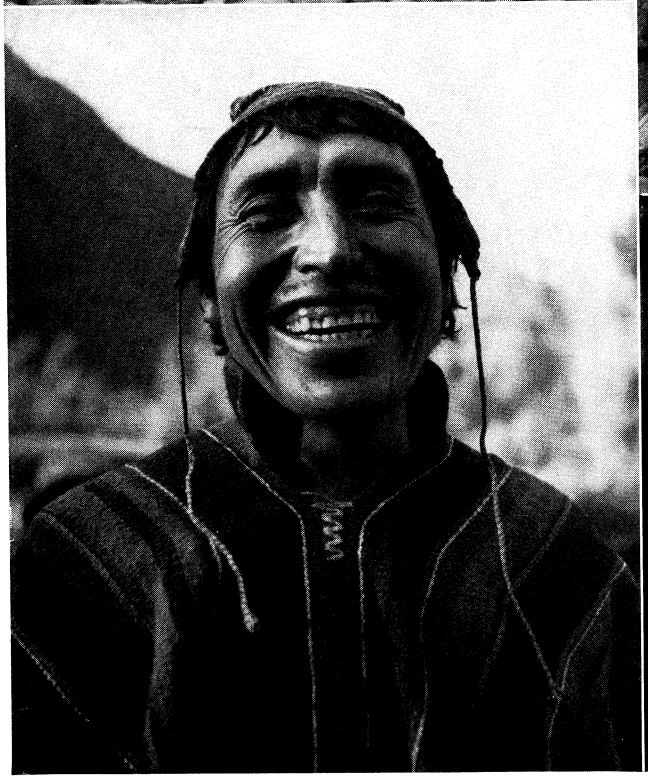
Public Health and Social Welfare. — The five years between 1948 and 1953 witnessed an over-all reduction in infectious disease by almost 30%. Approximately an equal number of cases of tuberculosis and malaria (more than 17,000 each) were reported in 1953, whereas the toll taken by whooping cough was said to have been slightly lower and outbreaks of dysentery, syphilis, typhoid and paratyphoid were substantially controlled.

To combat disease and look after the sick, the country had, in 1928, 45 hospitals, all of them charity hospitals. In 1953 there were 120 hospitals, public as well as charity, and private clinics, in addition to a growing number of antitubercular and antivenereal dispensaries, and to dental and first-aid stations. Social security and social insurance schemes aided the individual in meeting the cost of sickness, childbirth and disability and in protecting him against the hazards of old age. There were homes for orphans, the aged and the blind. Conscious of the close link between housing and national health, the government, helped by inter-American and Pan-American agencies, was undertaking extensive housing developments. The national budget for 1953 set aside slightly less than $4,500,000 for expenditures in health and social welfare, indicating a reduction of over $500,000 from the 1951 budget. Peru's birth rate was 33.5 per 1,000 persons on June 30, 1953, and the death rate was 11.3 per 1,000.

EDUCATION AND CULTURAL CONDITIONS

Education. — The budget for 1953 assigned almost $18,000,000 to national education. Standing fourth in the order of expenditures, its budgetary allotment was slightly below that of national defense. Primary education is free and obligatory for children from 6 to 14. In 1953 there were 11,769 elementary schools with 27.361 teachers and 1,046,836 pupils; and 318 secondary schools with 5,786 teachers and 83,344 pupils. While about 88% of all primary schools are public, almost two-thirds of the secondary ones are operated by private institutions, frequently with religious affiliation, or maintained by colonies of foreign residents. Trade





PHOTOGRAPHS (TOP LEFT) KURT SEVERIN FROM BLACK STAR, (TOP RIGHT, CENTRE RIGHT. BOTTOM RIGHT) PHILIP GENDREAU, (BOTTOM LEFT) MARY SCHLIVEK—PIX FROM PUBLIX

SCENES IN PERU

Top left: Llamas in a narrow, cobbled street of Cuzco
Top right: A street of Lima
Centre right: Indian market, Lima
Bottom left: Quechua Indian *of* the Sierra in traditional costume
Bottom right: Patio of San Marcos university, Lima, one *of* the oldest educational institutions in the western hemisphere

schools, emphasizing agricultural, industrial or commercial subjects, numbered 167 in 1953, with a teaching staff of 2,545 and 23,239 students. Next to Mexico, Lima became the earliest centre of Spanish power in America. The University of San Marcos was founded at Lima in 1551 and the first printing press was set up in that city in 1584, about half a century after it had been introduced into Mexico and half a century before it was to appear in the regions north of the Rio Grande. In addition to the National University of San Marcos, which reported an enrolment of 8,176 in 1953, there are three small national universities at Trujillo, Arequipa and Cuzco (in order of student enrolment) and a Pontifical university at Lima. The total university enrolment for 1953 was given as 12,805.

Literature and the Arts.—Peru's earliest literary documents relate to the colourful details of its conquest recorded in chronicle form by some of Pizarro's associates, such as Pedro Cieza de Léon and Francisco de Jérez. The first native-born chronicler, and one of the most renowned, was Garcilaso de la Vega (*q.v.*), known as "el Inca" (1539–1616), son of a Spanish conqueror and an Inca princess, thus fusing two races and two cultural traditions. His *Comentarios reales,* published in 1609 and 1617 (Eng. trans. of part I by Sir Clements R. Markham, 2 vol., London, 1869–71), are an indispensable reference work for the history as well as the cultural and social institutions of the Inca empire. The 17th and 18th centuries were somewhat static culturally in Lima, with strict censorship impeding importation of foreign books and all but stifling genuine literary expression at home. The elegant, somewhat laboured prose of Juan de Espinosa Medrano, "el lunarejo," the picaresque poetry of Juan del Valle y Caviedes and the learned products of the scholar and linguist Pedro de Peralta y Barnuevo illustrate some of the literary activity of this period. The publication in 1773 of a prose work, *Lazarillo de ciegos caminantes,* marked the timid beginnings of the novel, while the discovery, in 1781, of *Ollantay,* a play in Quechua dealing with an Inca subject, posed the question of its true date of origin.

In the wake of romanticism. Ricardo Palma (1833–1919), one of Peru's most renowned names. created a new literary genre in his delightful *Tradiciones peruanas,* in which he examined the country's colourful past, combining, in a light style, a sprinkling of historical truth with a dash of gossipy fiction.

The disastrous War of the Pacific turned Manuel González Prada, scion of a traditional Lima family, into a radical champion of political, social, aesthetic and orthographic reform. Of those who followed his reforms, mention should be made of José Santos Chocano (1875–1934), the poet who, in revealing America's tropical landscape in *Alma América,* proposed to share the hemisphere poetically with Walt Whitman, and Enrique López Albujar whose *Cuentos andinos* assured his fame as a prose writer. The generation born after the War of the Pacific included Francisco Garcia Calderón, essayist, José de la Riva Agiiero, historian, Victor Andrés Belaunde, student of international affairs, Ventura Garcia Calderón, the gifted short-story writer, and the sensitive poet José Gálvez. A reaction against Chocano is found in the poetry of José Maria Eguren, complex, introspective and divorced from life, often regarded as marking the beginning of Peru's modern verse. Subsequent writers revealed an intermingling of aesthetic and social objectives. Such poets as Alberto Hidalgo and particularly César A. Vallejo combined poetic sensitivity and elegiac melancholy with a keen social awareness; prose writers such as the essayist José Carlos Mariátegui, the literary critic Luis Alberto Sánchez and the historian Jorge Basadre showed, in addition to painstaking research in their respective fields, the same passionate concern with social reform. It was no longer the picturesque and colourful but primarily the social aspect of the Indian which inspired Vallejo and César Falcón in writing such novels as El *Tungsteno* and *Pueblo sin Dios,* violent protests against white exploitation, in the vein of the *Indianista* novel *Aves sin nido* (1889) by Clorinda Matto de Turner. Social protest became the keynote of the works by modern writers. Among these. Ciro Alegría (b. 1909) stood out; his novels. one of mhich, El *mundo es ancho y ajeno* (Eng. trans. by H. de Onís, *Broad and Alien is the World;* New York, 1941; London, 1942), received a literary prize in 1941, combine the quest for social justice with a high degree of artistic accomplishment.

There is a deeply ingrained popular tradition in Peruvian music and dance and a variety of rhythms, folk tunes and native instruments are used to celebrate religious festivals or to commemorate historical or political events. Such modern composers as Carlos Sánchez Málaga and Roberto Carpio, in reviving and adapting the anonymous folk material to the resources of modern harmony, are paying tribute to their native land and its cultural pattern.

As in literature and music, an emphasis on genuinely native subject material prevails in modern Peruvian art. While the foremost name is José Sabogal, whose canvases convey the essential spirit of his country and capture its peculiar charm, the art of Camilo Blas and Julia Codesido reflect the same deep and sympathetic insight into the region and its people.

Religion.––While Roman Catholicism is the official faith and its instruction is compulsory in the state schools, other religions are constitutionally sanctioned. The government makes all ecclesiastical appointments, subject to the Vatican's approval. and pays the church salaries. The bishopric of Cuzco was established in 1537, the see of Lima in 1541. In 1953 there were four ecclesiastical provinces, four vicarages and two prefectures in Peru. Each one of the provinces (Lima, Cuzco, Arequipa and Trujillo) comprised one archdiocese and from one to five dioceses. A total of 4,012 Catholic churches and chapels and 308 convents, monasteries and religious dwellings were counted throughout the country. Among the sierra Indians a blending of Catholic practices and native ritual is not infrequent.

ECONOMIC CONDITIONS

Transportation and Communication.— The country's railway network is made up of a number of relatively short lines mhich link inland mining and industrial centres with coastal points. The total mileage in 1953 was approximately 2,610, almost one-half of which (1,259) was controlled by the Peruvian corporation, owner of the two main systems, Central and Southern railways, while 586 were government operated and 765 belonged to smaller private interests. Peru's rail system, begun in 1851, received a powerful impetus 25 years later'with the completion of the Central and Southern railways project under the direction of the U.S. engineer, Henry Meiggs. Both railways are of a standard gauge, and the Central line is said to be the world's highest railway to operate on such a gauge. The Central provides the northern route between the mining country and the coast, while the Southern line not only connects the Cuzco area with southern ports, but extends to the shores of Lake Titicaca, opening up an increased flow of traffic to Peru's southeastern neighbour Bolivia. Negotiations to substitute a rail service for the steamers which have been operating between Puno and the Bolivian port of Guaqui were begun in 1955. Freight carried on Peruvian railways in 1953 amounted to 4,308,809 metric tons, an increase of almost 775,000 tons since 1949, while the passenger traffic of 5,439,201 for 1953 was 350,000 lower than that recorded in 1949.

Good highways play a vital role in a country like Peru, the rail system of which is not equal to the exacting demands made by the rugged terrain. At the end of 1953 more than 15,000 mi. of roads were available for satisfactory use by automobiles, with additional stretches under construction. More than 10% were asphalt roads (1,684 mi.), not quite 6,300 mi, hard-surface roads and the remaining 7,200 mi. were earth roads of less durable calibre. Of central importance in the country's road system is the Peruvian sector of the Pan American highway which supplies a territory not covered by rail service. Following the Pacific coast line it runs for more than 1,900 mi. from Tumbes on the Ecuadorean border to Tacna on the frontier with Chile, linking Lima en route to such coastal points as Piura, Chiclayo and Trujillo in the north and Ica. Nazca and Moquegua in the south.

From this chief north-south artery, a constantly growing number of roads issue in a general easterly direction to facilitate communications between the mining and agricultural areas and the coast. One such road joins Lima to Pucallpa, and connects by river launch with the Amazonian port of Iquitos. Another im-

portant highway goes to Puno on Lake Titicaca, via Arequipa. and still others are between Nazca and Abancay, and between Cajamarca and Chachapoyas. The maintenance and improvement of existing roads and the construction of new ones have an important place in the national budget and foreign loans are utilized for those purposes. In Aug. 1955, $5,000,000 was received from the International bank for highway maintenance. The virtual doubling in the number of motor vehicles counted during 1953 (91.989) as compared with the figure for 1949 (46,225) partially accounted for the aforementioned drop in railway passenger traffic, and reflected the continuous improvement in Peru's road conditions.

In 1953 a total of 10,477 steamships with a registered tonnage of 13,465,185 entered Peruvian ports. Of these vessels 7,185 accounted for 2,044,801 registered tons and flew the Peruvian flag, while 3,292 (11,420,384 registered tons) were of foreign origin: U.S. 840; Denmark 390; Norway 371; Great Britain 356; Chile 202; and Germany 181. In 1953 Peru's merchant marine had 15 steamships, of 20,002 registered tons.

The country's chief port is Callao; modernized with the aid of an International bank loan in 1951, its dock facilities handle 75% of Peru's imports and 20% of its exports. Other ports of note include Chimbote, a splendid natural harbour and particularly important in connection with the Santa valley project, the oil port of Talara near the northern tip and Matarani-Mollendo, the most convenient gateway to southern Peru. Among the smaller ports are Paita. Salaverry and Pisco.

Foreign telegraph and cable services are furnished by the West Coast of America Telegraph Co., Ltd., and All America Cables and Radio, Inc. The latter also gives international radiotelephone service. The government operates a domestic telegraph network. Three companies, controlled respectively by U.S., British and Swedish interests, share in the public telephone service for differerent areas. In 1952 there were 58 broadcasting stations functioning throughout the country, as compared with 8 in 1937.

Air Lines.—The Faucett Aviation company is Peru's foremost domestic air line. In 1953 it made 7,902 flights, covered 2,432,279 mi., served 127,115 passengers and carried almost 341 tons of mail and more than 9,839 tons of freight. Two smaller companies, the Mercantil Air Co. (Camsa) and Peruvian Air Transports (Tapsa), serve the eastern regions, while Army Air Transports (Tam) is operated by the Peruvian air force to fill in commercial service gaps on certain routes.

Among the international air lines which link Peru to outside points are Pan American-Grace Airways (Panagra) and Braniff Airways, as well as a number of others with less regular services. Peruvian air lines operate exclusively inside the country. The establishment of the Peruvian Corporation on Airports and Commercial Aviation (Corpac) in 1946 by the government, to improve existing facilities in addition to opening up new ones, marked a milestone in the history of Peru's civil aviation. Limatambo's modern airport terminal, one of Corpac's prize projects, is generally regarded as the finest of its kind in South America.

Commerce. — Peru's chief exports consist of agricultural commodities, petroleum and other minerals; its imports are chiefly capital goods, equipment for transportation and consumers' goods. Exports in 1953 accounted for a total value of 3,752,227,000 soles, constituting a 30% increase over the figures for 1950 (2,886,761,000 soles). During the same period, the value of its imports jumped from 2,867,427,000 to 4,945,247,000 soles. Despite a steady increase in the volume of foreign trade the balance was continually unfavourable from 1947, except for 1950, when exports exceeded imports by almost 20,000,000 soles. In evaluating the widening gap between exports and imports it must be borne in mind, of course, that some of the latter, such as surplus foodstuffs and machinery, are linked to U.S.-financed loans which tend to lessen the immediate strain on foreign exchange reserves. Table II shows Peru's foreign trade picture from 1951 to 1953 quoted in millions of soles.

World War II brought Latin America increasingly into Peru's trading picture at the expense of the European countries. In 1953, while supplying about 6% of Peruvian imports, South and Central America took roughly 25% of that country's exports, which was

TABLE 11.—*Trade of* ***Peru*** *From 1951 to 1953*
(in 000,000 soles)

Exports				Imports			
Market	Value			Supplier	Value		
	1951	1952	1953		1951	1952	1953
United States	890	1,031	1,429	United States	2,378	2,511	2,697
Chile	289	650	509	Great Britain	413	407	424
Great Britain	912	304	330	Canada	86	299	333
Japan	117	118	199	Germany	226	256	307
Belgium	326	219	164	Argentina	173	137	196
Germany	109	86	163	Switzerland	88	81	114
France	131	326	152	Belgium	102	65	112
Colombia	83	80	126	Netherlands	66	82	92
Argentina	212	166	112	Sweden	82	69	81
Bolivia	121	109	97	India	65	110	80
Netherlands	140	93	93	Chile	54	82	75
Uruguay	106	92	72	France	85	55	70
Ecuador	23	33	43	Japan	21	32	69
Others	353	379	243	Others	343	287	295
Total	3,812	3,686	3,752	Total	4,242	4,473	4,945

just slightly less than all the European countries. including Britain, combined. More than half of Peru's import needs were met by the U.S. which received more than one-third of its exports. In order of value, Peru's foremost export commodities roughly ranked as follows in 1953: metallic minerals led the list with 33% (see below on mining for details), closely followed by cotton with 32%. Sugar stood third with 18%, petroleum and its derivatives contributed 6%, silver and gold 5%, wool 4% and fish 2%. While sugar exports showed an upward trend in 1953, cotton lost some ground. Lead and copper exports rose considerably over the preceding year, and the development and exploitation of rich iron-ore deposits helped to expand the nation's mineral potential. Peru's chief imports in 1953 included machinery and motor vehicles (40%), foodstuffs, drinks and tobacco (15%), metal manufactures (13%), textiles (8%), chemical and pharmaceutical products (7%) and paper, fats, rubber and hides.

Agriculture. — Agriculture is the backbone of Peru's economy, providing a livelihood for over half its "economically active" population. In 1953 the total area under cultivation measured 1,717,160 ha.. surpassing by about 20,000 the figure recorded for 1952. Nonetheless, some foodstuffs had to be imported in order to offset the insufficiencies in domestic food production which the rise in the birth rate made acute. Cotton and sugar led the export list and the reforms in agricultural methods were reflected chiefly in these two commodities. Cotton, in 1953, covered an area of 204,992 ha., which yielded a crop of 256,458 metric tons. Among its three foremost varieties, 80% was Tangüis, grown in the central valleys around Lima, while the remaining 20%, Pima and Karnak, originated in northern Peru. The second big export product, sugar, is grown chiefly north of Lima in the coastal valleys near Trujillo and Chiclayo. The area under cultivation in 1953 was 55,041 ha., and the total sugar output, 626,373 metric tons. In addition to cotton and sugar, the irrigated coastal area yields rice, which has long been a favourite staple food among the population and is also exported. The rugged sierra produces wheat, corn, barley, oats, potatoes and alfalfa, while in the eastern montaña region relatively small quantities of sugar, tobacco, coffee, cocoa and bananas are grown. Rubber occurs in the Amazon basin. Peru's total agricultural output in 1953 was valued officially at 6,896,389,023 soles, approximately 18% for cotton, 18% for potatoes, 14% for vegetables, 13% for sugar, 7.5% for fruit and the balance in minor items such as maize, rice, wheat, barley, coffee, etc. The coca leaf, which has found wide acceptance among the sierra Indians because of its effect as a stimulant, is grown chiefly in the east.

Economic aid is extended to needy farmers by the Farm and Livestock Development bank, a government agency. Further help and expert counsel are available from the Cooperative Interamerican Service for Food Production (S.C.I.P.A.), a joint organization set up by the U.S. and Peru in 1943 for the purpose of furthering food production through modern agricultural machinery and, in general, improved farming methods.

Guano and Fishing. — The great fertilizer which stimulates the country's cotton and sugar growth is guano, deposited by aquatic birds on Peru's offshore islands and collected under a government monopoly by the Compania Administradora del Guano. The chief

producers are the cormorants that feed on anchovies from the Humboldt current. The year 1953 witnessed an all-time high in the extraction of guano, 260,797 metric tons. The commodity is not used for export any longer. as domestic needs absorb the existing supplies almost completely.

The Humboldt current supplies the country with foodstuffs that are inexpensive for domestic use and valuable for the export market. The total catch of fish in 1953 was 111,731 metric tons. a threefold increase in the annual output over 1948. Bonito, tuna and swordfish are among the principal varieties found. Fish and fish products contributed 2% to Peru's list of exports in 1953. The U.S. is by far the most important market and absorbs more than two-thirds of Peru's exports of fish.

Animal Husbandry. — Most of the country's stock raising is carried on in the sierras. The regions around Lake Titicaca and Cuzco are noted for their sheep, while cattle breeding takes place in different parts of the sierra, and alpacas and llamas are raised at higher altitudes. Wool figures as one of the country's minor export articles. In 1953 alpaca and sheep wool together accounted for close to 5,400,000 kg., valued at about 138,000,000 soles. Official estimates in 1953 gave the following livestock figures: sheep 16,189,700; cattle 3,412,500; llamas, alpacas and hybrids 3,388,300; goats 2,282,700; hogs 1,346,000; horses, mules and donkeys 1,089,600. The country's meat production is inadequate for domestic consumption and large quantities of frozen beef have been imported, mainly from Argentina. The government endeavours to achieve self-sufficiency by offering economic aid and technical advice through the Farm and Livestock Development bank.

Mining.—Second to agriculture in Peru's national economy, mining contributed close to 40% of the value of exports in 1953. A new mining code enacted in 1951 gave fresh incentive to outside capital and resulted in a substantial increase in production. Examination of the 1948 and 1953 statistics for Peru's leading metallic minerals, zinc, lead and copper, shows that the production of the first two increased by roughly 150%, while the copper output almost doubled during the five-year period. The Cerro de Pasco region in the central Andes constitutes the focal point for the nation's mining activities, the Cerro de Pasco corporation being the country's chief producer of zinc, lead, copper, silver and gold. There are substantial vanadium and bismuth deposits, in addition to antimony. tungsten and molybdenum. Deposits of manganese have been discovered in the southern department of Puno, but communication problems complicated their exploitation in the mid-1950s. Both gold and silver of great value for the country's export market are either extracted independently or as by-products from the mining of other metallic minerals, such as zinc, lead and copper. Peru stands fourth among the silver-producing nations of the world.

Coal is mined in Lima, Junin, Pasco, Ancash and La Libertad and preliminary figures covering the 1953 production of bituminous coal and anthracite gave a total of more than 210,000 metric tons. Ancash anthracite accounts for one-third of this figure and a value of close to 16,000,000 soles. The exploitation of rich iron-ore deposits near Marcona in southern Peru got under way in 1953 and preliminary figures for the first year of operation showed an estimated output of 853,500 metric tons valued at roughly 225,000,000 soles. Table III records the rise in the production of leading metals between the years 1948 and 1953 showing the widening gap between zinc and lead on one hand and copper on the other.

TABLE III.—*Production of Peru's Leading Metals*

Metal	1948	1951	1952	1953
Gold, g.	3,457,534	4,922,748	4,072,801	4,261,593
Silver, kg.	288,911	540,552	571,873	611,205
Zinc, metric tons.	58,842	101,300	127,845	139,102
Lead, metric tons	48,538	82,350	95,773	114,508
Copper, metric tons	18,069	32,304	30,448	35,401
Iron, metric tons.	...	...	...	853,553

Petroleum. — Though potentially rich oil fields are suspected in various parts of the country and chiefly in the Puno region. as well as in the montaña sector, actual exploitation is almost exclusively limited to the northern coast. Nearly 16,000,000 bbl. of crude oil were produced in 1953 (a drop of 400,000 since 1952), approximately 70% of which was by the International Petroleum company (affiliated with Standard Oil of New Jersey). less than 30% by the Lobitos company and about ½% by the government-controlled Compania Petrolera Fiscal and the Ganso Azul company. The last mentioned is the only company to operate in the Amazonian region. A constant rise in domestic consumption was responsible for a marked drop in petroleum exports of about one-third after 1949. Legislation passed in March 1952 was designed to attract foreign capital to assist in opening up the country's untapped oil wealth and operations began around Talara and in the montaña.

Manufacturing. — Textiles dominate the industrial scene by a wide margin. pointing to the country's foremost raw materials, as an ever-growing number of cotton, woollen and rayon fabrics come from domestic looms. Mineral refining establishments likewise play a large part, reflecting another important item on Peru's list of raw materials. Other industries which steadily gain in volume and importance include leather and leather goods, hollow ware, paper and paper products, chemicals and pharmaceuticals, as well as fish and meat canneries. flour mills, furniture, tire, soap and paint factories. The operation of sugar mills provides a by-product, bagasse, which is utilized to make paper. The numerous construction projects in progress during the 1950s placed the manufacture of cement and building materials high on the industrial list. The Compania Peruana de Cemento Portland is the principal, and the oldest, company engaged in the manufacture of cement, but other companies have been established to supply the growing market. Much of the timber needed for the making of furniture, chiefly cedar and mahogany, is derived from the jungles, east of the Andes and moved by way of the Amazonian river port of Iquitos. Manufacturing is concentrated mainly around Lima, Callao and Arequipa, though industries have been developing also in Trujillo and Chiclayo. Altogether, industrial expansion is bound to be gradual because of the limited home market and the keen competition from imports but the Industrial bank promotes local industry by offering long-term loans at low interest rates.

Foreign Investment. — Foreign direct investments in the mid-1950s were estimated at approximately $400,000,000. U.S. companies accounted for roughly 75% of this total. Mining and petroleum constituted by far the largest investment areas, and manufacturing, agriculture, trade and transportation followed far behind. More than half of the British holdings, which amounted to approximately 17% of the total, were in the field of transportation, while minor interests were found in petroleum, manufacturing, trade and finance and agriculture. Italian investments were in transportation, trade and finance and manufacturing, while Japanese holdings were mainly concerned with cotton growing. French interests were co-operating in the development of the Santa valley and the setting up of an iron and steel industry at Chimbote. As a result of President Odria's economic policies in eliminating trade controls and freeing the exchange rate, foreign investment experienced a boom and the development of natural resources advanced notably.

GOVERNMENT; DEFENSE; FINANCE

Government. — The country's chief executive is its president who holds office for six years, but cannot be re-elected immediately. Two vice- residents and a cabinet of 12 assist him in his duties. The legislative authority belongs to congress which is composed of 54 senators and 156 deputies. In accordance with the constitution of 1933 and its subsequent amendments, presidential elections are held every six years when direct popular vote determines the country's government. It is the president's privilege to select his cabinet and to provide congress with panels of names which are to guide members of the legislature in-appointing justices for supreme court duty and in filling high church positions, in the last case, subject to Vatican approval. Voting, hitherto compulsory for all literate male citizens between 21 and 60, was extended during the presidential elections in 1956 to include women for the first time.

Senators and deputies are elected also by popular vote, the

former in the departments, the latter in the provinces. In 1945 the senate was increased from 48 to 54 members; the number of deputies from 140 to 156. Congress sits for four months each year and its deliberations are translated into action by 12 ministries: interior (which includes police, postal and telephone service), foreign affairs, justice and worship, public education, finance and commerce, war, navy, aviation, development and public works, public health and social welfare, agriculture, labour and Indian affairs.

Army, Navy and Air Force.—Military conscription is the law of the land and, in theory, every male Peruvian citizen is obliged to serve 2 years in the active army, 10 years in the reserve army and 20 years in the national guard. The draft, however, is not usually enforced, and the active army numbers approximately 30,000 men, consisting in the main of volunteers. Army, navy and air force are U.S.-trained and. following World War II. their equipment underwent a substantial expansion and modernization, chiefly through purchases from the U S. and Britain. The president is the supreme commander of the nation's armed forces. exercising his authority through the secretaries of war, navy and aviation.

The three branches of the armed services figured in the 1953 budget with record expenditures, as 392,861,000 soles (or 16% of the total) applied to the army, 92,458,000 soles (almost 4%) to the navy and 116,749,000 soles (nearly 5%) to the air force.

Finance.--Whereas from 1949 to 1952 there were annual budget surpluses (the 1952 surplus was 8,750.964 soles), rising expenditures reversed the trend in 1953 and produced a deficit of 286,300,000 soles. Direct taxation increased steadily until in 1953 it made up 34% of the total taxes, while import and export duties accounted for the balance. Fiscal expenditures for 1953 amounted to 2,446,232,184 soles, and the most important government departments contributed roughly the following percentages: finance and commerce 21%; interior 17%; war 16%; education 15%; development and public works 7.6%; public health and social welfare 3 6%.

The total public debt (external, internal, floating and short term) at the end of 1953 was 1,859,194,890 soles, which constituted a rise of more than 250,000,000 soles over the 1952 figure. The total money supply, which at the end of 1952 had been approximately 3,200,000,000 soles, reached close to 3,800,000,000 soles by the end of 1954.

A debt readjustment plan submitted by the Peruvian government to the U.S. Foreign Bondholders Protective council was accepted by that body, and a similar settlement was reached with the British Council of Foreign Bondholders.

Currency.—The monetary unit of Peru is the sol. The official par value, which had been 6.5 soles per $1, was suspended in Nov. 1949, and a system which provided for two separate and fluctuating rates of exchange was established. These two free exchange rates were the certificate rate, which applied to exchange certificates resulting from the sale of export earnings to the Central bank, and the draft rate. During the first half of 1959 the average rate was 27.14 soles to the U.S. dollar.

The Banco Central de Reservas functioned as the central bank of Peru after the 1920s when it was set up with the standard functions of a central bank. It had the customary credit control powers, the note issue privilege and served as financial agent for the government. The rediscount rate of the central bank was set at 6% in 1947.

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PERUGIA (anc. *Perusia*), a city and archiepiscopal see of Italy, the capital of the province of Perugia in Umbria situated 1,444 ft. above sea level. Pop. (1951) 40,039. The town is finely situated upon a group of hills nearly 1,000 ft. above the valley of the Tiber. Its outline is very irregular; from the centre of the town, at the junction of several ridges. parts of it extend for a considerable distance along their summits, being divided from one another by deep valleys. This is the extent enclosed by the mediaeval walls; within them are considerable remains of the lofty terrace malls of the Etruscan period. The so-called Arco di Augusto is a town gate with a Decorated superstructure of the Etruscan period, bearing the later inscription *Augusta Perusia;* above this again is a Renaissance loggia. Five other gates of the Etruscan period can still be traced.

The citadel was erected by Pope Paul III in 1540–46, after the plans of Antonio da Sangallo the younger, and demolished in 1860. On one side of the Piazza del Duomo stands the cathedral of San Lorenzo, a Gothic structure of the 14th and 15th centuries, in the plan of a Latin cross; on the other the Palazzo Comunale with two fine Gothic façades (1297, completed in 1429–43), with the figures of the Perugian griffin and the Guelph lion above the outside stair; and in the centre the marble fountain constructed in 1277–80 by Arnolfo di Cambio, and adorned with statues and statuettes by Niccolo and Giovanni Pisano. In the Palazzo Comunale is the Pinacoteca Vannucci, with an important collection of Umbrian pictures, of ceramics, and illuminated mss. On the decoration of the Sala del Cambio, close by, Perugino put forth the full force of his genius. San Domenico, a Gothic edifice originally designed by Giovanni Pisano but rebuilt in 1614, contains the monument of Pope Benedict XI, and in its east front a large Gothic window with 15th century stained glass. San Pietro de' Cassinensi (outside the Porta Romana) is a basilica with nave and aisles, founded at the end of the 10th century, remarkable for its conspicuous campanile, its ancient granite and marble columns, its walnut stallwork of 1535 by Stefano de' Zambelli da Bergamo and its numerous pictures (by Perugino, etc.). The oratory of S. Bernardino has an early Renaissance polychrome façade, richly sculptured, of 1457–61, by Agostino d'Antonio di Duccio of Florence. S. Severo contains Raphael's first independent fresco (1505). The circular church of S. Angelo, with antique columns in the interior, probably dates from the 5th century. The university dates from 1307, and has faculties of law, science and medicine; it had 499 students in 1938–39. It contains an important museum of Etruscan and Roman antiquities. Three miles to the S.S E., lay the Etruscan necropolis. The large tomb of the Volumni (2nd century B.C.) hewn in the rock, with its carved cinerary urns, is interesting. (*See* E. Galli, *Il Museo Funerario del Palazzone all' Ipogeo dei Volunni*, 1921.)

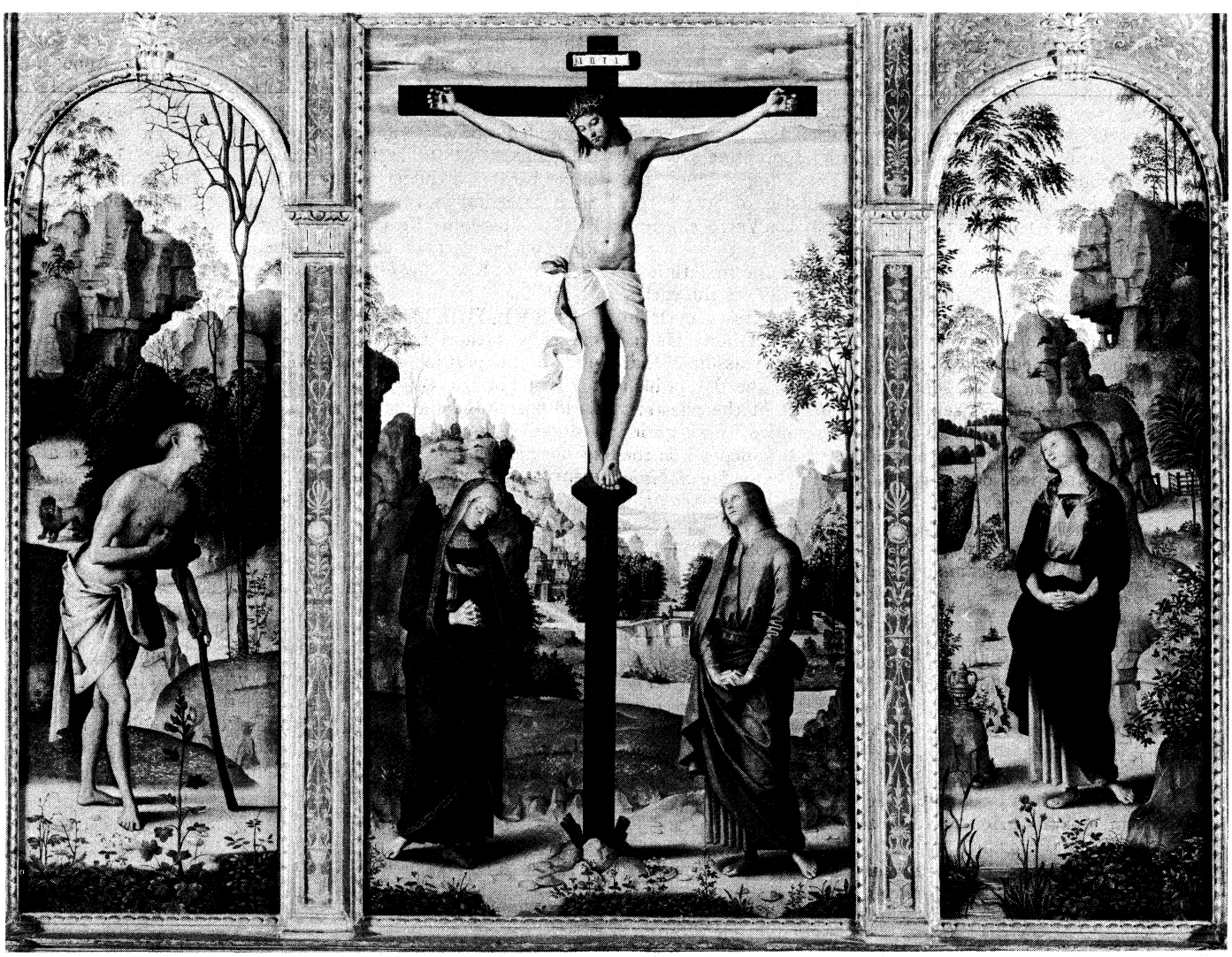
The ancient Perusia first appears in history as one of the 12 confederate cities of Etruria. It took an important part in the rebellion of 295 B.C. and was reduced, with Vulsinii and Arretium, to seek for peace in 294. In 216 and 205 it assisted Rome in the Hannibalic war; in 41–40 B.C., L. Antonius took refuge there, and it was reduced by Octavian after a long siege. A number of lead bullets used by slingers have been found in and around the city. The city was burnt, we are told, with the exception of the temples of Vulcan and Juno—the massive Etruscan terrace walls, naturally, can hardly have suffered at all. It must have been rebuilt almost at once, but is hardly mentioned except by the geographers until the middle of the 6th century.

In the 9th century, Perugia passed under the popes; but for many centuries the city continued to maintain an independent life, warring against many of the neighbouring lands and cities. It remained true for the most part to the Guelphs. On various occasions the popes found asylum within its walls, and it was the meeting place of the conclaves which elected Honorius II (1124), Honorius IV (1285), Celestine V (1294), and Clement V (1305); but when papal legates sought to coerce it by foreign soldiers, or to exact contributions, they met with vigorous resist-

ance. In the 15th century power was at last concentrated in the Baglioni family. Gian Paolo Baglioni was lured to Rome in 1520 and beheaded by Leo X; and in 1534 Rodolfo. who had slain a papal legate, was defeated by Pier Luigi Farnese, and the city, captured and plundered by his soldiery. was deprived of its privileges. The citadel was begun six years later. In 1797 Perugia was occupied by the French; in 1832, 1838 and 1854 it was visited by earthquakes; in May 1849 it was seized by the Austrians; and, after a futile insurrection in 1859, it was finally united to Piedmont in 1860. (T. A.)

PERUGINO (PIETRO DI CRISTOFORO VANNUCCI) (*c.* 1450–1523), Italian artist, the principal painter of the Gmbrian school and the master of Raphael. was born at Città della Pieve, near Perugia, from which city he takes his name. Giovanni Santi, Raphael's father. says that Perugino and Leonardo da Vinci were "of an age." It is known that Leonardo was born in 1452 and entered the guild in Florence in 1472, in which year Perugino was also registered; it is likely, therefore. that he was born about 1450. On the other hand, G. Vasari implies that he was born in 1445 or 1446, but this seems less likely than Santi's date. Nothing is known for certain of his early training, but he may have been a pupil of Fiorenzo di Lorenzo in Perugia and of Piero della Francesca in Arezzo, in which case he would have been a fellow pupil of Luca Signorelli. Certainly the two men were acquainted, and an occasional influence from Signorelli is visible in Perugino's work, notably in the direction of an increased hardness of drawing (*e.g.*, "Crucifixion and Saints"; Uffizi gallery, Florence). In Florence he almost certainly worked in the shop of Andrea del Verrocchio. where Leonardo was then also active.

The first certain work by Perugino is a "Saint Sebastian" at Cerqueto, near Perugia, the sole survivor of a series of frescoes in the church, recorded as having been signed and dated 1478. This already shows much of his typical style, and he must have made a considerable reputation by that date, since he is next recorded in 1478–79 in Rome, working in old St. Peter's for Pope Sixtus IV. These frescoes are lost. but the same pope employed him on the fresco decoration of the Sistine chapel. and his name occurs in the documents of 1481 and 1482. Several of his frescoes have been destroyed — most notably those on the altar wall, thrown down to make way for Michelangelo's "Last Judgment" — but his most important work there, the "Giving of the Keys to St. Peter." is fundamental to his development. It shows the apostles ranged in the foreground. watching Christ hand the keys to Peter; in the background is a centrally planned building. of the type then much in favour among advanced architects. It symbolizes the Old Dispensation, since it represents the Temple at Jerusalem, and the giving of the keys is a symbolic representation of the New, or Christian, Dispensation. The artistic importance of this fresco is very great, for it is simple and lucid in arrangement, and the first glance reveals the main action; by comparison, the frescoes by Botticelli in the same series appear both crowded and incomprehensible. It was Perugino's main claim to fame that he insisted on the qualities of simplicity and clarity that were to characterize the High Renaissance and, in particular, the work of



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"THE CRUCIFIXION WITH THE VIRGIN. SAINT JOHN. SAINT JEROME AND SAINT MARY MAGDALEN." BY PIETRO PERUGINO. IN THE NATIONAL GALLERY OF ART. WASHINGTON, D.C.

his pupil Raphael. It cannot be denied that among Perugino's very numerous works there are several that are less lucid and simple than insipid and vacant, but his not infrequent sentimentality should not obscure his merits and his historical importance.

Immediately after completing his work in the Sistine chapel, Perugino went back to Florence, where he was given a commission to work in the Palazzo della Signoria, and in 1491 he was invited to sit on the committee concerned with finishing Florence cathedral; in the same year he signed and dated the triptych now in the Villa Albani, Rome. There are several signed and dated works from the next decade, some of the principal ones being the "Madonna and Saints" (1493, Uffizi) and the same subject. also of 1493, in Vienna; in 1494 he painted a portrait of Francesco delle Opere (now in the Uffizi), which shows that he must have been well acquainted with Flemish portraits of the later 15th century, since the influence of Hans Memlinc is unmistakable. The "Pietà" (1495; Pitti. Florence) shows the calm resignation which his style was capable of expressing.

Between 1493 and 1496 he painted a fresco in the convent of Sta. Maria Maddalena de' Pazzi, in Florence. This takes up the entire wall surface. facing the entrance, of a room in the cloister. The roof is vaulted, so that the wall is divided into three bays by the corbels supporting the vaulting; below the corbels Perugino painted piers and made it seem that the room is in fact an open loggia, looking out on an extensive and beautiful Umbrian landscape, with the Crucifixion taking place in the central bay and the two side bays occupied by gently mourning saints. For the church of S. Pietro in Perugia he painted, between 1496 and 1498. a very large altarpiece of 15 panels. The central "Ascension" is now in the museum at Lyons, France, and other important parts are in the museum at Nantes, France, and in St. Gervais, Paris. A virtually identical "Ascension" is in Sansepolcro cathedral. In 1499 he was supposed to complete an altarpiece for the Certosa at Pavia, parts of which are now in the National gallery, London, and are an epitome of motives derived from Florentine art—the central Madonna owes a good deal to Fra Filippo Lippi, the archangel Michael derives from Donatello's statue of St. George, and the Raphael and Tobias is of a type used by the Verrocchio and Pollaiuolo workshops.

On Feb. 25, 1499, Perugino's name occurs for the first time in the records of the guild of bankers at Perugia; but, as the earlier books have been lost, the commission to paint a fresco cycle in their Sala del Cambio may well have been given earlier. He received the final payment in 1507; but it is generally assumed that the frescoes were completed shortly after 1500, the date which appears opposite Perugino's self-portrait on one of the pilasters. The ceiling is decorated with an Apollo surrounded by allegories of the planets. It has been shown that these scenes depend on the illustrations in Johannes de Spira's astrolabe tables, *Astrolabium planum* in *tabulis ascendens* (1494), and it is thought that the iconography of the whole Sala was planned by Francesco Maturanzio, a professor of rhetoric in Perugia. He certainly wrote the Latin verses which accompany the main fresco fields, representing allegorical figures of virtues and the principal exemplars of each virtue in classical antiquity or the Christian embodiment of it. The importance of these frescoes in the history of art lies in the fact that the young Raphael was Perugino's pupil around 1500 and probably had his grounding in fresco technique there. The figures of Fortitude and Horatius Cocles are often attributed to him. At about this date Perugino also painted an "Ascension" (Vatican), in which the sleeping soldier is sometimes attributed to Raphael; and the "Marriage of the Virgin" (Caen, France) is usually dated about 1503–04, since it seems to be the prototype of Raphael's finer "Sposalizio" (1504; Brera, Milan).

From this time Perugino's art began to decline, since he frequently repeated his earlier compositions in a routine manner. Vasari says that the critical Florentines began to lampoon him, and Perugino replied that they had once praised his work, and, if he now gave the same designs, they had no right to blame him. It is certainly true that the "Chastity" (now in the Louvre. Paris) was commissioned in 1503 by Isabella d'Este and was delivered only in June 1505, after a great many letters had passed between all concerned, at which time Isabella expressed herself as satisfied, but only moderately so. In fact, Perugino left Florence about 1505 and began to retire, working principally for the less critical public of Umbria. In 1508 he made a temporary comeback by painting roundels on the ceiling of the Stanza d'Eliodoro in the Vatican; but the commission for the room went to his pupil Raphael, who, in the few years after leaving Perugino's shop, had proved himself incomparably the greater artist. It is a curious fact that one of Perugino's last commissions was the completion in 1521 of some frescoes in S. Severo, Perugia, which had been begun years earlier by Raphael. He was still working in Feb. 1523, when he died of the plague at Fontignano, near Perugia, and was buried in a field there. The fresco of the "Nativity," in the National gallery, London, comes from Fontignano and is generally supposed to be Perugino's last work.

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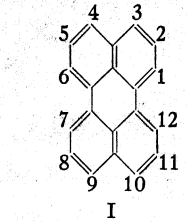
PERUZZI, BALDASSARE TOMMASO (1481–1536), architect and painter of the Italian Renaissance. probably was born at Siena. He was a man of varied attainments, but his architecture, characterized by extreme simplicity and delicacy. was superior to his painting. A contemporary of Raphael and Donato Bramante, he first appeared in 1501 as a painter of frescoes in the chapel of S. Giovanni in Siena cathedral. His first architectural work was the Villa Farnesina (1509–11), for Agostino Chigi, which contains frescoes by Raphael and one—the "Story of Medusa"—by Peruzzi himself. In 1516 or 1517 he produced his best frescoes, those for the Cappella Ponzetti in Sta. Maria della Pace. On Raphael's death in 1520 Peruzzi was appointed architect for St. Peter's, jointly with Antonio Sangallo, the younger. About 1523 he built the classical portal of S. Michele in Bosco near Bologna. The Palazzo Ossoli (1525) and the Palazzetto Spada, both in Rome. have been attributed to him; also the Palazzo Albergati in Bologna. At the sack of Rome (May 1527) he escaped to Siena, became architect to the republic in July and architect to Siena cathedral in 1529. His most important building was the Palazzo Massimo alle Colonne (1535), in Rome. He died in Rome on Jan. 6. 1536. and was buried in the Pantheon.

See W. W. Kent, *The Life and Works of Baldassare Peruzzi of Siena* (1925). (M. S. B.; X.)

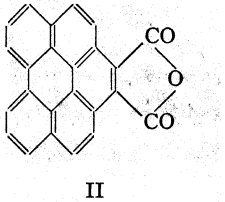
BERVIGILIUM VENERIS, the vigil or nocturnal festival of Venus, a short Latin poem. The occasion, author, date and place of composition are unknown. The poem probably belongs to the 2nd or 3rd century A.D. It describes in admirable if slightly florid poetry the springtime awakening of the world through the goddess. It consists of 93 trochaic septenarii, divided into groups of unequal length. A famous imaginative reconstruction of the manner of its writing is found in Pater's *Marius the Epicurean.*

See Editio princeps *(1577)*; many modern editions, either alone (as G. Bucheler, J. W. Mackail, C. Clementi, R. W. Postgate) or with Catullus; also in the *Anthologia Latina (see* ANTHOLOGY).

PERYLENE, an aromatic hydrocarbon present in small amounts in the highest boiling fractions of coal tar. It crystallizes in golden-yellow plates and has a melting point of 273°–274° C. Perylene, $C_{20}H_{12}$, has also been isolated from a sulfur dioxide extract of a petroleum distillate. Its dilute solutions have an intense blue fluorescence. The structure (I) of perylene is indicated by its formation from naphthalene and from 1:1′-dinaphthyl by heating with aluminum chloride and from 1:8-diiodonaphthalene by heating with copper. This is confirmed by synthesis from 9:10-bischloromethylanthracene.



I



II

Perylene has, to a certain degree, the character of a diene and

reacts with maleic anhydride in boiling nitrobenzene (*i.e.*, under oxidizing conditions) to give 1:12-benzoperylene-dicarboxylic anhydride (11), which may be decarboxylated to 1:12-benzoperylene, also a minor constituent of coal tar. Oxidation of perylene with chromic acid gives the 3:10-quinone, derivatives of which occur naturally as pigments in aphids. (J. W. CK.)

PESARO (anc. PISAURUM), a city and seaport of the Marche, Italy, the capital of the province of Pesaro and Urbino, situated on the coast of the Adriatic 37 mi. N.W. of Ancona. Pop. (1951) 34,647. Upon the Coles S. Bartolo, the Villa Imperiale, the foundation stone of which was laid by the emperor Frederick III, was built by the Sforza; it was decorated with fine stucco ceilings and wall paintings and pavements of majolica plaques.

A new palace was begun in 1530 by the Genga for Eleonora Gonzaga but it was never finished. The city walls were in 1830 transformed into a public promenade.

Other buildings erected there include a palace originally built in 1455–65 for the Sforza, and restored by Francesco Maria della Rovere in the 16th century, where various antiquities. pictures and a fine collection of majolica from the old Urbino and other manufactories were preserved; and the fortress of Rocca Costanza (built by Costanzo Sforza in 1474, Laurana being the architect). Pesaro is the centre of a rich agricultural district and is also a sea bathing resort.

Destroyed by Vitiges the Goth, the town was restored and strengthened by Belisarius, and afterward along with Ancona, Fano, Senigallia and Rimini formed the Pentapolis Maritima. In the course of the 13th century Pesaro was sometimes under the government of the popes, sometimes under that of the emperors; but the Malatesta family, which first took root in the city about 1285, gradually became the real masters of the place. In 1445 they sold their rights to Francesco Sforza; and in 1512, through the influence of Julius II, the Sforza were supplanted by his nephew Francesco Maria, duke of Urbino. Pesaro became the residence of the dukes of Urbino till the death of Francesco Maria II in 1631, when it reverted to the states of the Church.

PESCADORES (P'ENG-HU LIEH-TAO). a group of 64 islands of volcanic and coral origin in Formosa strait separated from Taiwan (Formosa) by the 30-mi.-wide P'eng-hu or Pescadores channel. Land area 49 sq.mi.; gross area more than 1,000 sq.mi. The largest islands are P'eng-hu, Pai-sha (connected with P'eng-hu by causeway), Yu-weng and Pa-chao. Relief is low, less than 300 ft. above sea level, and coral reefs are common. The islands are washed by the warm Kuro Shiwo (Japan) current and the climate is frost free. Mean monthly temperatures range between 59.5° F., in February and 82° F., in July. Except for summer, prevailing winds are northerly and frequently of gale force. Almost all of the 38 in. of annual rainfall falls between June and September.

Soils derived from basalt are sandy; those from coral reefs, droughty: natural vegetation is sparse.

Rich fishing grounds nearby explain the Portuguese-derived name Pescadores (fishermen's islands).

The population (1956) was 85.926, consisting primarily of Chinese from neighbouring Fukien province. More than half of the inhabitants reside on P'eng-hu island (site of P'eng-hu, the principal town).

Fishing and farming are the major occupations. Although 59% of the land is arable, poor soils and high winds make cultivation difficult. Millets, fruits (some exported), corn, sweet potatoes and peanuts are the chief crops.

The islands were occupied by the Dutch (1622–24), by the French and ceded to Japan (1895–1945). The islands, long a dependency of Formosa (*q.v.*), became one of the 16 hsien of Taiwan province in 1950. (S.S. G.)

PESCARA, FERNANDO FRANCESCO DAVALOS, MARQUIS OF (1489–1525), Italian ***condottiere,*** was born at Naples, of Spanish origin. At the age of six the boy was betrothed to Vittoria Colonna (*q.v.*), and the marriage was celebrated in 1509. In 1512 he commanded a body of light cavalry on the Spanish side at Ravenna.

When Francis I invaded Italy in 1524, Pescara was appointed as lieutenant of the emperor to repel the invasion. There was much discontent in the ill-paid army, but the tenacity, patience and tact of Pescara triumphed over all obstacles. On Feb. 24, 1525, he defeated and took prisoner Francis I by a brilliant attack. He destroyed the superior French heavy cavalry by assailing them in flank with a mixed force of harquebusiers and light horse. He died at Milan on Nov. 4. 1525.

BIBLIOGRAPHY —The life of Pescara was written in Latin by Paolo Giovio and is included in the ***Vitae illustrium virorum,*** printed at Basle (1578) Giovio's Latin ***Life*** was translated ***by*** L. Domenichi (1551). ***See*** also Mignet, ***Rivalité de François Ier et de Charles Quint*** (1875), which gives references to authorities.

PESCARA, a river and town of Italy. The river is formed by the confluence of the Gizio and Aterno, flowing into the Adriatic at Pescara (pop.. 1951. 47,907), the capital of the province of that name. This town occupies the site of ancient Aternum. In this valley, 22 mi. from the sea, was the site of the ancient Interpromium, a town belonging probably to the Paeligni.

PESELLINO (FRANCESCO DI STEFANO [GIUOCHI]) (1422–1457), Florentine painter of the early Renaissance. He was brought up by his grandfather, the painter Giuliano il Pesello (1367–1446), and worked as his assistant until Giuliano's death, when he became associated with Fra Filippo Lippi. In 1453 he went into partnership with Piero di Lorenzo di Pratese and during this period began, for the church of S. Trinità at Pistoia, the altarpiece of the Trinity that later was moved to the National gallery, London. It was left unfinished at his death on July 29, 1457.

Pesellino excelled in the execution of paintings on a small scale and is famous for his *cassone* pictures, intended for the decoration of marriage chests, in which he illustrated, in charming tapestrylike designs, an old legend or tale; several of these are in the Gardner museum, in Boston. A number of works by Pesellino may be seen in galleries in the United States; among these are the National Gallery of Art, Washington, D.C.; the Metropolitan Museum of Art, New York city (a fine panel of the Madonna and saints); and the Museum of Art of Toledo, O.

PESETA. The monetary unit of Spain, the peseta is divided into 100 centimos. In its modern form it was introduced by a law of Oct. 19, 1868, although coins of that name date back at least to the currency reform of 1772–86.

PESHAWAR, a municipal town, tehsil, district and division in West Pakistan. The town is situated near the left bank of the Bara river. 11 mi. from Jamrud and the entrance to the Khyber pass, and 1,04j mi. from Karachi. Pop. (1951) 151,776 including 42,061 in the cantonment area. Formerly it was enclosed within a protective wall, with 16 gates, enclosing an area of j sq.mi., but this has been partially removed to allow for expansion. The cantonment, 2 mi. W. of the city, is the largest military headquarters on Pakistan's western frontier and its proximity to the Khyber pass gives it great strategic importance. The university of Peshawar is situated about j mi. from the town. For many centuries the Powindahs, or Afghan traveling merchants, led their caravans every autumn to Peshawar from Kabul, Bukhara and Samarkand bringing horses, wool, woolenstuffs, silks. dyes, gold thread. fruits, precious stones, carpets and posteens (sheepskin clothing). It is still an important trading centre. The chief cottage industries are the manufacture of copper utensils and leather goods, especially chappals. Peshawar tehsil (pop. [1951] 386,293) covers an area of 460 sq.mi.

PESHAWAR DISTRICT (area 1,548 sq.mi.; pop. 1951, 903,230), apart from the area covered by low hills at Cherat in Nowshera tehsil. consists mainly of highly irrigated plains. The inhabitants are mostly Pathans with some Hindkis, Awans forming the most numerous Hindki tribe. (K. S. AD.)

History. — References to the district of Peshawar occur in early Sanskrit literature and in the writings of Strabo. Arrian and Ptolemy. It once formed part of the ancient Buddhist kingdom of Gandhara and the area is still studded nith crumbling stupas. Rock edicts of Asoka are to be found at Shahbazgarhi and Mansera. Purushapura (the ancient name for the town) was the capital of Kanishka's dominions. Between the 15th and 16th centuries the district was occupied by Pathan tribes from what is now Afghan-

istan. The Mogul emperors always found difficulty in maintaining their authority over these tribes. Peshawar was a favourite residence of the Afghan dynasty founded by Ahmad Shah Durani. and there Mountstuart Elphinstone came as ambassador to Shah Shuja in 1809. A few years later Ranjit Singh crossed the Indus, and after much hard fighting Sikh authority was firmly established under Gen. Paolo di Avitabile in 1834. In 1849 Peshawar passed to the British. In the years before the formation of Pakistan the Peshawar valley was seriously disturbed by the activities of Abdul Ghaffar Khan, founder of the "Red Shirt" movement *(see* INDIA: *History: Political Assassination, 1923–32*). After Pakistan was established he led the Pathan separatist movement and the agitation for a Pushto province. He was arrested near Peshawar in 1956. (C. C. D.)

PESNE, ANTOINE (1683–1757). French painter of historical subjects and portraits and court painter in Berlin, was born on May 23, 1683, in Paris. After being taught by his father, Thomas Pesne, and his maternal great-uncle, Charles de Lafosse, Pesne later studied at the Paris academy, where he was influenced by the leading French portraitists, Hyacinthe Rigaud and Nicolas de Largillière. In Rome and Naples, and particularly in Venice, where he studied with Andrea Celesti, Pesne developed a marked colouristic talent. The elegant style of his early portraits was greatly influenced by the paintings of his countryman Jean Raoux, as well as by Dutch masters and the elegant pastels of the Venetian artist Rosalba Carriera.

In 1707 Pesne's full-length portrait of the Prussian ambassador to Venice, von Kyphausen, attracted the attention of Frederick I of Prussia; and the artist was appointed court painter to the royal court of Berlin, where he remained, except for short intervals, from 1710 until his death on Aug. S, 1757. Pesne became the portraitist of the court and of the aristocracy and eminent personages of Brandenburg-Prussia. When Frederick II came of age, Pesne was able to give full scope to his colouristic gifts in mythological and allegorical ceiling paintings and murals, decorating the interiors of the palaces at Rheinsberg, Charlottenburg, Berlin and Potsdam. He continued to paint portraits, some of which achieve by their brushwork and brilliant colouring an almost impressionistic effect reminiscent of Renoir. Of special interest are the various representations of Italian and French dancers and actresses whom Frederik II engaged for the Berlin Opera. They are in the style of Watteau, but as the first European painter to give these portraits an individual character, Pesne developed here the most famous side of his work.

BIBLIOGRAPHY.—C. F. Forster, article on Pesne in Thieme-Becker, *Allgemeinen Lexikon der Bildenden Künstler,* vol xxvi, p 467 ff. (1932); E. Berckenhagen *et al., Antoine Pesne,* with introduction by G. Poensgen (1958); catalogue of the Pesne bicentenary memorial exhibition in Berlin (Nov. 1957). (G PN.)

PESO. The monetary unit of several Latin-American countries and the Republic of the Philippines, the peso is divided into 100 centavos. It was first coined by Ferdinand and Isabella, who reformed the Spanish coinage system in 1497, but it became common only under Charles I (the emperor Charles V) (1516–56).

Under the monetary reform of 1772–86 the peso, which was originally divided into eight reales, became the basis of the silver coinage of the Spanish empire, and in the Americas was called piece of eight or Spanish milled dollar. It was the prototype of the U.S. silver dollar. which under the first coinage law of the United States (1792) was defined as a coin approximating closely the Spanish American peso of 1786 in weight and fineness and hence in value.

When most of the Spanish colonies in America gained their independence in the second and third decades of the 19th century, they maintained the peso as the basis of their currencies. Subsequently all of the countries introduced the decimal system in their coinage, following the practice of the United States, and in several countries, the name peso was changed to a local name. In Peru, for example, it was renamed sol in 1863; in Venezuela, bolivar; in Ecuador, sucre; in El Salvador, colón and in Costa Rica, colon. In Panamá the name of the local currency unit became balboa; in Honduras, lempira; in Guatemala, quetzal; in Nicaragua, córdoba; and in Bolivia, boliviano. In 1943 Paraguay changed the name from peso to guarani.

The severe fall in the value of Latin-American currencies during the depression of the 1930s was caused primarily by the serious decline in raw material prices. which formed the chief exports of these countries.

To prevent further deterioration of their exchanges, many countries tied their currency to the U.S. dollar and a so-called dollar area was formed, embracing, besides the U.S. and Canada, most of the countries of Middle America and the Caribbean, within which U.S. currency came to move freely and to form the basis of the various national currencies. In the countries of South America, which were not included in the dollar area, currencies fluctuated, on the whole, more than those of the dollar-area republics. Venezuela, as a result of large exports of petroleum, proved an exception.

PESSANHA, CAMILO (1867–1926), the representative in Portuguese poetry of symbolism at its purest and most genuine and the chief precursor of so-called "modernist" poetry. He was born in Coimbra, Sept. 7, 1867, the son of an undergraduate and a girl of the lower classes. He went to the grammar school in Coimbra and entered the faculty of law at the university there, concluding his studies in 1891. After being employed as an assistant to the public prosecutor in Mirandela, he was appointed head of the philosophy department at the Liceu at Macao. He went to this colony in China in 1893 and remained there. apart from two or three visits home, until his death in 1926. From the beginning Pessanha assumed oriental customs, including the opium habit, attracted to them by his somewhat passive temperament. He learned Cantonese and was one of the last Portuguese men of letters to speak the Chinese language, from which *inter alia* he translated some elegies, Oito *Elegias Chinesas,* accompanied by a preface that demonstrates his knowledge of oriental literature. He also collected Chinese *objets d'art* which he bequeathed to the Museu Machado de Castro in Coimbra. His writings on China, in particular the *Introdução a um Estudo sobre a Civilização Chinesa* and the *Elegias,* were collected in *China* (1943). Although he began to write verse in Coimbra, Pessanha was virtually unknown until 1916 when his poetry. which unites the purest symbolist spirit with the most modern poetic technique, was made known to a new generation in the pages of a progressive review. *Centauro.* Collected in the volume, *Clepsidra* (1920), his poetry became a kind of breviary for the modernist poets. Musical. subtle, penetrated by the mystery of oriental poetry, Camilo Pessanha is one of the most lyrical of Portuguese poets.

See A. Dias Miguel, *Camilo Pessanha* (1956); Ester de Lemos, *A "Clepsidra" de Canzilo Pessanha* (1956); *J.* Gaspar Simões, *Historia da Poesia Portuguesa do seculo XX* (1959). (J. G. Ss.)

PESSIMISM, a word coined in modern times (from Latin *pessimus,* worst) to denote an attitude of hopelessness toward life and toward existence, coupled with a vague general opinion that pain and evil predominate in the world; the antithesis of "optimism," which denotes an attitude of general hopefulness, coupled with the view that there is a balance of good and pleasure in the world. To describe an attitude as pessimistic need not, however, mean that it involves no hope at all: it may locate its objects of hope and of appraisal in a region beyond ordinary experience and existence; and it may also direct such hope and appraisal to the complete cessation and cancelling of existence.

Unsystematic pessimism is a reflection of material circumstances, of bodily health or of general temperament; it is characteristically expressed in the language of *Ecclesiastes* that "all is vanity." There are, however, systematic forms of pessimism, both philosophical and religious. The Orphic-Pythagorean view of the world was one of qualified pessimism, fleshly existence being regarded as a periodic penance undergone by the impure or guilty soul, until it can at last be freed from the "cycle of becoming" by ceremonial purification or by philosophical contemplation. This same qualified pessimism in regard to fleshly existence and experience is found in Platonism, for which things in this world necessarily deviate from and fall short of their ideal exemplars and for which (as in the *Phaedo)* fleshly tendencies and experiences only represent hindrances in the carrying-out of activities which

will be fully performed after death. Eastern pessimism (of a qualified sort) may be illustrated in Buddhism. where all conscious personal existence is held to involve pain or ill. where the cause of such ill lies in personal striving or desire and where positive appraisal is directed to a consummation (nzrvana) which involves the cessation of striving and of conscious personal existence. It is similarly represented in the main currents of Hindu thought, with the additional thesis that the world is not only painful and evil but also illusory. A qualified pessimism is, of course, deeply characteristic of Christianity, where our world is a fallen world, in which human reason and will are corrupted, and where it is only by redemptive action coming from beyond the world and fulfilling itself in another order that such ills can be rectified.

Philosophical pessimism was strong in the 19th century and was represented in the systems of Arthur Schopenhauer and Karl Robert Eduard von Hartmann. Schopenhauer presented a synthesis of Kantianism and Buddhism, the Kantian thing-in-itself being identified with a blind irrational will behind phenomena; our world, being the manifestation of such an unhappy will, must itself be unhappy. In the first half of the 20th century critical philosophy tended to steer clear of the whole issue of optimism versus pessimism; feeling themselves incompetent to make many general assertions about the world, philosophers were particularly unwilling to make general assessments of its goodness or badness. A qualified pessimism in regard to the world and to human nature was, however, characteristic of several theological systems (*e.g.*, the theologies of Karl Barth, of Emil Brunner and of the Dutch neo-Calvinists Herman Dooyeweerd and D. H. T. Vollenhoven). Perhaps the most uncompromisingly pessimistic system ever developed is that of the existentialist philosopher Martin Heidegger for whom death, nothingness and anxiety are central topics of interest and for whom the highest possible act of human freedom is a coming to terms with death.

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(I. N. F.)

PESSINUS (PESSINOUS, PESINOUS), an ancient city of Galatia in Asia Minor, situated on the lowest southern slope of Mt. Dindymus. The ruins, discovered by Texier, lie around the village of Bala-Hissar, 8 or 9 mi. S.E. of Sivri-Hissar. Originally a Phrygian city, it became the capital of the Gallic tribe Tolistobogii and the chief commercial city of the district. It contained the most famous sanctuary of the mother of the gods (Cybele), who here went by the name of Agdistis and was associated with the god Attis, as elsewhere with Sabazius, etc. Her priests were also princes, who bore rule not only in the city (the coinage of which, beginning about 100 B.C., was for long issued by them) but also in the surrounding country, deriving a large revenue from the temple estates; but in the time of Strabo (A.D. 19–20) their privileges were much diminished. Some time before the year 164 B.C. Pessinus fell into the power of the Gauls, and the membership of the priestly college was then equally divided between the Gauls and the old priestly families. Like Ancyra and Tavium, Pessinus was Romanized first and Hellenized afterwards. Only about A.D. 165 did Hellenic ways and modes of thought begin to be assumed; before that we find a deep substratum of Celtic feeling and ways, on which Roman elements had been superimposed without filtering through a Hellenic medium. Christianity was introduced late; it cannot be traced before the 4th century. When Galatia was divided into two provinces (A.D. 386–395) Pessinus was made the capital of Galatia Secunda or Salutaris, and it became a metropolitan bishopric. After the 16th century it disappears from history.

PESSOA, FERNANDO ANTÓNIO NOGUEIRA (1888–1935), the greatest literary figure in Portuguese "modernism," the movement which gave Portuguese literature of the first half of the 20th century its European significance. He was born in Lisbon on June 13. 1888. His father died when Pessoa was five and his mother married the Portuguese consul in Durban. and in 1895 took him to South Africa uhere he was educated. In 1903 he uas outstandingly successful in the entrance examination of Cape Town university, winning the Queen Victoria prize for English style. In 1905 he returned to Portugal, and enrolled at the Curso Superior de Letras in Lisbon in 1906 but ceased to follow the courses there in the following year and sought openings in commercial life, in which he displayed much initiative but a total absence of tact. He eventually settled down as foreign correspondent for various commercial firms in Lisbon. Though he tried at different times to fend for himself, he always returned to lodgings, first with an aunt and later with his half sister. A bachelor and not particularly sociable, he preferred the acquaintanceship of fellow solitaries in the cafés to the solid joys of a settled family life. A doleful existence, though sublimated by his intelligence and tempered by nostalgic evocations of his childhood, lies behind his work, most of which was unpublished at the time of his death in Lisbon, Nov. 30, 1935.

In the previous year Pessoa had published his first book in Portuguese, Mensagem. All that was known of his work at his death were some booklets of poems in English—a language which Pessoa, who was virtually bilingual, wrote with ease—Antinous and 35 Sonnets (1918) and Inscriptions (1920), collected in three volumes under the title English Poems (1921); some literary and political manifestoes—Aviso por Causa da Moral (1923) and Interregno (1928); his editorship of the review *Athena* (1924–25) and his frequent contributions to the avant-garde reviews, especially Orpheu (1915), the organ of the modernist movement in which Pessoa, with Mario de Sá-Carneiro and José de Almada Negreiros, was a leading spirit. The posthumous edition of his complete works consists of eight volumes; the poems are grouped under the various names or pseudonyms which the poet employed during his lifetime, each name purporting to represent one of the different personalities which he felt to exist within himself: the personality and the style can vary, therefore, according to whether a poem is signed by Fernando Pessoa himself, "Alberto Caeiro," "Álvaro de Campos" or "Ricardo Reis." The most important volumes in the collected edition are Poesias de Fernando Pessoa (1942), *Poesias de Álvaro de Campos* (1944), *Poemas de Alberto* Caeiro (1946) and Odes de Ricardo *Reis* (1946), in addition to the *Mensagem* of 1934. Examples of his prose writings as a critic and thinker of a paradoxical spirit can be found in the collection entitled *Páginas* de Doutrina *Estética* (1946). A good selection of his work, with an introduction, is in A. Casais Monteiro, Fernando *Pessoa* (1945).

See J. do Prado Coelho, *Diversidade e Unidade em Fernando Pessoa* (1949); J. Gaspar Simões, *Vida e Obra de Fernando Pessoa*, 2 vol. (1950).

(J. G. Ss.)

PESTALOZZI, JOHANN HEINRICH (1746–1827), Swiss educator, revered in Switzerland because of his tireless efforts to aid poor, orphaned and helpless children, was born at Zürich on Jan. 12, 1746. Active even in his student days in Zürich in social and political reform, he early earned a reputation as champion of the underprivileged and exploited. He established (1774) an orphanage, where he attempted to teach neglected children the rudiments of agriculture and simple trades that they might lead productive, self-reliant lives. This philanthropic experiment failed in 1780, and Pestalozzi, in a period of despair, wrote what can be considered a key to his philosophy, *The* Evening *Hour of a Hermit,* a profound and moving series of reflections and aphorisms.

During the next decade he published a widely read four-volume novel, *Leonard and Gertrude,* which delineated and publicized his ideas on social, moral and political reform. When the town of Stans was destroyed and the inhabitants massacred during the Napoleonic invasion of 1798, Pestalozzi collected several dozen destitute children and cared for them under most arduous and pitiful conditions.

In 1805 Pestalozzi founded at Yverdon his famous boarding school. which flourished for 20 years. was attended by students from every country in Europe and was visited by hundreds of the most important figures of the time. Pestalozzi's overarching educational principle, elaborated in Now Gertrude Teaches Her *Children* (1801), was "sense impression": accurate, clear thinking is dependent upon accurate observation of actual objects; words and

ideas thus have meaning only when related to concrete things. The Yverdon curriculum, therefore, emphasized such pupil activities as drawing and writing. singing, physical exercise, group rather than individual recitations, models, collections. map making and field trips. Carefully graded instruction, allowance for individual differences, and ability groupings were novel features. An important undertaking was the teacher-training department. Educators journeyed to Yverdon to study "the method." carried Pestalozzi's ideas throughout Europe and America and established scores of Pestalozzian schools. Froebel and Herbart learned much from Pestalozzi. as did Ritter, the geographer. The object-lesson approach used in a highly successful Pestalozzian school in England, conducted by Charles and Elizabeth Mayo, was adopted in the United States (1861) by the Oswego Normal school and became the guiding principle in the United States' foremost teacher-training institution.

Pestalozzi's greatest influence was upon Prussia. The German philosopher Fichte, indeed, told a Germany prostrated at Jena that only through a strong educational system based upon Pestalozzian principles could the country expect to recover. Pestalozzi died at Brugg on Feb. 17, 1827.

There are several German editions of Pestalozzi's collected works. His writings referred to above. and Letters on Early Education, have been translated into English.

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PÉTAIN, HENRI PHILIPPE BENONI OMER JOSEPH (1856–1951), French soldier and "chief of state" (1940–44), was born on April 24, 1856, at Cauchy-à-la-Tour in the Pas-de-Calais. He was trained as a professional soldier at Saint Cyr and at the École de Guerre and filled the various staff posts until 1914. When World War I broke out he was already 58, had not served outside France and had known no active service. Yet, in conflict with the prevailing staff theories of the need to maintain the offensive at all costs, he had evolved views of his own about the value, in modern warfare. of defensive strategy provided that infantry were supported by the co-ordinated fire power of artillery. These were to prove correct once the war in France had become one of attrition.

He was put in command first of an infantry regiment. then (on Oct. 25, 1914) of the 33rd army corps in Artois. He distinguished himself during the offensive near Arras in May 1915, and in June was given command of the 2nd army as a full-ranking general. Four months later he launched the offensive in Champagne. which cost the French 80,000 killed and 100,000 sick and wounded but achieved only moderate success. In 1916, when the Germans opened the attack on Verdun, he was given the task of stopping it at all costs. He showed skill and energy in organizing, deploying and supplying his forces, and although the operation cost France about 350,000 men he held Verdun. This made him a popular hero, and he was appointed chief of the general staff in April 1917 and commander in chief in May. The morale of the French troops had deteriorated, and it became his special task to stop mutiny. By a combination of repression and reform of grievances, he again succeeded, so that the French army was ready to meet the final German offensive of 1918. After March 1918, with Foch as generalissimo to co-ordinate French. British and United States forces, Pétain was in charge of the operations assigned to the French armies. He prepared the offensives of August and September and was responsible for pushing the Germans back to the Ardennes.

His achievements during World War I were, therefore, great: and between the wars, as the veteran "saviour of Verdun" and as a *maréchal* de France, he came to be regarded as a high military authority. He served as vice-president of the supreme war council (1920–30), as French commander in chief against Abd el-Krim (1925), as war minister in Gaston Doumergue's cabinet (1934) and as ambassador in Madrid (1939–40). After the deaths of the marshals Foch and Joffre, he dominated French military policy and remained a firm advocate of defensive strategy. The construction of the Maginot line, the obsession of the high command with defense and the neglect of the new factors introduced by the development of the tank and of the aeroplane were the main consequences of this strategy. Successive governments and public opinion alike welcomed a policy designed to be thrifty with French lives in the event of another war. The costs of extensive re-equipment and modernization of the armed forces were shirked, in favour of lavish expenditure on static fortifications and defenses.

These conservative military doctrines had their counterpart in political conservatism. Marshal Pétain made no secret, during the period of popular front government of 1936, of his contempt for parliamentary government, of his antipathy to Socialist ideas or of his preference for dictatorial regimes which brought strength and prestige to their countries. R'hen World War II broke out in 1939 he was, at the age of 83, a natural focus of hopes for those who believed that the strong government needed for war might be used to overthrow the parliamentary regime of the third republic.

The rapid collapse of the French forces in 1940 was, in most respects, the consequence of the outdated principles on which they had been organized and of the lack of mechanized equipment needed to meet the superior weight and mobility of the German army. In the moment of defeat France turned to the veteran marshal, whose name still represented victory although his attitude had long been defeatist. In May the premier, Paul Reynaud recalled him from Spain, and on June 16 Pres. Albert Lebrun asked him to form a new ministry. His task was, amid conditions of almost complete disorganization and military defeat, to make a speedy armistice with Germany. This he accomplished by June 22; and two days later he completed a similar convention with Italy. By the terms of these armistices his government was left in charge of the French fleet and colonies and was allowed to maintain an "armistice army" of not more than 100,000 men at home. France was divided into two zones; the northern part and the Atlantic coastline remaining under German military occupation, the southern part and the Mediterranean coastline being under the direct administration of the French government. On July 10 the national assembly, specially summoned at Vichy to ratify the terms of the armistices, granted him emergency powers until a "new constitution" could be promulgated. (See FRANCE, History.) He made himself "chief of state," with at first Pierre Laval and then Pierre Etienne Flandin as his prime minister.

From July 1940 until the liberation of France in 1944, Pétain served as chief of state for the governments of Vichy and prolonged his authoritarian regime by constantly postponing promulgation of the new constitution. He became the object of a cult and of much adulation. His aim was to keep France out of the war and to hold Germany as closely as possible to the terms of the armistice which, when it had failed to defeat Great Britain and become deeply engaged in Russia, proved increasingly favourable to France. But this involved him in a certain amount of active collaboration with Germany, and after 1942 the pressure of German demands on French labour and supplies intensified. In 1941 Admiral Jean Darlan replaced Laval as premier; but Laval returned to power in April 1942 and remained the real ruler at Vichy until it collapsed. It seems probable that because of senility and illness Pétain ceased to understand fully what was happening, and much was done in his name of which he was unaware. Yet, by remaining in office even after the ardent collaborationists assumed power at Vichy in Jan. 1944, he became implicated in responsibility for their betrayals of French national interests. He left Vichy for Belfort in Aug. 1944 and Belfort for Sigmaringen in September but voluntarily returned in April 1945. For his whole behaviour after 1940 he was put on trial by the provisional government under Gen. Charles de Gaulle and was condemned to military degradation and death (Aug. 1j, 1945). The sentence was changed to life imprisonment. He was imprisoned first at Portalet, then on the fle d'Yeu in a fortress, whence, after prolonged illness, he was moved to a villa in Port-Joinville a month before his death. He died on July 23, 1951, an acutely contro-

versial figure in French politics: while many regarded him as a traitor, others idolized him as a patriot who had "stood by a stricken France" and had sacrificed himself in its cause.

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PETALITE, a mineral species consisting of lithium aluminum silicate, is an important source of lithium (*q.v.*), the lightest metallic element. It was discovered in 1800 as cleavage masses in an iron mine on the island of Utö, near Stockholm, where it is associated with lepidolite and spodumene, also ores of lithium, and tourmaline. It is mined in Southern Rhodesia, in the Federation of Rhodesia and Nyasaland and in the territory of South-West Africa, U. of S. Af. In the United States it occurs in Maine, hlassachusetts and Wyoming.

The formula of petalite is $LiAl(Si_2O_5)_2$. In form, the monoclinic crystals approach spodumene (*q.v.*), which is also a lithium aluminum silicate with the formula $LiAl(SiO_3)_2$. There is a perfect cleavage parallel to the basal plane, and the mineral usually occurs in platy cleavage masses; because of this it was named from the Greek *petalon* (a leaf). The hardness is 6.j and the specific gravity 2.4 (that of spodumene being 3.16). The mineral is colourless or occasionally reddish, varies from transparent to translucent and has a vitreous lustre.

PETER, ST., the Apostle who is referred to in the New Testament by several names. Most commonly he is called Peter, but we also find Simon, Simon Peter, Cephas, and once Symeon. We may infer that the Apostle's name was the common Hebrew "Symeon" (שִׁמְעוֹן) which was generally rendered by the Greek "Simon" (Σίμων); he also received the title "Cephas" (כֵּיפָא) which was Graecized according to the sense of "stone" or "rock" into "Peter" (Πέτρος). There is no certain evidence that either "Cephas" or "Peter" was already in use as a proper name. The bestowal of the name Cephas is mentioned by Mark in connection with the sending forth of the twelve (iii. 16), by Matthew in connection with Peter's confession at Caesarea Philippi (xvi. 18), and in the fourth gospel in connection with the first call of Simon near the scene of John's baptizing (i. 42).

Prominence of St. Peter.—The gospels agree in representing St. Peter as the most prominent of the disciples during the ministry of Jesus. He is mentioned by Mark 23 times, by Matthew 24 times, by Luke 27 times, by John 39 times, and 182 times in the whole of the New Testament. Together with the sons of Zebedee, he formed an inner circle among the disciples, and was constantly in the company of the Master. Thus he is mentioned as present on several notable occasions such as the raising of Jairus' daughter (Mark v. 22 sqq. and parallels), the Transfiguration (Mark ix. 2 sqq. and parallels), and in the Garden of Gethsemane (March xiv. 32 and parallels). Early tradition (Papias) makes Peter the ultimate source of the Marcan narrative, to which Matthew and Luke were indebted. If so, the frequency of Peter's appearances may be partly explained; but it is Matthew rather than Mark who exalts Peter, and there is no reason to doubt that he was indeed the leader of the Twelve.

Early History.—Of his earlier history nothing is known. In Matthew xvi. 17 he is called "Simon Barjona" (*i.e.*, Simon Son of Jonas), whereas in John i. 42 and xxi. 15 he is referred to as "Simon son of John." Jonas and John are quite distinct names, but among Greek-speaking Christians the confusion would not be difficult. He was married and lived in a house at Capernaum with his brother Andrew and his mother-in-law (Mark i. 29). His occupation was that of a fisherman, and Luke says he was in partnership with James and John.

Call of St. Peter.—The synoptic gospels describe the call of Peter to discipleship as taking place by the Lake of Galilee (hlark i. 16 *sqq.*, Matt. iv. 18 sqq., Lk. v. 1. sqq.). No explanation is given of the suddenness of the call or of the ready response which it evoked. But the fourth gospel represents the earliest disciples of Jesus as previously disciples of John the Baptist and as leaving John to follow Jesus. One of these disciples was Andrew, who brought his brother Simon to Jesus with the announcement, "We have found the Messiah," and Jesus received him with the words "Thou shalt be called Cephas," which is by interpretation Peter. It is difficult to accept this account wholly as it stands, for the synoptic gospels make it plain that the disciples did not at first regard their Master as the promised Messiah; but it may embody a genuine tradition that the disciples had been connected with John's work, and thus explain why on a later occasion Peter was so ready to obey the call of Jesus. On the other hand it is possible that the account of the fourth gospel is coloured by a desire to minimize the importance of the Baptist save as a forerunner of the Christ. It is not improbable that a rival sect of the Baptist persisted to the end of the first century (Acts xviii. 25), and it was for that reason that the author of the fourth gospel omitted to mention John's independent work, and represented him as surrendering his disciples to Jesus.

Mark and Matthew agree closely in their accounts of the call of Simon and Andrew, and both quote the saying, "I will make you fishers of men." Luke has a good deal of non-Marcan material, and his account difiers considerably. He places the visit to Capernaum and the healing of Simon's mother-in-law before the call to Simon, and he connects the call with the story of the miraculous draught of fishes which appears in the fourth gospel after the resurrection (John xxi.). If the story of the miraculous draught arose from the prophecy that Peter should catch men, Luke's arrangement is in a sense justified. According to John the catch numbered 153—probably men of every race whom Peter was to attract by his teaching.

Confession of St. Peter.—Of the incidents during the ministry in which Peter played a prominent part it is only possible here to deal with one in detail. Critics attach considerable importance to the account of Peter's confession at Caesarea Philippi (Mark viii. 27 sqq., Matt. xvi. 13 sqq., Luke ix. 18 sqq.). According to all three synoptic gospels, at a comparatively late date in the history of the ministry Peter, in answer to a question of Jesus, acknowledged him to be the Messiah. Jesus then spoke of his coming passion, and Mark and Matthew add that Peter brought upon himself a severe rebuke by protesting against such an unwelcome development. The gospels make it clear that this was a turning-point in the history of the ministry and in the education of the Twelve. Matthew emphasizes the importance of the occasion by the insertion of a remarkable paragraph concerning Peter. "And Jesus answered him, Blessed art thou Simon Barjona, because flesh and blood did not reveal it to thee, but my Father in Heaven. And I say to thee that thou art Peter and upon this rock I will build my church, and gates of Hades will not prevail against it. I will give thee the keys of the kingdom of the heavens, and whatsoever thou shalt bind on earth shall be bound in the heavens, and whatsoever thou shalt loose on earth shall be loosed in the heavens." Here difficulties multiply, but two points seem clear. (1) Peter is to have unique importance in the future corresponding to the unique insight which he has displayed; he is the rock on which a new ecclesia will be founded to triumph over death. (2) Peter will have unique authority to admit to the new ecclesia and to legislate for its members. We must consider these points in greater detail. (1) Peter has received a definite revelation from Heaven, and his confession does not reflect the opinion of men (cf. Gal. i. 16). In virtue of this insight he is to become the foundation of "my church," that is, of an ecclesia comparable with the old Israel which is frequently referred to in the Old Testament as "the congregation" (Heb. קָהָל LXX. ἐκκλησία).

C. Taylor (Sayings *of the Jewish* Fathers) quotes a remarkable rabbinic parallel: When the Holy One wanted to create the world, he passed over the generations of Enoch and of the flood as unsound; but when he saw Abraham who was going to arise he said, Lo I have discovered a rock (petra) to build and to found the world upon. Therefore he called Abraham "rock" (שׁוּר), as it is said, "Look unto the rock whence ye are hewn." In what sense Peter is to be the foundation of the new ecclesia is perhaps

explained in the following words: "Peter will bear witness to the resurrection, and against the Church thus encouraged to face death the gates of Hades (Death. not Hell) will not prevail."

(2) Peter will receive the keys of the kingdom and will have unquestioned authority to bind and to loose, that is to legislate for the community. As to the keys, Is. xxii. 20–23 should be studied, and, for a Christian parallel, Rev. iii. 7. Two ideas seem to be combined: a chief steward bears the keys of a house as the sign of his authority, and a teacher of truth has the means of admission to the kingdom of Heaven (*cf.* Luke xi. 52 where the lawyers are blamed for taking away the key of knowledge). St. Peter will have authority in the new church such as Eliakim had in the old; and, as the ideal Scribe, St Peter will admit many to the kingdom by his teaching. It is remarkable that in Matt. xviii. 18 a similar power of binding and loosing is bestowed upon all the disciples (B T D. Smith, *St Matthew,* pp. 151, sqq.)

Opinions differ as to the authenticity of this saying addressed to Peter. The use of *ecclesia* for the Christian Church as a whole seems to reflect later usage (cf. Matt. xviii. 17 where the word means a local congregation); and the whole passage implies a reverence for St Peter such as might be felt by the second generation of Christians, especially by some community (?the Church of Antioch) which regarded him as its founder. John vi. 68 records another confession of Peter which is perhaps the Johannine equivalent of the synoptic "Thou art the Christ."

St. Peter and the Resurrection.— The New Testament implies that St. Peter was specially famous in the early church as a witness to the resurrection of Jesus St. Paul (I. Cor. xv. 5) mentions an appearance to Cephas first among the evidences of the resurrection. The "young man" of Mark xvi. thus instructs the women at the tomb, "Go tell his disciples and *Peter* that he goeth before you into Galilee and there ye shall see him"; from which we may infer that Mark intended to relate an appearance in Galilee at which Peter was specially prominent. Luke testifies to a belief in an early appearance to Simon (xxiv. 34), although he does not describe it and it does not fit easily into his scheme. It is xery strange that the description of this appearance has dropped out of the synoptic tradition, for it seems to have belonged to a very early stratum. The omission may be variously explained. The original ending of Mark is almost certainly lost. Luke and John adopted the belief that the disciples stayed in Jerusalem after the crucifixion, and both were therefore bound to omit a story of an early appearance in Galilee. Matthew seems to have deliberately preferred an account of an appearance to all the disciples on a mountain, perhaps because he thought it evidentially superior. But it is very probable that the appendix to St John (ch xxi) reproduces a late version of the half-forgotten story; and, so far as me can judge, the apocryphal gospel of Peter ended with a similar account. In the Johannine narrative Jesus appears to seven disciples, and Peter is prominent. The apocryphal account begins, "And I Simon Peter. .·. ." It has been suggested that the story of Jesus' walking on the water (Mark vi. 48 and parls) is another version of the same incident, for Matthew represents Peter as acting in a similar way on that occasion, jumping out of the boat to meet Jesus. (Matt. xiv 29, *cf.* Joh xxi. 7)

Later History and Death.— The last chapter of the fourth gospel is important as containing what is certainly the earliest reference to the death of St Peter. Three times Jesus tests his love which three times he had denied, and three times entrusts to him the pastoral duty to "feed my sheep." The sheep (or lambs, *v.* 15) are doubtless members of the early Church dependent upon Peter's teaching for their spiritual food. So we have a further testimony to the Apostle's great reputation as a teacher, and a suggestion that his life was devoted to pastoral rather than to missionary work The reference to his death is to us obscure, though probably it was clear enough to the original readers of the gospel. "Verily verily I say unto thee, when thou wast young thou didst gird thyself and walkedst whither thou wouldest; but when thou shalt be old thou shalt stretch forth thy hands and another shall gird thee, and bear thee whither thou wouldest not Now this he spake signifying by what manner of death he should glorify God." The inference seems to be that the life of St. Peter was prolonged to an age at which he was unable any longer to attend to himself, that he lived under some kind of restraint, and that his death was somehow connected with these circumstances. To the Church it was a martyrdom by which he glorified God, but the words do not necessarily imply more than that Peter died of old age, bearing bravely its infirmities and indignities. Clement of Rome (*Ep.* 5 Πέτρος μαρτυρήσας) perhaps implies more than this, but the tradition that Peter was crucified rests upon a misunderstanding of the words "thou shalt stretch forth thy hands" (*i* e., to allow another to gird thee), and has nothing but a respectable antiquity (Tertullian and Origen) to commend it.

The first part of the Acts is largely a record of Peter's doings, and from these chapters it appears that for some time after the Ascension he was the acknowledged head of the Jerusalem church His prominence brought him into collision with the Jewish authorities, and twice he was arrested by the priests (iv. 3, v. 18, possibly a doublet). Accompanied by John he made a journey to Samaria to see the results of Philip's preaching, and thus he was concerned in the earliest expansion of the Church (viii. 14 *ff.*). At a later date he travelled further afield, visiting Lydda, Joppa and Caesarea. At Caesarea he baptized Cornelius, and thus it was Peter who admitted the first Gentile to the Church, though Cornelius was no heathen (x. 1 *ff.*). Returning to Jerusalem Peter met criticisms of his policy by relating his experiences, and he was successful in convincing his critics; but it must not be assumed that either St. Peter or the other authorities had as yet any idea of dispensing with circumcision as generally necessary to salvation. There followed (at what interval we do not know) a persecution by Herod in which Peter was arrested, and a famine in which the Jerusalem church, weakened economically by socialistic experiments, suffered severely.

The famine probably continued after Herod's death, and Peter may have been present throughout, for "another place" to which he departed (xii. 17) may mean no more than another house. If he was present during the famine he must have met Saul and Barnabas when they brought relief from Antioch (xi. 30), and this may be the meeting described in Gal. ii. 1 *ff.* at which an agreement was reached between Paul and the senior Apostles on the question of preaching to the Gentiles. This is the view of Sir William Ramsay, and it has the great advantage that it acquits St. Paul of the charge that in writing to the Galatians he omitted to mention one of his visits to Jerusalem.

Peter's last appearance in Acts is in connection with the Council of Jerusalem where he stands up to champion a liberal policy towards the Gentiles. The veracity of the author of Acts has been questioned here, for in Gal. ii. 11 St. Paul discloses the fact that even after the agreement reached at Jerusalem Peter vacillated in his policy towards the Gentiles. If the encounter at Antioch took place after the Council at Jerusalem of Acts xv. then Peter's weakness is as hard to understand as is the obstinacy of the Jewish party. But if Ramsay's view be accepted it is much easier to reconstruct the history of events. At an informal conference in Jerusalem Peter and other leaders were persuaded to sanction an approach to the Gentiles, but not all the Jerusalem party consented nor indeed had they been consulted. The exact terms on which Gentiles might be admitted were not decided. Later, at Antioch, Peter encountered strong conservative opposition and began to waver, but at the subsequent council at Jerusalem he recovered courage enough to state his own convictions, the Jewish party were compelled to bow to the logic of facts, and the whole question was settled. Such a course of events is not inconsistent with what we know of St. Peter's character.

There are one or two hints in the New Testament as to St. Peter's later history. I. Cor. i. 12 mentions a party of Cephas at Corinth, and some have supposed that this implies a residence of St. Peter at Corinth as a consequence of which a party of his admirers was formed. But this is by no means certain, and the evidence of Dionysius of Corinth (c. 170) is too late to give substantial support to the belief.

If the first Epistle of Peter be genuine—and to some extent even if it be not—it furnishes some information about the Apostle's subsequent activities. It may suggest a ministry in Asia

Minor (i. 1), and it implies a residence in "Babylon." Babylon has been very commonly taken to mean Rome (Rev. xvi. 19, xvii. 5, etc.), and, if so, we have very early evidence of St. Peter's residence in the capital of the Empire. The belief that Peter lived in Rome goes back to Irenaeus (3 I. i.), Clement of Alexandria (*Comment. on* I. Peter), and Tertullian (*Scorp.* 15). Some hold that it is implied by Clement of Rome who couples the names of Peter and Paul as "champions nearest to us" (I. Ep. v.), and by Ignatius who says to the Romans, "I do not command you as Peter and Paul" (ad. *Rom* iv)

Irenaeus states that Mark acted as Peter's assistant in Rome, and this tradition receives support from I. Pet. v. 14 and from Papias (Euseb. H.E. iii. 39, 15).

Thus the evidence that St. Peter was at Rome is strong though not conclusive.

Early tradition (Origen, Clementines, Eusebius, Apostolic Constitutions and Jerome) also connects Peter with Antioch of which church he was said to have been the first bishop. Whether this belief was more than an inference from Gal. ii. 11 we do not know.

Nothing definite is known about the Apostle's death. Tertullian states that he was crucified under Nero, and Origen adds that at his own request he was crucified head downwards. But this testimony is late, and we have seen that Joh. xxi. suggests rather that Peter's sufferings were those of old age and restraint upon his liberty. Clement's reference to Peter's fate is very vague. If the Apostle was the author of I. Peter it is almost certain that he lived to a later date than the reign of Nero (see PETER, FIRST EPISTLE OF). Early in the third century the grave of Peter and Paul was shown in the Vatican (Euseb. H.E. 2. 25, *Acta* Petri 84), and the relics were moved to the catacombs in AD. 258. Whether or not they were genuine we have no means of judging.

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(P. G.-S., X.)

PETER I., called "the Great" (1672–1725), emperor of Russia, son of the tsar Alexius Mikhailovich and Natalia Naruishkina, was born at Moscow on May 30, 1672. His earliest teacher (omitting the legendary Scotsman Menzies) was the dyak, or clerk of the council, Nikita Zotov, subsequently the court fool, who taught his pupil to spell out the liturgical and devotional books on which the children of the tsar were generally brought up. After Zotov's departure on a diplomatic mission, in 1680, the lad had no regular tutor. From his third to his tenth year Peter shared the miseries and perils of his family. His very election (1682) was the signal for a rebellion. He saw one of his uncles dragged from the palace and butchered by a savage mob. He saw his mother's beloved mentor, and his own best friend, Artamon Matvyeev, torn, bruised and bleeding, from his retaining grasp and hacked to pieces. The haunting memories of these horrors played havoc with the nerves of a supersensitive child. The convulsions from which he suffered so much in later years must be partly attributed to this violent shock.

During the regency of his half-sister Sophia (1682–1689) he occupied the subordinate position of junior tsar, and after the revolution of 1689 Peter was still left pretty much to himself. So long as he could indulge freely in his favourite pastimes—shipbuilding, ship-sailing, drilling and sham fights—he was quite content that others should rule in his name. He now found a new friend in the Swiss adventurer, François Lefort, a shrewd and jovial rascal, who not only initiated him into all the mysteries of profligacy (at the large house built at Peter's expense in the German settlement), but taught him his true business as a ruler. His mother's attempt to wean her son from his dangerous pastimes, by forcing him to marry the beautiful but stupid Eudoxia Lopukhina (Jan. 27, 1689), was a disastrous failure. Peter practically deserted his consort about a year after their union.

The death of his mother (Jan. 25, 1694) left the young tsar free to follow his inclinations. Tiring of the great lake at Pereyaslavl (he had seen the sea for the first time at Archangel in July 1683) he returned to Archangel on May 1, 1694, to launch a ship built by himself the year before. Shortly afterwards he nearly perished in a storm in an adventurous voyage to the Solovetsky Islands in the White Sea. From the first the lad had taken an extraordinary interest in the technical and mechanical arts, and their application to military and naval science. He was taught the use of the astrolabe (which Prince Yakov Dolgoruki, with intent to please, had brought him from Paris) by a Dutchman, Franz Timmerman, who also instructed him in the rudiments of geometry and fortifications.

Peter had begun to build his own boats at a very early age, and the ultimate result of these pastimes was the creation of the Russian navy. He had already surrounded himself with that characteristically Petrine institution "the jolly company," or "the company," consisting of his personal friends and acquaintances. "The company" was graduated into a sort of mock hierarchy, political and ecclesiastical, and shared the orgies and the labours of the tsar. Merit was the sole qualification for promotion, and Peter himself set the example to the other learners by gradually rising from the ranks. In 1695 he had only advanced to the post of "skipper" in his own navy and of "bombardier" in his own army. The disreputable Lefort, for the sake of his own interests, diverted the young tsar from mere pleasure to serious enterprises, by persuading him first to undertake the Azov expedition, and then to go abroad to complete his education.

Creator of **the Russian** Navy.—By this time the White Sea had become too narrow for Peter, and he was looking about him for more hospitable waters. The Baltic was a closed door to Muscovy, and the key to it was held by Sweden. The Caspian remained; it had for long been a common saying with foreign merchants that the best way of tapping the riches of the Orient was to secure possession of this vast inland lake. But so long as the Turks and Tatars made the surrounding steppes uninhabitable the Caspian was a possession of but doubtful value. The first step making for security was to build a fleet strong enough to provide against the anarchical condition of those parts; but this implied a direct attack not only upon the Crimean khan, who was mainly responsible for the conduct of the Volgan hordes, but upon the khan's suzerain, the Turkish sultan. Nevertheless Peter did not hesitate. War against Turkey was resolved upon. and Azov, the chief Turkish fortress in those regions, which could be approached by water from Moscow, was attacked from July 8 to Sept. 22. On Nov. 22, Peter re-entered Moscow. His first military expedition had ended in unmitigated disaster.

Immediately after his return he sent to Austria and Prussia for as many sappers, miners, engineers and carpenters as money could procure. He meant to build a fleet strong enough to prevent the Turkish fleet from relieving Azov. The guards and all the workmen procurable were driven, forthwith, in bands, to fell timber in the forests of the Don, and the shipwrights worked day and night, turning out scores of vessels of all kinds. Peter himself lived among his workmen, himself the most strenuous of them all, in a small two-roomed wooden hut at Voronezh. By the middle of April two warships, twenty-three galleys, four fireships and numerous smaller craft were safely launched. On May 3, "the sea caravan" sailed from Voronezh, "Captain Peter Aleksyeevich" commanding the galley-flotilla from the galley "Principium," built by his own hand. The new Russian fleet prevented the Turks from relieving Azov by sea; and on July 18 the fortress surrendered. Peter thereupon established a new naval station, named Taganrog, at the head of the Sea of Azov.

Turkey was too formidable to be fought single-handed, and it was therefore determined to send a grand embassy to the principal western powers to solicit their co-operation against the Porte. On March 10, 1697 this embassy, under the leadership of Lefort, set out on its travels. Peter attached himself to it as a volunteer sailorman, "Peter Mikhailov," so as to have greater facility for learning ship-building and other technical sciences. As a political mission it failed utterly, the great powers being at that period far more interested in western than in eastern affairs. But personally Peter learnt nearly all that he wanted to know—gunnery at Konigsberg, shipbuilding at Saardam and Deptford, anatomy at Leyden, engraving at Amsterdam—and was proceeding to Venice

to complete his knowledge of navigation when the revolt of the ***stryeltsy,*** or musketeers (June 1698), recalled him to Moscow. This revolt has been greatly exaggerated. It was suppressed in an hour's time by the tsar's troops, of whom only one man was mortally wounded; and the horrible vengeance (September–October 1698) which Peter on his return to Russia wreaked upon the captive musketeers was due not to any actual fear of these antiquated warriors, but to his consciousness that behind them stood the reactionary majority of the nation who secretly sympathized with, though they durst not assist, the rebels.

Peter's foreign tour had more than ever convinced him of the inherent superiority of the foreigner. Imitation had necessarily to begin with externals, and Peter at once fell foul of the long beards and Oriental costumes which symbolized the arch-conservatism of old Russia. On the 26th of April 1698 the chief men of the tsardom were assembled round his wooden hut at Preobrazhenskoye, and Peter with his own hand deliberately clipped off the beards and moustaches of his chief boyars. The ***ukaz*** of the 1st of September 1698 allowed as a compromise that beards should be worn, but a graduated tax was imposed upon their wearers. The wearing of the ancient costumes was forbidden by the ***ukaz*** of the 4th of January 1700; thenceforth Saxon or Magyar jackets and French or German hose were prescribed. That the people themselves did not regard the reform as a trifle is plain from the numerous rebellions against it. By the ***ukaz*** of the 20th of December 1699 it was next commanded that henceforth the new year should not be reckoned, as heretofore, from the 1st of September, supposed to be the date of the creation, but from the first day of January, *anno domini.*

The Great Northern War.—The year 1700 is memorable in Russian history as the starting-point of Peter's long and desperate struggle for the hegemony of the north. He had concluded peace with the Porte (June 13, 1700) on very advantageous terms, in order to devote himself wholly to a war with Sweden to secure for Russia her proper place on the Baltic. The possession of an ice-free seaboard was essential to her natural development; the creation of a fleet would follow inevitably upon the acquisition of such a seaboard; and she could not hope to obtain her due share of the trade and commerce of the world till she possessed both. All the conjunctures seemed favourable to Peter. The Swedish government was in the hands of an untried lad of sixteen; and the fine fleets of Denmark, and the veteran soldiers of Saxony, were on the same side as the myriads of Muscovy. It seemed an easy task for such a coalition to wrest the coveted spoil from the young Charles XII.; yet Peter was the only one of the three conspirators who survived the Twenty-one Years' War in which they so confidently embarked during the summer of 1701. He was also the only one of them who got anything by it. Charles's "immersion in the Polish bog" (1702–1707), as Peter phrased it, enabled the tsar, not without considerable expense and trouble, to conquer Ingria and lay the foundations of St. Petersburg (Leningrad).

In these early days Peter would very willingly have made peace with his formidable rival if he had been allowed to retain these comparatively modest conquests. From 1707 to 1709 the war on his part was purely defensive; Charles would not hear of peace till full restitution had been made and a war indemnity paid, while Peter was fully resolved to perish rather than surrender his "paradise," Petersburg. After Pultava (June 26, 1709), Peter, hitherto commendably cautious even to cowardice, but now puffed up with pride, rashly plunged into as foolhardy an enterprise as ever his rival engaged in. The campaign of the Pruth (March to July 1711) must have been fatal to the tsar but for the incalculable behaviour of the omnipotent grand vizier, who let the Russian army go at the very instant when it lay helpless in the hollow of his hand. Even so, Peter, by the peace of the Pruth, had to sacrifice all that he had gained by the Azov expedition fifteen years previously. On receiving the tidings of the conclusion of the peace of Nystad (August 30, 1721), Peter declared, with perfect justice, that it was the most profitable peace Russia had ever concluded. The gain to Russia was, indeed, much more than territorial. In surrendering the pick of her Baltic provinces, Sweden had surrendered with them the hegemony of the north, and her pretensions to be considered a great power.

Reforms.—The Great Northern War was primarily a training school for a backward young nation, and in the second place a means of multiplying the material resources of a nation as poor as she was backward. During the whole course of it the process of internal domestic reformation had been slowly but unceasingly proceeding. Brand-new institutions on Western models were gradually growing up among the cumbrous, antiquated, worn-out machinery of old Muscovy; and new men, like Menshikov, Goloykin, Apraksin, Osterman, Kurakin, Tolstoy, Shafirov, Prokopovich, Yaguszhinsky, Yavorsky, all capable, audacious, and brimful of new ideas, were being trained under the eye of the great regenerator to help him to carry on his herculean task. At first the external form of the administration remained much the same as before. The old dignities disappeared of their own accord with the deaths of their holders, for the new men, those nearest to Peter, did not require them. "The Administrative Senate" was not introduced till 1711, and only then because the interminable war, which required Peter's prolonged absence from Russia, made it impossible for him to attend to the details of the domestic administration. Still later came the "Spiritual Department," or "Holy Synod" (January 1721), which superseded the ancient patriarchate. It was established, we are told, "because simple folks cannot distinguish the spiritual power from the sovereign power, and suppose that a supreme spiritual pastor is a second sovereign, the spiritual authority being regarded as higher and better than the temporal."

The official birthday of the Russian empire was Oct. 22, 1721, when, after a solemn thanksgiving service in the Troitsa Cathedral for the peace of Nystad, the tsar proceeded to the senate and was there acclaimed: "Father of the Fatherland, Peter the Great, and Emperor of All Russia." Some Russians would have preferred to proclaim Peter as emperor of the East; but Peter himself adopted the more patriotic title.

Towards the end of the reign the question of the succession to the throne caused the emperor some anxiety. The rightful heir, in the natural order of primogeniture, was the little grand duke Peter, son of the Tsarevich Alexius, a child of six; but Peter decided to pass him over in favour of his own beloved consort Catherine. The ***ustav,*** or ordinance of 1722, heralded this unheard-of innovation. Time-honoured custom had hitherto reckoned primogeniture in the male line as the best title to the Russian crown; in the ***ustav*** of 1722 Peter denounced primogeniture in general as a stupid, dangerous, and even unscriptural practice of dubious origin. The ***ustav*** was but a preliminary step to a still more sensational novelty. Peter had resolved to crown his consort empress, and on Nov. 15, 1723 he issued a second manifesto explaining at some length why he was taking such an unusual step. The whole nation listened aghast to the manifesto. The coronation of a woman was in the eyes of the Russian people a scandalous innovation, and the proposed coronation was doubly scandalous in view of the base origin of Catherine herself. (See CATHERINE I.) The ceremony took place at Moscow on May 7, 1724.

During the last four years of his reign Peter's policy was predominantly Oriental. He had got all he wanted in Europe, but the anarchical state of Persia at the beginning of 1722 opened up fresh vistas of conquest. The war which lasted from May 1722 to September 1723 resulted in the acquisition of the towns of Baku and Derbent and the Caspian provinces of Gilan, Mazandaran and Astarabad. The Persian campaigns wore out Peter's health. A long and fatiguing tour of inspection over the latest of his great public works. the Ladoga Canal. during the autumn of 1724, brought back another attack of his paroxysms, and he died after terrible suffering. on Jan. 28, 1725.

Character.—Peter's claim to greatness rests mainly on his recognition of the requirements of the Russian nation and his own obligations as its ruler. It would have materially lightened his task had he placed intelligent foreigners at the head of every department of state, allowing them gradually to train up a native bureaucracy. But he was determined that, at whatever cost,

hardship and inconvenience, Russia should be ruled by Russians, not by foreigners; and before his death every important place in his empire was in the hands of capable Russians of his own training. Even in his most sweeping reforms he never lost sight of the idiosyncrasies of the people. He never destroyed anything which he was not able to replace by something better. He possessed, too, something of the heroic nature of the old Russian *bogatuirs*, or demigods, as we see them in the *skazki* and the *builinui*. His expansive nature loved width and space.

No doubt this last of the *bogatuirs* possessed the violent passions as well as the wide views of his prototypes. All his qualities, indeed, were on a colossal scale. His rage was cyclonic: his hatred rarely stopped short of extermination. His banquets were orgies, his pastimes convulsions. He lived and he loved like one of the giants of old. There are deeds of his which make humanity shudder, and no man equally great has ever descended to such depths of cruelty and treachery. Yet it may generally be allowed that a strain of nobility, of which we occasionally catch illuminating glimpses, extorts from time to time an all-forgiving admiration. Strange, too, as it may sound, Peter the Great was at heart profoundly religious. Few men have ever had a more intimate persuasion that they were but instruments for good in the hands of God.

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(R. N. B.)

PETER II. (1715–1730), emperor of Russia, only son of the Tsarevich Alexius, was born on Oct. 18, 1715. From his childhood the orphan grand duke was kept in the strictest seclusion. On May 18, 1727 Peter II., according to the terms of the supposed last will of Catherine I., was proclaimed sovereign autocrat. The education of the young prince was entrusted to the vice-chancellor Osterman. Menshikov, who lodged Peter II. in his own palace on the Vasily island, had intended to marry him to his daughter Maria; the scheme was frustrated by his fall (Sept. 21, 1727). Peter fell into the hands of the equally unscrupulous Dolgoruki, who carried him away from Petersburg to Moscow, where he was crowned on Feb. 25, 1728. He was betrothed to Catherine, second daughter of Alexis Dolgoruki, but on the day fixed for the wedding (Jan. 30, 1730) the emperor died of small-pox.

PETER III. (1728–1762), emperor of Russia, only son of Charles Frederick, duke of Holstein-Gottorp, and of Anne, eldest surviving daughter of Peter the Great, was born at Kiel on Feb. 21, 1728. In December 1741 he was adopted by his aunt, Elizabeth Petrovna, as soon as she was safely established on the Russian throne, and on Nov. 18, 1742 was received into the Orthodox Church, exchanging his original name of Karl Peter Ulrich for that of Peter Fedorovich. On Aug. 21, 1745, by the command of his aunt, he married the princess Sophia Augusta Frederica of Anhalt-Zerbst (Catherine Alekseyevna). The union between a prince who physically was something less than a man and mentally little more than a child, and a princess of prodigious intellect and an insatiable love of enjoyment, was bound to end in catastrophe. But there is no foundation for the stories of Peter's neglect and brutality. Even when Peter III. succeeded Elizabeth on Jan. 5, 1762, he paid off Catherine's debts, without inquiring their origin. He gave her a magnificent establishment and great domains. His infidelities Catherine took as a matter of course, provided her own loae affairs were not interfered with.

Peter's foreign policy reversed that of Elizabeth. He had not been on the throne for two months when he made pacific overtures to the king of Prussia, whom he habitually alluded to as "the king my master.', Peter's worship of Frederick resulted in a peace (May 5) and then (June 19) in an offensive and defensive alliance between Russia and Prussia, whereby Peter restored to Prussia all the territory won from her by Russia during the last five years, and engaged to defend Frederick against all his enemies. This was followed up by a whole series of menacing rescripts addressed by Peter to the court of Vienna, in which war was threatened unless Austria instantly complied with all the demands of the king of Prussia. Finally he quarrelled with Denmark, and the Russian army received orders to invade Denmark by way of Mecklenburg. But before the actual collision took place news came of the coup d'état at St. Petersburg, by which Catherine (see CATHERINE II.) succeeded to the throne of Russia. From July 9 to July 17 Peter was in custody at the castle of Ropsha. His end is uncertain, but the evidence points to his murder (July 17, 1762) by Alexis Orlov, Theodore Baryatinski, and several other persons still unknown.

See R. N. Bain, *Peter III., Emperor of Russia* (London, 1902); V. A. Bilbasov, *History of Catherine II.* (Rus.), vol. i. (Berlin, 1900).

(R. N. B.)

PETER (PEDRO), the name of several Spanish kings.

PETER I., king of Aragon (d. 1104), son of Sancho Ramirez, recovered Huesca from the Mohammedans in 1096.

PETER II., king of Aragon (1174–1213), son of Alphonso II., and Sancia, daughter of Alphonso VIII. of Castile, had a very parked and curious personal character. As a Spanish prince he was a crusader, and took a distinguished part in the victory over the Almohades at the Navas de Tolosa in 1212. His lands to the north of the Pyrenees brought him in touch with the Albigenses and in 1213 he fought against Simon de Montfort's crusaders, moved not by sympathy with the Albigenses, but by hostility to the conquering intervention of the north under pretence of religious zeal. A favourer of the troubadours, he combined great personal valour with the most lax morality. He was killed at the battle of Muret (Sept. 12, 1213).

See J. Forster, *Chronicle of James I. of Aragon* (Trans. London, 1883); F. Darwin Swift, *Life and Times of James the First the Conqueror* (Oxford, 1894).

PETER III., king of Aragon (1236–1286), son of James the Conqueror and Yolande, daughter of Andrew II. of Hungary. Through his marriage with Constance, daughter of Manfred of Beneventum, he claimed Naples and Sicily from Charles, duke of Anjou, thus beginning the strife of the Angevin and Aragonese in southern Italy. His conquest of Sicily earned him the surname of "the Great." He repelled an invasion of Catalonia by the French king and died Nov. 8, 1286.

See Ramon de Muntanez, *Chronica . . .* ed. R. Lanz (Stuttgart, 1844, Fr. trans. by Buchon, Paris, 1824–28. Coll. des chroniques nationales); O. Cartellieri, *Peter von Aragon u. die Sizilianische Vesper* (Heidelberg, 1904).

PETER IV., king of Aragon (d. 1387), son of Alphonso IV. and Teresa d'Enteca, known as "The Ceremonious" by the rigid etiquette he enforced, and as "he of the dagger" because he wounded himself in cutting to pieces the so-called "charter of the Union" which authorized the rebellions of his nobles. His life was spent in warfare. He routed his nobles at Epila (1348), reannexed the Balearic islands, was engaged in conflict with Peter the Cruel of Castile until the accession of Henry of Trastamara (1369), conquered Sicily in 1377 and ceded it to his son Martin (d. 1410). He was three times married: to Mary, daughter of the king of Navarre; to Eleanor, daughter of Alphonso IV. of Portugal; to Eleanor, daughter of Peter II. of Sicily, by whom he had a daughter, Eleanor, whose marriage with John I. of Castile carried the crown of Aragon to the Castilian line.

See Zurita *Anales de Aragon* (Saragossa, 1610).

PETER, "the Cruel," king of Castile (1333–1369), son of Alphonso XI. and Maria, daughter of Alphonso IV. of Portugal, began to reign at the age of 16. Controlled at first by his mother, he emancipated himself with the encouragement of the minister Albuquerque, against whom he turned under the influence of his

mistress, Maria de Padilla, the one woman of his harem of whom he never became tired. In 1354 he was coerced into marrying Blanche of Bourbon, and deserted her at once. Imprisoned in the period of turmoil that ensued, he escaped from Toro to Segovia, and from 1356–66 he was master, and was engaged in continual wars with Aragon. It was at this time that he perpetrated the series of murders which made him odious, earning the reputation of monstrous cruelty indicated by his title. In 1366, attacked by Henry of Trastamara, he fled and took refuge with the Black Prince, who reinstated him. When the Black Prince left Spain, disgusted by his ally's ferocity, Peter was overthrown by Henry, with the aid of du Guesclin, in whose tent he was murdered March 23. 1369.

See P. Lopez de Ayala, *Crónicas de los reyes de Castilla* . . . (Madrid, 1779–80, 2 vols.); P. Mérimée, *Histoire de Don Pèdre I.*, roi *de Castille* (Paris, 1848; Eng. trans., 1849).

PETER I. (1844–1921), first King of the Serbs, Croats and Slovenes, was the eldest son of Alexander Karagjorgjević, who had been elected as Prince of Serbia on the expulsion of the Obrenovid dynasty in 1842, and was therefore grandson of Kara George, the first leader of Serbian independence. His father lost his throne in 1858, and withdrew to Austria, where Peter grew to manhood. Accused of conspiring against Prince Michael Obrenovid (1868), Prince Alexander transferred himself to Switzerland, and Peter made Geneva his headquarters for many years.

In 1870 he joined the French Army as a volunteer, and served with distinction in the campaign against Germany. In 1876 he joined the Bosnian insurgents against Turkey and fought under the assumed name of Peter Mrkonjić, leaving behind him a legend which had its influence on the young revolutionaries of a later generation. In 1882 he, the exiled Pretender, and not the newly proclaimed King of Serbia, was invited to attend the coronation of Tsar Alexander III., who resented Milan's dependence upon Vienna; and it was very largely due to the Tsar's personal influence that in 1883 Peter married Zorka, daughter of Prince Nicholas of Montenegro. For a time he lived at Cetinje, but after his wife's death in 1890 he again lived in Geneva.

In 1903 shortly after the murder of King Alexander and Queen Draga by a military gang, Peter was unanimously elected King of Serbia and though he was gravely embarrassed at home by the political interference of the regicides, and abroad by the odious circumstances to which he owed his accession, he set himself steadily to work for constitutional government, his tact, self-effacement and liberal outlook forming a marked contrast to the attitude of Serbia's previous rulers and contributing to the rapid political consolidation which followed the upheaval of 1903. In June 1914 ill-health forced him to entrust Crown Prince Alexander with the regency, and condemned him to a passive rôle during the World War. But the simplicity of his life, his stirring proclamations to his soldiers and the visits which he paid to the trenches in a half crippled condition, did much to encourage Serbian resistance; and he shared the privations of the great retreat across Albania, lying in a litter. After the war and his election as "king of the Serbs, Croats and Slovenes," he lived mainly in retirement at Topola and died on Aug 16, 1921. (R. W. S.-W.)

PETER, FIRST EPISTLE OF. The Epistle is addressed to the elect who are sojourners of the dispersion (*diaspora*) in Pontus, Galatia, Cappadocia, Asia and Bithynia. The term "dispersion" suggests scattered Jews, but references in the epistle to their previous benighted state (i. 14, ii. 9–10, iv. 3) seem rather to imply that the recipients were Gentiles, and if so, the word "dispersion" is used metaphorically for Christians scattered among the heathen. The primary purpose of the writer seems to have been to strengthen the courage of these Asian Christians who were faced with persecution, and to enjoin on them such conduct as would remove all excuse for the common confusion between Christianity and crime.

The questions of date and authorship are closely connected, for many critics have maintained that the contents of the epistle imply a date subsequent to the death of St. Peter. (a) References to persecution occur in i. 6, ii. 12, iv. 12–19, v. 9; the recipients are undergoing a "fiery trial"; they have to bear reproaches, and to endure an evil reputation; they may "suffer" as do thieves and murderers, although it is not clear that death is the inevitable penalty; so severe is the trial that it must mark the beginning of the end; persecution is general, and not confined to the provinces addressed. These are very similar conditions to those implied in Pliny's letter to Trajan, and therefore it is argued that I. Peter belongs to the same period and was written long after the Apostle's death.

It is true that if we accept the tradition of Peter's death under Nero it is very difficult to suppose that these conditions existed during his lifetime. There was certainly no general persecution before Nero, and our only real authority (Tacitus) gives no hint that the Neronian persecution extended beyond the city of Rome where it was due to local causes. Systematic religious persecution was so strange to the easy tolerance of Rome that most scholars think that a considerable time must be allowed for the policy to have developed. Ramsay thinks that the Flavian emperors began systematic persecution after the Jewish war; others believe that there was nothing serious in the provinces before the reign of Domitian (81–96), and Professor Merrill (Essays *in* Early Christian History) is sceptical even about that. But the evidence of the Apocalypse seems decisive that Rome persecuted systematically in the time of Domitian, at least in Asia. I. Peter appears to have been written at a time when the conditions reflected in Pliny's letter were just coming into being; the imperial authorities were manifesting hostility due to a lack of understanding, but there had been few if any martyrdoms, and the author betrays none of the ferocious resentment against Rome which characterizes the Apocalypse, indeed he still entertains a respect for the authorities not unlike that of St. Paul (I. Pet. iii. 13). There is no allusion to the Emperor-worship which caused trouble in Domitian's time. On these grounds it seems possible to date the epistle roughly. The terminus ad quem is fixed by the full development of the Domitian policy. If Ramsay is right in connecting persecution with the Jewish war, 70 is the *terminus* a quo; if not, 85–90 is the most probable date, but the epistle must be considerably earlier than the Domitian portions of the Apocalypse. (b) It is generally agreed that the epistle has close affinities with some other early Christian works, notably the Epistle to the Romans (*q.v.*), the Epistle to the Ephesians (*q.v.*), the Epistle of James (*q.v.*), and the Epistle of Polycarp. Unfortunately the dates of some of these works are uncertain, and it is not agreed on which side is the dependence. The majority of scholars allow that in the case of Romans the dependence is on the side of Peter, and the balance of opinion favours the priority of Ephesians, though not of James. If so, the author of I. Peter wrote at a time when Romans and Ephesians were well known at least in his neighbourhood. If the Pauline authorship of Ephesians is rejected the inference must be that I. Peter was written at a time when a pseudo-Pauline epistle had had time to gain currency, and that could hardly be earlier than the second century. But, as we have seen, there are difficulties in dating I. Peter after the Apocalypse. If Ephesians be a genuine work of St. Paul then I. Peter may have been written at any time after St. Paul's imprisonment. If James is dependent on I. Peter then we have an additional argument for the early date of I. Peter. The objection that Peter would not be likely to quote Paul is only forcible on the old Tübingen theory of a life-long feud between them. (c) The theology of I. Peter is simple and bears marked resemblances to that which finds expression in the early speeches in Acts. Its "Paulinism" has been much exaggerated. Jesus is the promised Messiah, and "the Spirit of Christ" is the spirit which was in the prophets. His suffering for sin had rescued the elect, and his endurance was an example for Christians faced with persecution. After death Jesus preached to "the spirits in prison." The source of Christian life is to be found in belief in God and in baptism. Christians are a royal priesthood, a holy nation, destined at the end of the world, which is close at hand, to inherit the promises. Church organization as it appears in this epistle is very simple and primitive; there are elders who shepherd the flock, but there is nu trace of a developed organization. There is nothing in these facts to preclude a belief in the Petrine author-

ship of the epistle. If, in spite of tradition to the contrary, St. Peter survived the days of Nero and lived subsequently in Rome, he may well have been acquainted with some of St. Paul's letters, particularly with one written to the Romans and with another written during the Apostle's imprisonment in the city. Re may have lived to see the beginnings of that persecuting policy uhich wrought such havoc in the time of Domitian and which we find fully established in the days of Pliny. Nor is the language difficulty serious. St. Peter had lived for many years among Greek-speaking communities, and he would doubtless employ an amanuensis. I. Peter was the first of the Catholic epistles t~ secure a place in the canon of Scripture, and it seems to have been widely accepted by the end of the second century. It is, however, omitted from the Muratorian canon which probably represents the opinion of Rome about AD. zoo. The omission may have been accidental, and Zahn would emend the text.

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PETER, SECOND EPISTLE OF. This epistle claims to have been written by "Simon (or Symeon) Peter, a servant and Apostle of Jesus Christ" The author, after a preliminary exhortation, declares his desire to testify again to the power of Jesus. He bases his testimony partly on his own experience "in the holy mount," and partly "on the word of prophecy." The mention of prophecy leads him to deal with the question of false prophets who are accused of false doctrine and immoral practices. In this section (ii. 1–22) is included almost the whole of the epistle of Jude (q *v.*). The author then deals with the expectation of the *Parousia* which some were beginning to doubt. This is the main object of the letter, to attack the false prophets and to defend the certainty of the *Parousia* of the Lord.

As I Peter was the first of the Catholic Epistles to be admitted into the canon, so II. Peter was the last. It was accepted at Alexandria in the third century, thence it passed into the canon of the church of Constantinople; but not until the fourth century was it accepted at Rome, and the Syrian church admitted it in the sixth century.

The cumulative weight of the following objections to its authenticity is generally held to disprove its claim to Petrine authorship:— (a) Origen, the first to mention it as Petrine, admits that its authorship was disputed. (b) The style, language and thought not only differ from I. Peter but from the rest of the New Testament. (c) References to immorality associated with false teaching seem to belong to a date much later than that of the Apostle Peter. (d) The incorporation of Jude makes Petrine authorship improbable. (e) The attribution of scriptural authority to the Pauline epistles (iii. 16) points to a date not earlier than the second century.

It is impossible to say when or where the epistle originated. For the date, a *terminus* a *quo* must be fixed by (1) the prevalence of an immoral gnosticism; (2) the attainment by the Pauline epistles of a quasi-scriptural authority: (3) the use made of the epistle of Jude, and perhaps of the Apocalypse of Peter. The *terminus ad quem* is the use of the epistle by Origen. We may say that the most probable date for its composition is the middle of the second century.

It may have been written in Egypt, where it first appears; or, as Deissmann thinks, it may have originated in Asia Minor.

The theology of II. Peter is suggestive of a late date Christ is referred to as "our God and Saviour," and the fatherhood of God seems to be understood only in reference to the Son. The work of Christ was the redemption of the elect, and this redemption awaits its consummation in the *Parousia.* The present world will be destroyed by fire, and the wicked, whether angels or men, will be finally condemned; then will begin a new era of happiness for the elect.

BIBLIOGRAPHY.—*See* the bibliographies to PETER, FIRST EPISTLE OF, JUDE, EPISTLE OF. (P. G.-S.)

PETERBOROUGH, a city and port of entry of Ontario, Can, and capital of Peterborough county, situated 7j mi. N E. of Toronto, on the Otonabee river and the Canadian National and the Canadian Pacific railnays. The population (1951) was 38,272.

The five falls of the Otonabee at this point, nith a total descent of jo ft., furnish power for a large and increasing nurnber of manufacturing establishments. nhile its canalization as part of the Trent canal gives communication nith Lake Ontario and Georgian hay. Peterborough is the centre of Canada's watch and clock industry, has a cereal and flour mill and manufactures electric machinery, dairy equipment, knitted goods, health foods and canoes.

PETERBOROUGH, a city in the separate administrative county of the Soke of Peterborough, Northamptonshire, Eng., 41 mi. N.E. of Northampton by road. Pop. (1951) 53,417. Area, 15.7 sq.mi. It is on the western border of the fen country astride the Sene river. which is navigable to the sea by ships of 400 tons burden. It is the focus of important rail and road services and a great ecclesiastical, commercial and agricultural centre. There are railway and engineering works. factories for textiles and beet sugar. and numerous smaller industries, Many inhabitants are employed at the large brickworks at Fletton, in the belt of Oxford clay on the south side of the tonn, in Huntingdonshire

A village called Medeshamstede ("the settlement in the meadows") was there in 655 when Peada king of the Middle Angles, founded the Benedictine abbey of Sts. Peter. Paul and Andrew. Its name nas changed to Burgh between 992 and 1005 after Abbot Kenulf had made a wall around the minster, but the town was not a borough until the 12th century. The burgesses received their first charter from "Abbot Robert," probably Robert of Sutton (1262–73). Peterborough mas created a city by letters patent in 1541. Until the 19th century the dean and chapter. who succeeded the abbot as lords of the manor, appointed a high bailiff, and the constables and other borough officers were elected at their court leet, but the borough was incorporated in 1574. Among the privileges claimed by the abbot as early as the 13th century nas that of having a prison for felons taken in the soke and borough. In 1576 Bishop Scamble sold the lordship of the hundred of Nassaburgh, coextensive nith the soke, to Queen Elizabeth I, who gave it to Lord Burghley. and from that time until the 19th century he and his descendants, marquesses of Exeter, had a separate jail in I'eterborouph. The city sent two members to parliament for the first time in 1547, but the number was reduced to one in 1885, and in 1918 representation of the city was merged with that of the county.

Weaving and wool combing were carried on in the town in the 14th century.

The cathedral of St. Peter is the third church to occupy the site. The first, founded by Peada about 655, was destroyed by the Danes in 870; the second was accidentally burned donn in 1116 (foundations of the Saxon choir may still be seen). The present building dates from the first half of the 12th century, with some later nork, and presents a splendid picture of the transition through the various Norman styles to Early English. Most of the oolitic limestone used was quarried at Barnack, 8 mi. N.W. of the city.

The first portions to be rebuilt by Abbot John de Sais after the fire of 1116 were the choir and the transepts. Two bays of the nave had been completed and the central tower begun. This was finished by Abbot William de Waterville (1155–7j). Abbot Benedict finished the nave to the west transepts, which are the work of Abbot Andrew (1195–1200).

The magnificent west façade was put up in the early 13th century, its porch being added about 1370. The painted nooden ceiling of the nave. with its lozenge-shaped divisions, is Norman and is probably the oldest in England.

In 1270 a Lady chapel nas built but mas pulled down to provide material for the repair of the cathedral which lay almost in ruin after Cromwell's men had stripped the lead from the roof, burned stalls, screens and other noodnork and smashed the stained-glass windows. Finally, in the late 15th century "the new building" was added at the east end an ambulatory nith fan vaulting. Among the most important restoration works later

undertaken was the rebuilding of the central tower (1883), which had become insecure.

Catherine of Aragon was interred in the north choir aisle in 1536. A monument in the south choir aisle marks the place where the body of Mary, queen of Scots, lay after her execution at Fotheringay (1587) until it was removed (1612) to its final resting place in Westminster abbey.

Remains of other monastic building include the great gateway from the market place erected by Abbot Benedict (1177–93). Over it was the chapel of St. Nicholas. Immediately north of it is the chancel of the chapel of St. Thomas Becket, the nave of which provided material for the parish church of St. John the Baptist. On the south side of the precincts is the gateway (*c.* 1302) known as the Knight's gateway. The cloisters were ruined by Cromwell's men but still retain old doorways, etc., in the outer walls. Ruins of the refectory and the infirmary remain.

The old parish church of St. John the Baptist was situated to the east of the cathedral, but was rebuilt on its present site in the market square in 1401–07. East of the church is the old tonn hall (1671); modern buildings housing city and county administration were erected 1929–33 in Bridge street. In 1939 a new building to house an art gallery was erected adjoining the museum, which has a good varied collection of local antiquities, etc.

Educational establishments include the King's school, founded by Henry VIII in 1541 and Deacon's school, founded by Thomas Deacon in the 18th century.

Peterborough has an important agricultural show in July. The Bridge fair (first Tuesday, Wednesday and Thursday in October) dates from 1439. There is a Wednesday market (miscellaneous) and a vegetable and fruit market on Saturdays.

The city of Peterborough is a noncounty borough within the administrative county of the Soke of Peterborough, the usual functions of a noncounty borough council being exercised throughout the city area by the city council. City and county councils combine to form the Peterborough Joint Education board as the local education authority for the administrative county and to vest police powers in the Peterborough Combined Police authority. Quarter sessions for the Liberty of Peterborough are held in the city.

PETERBOROUGH AND MONMOUTH, CHARLES MORDAUNT, 3RD EARL OF (c. 1658–1735), English soldier and statesman, son of John Mordaunt, created Viscount Mordaunt of Avalon and Baron Mordaunt of Reigate, in 1659, and Elizabeth Carey. He served in the Navy and then became a Whig and keen opponent of James II. In Holland in 1686 he proposed to William of Orange the invasion of England; and, later, when William was king, Mordaunt was made a privy councillor, first lord of the treasury. and earl of Monmouth. Against the king's wishes, he introduced a bill for triennia! parliaments in 1693, and in 1697 he was sent to the Tower on the ground of complicity in Sir John Fenwick's conspiracy. Soon after, on the death of his uncle, Henry Mordaunt, he became earl of Peterborough.

In the reign of Anne he drew down on himself in 1702 the censure of the Commons for his action in trying to secure the return of his nominee at Malmesbury, and was sent off in 1705 to command an expedition in Spain. He besieged Barcelona and in 1706 entered Valencia in triumph. It is difficult to understand the action of Peterborough during this campaign, unless on the supposition that he was out of sympathy with the movement for placing the Austrian prince Archduke Charles on the throne of Spain. He was recalled to England to explain his conduct and joined the Tories in 1707.

The differences between the three peers, Peterborough. Galway and Tyrawley, who had served in Spain, caused angry debates in the Lords, but the majority declared for Peterborough, and votes of thanks were passed to him in 1708. He next went to Vienna, where he engaged the ministry in pledges of which they disapproved. Nevertheless, he was made a Knight of the Garter. With the accession of George I. Lord Peterborough's influence was gone, and he died at Lisbon on Oct. 25, 1735.

Short in stature and spare in habit, he was of fierce and turbulent disposition. He is said to have seen more kings than any man in Europe, and the point of Swift's lines on "Mordanto" consists in a description of the speed with which he hastened from capital to capital. He was eloquent in debate and intrepid in war, but his influence was ruined by inconsistency and his want of union with his colleagues. His first wife, Carey, daughter of Sir Alexander Fraser of Dores, Kincardineshire, died in 1709. In 1722 he secretly married Anastasia Robinson, a famous singer of great beauty and sweetness; but she lived apart from him (regarded as his mistress), and it was only shortly before his death that she was acknowledged as the countess of Peterborough.

BIBLIOGRAPHY.--*See* the life by William Stebbing (1890), and *War of the Succession in Spain,* by the Hon. Arthur Parnell (1905). The earlier lives are founded on the memoir of Capt. George Carleton (1728). which was dismissed as a fictitious narrative inspired by Swift, in the *Eng. Hist. Rev.* (1891), vi. 97–151.

PETER CHRYSOLOGUS, SAINT, (c. 4001406–c. 450), Latin father and doctor of the church. Little is known with certainty of his life. He was born at Imola in northern Italy and about 433 became bishop of Ravenna, the residence of the western Roman emperor. Peter was a zealous pastor, who preached regularly to his flock and, with 'the aid of the empress regent Galla Placidia, promoted the construction of church buildings. He was a close friend of Pope Leo the Great and was revered in both the east and the west for his eloquence and orthodoxy. In 448 Eutyches, the Monophysite heresiarch. appealed his condemnation to Peter as well as to Pope Leo. Peter's kindly reply withheld judgment but counseled obedience to the bishop of Rome. Soon afterward he retired to Imola and there died about 450. Many of his homilies survive, together with the letter to Eutyches. In the standard collection of 176 sermons, however, made in the 8th century, several are unauthentic, while other genuine homilies probably exist among the works of other authors. His sermons are short and popular, stressing the fundamental Christian doctrines and the duties of Christian life. They are not profound, original or elegant, but they reflect the needs and ideals, the virtues and vices of the times. The appellation *Chrysologus* ("Golden Orator") arose later, probably to create a western counterpart to the east's John Chrysostom. He was given the title of doctor of the church in 1729. His feast day is Dec. 4.

See G. Ganns, *Saint Peter Chrysologus: Selected Sermons* (1953).
(JN. SR.)

PETER CLAVER, SAINT (PEDRO CLAVER) (1581–1654), missionary to the Negro slaves in Spanish America, was born at Verdu, Catalonia. in 1581 and entered the Society of Jesus in 1602. While studying at the college of Palma in Majorca he was inspired by the holy lay brother St. Alphonsus Rodriguez to volunteer for the missions of New Spain. In 1612 he was sent to Cartagena (in modern Colombia). where he was ordained in 1616. At Cartagena. the chief slave market of the new world, every month slave ships disembarked 1.000 or more Negro slaves. The condition of these poor wretches aboard ship and in the slave pens was horrible beyond description, and the new priest, declaring himself "the slave of the Negroes forever," dedicated his life to them. Accompanied by interpreters and carrying food and medicines, he boarded every incoming slave ship and constantly visited the slave pens, befriending and defending the oppressed, nursing the sick and dressing their sores, teaching religion and baptizing them. His heroic labours met with strong opposition: and even ecclesiastics lent their ears to charges of indiscreet zeal. Claver persevered for 38 years, baptizing, according to reliable estimates, 300.000 slaves.

He died at Cartagena Sept. 4, 1654. Pope Leo XIII canonized him on Jan. 15, 1888, and on July 7, 1896, declared him the patron of all Catholic missions to Negroes. His feast day is Sept. 9.

BIBLIOGRAPHY.—Antonio Astrain, S. J., *Historia de la Compañia de Jesus en la Asistencia de España,* vol. v, pp. 479–495 (1916); Arnold Lunn, *A Saint in the Slave Trade* (1935); J. Sola, *Vida de San Pedro Claver* (1888). (*M. P.* H.)

PETER DES ROCHES (d. 1238), bishop of Winchester under John and Henry III, was a Poitevin by extraction. He received the office of chamberlain toward the close of Richard's reign, and under Richard's successor became an influential counsellor. In 1205 he became bishop of Winchester, and though his

election was disputed, it was confirmed by Pope Innocent III, who honoured Peter by consecrating him in person. None the less, the bishop stood by his royal patron during the period of the interdict and during the struggle with the barons. In 1213 he was made justiciar in succession to Geoffrey Fitz Peter. At the battle of Lincoln (1217) Peter led a division of the royal army and earned some distinction by his valour; but he played a secondary part in the government so long as William Marshal held the regency. After Marshal's death (1219) Peter led the baronial opposition to Hubert de Burgh, with varying success. At first the justiciar was successful. In 1221 Peter meditated going on crusade; 1223–1224 saw his party broken up by Hubert's energetic measures. In 1227 he was himself dismissed from his office and left England to join the crusade of the emperor Frederick II. He was absent from England until 1231; but in the meantime enhanced his reputation both as a soldier and diplomatist. After the fall of de Burgh he kept in the background, but offices and honours were heaped on his dependants. This foreign party triumphed over the revolt which was headed by Richard Marshal in 1233. But the primate, Edmund Rich, denounced Peter as a mischief maker, and demanded his dismissal. Peter was permitted to leave the country with a pardon (1235); he conciliated Gregory IX by rendering efficient aid in a war with the citizens of Rome (1235); and in the next year returned without molestation to his see. Peter died in 1238, and was buried at Winchester.

PETERHEAD, a small burgh and seaport in the Buchan district of Aberdeenshire, and the most easterly town in Scotland, 32 mi. N.N.E. of Aberdeen by road. Pop. (1951) 12,763. The town is built of locally quarried red granite. A statue to Marshal F. E. J. Keith (*q.v.*), born in 1696 at Inverugie castle, 2 mi. N.W., was presented to the burgh in 1868 by William I of Prussia. There is much local trade from the port, which is an important station of the herring fisheries and head of a fishery district, with a large herring fleet which has been converted from steam fishing drifters to modern wooden dual-purpose vessels. The north and south harbours lie between the town and Keith-Inch, an island suburb, and the isthmus dividing them is pierced by a canal; in the north harbour there is a graving dock and a patent slipway. The breakwater, enclosing about 400 ac. of water (the Harbour of Refuge), has been built partly by convict labour; and prisoners from the same prison. Salthouse Head, still quarry the stones for it.

The town and lands belonged of old to the abbey of Deer, but when the abbey was erected into a temporal lordship in the family of Keith the town passed to the earl marischal, with whom it continued till the forfeiture of the earldom in 1716. It was bought in 1720 by an English building company, which failed, and then by the Merchant Maidens' hospital of Edinburgh, which is still the overlord. Peterhead, made a burgh of barony in 1587 by George Keith. 5th earl marischal, was the scene of the landing of the Old Pretender on Christmas day, 1715. In addition to granite quarrying and polishing, now almost extinct, the leading industries are shipbuilding, fish curing, fish and vegetable canning, woollen manufactures and light engineering.

PETERLOO, or the Manchester massacre, a name given to a meeting held on Aug. 16, 1819, in St. Peter's fields, Manchester. Its object was to demand the reform of parliament and it was attended by about 60,000 persons, including an unusually large proportion of women and children. None were armed and their behaviour was admittedly wholly peaceable, but the magistrates, who were in a nervous condition, ordered the Manchester yeomanry to seize the speakers immediately after the meeting had begun. The yeomanry, who were untrained Manchester businessmen, did not confine themselves to arresting the leaders, but made a general attack upon the audience, crying "Have at their flags," and cutting them down with the edge as well as the flat of their sabres. The chairman of the bench of magistrates thereupon ordered the 15th hussars and the Cheshire yeomanry also to charge the crowd, and in ten minutes the place was cleared except for bodies, "some still groaning, others with staring eyes, gasping for breath; others will never breathe more; all silent save for those low sounds and the occasional snorting and pawing of steeds." The numbers of killed and wounded were disputed; 600 authenticated cases are known. The indignation caused by the behaviour of the yeomanry and its endorsement by the government contributed largely to the ultimate success of the reform movement.

A Peterloo medal, now rare, was struck, bearing the legend "The wicked have drawn out the sword, they have cut down the poor and needy and such as be of upright conversation" (Ps. xxvii, 14).

See *Memoirs of* H. *Hunt, Esq.* (1820–22); S. Bamford, *Passages in the Life of a Radical* (1893); *F. A.* Bruton, *Story of Peterloo* (1919), *Three Accounts of Peterloo* (1521). (R. W. P.)

PETER MARTYR, a name commonly used in English for (1) ST. PETER MARTYR (d. 1252), killed by Cathars; (2) PIETRO MARTIRE D'ANGHIERA (1457–1526), Italian historian; and (3) PIETRO MARTIRE VERMIGLI (*q.v.*).

PETER NOLASCO, SAINT (PIERRE NOLASQUE) (c. 1189–1256), founder of the order of Our Lady of Ransom (de Mercede), commonly called Mercedarians, was born of noble parents at Mas-Saintes-Puelles in Languedoc. The facts of his life are obscure and controversial. Declining to marry, he dedicated himself to God's service among the poor and abandoned. The belief that he took part in the Albigensian campaign or was tutor to James I, king of Aragon, has been doubted. He uent to Spain, where the Moors held many Christians in slavery. Peter spent his patrimony ransoming them and got others to contribute. Later he determined to found a religious institute whose primary object would be the ransoming oi Christian slaves. The extent of Raymond of Peñafort's influence on the founding of the order has been disputed by the Dominicans and Mercedarians, and consequently the date of ceremonial foundation in Barcelona is variously given as 1218, 1223, 1228 and 1234. The documento de *los sellos,* a notarial act, treating of Our Lady's simultaneous apparitions, commanding the founding of the order, to Peter himself, Raymond and James I, has been proved a forgery. Peter twice went to Africa to redeem slaves. He resigned his offices of master general and ransomer some years before his death at Barcelona on Dec. 24/25, 1256. He was canonized in 1628, and his feast day is Jan. 28.

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PETER OF BLOIS (PETRUS BLESENSIS) (c. 1135–*c.* 1205), French writer, the son of noble Breton parents. mas born at Blois. In 1167 he went to Sicily. where he became tutor to the young king William II, and keeper oi the royal seal. He made many enemies and soon asked permission to leave the country, returning to France about 1170. Peter entered the employ of Henry II of England about 1173. He became archdeacon of Bath and soon aiterward chancellor, or secretary, to Richard, archbishop of Canterbury, and to Richard's successor, Baldwin, being sent on two occasions to Italy to plead the cause of these prelates before the pope.

After the death of Henry II in 1189, he was for a time secretary to his widow, Eleanor, in Normandy; he obtained the posts of dean of Wolverhampton and archdeacon of London. He died some time after March 1204.

Peter's writings fall into four classes, letters, treatises, sermons and poems. His Epistolae, collected at the request of Henry II, are an important source for the history of the time; they are addressed to Henry II. and to various prelates and scholars, including Thomas à Becket and John of Salisbury. His treatises include De Ierosolymitana peregvinatione *acceleranda,* an exhortation to take part in the third crusade, and *Dialogus* inter *regem Henricum* II et *abbatem Bonaevallensem;* his extant sermons number 65 and his poems are unimportant. Peter's works were printed in several collections, including the Patrologia of J. P. Migne and the *Historiae francorum* scriptores of A. Duchesne. Of separate editions the best are by Pierre de Goussainville (1667) and J. A. Giles (1846–47).

See W. Stubbs, Lectures on Mediaeval and Modern History **(Oxford,**

1886); Sir T. D. Hardy, *Descriptive Catalogue of Materials Relating to the History of Great Britain* (1862–67); C. L. Kingsford in vol. xlv of the *Dict. Nat. Biog.*

PETER OF COURTENAY (d. 1219), emperor of Rumania (or Constantinople), was a son of Peter of Courtenay (d. 1183), and a grandson of the French king, Louis VI. Having, by a first marriage, obtained the counties of Nevers and Auxerre, he took for his second wife Yolande (d. 1219), a sister of Baldwin and Henry of Flanders, who were afterward the first and second emperors of the Latin empire of Constantinople. Peter accompanied his cousin, King Philip Augustus, on the crusade of 1190. fought against the Albigenses and was present at the battle of Bouvines in 1214. When his brother-in-lam, the emperor Henry, died without sons in 1216, Peter was chosen as his successor. Consecrated emperor at Rome, in a church outside the walls, by Pope Honorius III on April 9, 1217, he borrowed some ships from the Venetians, promising in return to conquer Durazzo for them; but he failed in this enterprise, and sought to make his way to Constantinople by land. On the journey he was seized by the despot of Epirus, Theodore Angelus, and, after an imprisonment of two years, died, probably by foul means.

PETER OF SAVOY (*c.* 1203–1268), earl of Richmond, younger son of Thomas I (Tommaso), count of Savoy, was born at Susa. After spending several years as an ecclesiastic, he resigned his preferments, and in 1234 married his cousin, Agnes, daughter and heiress of Aymon II, lord of Faucigny. On the invitation of the English king, Henry III, who had married his niece, Eleanor of Provence, Peter went to England in 1240, and was created earl of Richmond, receiving also large estates and being appointed to several important offices. During several visits to the continent of Europe Peter increased his possessions in the Vaud district, and, returning to England in 1252, he became associated with Simon de Montfort, retaining at the same time the king's friendship. He was employed by Henry to negotiate with the pope and Louis IX of France, but supported Earl Simon in his efforts to impose restrictions upon the royal power. He went over to Henry's side in 1260, and was consequently removed from the council. In 1263 he left England, and when his nephew, Boniface, count of Savoy, died in the same year he assumed the title of count of Savoy. This was also claimed by another nephew, Thomas; but Peter compelled the inhabitants of Turin to submit to him and secured possession of the county. He died on May 16 or 17, 1268. Peter gave his name to the Savoy palace in London.

PETERS or PETER, **HUGH** (1598–1660), English Independent clergyman, was educated at Trinity college, Cambridge, where he graduated M.A. in 1622. He took Anglican orders, and was appointed lecturer at St. Sepulchre's, but his unorthodox opinions drove him to the continent, where he remained till 1635. In that year he sailed for America, where he already had connections, and he became minister at Salem! Mass. He played a leading part in the affairs of the colony and in the founding of Connecticut. Returning to England as agent for the new colony in 1641, he became involved in political matters. He was chaplain to the force of adventurers in Ireland, served in Lord Forbe's expedition and in the campaigns of 1645 and 1646, and by his eloquence is said to have materially assisted the parliamentary cause.

Although an influential leader of the Independents, Peters was disliked by the presbyterians. He supported the army in its quarrel with parliament, and in 1649 he accompanied Cromwell to Ireland and was present at the fall of Wexford; also the battle of Worcester. Appointed chaplain to the council of state (1650), he preached at Whitehall continually during the protectorate, and gained much influence. In 1652–53 he protested against the Dutch war, and was severely reprimanded. Soon after he retired from public life. At the Restoration he was specially exempted from the Act of Indemnity, tried for abetting the execution of Charles I, found guilty and executed on Oct. 16, 1660.

PETERS, KARL (1856–1918), German explorer, one of the founders of German East Africa, was horn at Neuhaus on the Elbe on Sept. 27, 1856. He visited London to study English principles of colonization and on returning to Berlin founded the Society for German Colonization in 1884. The same year he went to the coast of east Africa where he made treaties in favour of Germany with native chiefs. A further expedition led by Peters under the auspices of the German East Africa company in 1887, avowedly for the relief of Emin Pasha, extended the sphere of German influence. Peters reached Uganda early in 1890 and concluded a treaty with the king, but without the support of the German government. This treaty was declared void as an agreement had been reached between Germany and Great Britain by which Uganda was left in the British sphere. Back in Germany Peters published in 1891 an account of his expedition, *Die deutsche Emin Pasha Expedition (New Light on Dark Africa).* He was imperial high commissioner for Kilimanjaro in 1891, but in 1897 was deprived of his comtnission for misuse of official power in his treatment of the natives; he was reinstated in 1906. From 1899 to 1901 he explored the Fura district and Macombe's country on the Zambezi, with a view to commercial exploitation, and described his discovery of ancient cities and deserted gold mines in *Im Goldland des Altertums (The Eldorado of the Ancients;* 1902). Peters died at Woltorf, near Brunswick, on Sept. 10. 1918.

See H. T. Schorn, Dr. *Carl Peters* (1920).

PETERSBURG, a city of southern Virginia, U.S., 23 mi. S. of Richmond on the Appomattox river. In 1646 Ft. Henry was built at the falls of the Appomattox, the site of the present city. Maj. Peter Jones became commander of the fort in 1675; from him, directly or indirectly. Petersburg seems to have derived its name. In 1733 Col. William Byrd II surveyed the site but it was not until 1748 that an act of the colonial legislature estahlished the town of Petersburg. In 1784 Petersburg, Blandford, Pocahontas and Ravenscroft were combined and incorporated as one tonn, Petersburg During the American Revolution it was captured by British troops under William Phillips and Benedict Arnold on April 25, 1781 On May 20 Cornwallis arrived nith his army and a few days later began the campaign that was to end with his surrender at Yorktown

Petersburg was the scene of prolonged and bitter fighting during the American Civil War. In June 1864 following his costly failure to defeat Gen Robert E. Lee at Cold Harbor, Gen. U. S. Grant moved his army to the south side of the James. The southern approaches to Richmond nere blocked by Petersburg and Grant's efforts to take the city developed into a virtual siege that lasted for 10 months. On April 2, 1865, his defenses crumbling and his army in danger of destruction, Lee ordered a withdrawal from Petersburg. Richmond was evacuated on April 3 and the mar was all but over. (See also PETERSBURG CAMPAIGN.)

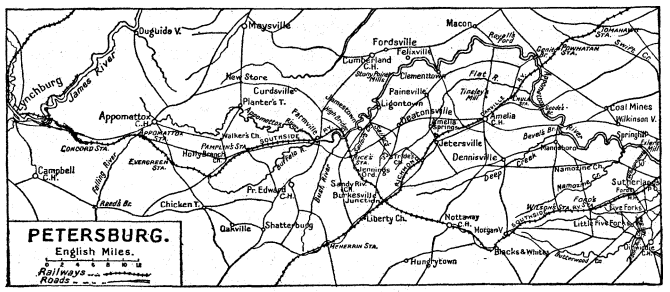
Petersburg National Military park. which embraces portions of the battlefield, is only one of many historic sites in and around Petersburg. Centre Hill mansion. built in 1823, was an antebellum show place; it now houses an important collection of Civil War relics. Bristol parish church in Blandford, built in 1737, has been restored. Adjoining it is the Confederate cemetery.

Petersburg has more than historic importance; it is a progressive city engaged in a long-range, comprehensive program of modernization and improvement. Its industrial output includes cigarettes and other tobacco products, optical lenses and frames, trunks and hand luggage, wearing apparel and Fiberglas boats. Nearby Hopewell has large plants producing industrial chemicals, paper and allied products and synthetic fibres. Petersburg has a council-manager form of government, in effect from 1920.

Virginia State college and Central State hospital lie just outside Petersburg Ft. Lee, the U S. army quartermaster training command, is one-half mile east of the city. For comparative population figures *see* table in VIRGINIA. *Population.* (M. **BR.**)

PETERSBURG CAMPAIGN (1864–65). The name of Petersburg is associated with operations in the American Civil War, which formed the sequel of the Wilderness Campaign (q *v.*) and the last act in the struggle between the armies of Grant and *Lee* for supremacy. Petersburg and Richmond, Virginia, connected hy rail and covered north, east and south by 40 mi of entrenchments, formed the salients of a vast fortress, into which reinforcements and supplies could be poured from the rear by means of the James canal, the Virginia Central, the Lynchburg, the Dan-

ville and the Weldon railroads—the latter bringing up to Petersburg from Wilmington (225m. distant) the cargoes of blockade runners. Petersburg became a strategic point as soon as Grant determined to carry the army of the Potomac—defeated at Cold Harbor on the Chickahominy (see WILDERNESS CAMPAIGN)—south of Richmond, and, being joined by Butler's Army of the James (momentarily checked in the Bermuda Hundred peninsula



LEE'S RETREAT

by a small army under *Beauregard*), to operate from the east, depending on the James river as his line of supply. The policy of the Confederate president was to employ Robert *E.* Lee's army to protect his capital. Petersburg was nearer than Richmond to the navigable part of the James river—City Point is only 10m. distant—and the capture of Petersburg would involve the fall of Richmond and the capitulation or flight of Lee's army.

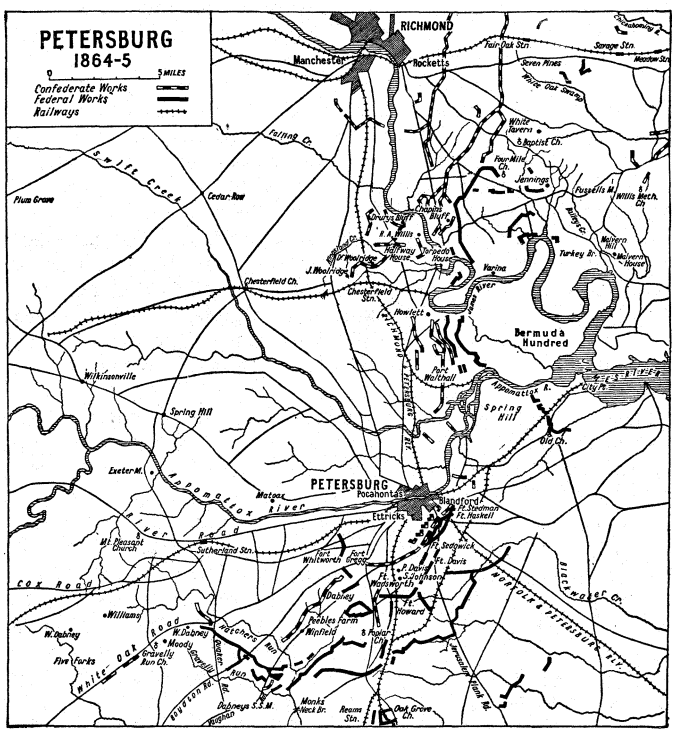
As early as June 9, 1864, while the main armies were still north of the James and Petersburg was garrisoned by a brigade under Gen. *Wise*, a Federal expedition from the Army of the James approached the city. The column on the City Point road discovered strong earthworks, and that on the Jerusalem Plank road experienced a repulse: the total force of the Federals was 4,500, and *Wise's* brigade (2,400) had been quickly reinforced from *Beauregard's* central position at Bermuda Hundred. A week later a more serious attempt was made to break through the defences, while Gen. Lee's main army was detained north of Richmond. Grant detached the II. and XVIII. Corps under Generals Smith and Hancock, who were to unite and operate along the City Point railroad and capture the outer line of works about 2m. from Petersburg while a demonstration was made along the Norfolk railroad by cavalry under Kautz. On June 1j Smith attacked and captured five redans before Hancock came up, and when next day Burnside's corps (IX.) arrived and Gen. Meade assumed control of the three corps, he attacked again at 6 P.M. On June 17 Warren's (V.) corps arrived, and Meade made a third assault with two corps (V., IX.). On June 18 the attack was renewed with three corps (II., V., IX.) late in the afternoon, and the results of the four days' fighting were so far satisfactory that ground was won which could be entrenched and held against any sortie of the Petersburg garrison. Probably on June 18 the town of Petersburg might have been captured by Meade, for at this crisis Lee was in temporary eclipse.

It was late on June 17 when Beauregard, who had for three days valiantly held his main lines south of Richmond with some 14,000 infantry against three Federal corps, succeeded in convincing Lee that the main army was in the wrong place. But when at last the Confederate leader was aroused to a sense of his danger he soon filled every road with divisions marching to save Petersburg: they marched all night; they slept in the trenches on arrival, and on June 19 these reinforcements convinced Meade that his main attack between the Appomattox river and the Jerusalem Plank road was delivered a day too late. At a cost of 10,000 casualties Meade had gained half a mile of ground, but the Confederates in falling back had concentrated, and now that the new plan of operations was exposed and the main bodies were again face to face the power of defensive tactics reasserted itself.

Yet June was not to close without adding some 8,000 men to the Federal casualties, for in addition to daily losses by sharpshooting along the front, over 5,000 men fell or were captured in operations directed against, the southern railroads. Grant. had resolved to deprive his enemy of these lines of supply: his plan was to prolong his line of investment westward and construct redoubts (such as Fort Davis, Fort Stedman and Fort Sedgwick) as a continual menace to the Confederate garrison and a defence against sorties, while his cavalry and portions of five corps (II., V., VI., IX. and XVIII.) engaged in enterprises which it was hoped would tempt Lee to fight outside his works. A decisive victory in the field, a successful assault on the defences between Richmond and Petersburg, or the complete destruction of the railroads, would precipitate disaster to the South, and of these three methods the last would be the surest in its effects. But such a method was necessarily slow. Wilson's cavalry (5,500) destroyed 30m. of the Lynchburg or South Side railroad, and 30m. of the Danville railroad, together with Burkesville junction and Ream's station on the Weldon railroad; but Wilson was caught by the Confederate cavalry 100m. from Petersburg and escaped only by destroying his wagons and limbers and abandoning 12 guns. Even the Virginia Central railroad could not be held by the Federals after Sheridan with the main body of the cavalry had been called back to White House on the Pamunkey to escort a great convoy.

By the end of June the whole of the rival forces were concentrated about the Richmond-Petersburg defences, and Gen. *A. P. Hill* had already sallied out on June 21 to drive the II. Corps from the Weldon railroad. Federal policy and Federal strategy, surmounting the crisis of Cold Harbor, were, however, at last in unison. Grant had a free hand in respect both of his dispositions and his resources in men and money, and had resolved to use unsparingly the resources placed at his disposal.

On July 25 Grant resolved to weaken the enemy on his front by a demonstration north of the James, and accordingly moved a corps (II.) and two cavalry divisions across the river to Malvern hill under cover of Foster's corps (X.). But *Lee* possessed the inner line, and the Federal detachment found two cavalry divisions in its front, and the Richmond defences had been



strengthened by three divisions of infantry. The expedition then returned to take part in a fresh enterprise, which ended disastrously to the Federals. A Confederate redan faced Burnside's IX. corps 100yds. distant, and this strong work was to be destroyed by mining operations. The mine was fired and produced a crater 150ft. long, 60ft. wide and 25ft. deep, into which the Federals poured. But the troops could be got no farther before the Confederate counterattack was upon them, and Burnside's corps lost 4,300 men.

In Aug. Sheridan was detached to operate against Early in the

Shenandoah valley, and in order to prevent *Lee* reinforcing *Early* another demonstration against Richmond was planned. But *Lee* again strengthened his left and the result of the fighting was a loss to the Federals of nearly 3,000 men. Meanwhile another attack on the Weldon railroad by Warren's corps was met by *A. P. Hill* on Aug. 20, and the possession of the railroad cost the Federals 3,000 men. A further attempt on this railroad by Hancock's II. Corps and Gregg's cavalry division at a point 3m. south of Ream's Station was foiled by *A. P. Hill*, now aided by *Hampton's* two cavalry divisions, and the Federals here lost 2,372 men and nine guns. The Confederates, therefore, still retained possession of the railroad to a point within one day's hauling by wagon to Petersburg. During Sept. another Federal enterprise north of the James with two corps (X. and XVIII.) resulted in the capture of Fort Harrison near Chaffin's Bluff, and when *Lee* reinforced his left and counter-attacked his troops were repulsed with heavy loss. The Federals lost over 2,000 men and failed in the attempt to take Fort Gilmer, Confederate gunboats below Richmond aiding in the defence. While this operation was in progress on the Confederate left under Grant's personal supervision *Lee* was apprised of attacks on his extreme right at Peebles farm by four divisions, which captured a Confederate redoubt covering the junction of two routes to the south-west. *A. P. Hill* prevented a further advance of the enemy by a vigorous counter-attack which caused Warren and Parke (IX.) a loss of 2,000 men, of whom nearly three-fourths allowed themselves to be captured; for the ranks, since the losses of the May battles, had been swamped with drafted and substitute recruits of poor quality and almost insignificant training. The Federals had, however, by these operations pushed their entrenchments beyond the Weldon railroad westward and established new works within a mile of the Confederate right. At the end of Oct. Grant resolved to make a serious effort to bring the South Side railroad within his lines and deprive the enemy of this important line of supply. Parke (IX.), Warren (V.) and Hancock (II.) took each some 11,000 infantry with four days' rations on pack animals. Gregg's cavalry (3,000) were attached for the operation, and both Grant and Meade accompanied the troops. *A. P. Hill* encountered this force with three divisions (14,000) and Hampton's cavalry (5,500), and he contrived to hold two corps with one division and attack Hancock (II.) with his main body. The Federals were stopped when 6m. from the railway.

Lee meanwhile had been called to Chaffin's Bluff, where again Butler was demonstrating with the Army of the James on the approaches to Richmond. But *Longstreet* signalized his return to duty with the Army of Northern Virginia by driving Butler off (Oct. 27). In Dec., however, Warren contrived to evade *A. P. Hill* and destroy the Weldon railroad at a point on the Meherrin river 40m. from Petersburg.

There seemed now little to tie *Lee* to the lines he had so painfully constructed, for his army was without coffee, tea or sugar, and though of foreign meat they had 3½ million rations and of bread 24 million rations in reserve, the troops lived chiefly on cornbread. *A. P. Hill* on the right held on from Hatcher's Run to Fort Gregg, whence *Gordon* and *Anderson* prolonged to the left as far as the Appomattox river, and *Longstreet* continued the line northwards along the Bermuda front across the James as far as White Oak swamp (37m. in all). The winter was very severe, and the continual trench-work and outpost duty overtaxed the patriotism of *Lee's* 50,000 infantry and stimulated desertion. Supplies were brought in by wagons, as the rolling stock on the railways was worn, and on Feb. 5, 1865, Gen. Gregg moved out to the Boydton Plank road to intercept the Confederate convoys. Gregg failed to locate the wagons, and *Lee*, hearing of the expedition, sent out a force which drove him back. Sheridan, after driving *Early* from the Valley in Oct., destroyed the railways about Staunton, Charlottesville, Gordonsville and Lynchburg, and even rendered the James canal useless as a line of supply.

Grant recalled Sheridan to the main army in March, and at the end of the month prepared for a turning movement westward with the object of drawing *Lee* out of his lines. *Lee* had anticipated such an attempt, and had resolved to abandon his lines and unite with Johnston in North Carolina, but the roads were **not** yet in a state for the movement of artillery and wagons, and it was to gain time that he now ventured upon a bold offensive stroke—a night attack upon a strong point in the Federal right called Fort Stedman—the success of which might cause Grant to call in the detachments on his left and so facilitate the proposed movement of the Confederates towards Danville. Gen. *Gordon* was selected to conduct the operation and his corps was strongly reinforced for the occasion. The opposing lines east of Petersburg were only 150yds., and the sentries of each side 50yds. apart. *Gordon's* men dashed across the intervening space at 4:30 A.M. on March 25, surprised the garrison and occupied Fort Stedman, but when daylight broke and the Federal guns could be brought to bear the fort was found to be untenable. Parke's corps (IX.) recaptured the work at a cost of 1,000 men, and *Gordon* fell back, leaving nearly 2,000 men in the hands of the Federals.

At this time Sherman visited Grant at City Point and proposed to move at the end of ten days on Burkesville junction and so cut off *Lee* from Danville and Lynchburg; it was while Sherman was preparing for this operation that Grant finished the campaign. Secure behind his formidable entrenchments, Grant had no fear for his base on the James river, and transferred large bodies of troops to his left without *Lee's* knowledge. Sheridan was instructed on March 29 to gain the enemy's right and rear, moving by Dinwiddie Court-House and across Hatcher's Run. But the Confederates were on the alert and quick to extend their right. Sheridan got into a flat country of dense forest, tangled undergrowth, streams and swamps, and the soil of clay and sand was impassable for wagons and guns until he had corduroyed the route. On March 29 *Lee* perceived that the object of Grant was to seize the routes south of the Appomattox river, by which a movement south-west could be made to unite with Johnston's army, and he endeavoured to cover these roads, including the South Side railway, without losing his hold upon his works about Richmond and Petersburg, but in such a contest it was evident that numbers must prevail.

Sheridan's cavalry had reached Five Forks on the White Oak road on March 31, and on his right Humphreys and Warren (II. and V.) held the Confederates to their works along Hatcher's Run astride the Boydton Plank road; yet *Lee* was able to concentrate his three cavalry divisions, and supported them by *Pickett's* five infantry brigades. Sheridan was attacked and driven south as far as Dinwiddie Court-House; but Humphreys and Warren held their ground (action of White Oak ridge) at a cost of 2,000 men. *Pickett* and the cavalry fell back to Five Forks during the night and hastily entrenched, for he had been ordered to defend this position; since the Boydton Plank road could no longer be held, the possession of White Oak road and the South Side railway became necessary for the flank movement which *Lee* had resolved to attempt. Grant meanwhile had ordered Warren to support Sheridan in an attack on *Pickett* at daybreak. Sheridan advanced on April 1 and at 3 P.M. issued his orders for attack, explaining verbally a diagram he had prepared for the use of divisional commanders. *Pickett* held a front of 2m. with a division of cavalry on either flank and *Rosser's* cavalry guarding the baggage behind Hatcher's Run, and when attacked at 4 P.M. he was with *Rosser* 1½m. in rear. Before *Pickett* was made aware of a battle being in progress his left was destroyed. *Lee* seems to have made no arrangements to support him in this direction. *Pickett's* position on the right was finally carried by Sheridan's cavalry dismounting and storming the entrenchments frontally. *Pickett's* routed brigades were rallied at the South Side railroad, but the Confederates had lost White Oak road, and unless *Lee* was capable of a vigorous counterstroke on his extreme right it was evident he must also lose the South Side railroad.

But a crisis was approaching. Sheridan's success at Five Forks induced Grant to deliver a general assault on April 2. The Confederate lines were bombarded all night, and on April 2 with Wright's corps (VI.), Grant attacked the weakest part of *Lee's* line and broke through, losing 1,100 men in 15 minutes. *A. P. Hill* was killed and his corps broke and was cut off from Peters-

burg. At the same time Parke's corps (IX.), on the right of the VI, attacked the eastern front near Fort Stedman but was repulsed; then Humphreys' corps (II.) on the left attacked a Confederate division and forced it to retreat to the South Side railroad, where at Sutherland station a final attack dispersed it. Wright, supported by Gen. Ord (commanding the Army of the James), afterwards won the strong redoubts called Fort Whitworth and Fort Gregg, and thus in a day the Confederate right had been destroyed from Five Forks to a point some two or three miles west of the Weldon railroad; 10m. of works had been abandoned, and if Grant had been able to press his advantage at once the campaign must have ended. But Grant was not aware of the enemy's plight, and so resolved to wait until the morrow before completing his victory.

Meanwhile *Lee* perceived that the hour had come at last when Richmond must fall, and at 3 P.M. he had issued orders for the march of the remains of his army to Lynchburg via Amelia Court-House, a march which evidently must partake of the character of a forlorn hope, hastily planned ill prepared, and undertaken by troops whom the disasters and hardships of the past six months had weakened physically and morally. Yet if *Lee* had negotiated *a* peace on April 2 military history would have lost one of the finest examples of the strategic pursuit. *Lee's* proposed movement involved the transfer of the army and its baggage 100m. on bad roads across the front of an enemy, and nothing but mischance could prevent the Federals intercepting *Lee's* columns by a shorter route and seizing the South Side railroad, on which supplies were to be forwarded from Lynchburg to meet the retreating army at Appomattox station, Pamplin's station or Farmville station. The Appomattox river must be crossed two or three times at its bends. Various creeks and swamps must be bridged, and the bridges destroyed after crossing. The wagons must move on separate roads so as to be covered by the columns during marches and combats and the infantry were to follow the artillery on the roads *Longstreet*, *Gordon* and *Mahone's* division from Richmond all crossed the Appomattox at Goode's bridge. *Ewell* from Richmond crossed the Appomattox by the Danville railroad bridge north of Goode's bridge. *Anderson* commanded the flank guard which moved south of the Appomattox with *Fitzhugh Lee's* cavalry. *Lee* gained a day's start by moving at 8 P M., for Grant was making preparations to attack the entrenchments next day (April 3), but the start was lost in waiting for President *Davis* and the Government to escape from Richmond. Sheridan's cavalry got in touch with *Lee's* flank-guard early on April 3 near Namozine creek, and at nightfall the Federal advance-guard was at Deep creek. On April 4 Sheridan reached the Danville railroad at Jetersville, and on April j. when *Lee* had halted at Amelia Court-House on the railroad to get supplies, the Federals had three corps (II., V., VI.) in support of Sheridan 8m. nearer than *Lee* to Sailor's creek, the point where he must again cross the Appomattox.

Interception was now a *fait accompli,* though neither side suspected it. *Lee* was unaware of the enemy's proximity. and Grant believed that *Lee* would remain at Amelia Court-House, but *Lee* mbved west, crossing Flat creek at sunset on April 5, to the Lynchburg railroad (*Longstreet,* marching all night, reached Rice's station at sunrise on April 6), while the Federals moved northward on the same day to attack *Lee* at Amelia Court-House, and on discovering *Lee's* evasion the three Federal corps effected a wheel to the left and advanced on Deatonsville after bridging Flat creek. Meanwhile the Federal cavalry had located and destroyed a convoy at Painesville, but had in turn been attacked by *Fitzhugh Lee's* cavalry and driven back on the main body at Flat creek. The rearguard of *Lee's* army was *Gordon's* command, which was at Amelia springs at 8 A.M. on the 6th of April. *Lee's* army stretched out for 15m., and when its advance-guard was at Rice's station its rearguard was still at Amelia Court-House. Rice's station is 62m. from Lynchburg. Here *Longstreet* waited all day for *Anderson, Ewell* and *Gordon* to close up, and then at night he moved 8m. to Farmville station (68m. south-west of Richmond), where 80,000 rations had been railed from Lynchburg; then *Longstreet* crossed the Appomattox, and on April 7 moved forward towards Lynchburg, covered by *Fitzhugh Lee's* cavalry. Meanwhile the remainder of *Lee's* army had been practically destroyed within a few miles of the point where *Longstreet* had halted. Sheridan's cavalry and two corps (II., VI.) had caught it entangled with the trains of the army attempting the passage of Sailor's creek; and Ord would even have attacked *Longstreet* (whom he had located late at night) had his march been delayed.

Complete disorganization and demoralization seem to have taken hold of the Confederates on this fatal day, and *Lee* was once more in eclipse. The Federal cavalry headed the column, the infantry attacked it, and *Ewell* became the victim of tactical envelopment after *Anderson* had been defeated and *Gordon* had failed to save the trains of the army. Surrender or massacre being the alternatives, *Ewell* surrendered, and here in fact the career of the army of Northern Virginia ended, as Grant plainly saw, for at 5:30 P.M. he addressed a demand to *Lee* for his capitulation. But *Lee* clung to his diminished forces for another 48 hours. *Longstreet* in crossing at Farmville had burnt the bridges and thus delayed the pursuit; but *Gordon* and *Mahone,* who had crossed at High bridge (the railroad bridge), failed to check Humphreys' corps (II.), and so were compelled to take up a position of defence on the north bank until darkness enabled them to slip away. *Lee* was with this remnant of the army. Meanwhile Sheridan with the cavalry and two corps (V., XXIV.) had hastened along the South Side railroad, seizing the supplies waiting for *Lee* at Pamplin's Station, and then moving on another 12m. to Appomattox station. At nightfall he found that he was astride the enemy's line of operation, which was also his line of supply, and so *Lee* would be compelled to give battle or capitulate on the morrow.

Lee, quitting Farmville heights on the night of April 7 changed the order of march during the next day, so that *Gordon* (8,000) was in the van and *Longstreet* (15,000) furnished the rear-guard. *Ewell's* corps u-as now represented by 300 effectives. The cavalry still numbered some 1,600 sabres. *Lee's* column was pursued along the Lynchburg road by two Federal Corps (II., VI.), which marched 26m. in 18½ hours. and at midnight halted within 3m. of *Longstreet,* who had entrenched near Appomattox Court-House, facing east and covering the road on which *Gordon's* corps and the cavalry was to press forward to Lynchburg at daylight. But *Gordon* on the morning of April 9 found Sheridan's cavalry in his front, and in accordance with plans made overnight he commenced an attack, driving the Federals back until he encountered at 10 A.M. two corps of infantry (V., XXIV.) under Ord, who had marched 29m. in order to support Sheridan at the crisis; and when at the same moment *Longstreet* was threatened by Humphreys and Wright (II., VI.) the situation had arisen which *Lee* considered would justify surrender, an event which had been anticipated on both sides as the result of the fighting about Farmville on April 6 and 7.

The closing operations from March 29 to April 9 were all in favour of the Federals, but, nevertheless, the historian counts their losses during this period at nearly 10,000 in the five corps and cavalry which constituted Gen. Grant's field army. On April 9, at the Appomattox Court-House. the two leaders exchanged formal documents by which 2.862 officers and 25,494 enlisted men were paroled, all that remained in the field of some 55,000 Confederates who were drawing rations on Feb. 20 as the army of Northern Virginia. (G. W. R.)

PETER'S PENCE or ROMESCOT, a tax of a penny on every hearth. formerly paid annually to the popes, now represented by a voluntary contribution made by the devout in Roman Catholic churches. Its date of origin is doubtful. The first written evidence of it is contained in a letter of Canute (1031) sent from Rome to the English clergy. At that time it appears to have been levied on all families possessed of land worth 30 pence yearly rental out of which they paid one penny At the Norman Conquest it appears to have fallen into arrears for a time, for William the Conqueror promised the pope in 1076 that it should be regularly paid The threat of withholding Peter's pence proved more than once a useful weapon against recalcitrant popes in the hands of English kings. Thus in 1366 and for several years after it was

refused on the ground of the pope's obstinacy in withholding his consent to the Statute of Praemunire. The tax was fairly regularly paid by the English until 1534, when it was abolished by Henry VIII.

PETER THE HERMIT, a priest of Amiens, Fr., was one of the preachers whose eloquence attracted pilgrims to take part in the first crusade. Legend was to credit him with the role which in fact was played by Pope Urban II—that of founder and organizer of the whole movement. But the work of Peter (who may have attempted a pilgrimage to Jerusalem before 1096) was more limited; he preached in northern France, from Berry through Champagne and the Meuse valley and so to the Rhine. His success was spectacular; his very donkey became an object of popular devotion. The thousands of peasants who took the cross at his bidding were joined by no great men; but they set out for the east, and their journey to Constantinople, preceding that of the princes, formed the first act of the first crusade. Peter himself led one section of the popular expedition. which arrived at Constantinople in July 1096. There he joined the only other section which had succeeded in reaching Constantinople—that of Walter the Fenniless—and he crossed to the Asiatic shore in the beginning of August. In spite of his warnings, the pilgrims began hostilities against the Turks. and Peter returned to Constantinople. In his absence the army was cut to pieces by the Turks, and he was left in Constantinople without any followers during the winter of 1096–97 to wait for the princes. He joined their ranks in May 1097 and marched with them through Asia Minor to Jerusalem. Thereafter he played a subordinate part in the history of the crusade. Early in 1098 he attempted to escape from the privations of the siege of Antioch—showing himself, as Guibert of Nogent says, a "fallen star." In the middle of the year he was sent by the princes to invite Kerbogha to settle all differences by a duel; and in 1099 he appears as treasurer of the alms at the siege of Arca (March) and as leader of the supplicatory processions in Jerusalem that preceded the battle of Ascalon (August). At the end of the year he went to Laodicea and sailed west. Albert of Aix records that he died in 1151, as prior of a church of the Holy Sepulchre that he had founded in France.

A popular belief which made Peter the instigator of the first crusade passed from the pages of Albert of Aix (writing *c.* 1130) and William of Tyre into the French vernacular epic poems on the first crusade.

See H. Hagenmeyer, *Peter der Eremite* (1879), French trans. (1883); S. Runciman, *History of the Crusades,* vol. i (1951).

PÉTION DE VILLENEUVE, JEROME (1756–1794), French writer and politician, was the son of a *procureur* at Chartres. He became an avocat in 1778. In 1789 he was elected a deputy to the Tiers Etat for Chartres and showed himself a radical leader. He supported Mirabeau on June 23, and was elected president on Dec. 4, 1790. On June 15, 1791 he was elected president of the criminal tribunal of Paris. After the last meeting of the assembly on Sept. 30, 1791 Robespierre and Pétion were made the popular heroes and were crowned by the populace with civic crowns. Pétion was elected on Nov. 16, 1791, mayor of Paris in succession to Bailly. On Aug. 3, 1792, at the head of the municipality of Paris, Pétion demanded the dethronement of the king. He was elected to the Convention for Eure-et-Loir and became its first president. L. P. Manuel's proposal that the president of the Assembly should have the same authority as the president of the United States, was rejected, but Pétion got the nickname of "Roi Pétion," which contributed to his fall.

His jealousy of Robespierre allied him to the Girondin party. He was elected in March 1793 to the first Committee of Public Safety; and he attacked Robespierre, who accused him of knowing and keeping secret Dumouriez's project of treason. His name was among those of the twenty-two Girondin deputies proscribed on June 2. He escaped to Caen and raised the standard of provincial insurrection against the Convention; and, when the Norman rising failed, he fled to the Gironde. At last, a month before Robespierre's fall in June 1794, he committed suicide.

See *Mémoires inédits de Pétion et mémoires de Buzot et de Barbaroux, précédés d'une introduction par C. A. Dauban* (1866).

PETITION, a term meaning generally a prayerful request for redress by a person aggrieved. It may be made in Great Britain to the crown or its officers, or to either house of parliament or in certain cases to courts of justice.

The right of petitioning the crown was recognized indirectly as early as Magna Carta in the famous clause. *Nulli vendemus, nulli negabimus aut differemus, rectum vel justitiam* ("To no one will we sell, to no one will we deny or delay, right or justice" art. 40.), and directly at various later periods, *e.g.*, in the articles of the house of commons assented to by Henry IV, by which the king was to assign two days in the week for petitions *(Rot. Parl.* 8 Hen. IV, p. 585). The case of the seven bishops in 1688 confirmed the right, and finally the Bill of Rights in 1689 declared "that it is the right of the subjects to petition the king. and all commitments and prosecutions for such petitioning are illegal." At first, petitions to the crown appear to have been for the redress of private and local grievances, or for remedies which the courts of law could not grant (Erskine May. *Parl. Pr.,* 11th ed., p. 532). As equity grew into a system, petitions of this kind not seeking legislative remedies tended to become superseded by bills in chancery. Statutes were originally drawn up by the judges at the close of the session of parliament from the petitions of the commons and the answers of the crown. Under this system of drafting, it was found that the tenor of the petition and answer were not always stated correctly. To obviate this inconvenience, demands for legislation came in the reign of Henry VI to be drawn up in the form of bills which the crown could accept or reject, but could not alter. *(See* W. R. Anson. *The* Law *and Custom of the Constitution,* 1886). In the same reign. the words "by authority of parliament" were added to the words of enactment, and from the time of Henry VII public legislation has been by bill and not by petition. The right to petition is thus closely interwoven with the history of parliamentary legislation.

Petitions to either house of the legislature seem to have been later in origin than petitions to the crown. They are not referred to in the Bill of Rights, but the right of petition is a convention of the constitution. Petitions to the house of lords or the whole parliament can be traced back to Henry III. No petition to the commons has been found earlier than Richard II, but from the time of Henry IV petitions to the commons have been freely made.

The political importance of petitioning dates 'from about the reign of Charles I. The development of the practice of petitioning had proceeded so far in the reign of Charles II as to lead to the passing in 1661 of an act (13 Car. II St. 1 c. 5) against "tumultuous petitioning." It provided that no petition or address should be presented to the king or either house of parliament by more than 10 persons; nor should anyone procure more than 20 persons to consent or set their hands to any petition for alteration of matters established by law in church or state, unless with the previous order of three justices of the county or the major part of the grand jury.

Up to 1688, petitions to either house usually dealt only with some specific grievance. From that time dates the practice of petitioning with regard to general measures of public policy. Petitioning as a device of political agitation became very common in the later 18th century, and afforded a basis for radical organizations seeking parliamentary reform. The number of petitions presented annually increased 2j-fold between 1780 and 1830, and culminated in the monster petitions for electoral reform in 1830–32 and the great Chartist petitions of 1839, 1842 and 1848. *(See* CHARTISM.)

In modern conditions, the presentation of public petitions plays little effective part in parliamentary affairs. Most fail to conform to the very strict tests of technical validity. Petitions to the houses of lords or commons must be framed in the form prescribed by the standing orders, must be properly superscribed and must conclude with a prayer. Petitions to the commons must be in writing, must contain none but genuine signatures and must be free from disrespectful language or imputations upon any tribunal or constituted authority. They must be presented by a member of the house, except petitions to the house of commons from the corporation of London. which may be presented at the

bar by the sheriffs. The rules as to petitions to the house of lords are similar. Applications for leave to bring before either house bills for private or local and personal matters must under the standing orders of both houses be made by petition. and the same rule obtains as to applications for leave to be heard in opposition to such bills. *See* PETITION OF RIGHT; PRIVY COUNCIL, JUDICIAL COMMITTEE OF; REPRESENTATION.

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United States.—The right under the 1st amendment to the U.S. constitution to petition the government for redress of grievances is one of the basic guarantees of U.S. liberty, being closely associated historically with freedom of assembly. The political theory of the American Revolutionary era emphasized strongly that the colonists were entitled to all the historic guarantees of English liberty. As one such right, freedom of petition found its way into several of the state constitutions drafted in the Revolutionary period; while Thomas Jefferson in the Declaration of Independence significantly listed the flouting of "petitions for redress" as a major grievance against the British king. In 1789. the 1st congress incorporated the right of petition. along with freedom of religion. press. speech and assembly. in the first of a series of proposed amendments submitted to the states. Ratification of the 1st amendment thus made freedom of petition an integral part of the so-called federal Bill of Rights. *(See* also BILL OF RIGHTS. UNITED STATES; CIVIL LIBERTIES.) Thereafter, virtually all the states incorporated guarantees of petition in their own constitutions.

The right to petition has been exercised constantly in U.S. political life. both congress and the various state legislatures having well-defined procedures for receiving, tabling or referring materials of this kind. Virtually the only constitutional argument of consequence involving petition occurred when the national house of representatives in 1836 adopted a so-called "gag rule" against the receipt of abolitionist petitions condemning the institution of slavery. Antislavery Whigs under the leadership of John Quincy Adams thereafter attacked the "gag rule" *(see* GAG Laws) as a violation of the right of petition as guaranteed in the 1st amendment and finally forced its repeal in 1844.

See G. H. Barnes, *The Antislavery Impulse, 1830–1844* (1933); Samuel F. Bemis, *John Quincy Adams and the Union* (1956).
(A. H. K.)

PETITION OF RIGHT. This term is now specifically appropriated in English law to the peculiar procedure by which a subject may sue the crown. At common lam the crown—a term which is. in constitutional law, merely an abstraction for the king in his official capacity—could not be sued in the king's courts: the king was, historically, the supreme lord of those courts, administering justice therein between his subjects, and as the supreme lord he was not amenable to their jurisdiction. His writs could not run against himself. Hence a practice arose. uhere a subject's real or personal property had come into the possession of the king or his servants without legal title. for the subject to "petition" the king in council praying for its restoration. The king then might or might not in his discretion. refer the suppliant's petition to one of his courts, usually the old court of exchequer, with a writ directing the judges to do what is just. Although the procedure of petition of right has now been regulated by statute, the discretion of the king, or rather of his ministers, is still absolute and no one can sue the crown directly except by the crown's grace and favour.

Originally the scope of a petition of right was confined to issues of fact. Where the subject relied on some title appearing by record, such as letters patent issued by the crown. he could proceed by what was known as a *monstrans de droit* or "manifestation of right." Another method, known as a traverse of inquest of office, allowed a subject in certain cases, such as escheat or forfeiture, to challenge the king's title to land or chattels These antiquities are of little importance today in vieu of the Petition of Right act, sometimes known as Bovill's act, of 1861

The Petition of Right act (1861) creates no right nor abolishes any prerogatives. It merely regulates procedure, providing that anyone seeking to sue the crown shall file a petition, in effect a statement of claim, with the home secretary, who invariably refers it to the attorney general for advice. If he advises that there is substantial "cause of action," the home secretary endorses it with his *fiat.* If he refuses it, the subject is without remedy. The discretion of the secretary of state is absolute. In practice the *fiat* is rarely refused, unless the claim appears purely frivolous.

Once the *fiat* is granted, the proceedings are like an ordinary action between subject and subject. The crown must enter an appearance within 28 days. It can, however, avail itself of many prerogatives in practice and pleading at the expense of the subject, most importantly the prerogative as to "Discovery," succinctly expressed "The law is that the Cromn is entitled to full discovery, and that the subject as against the Crown is not." This means that the suppliant cannot, as in an ordinary action between subject and subject, compel the other party, *i.e.,* the crown, to produce for inspection documents which may be essential to prove his case. So too with "amendment.!' The crown may amend its answer to any extent but the subject cannot amend his petition with the same freedom as a plaintifi may amend his pleadings in an ordinary action. Furthermore the crown may claim "privilege" in respect of any attempt by the suppliant to compel a witness to disclose "matter of state." though this prerogative is not peculiar to procedure by petition of right. In all these respects the crown has an immense advantage over the suppliant. On the other hand, the suppliant has one great advantage, nhich the plaintiff in an ordinary action does not possess. in that his claim cannot be barred by the cronn pleading the Statute of Limitation of 21 James I by which statute action of contract must be brought within six years Another peculiarity of proceedings by petition of right is that the subject cannot demand. as of right. trial by jury even where. had it been an action between subject and subject, he might have done so. The suppliant, if successful. is entitled to his costs; if unsuccessful. he is liable to pay the costs of the crown. a statutory exception to the common-law rule that it is "beneath the dignity" of the crown either to pay costs or to receive them.

Judgment is given in the ordinary way. But the "execution" of the judgment is quite another matter. The courts cannot decree execution against the crown and its servants. The act of 1861 provides, however, that, where judgment is in favour of the suppliant. it shall be "certified" by the court to the treasury which shall then satisfy it out of the public funds.

Scope of the Remedy.—For a long time it appears to have been held. although the matter is not free from doubt, that the remedy would only lie to recover possession of real or personal property in the hands of the crown. But in the leading case of *Thomas* v. *the Queen* (1874) 44 L.J.Q.B. 9, the courts held that a petition of right would lie for unliquidated damages for breach of contract. It has since been held that it will also lie for the recovery of duty overpaid to the revenue authorities (*In re Nathan,* 1884. *12* Q.B.D. 461), for compensation for the requisitioning of premises for national defense *(The De Keyser Case,* 1920. A. *C.* 508), and for such "implied contracts" as "Quantum Meruit" and "Money had and received." Petition of right will, however, never lie to enforce a contract or service with the crown, whether civil or military, for it is the crown's prerogative to determine such contracts at its pleasure *(see* PREROGATIVE).

On the other hand, the scope of the remedy is subject to considerable limitations of which the most important is the exclusion of any redress against the crown for "wrongful." *i.e.,* tortious acts such as. for example, negligence, trespass or the infringement of a patent. The only remedy open to the subject in such a case is to sue. in an ordinary action. the particular officer of the crown nho was responsible for the wrongful act or omission. The subject is far better protected in France and Germany. under whose law the state is responsible, and can be sued in the ordinary way for the torts of its servants. Moreover. in England the rule of *respondeat superior* by which a person wronged can sue the employer, whether an individual. a partnership or a company, for the wrongful acts of his servants does not apply in the case of

torts committed by the servant of a governmental department. In such a case not only can the crown not be sued but neither can one sue the immediate superior of the servant committing the wrongful act The postmaster general, for example, is not liable for the negligence of a post-office engineer. Further, the servant of the crown, although personally liable. was given the advantage. as against the plaintiff. of a "Statute of Limitations" of a very peculiar and invidious kind, knoun as the Public Authorities Protection act of 1893, which required all actions for tort against "public authorities," including servants of the crown as well as local authorities to be brought not. as in the case of an action between subject and subject, in six years but in six months. And if plaintiff was a day too late in bringing his action, he not only lost it but was subjected by the act to penalties, in the matter of special costs, not known to the common law.

Reform. — The decision of the courts in the famous case of *Dyson* v. *the Attorney-General* (1911) 1 *K.B.* 410 that a subject might apply directly to the courts, without recourse to a petition of right, for a '(declaration," *i.e.*, a "declaratory judgment," as to whether the crown was illegally invading his rights (in that case the question was whether the plaintiff was bound, under penalty, to answer certain questions contained in "forms" issued by the revenue authorities), and that the courts could declare the action of the crown illegal, was a great victory for the rights of the subject. But that decision was specifically made subject to the qualification that no such declaration could issue where the proper remedy was by petition of right. The advocates of reform of the law therefore directed their agitation to two things: (I) that the subject should no longer be dependent on the grace of the executive where he conceives himself to have what amounts to a cause of action against the cronn. but should be enabled to sue the crown in the same way as he can sue a fellow subject; (2) that the crown. thus made directly suable, should be liable in tort. In some of the commonwealth countries, most notably in Australia, this reform was effected by statute. In Scotland the law is equally enlightened.

See H. Morgan, *Remedies Against the Crown (1926).* (J. H. Mo.; X.)

PROCEEDINGS AGAINST THE STATE IN THE UNITED STATES

The rule that the sovereign was immune from suit at the hands of the private citizen is an accepted principle of U.S. law. Both the federal government and the states, whose sovereignty had not been surrendered to the national government, were clothed with this immunity. The constitution authorized the supreme court to take original jurisdiction in all cases "in which a State shall be a Party." and in 1793 the supreme court in *Chisholm* v. *Georgia,* (2 Dall. 419), held that it could take cognizance of a suit by a citizen against a state. This decision, contrary to the general expectation of the framers of the constitution, so aroused the nation that in 1798 the 11th amendment to the constitution was adopted which re-established the original theory that the states were immune from suit by private citizens. No such procedure as the petition of right was known to American law. Claimants against the United States were originally referred to auditors of various governmental departments and, in the event of unsatisfactory treatment, were obliged to petition congress. Such petitions were ordinarily disposed of before committees, which might recommend a pecuniary grant from congress. In a few instances congress by special legislation authorized suit to be brought against the government and the claims would be adjudicated in the courts. The unsatisfactory character of this method of dealing with claims against the government led in 1855 to the establishment of the court of claims. At first the court was simply authorized to hear claims and by appropriate bills refer them to congress for payment. In 1863 the court was authorized to give judgments subject to revision by- the secretary of the treasury. The secretary was shortly thereafter deprived of this power and the court is now empowered to render final judgments against the United States subject to an appeal to the supreme court. The jurisdiction of the court of claims illustrates that in the United States suits against the government are governed by much the same principle as that underlying the English procedure by petitions of right.

A few of the states have established courts of claims upon the model of the C.S. court of claims, but in most states the procedure of enforcing claims against the state government is by petitioning the legislature. (J. M. LA.; X.)

PETITOT, JEAN (1607–1691), French-Swiss painter of miniature portraits in enamel, was born in Geneva, the son of the sculptor Faulle Petitot. He was apprenticed to a jeweler from 1622 to 1626, but about 1633 he went to France, and there probably became the pupil of Jean and Henri Toutin, the originators of the art of painting miniature portraits in enamel. In or before 1637 Petitot went to England. where he was patronized by Charles I and his court; a handful of miniatures are known from this period, all copies of portraits by Sir Anthony Van Dyck. Petitot formed high expectations of his stay in England but the Civil War disappointed his hopes, and he returned to France. There he enjoyed for many years the patronage of Louis XIV and his courtiers. A complete catalogue of Petitot's enamels would comprise many authentic portraits of the king, his family and the most celebrated figures in his entourage, the majority based upon paintings by fashionable artists. Petitot worked in partnership with Jacques Bordier until the latter's death in 1684. On the revocation of the Edict of Nantes in 1685. Petitot, as a Protestant, was imprisoned until, worn out by fever and old age, he signed a recantation. In 1687 he was allowed to return to Geneva and was received back into the Reformed Church. He died at Vevey, Switz., in 1691.

Although priority in the discovery of the art of painting enamel miniature portraits belongs to the Toutins, it was Petitot who by his incomparable facility raised the art to a pitch never surpassed. While relying primarily on original portraits by others, he preserved to a remarkable degree the character of the presentation which he was transforming into a small jewellike roundel. The most important collections of his works are in the Victoria and Albert museum, London, and the Louvre, Paris. His style, much imitated in his own time. called into being a vast number of 18th- and 19th-century copies or imitations. Petitot's journal gives many details about his life.

His son JEAN LOUIS PETITOT (1653–after 1699) painted portrait enamels in a style closely resembling his father's. (G. Rs.; X.)

PETITS CHEVAUX (Fr. for "little horses"), a gambling game played with a mechanical device consisting of a board perforated with a number of concentric circular slits, in which revolve. each independently on its own axis, figures of jockeys on horseback, distinguished by numbers or colours. The bystanders having staked their money according to their choice on a board marked in divisions for this purpose, the horses are started revolving rapidly together by means of mechanism attached to the board, and the horse which stops nearest a marked goal wins, every player who has staked on that horse receiving so many times his stake.

Figures of railway trains and other objects sometimes take the place of horses.

PETN (pentaerythrityl tetranitrate, $C_5H_8N_4O_{12}$; pentrite) was first prepared by L. Vignon and F. Gerin in 1901, but was not in systematic use prior to World War II. It is a powerful and sensitive high explosive. Its structural formula is $C(CH_2ONO_2)_4$. The manufacture involves the nitration of pentaerythritol with concentrated nitric acid and a subsequent washing to eliminate acid. Pentaerythritol, $C(CH_2OH)_4$, is synthesized by the reaction of acetaldehyde with formaldehyde, catalyzed by calcium oxide. PETN is a white crystalline powder, melting point 139° C.. specific gravity 1.7;. It is insoluble in water but is soluble in acetone and several other organic solvents. It finds use as an ingredient of detonators (*q.v.*) and as the charge of the detonating fuze Primacord; for use as a bursting charge of military devices it is usually mixed with other ingredients, largely T.N.T., to reduce its sensitivity to percussion and to make it suitable for loading by casting. *See* DETONATORS ; EXPLOSIVES.

See A. Stettbacher, *Die Schiess- und Sprengstoffe (1919)*; *T*. L. Davis,

The Chemistry of Powder and ***Explosives,*** *2* vol. (1941). *(G.* B. K)

PETŐFI, SÁNDOR (1823–1849). one of the greatest Hungarian poets. was born at Kiskoros. Jan. 1. 1823. Petofi had an eventful youth; he studied at eight different schools. joined for a short time a group of strolling players and enlisted as a private soldier, but because of ill health was soon dismissed from the army. He traveled extensively in Hungary, mostly on foot. As a schoolboy he displayed a keen interest in the stage and in literature, and his first poem was published in 1842. After years of vicissitudes and misery. in 1844, on the recommendation of Mihály Vorosmarty. then the leading Hungarian poet, he became an assistant editor of the literary periodical Pesti *Divatlap.* His first volume of poetry, Versek, appeared in the same year, and made him famous at once, though the tone of his poems scandalized many. In 1847 he married Julia Szendrey who inspired his best love poems.

Petőfi played a leading role in the literary life of the period preceding the outbreak of the Hungarian revolution of 1848. After 1847, together with Mór Jókai, he edited the magazine *Életképek.* A fervent partisan of the French Revolution, an admirer of Jean-Pierre de Béranger and Hégésippe Moreau, he castigated in violent terms the social conditions of his country, attacking the privileges of the nobles and the monarchy. Politically he was an extreme radical, an inspired agitator, but he was lacking in experience and failed to obtain a seat in the diet. His poems were glowing with political passion, and one of them, "Talpra magyar". ("Rise Hungarian"), written on the eve of the revolution, became its anthem. During the revolution he became the aide-de-camp of Gen. József Bem, then head of the Transylvanian army, who had great affection for the somewhat unsoldierly but enthusiastic poet. Petofi disappeared during the battle of Segesvár, July 31, 1849. Public opinion refused to believe in his death and for many decades hoped to see him return.

Petofi's poetry meant a revolution in Hungarian literature. Opposed to the fashionable literary conventions and mannerisms, he introduced a direct, unpretentious style. and a clear, unornamented construction adapted from national folk songs. This simplicity was the more arresting as it was used to reveal extremely subtle emotions and political or philosophical ideas. His poetry is characterized by realism, humour and descriptive power and imbued with a peculiar vigour. Of his epic poems the Jdnos *vitéz* (1845), an entrancing fairy tale is the most popular Petofi's popularity has never diminished in Hungary, and were it not for the barrier of language his name would probably take its place with those of Burns and Heine in world literature. In his homeland his poetry and his personality have remained the symbols of the people's desire for freedom.

A critical edition of Petofi's works by B. Varjas Béla was published in six volumes, 1948–56.

See J. Horváth, *Petőfi* (1922); *G* Illyés, *Petőfi* (1954). (N. KI.)

PETRA, a ruined site in Jordan, lying in a rock basin on the eastern side of the Wadi 'Araba, the great valley that continues the rift of Jordan southward to the Gulf of Aqaba. The descriptions of Strabo (Geography, xvi, p. 779), Pliny (*Natural* History, vi, 32) and other writers leave no doubt as to the identity of this site with the famous capital of the Nabataeans (*q.v.*) and the centre of their caravan trade. The country around is assigned by tradition to the Horites, *i.e.*, probably "cave-dwellers," the predecessors of the Edomites. The tombs at Petra offer some evidence of the early Nabataean settlement. Two types of tombs may be distinguished, the h'abataean and the Graeco-Roman. The former start from the simple pylon-tomb of pre-Hellenic age (about the 6th century B.C.); they then pass through various stages evolving to the full Nabataean type, nhich retains all the native features and at the same time shows characteristics which are partly Egyptian and partly Greek. The next stage in the evolution of the tombs gives tomb fronts terminating in a semicircular arch, a feature derived from north Syria, and there finally appear the elaborate façades from which all trace of native style has vanished. copied from the front of a Roman temple. After the period of the pre-Hellenic tombs we notice a period which combined Greek, Egyptian and Syrian elements, clearly pointing to the age of the Ptolemies. Toward the close of the 2nd century B *C.*, when the Ptolemaic and Seleucid kingdoms were equally depressed, the h'abataean kingdom came to the front; under Aretas III Philhellene (c. 85–60 B.C.) the royal coins began; at this time probably the theatre was excavated and Petra must have assumed the aspect of a Hellenistic city. It is to the long and prosperous reign of Aretas IV Philopatris (9 B.C.–A.D. 40) that the fine tombs of the el Hejr type may be dated, and perhaps also the High-place. Then the city became more and more romanized. In A.D. 106 Arabia Petraea ("Arabia belonging to Petra") was absorbed into the Roman empire, and the native dynasty came to an end. When the city was more prosperous than ever, at the time of Alexander Severus (AD 208–235), the issue of coinage came suddenly to an end. Meanwhile. Palmyra was growing in importance. and attracted much of the Arabian trade away from Petra, and the latter declined. It seems, however, to have lingered on as a religious centre. Christianity found its way into Petra in early times. The Christianity of Petra, as of north Arabia, was swept away by the Moslem conquest in A.D. 633–640. Under the Latin kingdom, Petra was occupied by Baldwin I; it was held by the Franks till 1189; fragments of the Crusaders' citadel are still standing.

PETRARCH (FRANCESCO PETRARCA) (1304–1374), Italian poet, the first humanist and the first modern lyric poet, was born at Arezzo, July 20. 1303, son of a notary Ser Pietro di Ser Parenzo of Incisa in Valdarno, and his wife, Eletta Canigiani. His father (who after 1312 is referred to as Petrarca, the surname which his son made famous), had been banished from Florence. on Oct. 20, 1302, probably as the result of personal differences with Albizzo Franzesi. a leader of the Blacks, and not, as his son allowed it to be understood, for political reasons, like Dante. Francesco remained at Arezzo for less than a year; then his family moved, to Incisa (where they stayed until c. 1310). to Piss (where perhaps he met Dante) and finally to Xvignon (1311), at that time the seat of the papacy, where his father hoped to find suitable employment. Owing to the difficulties of finding lodgings, the family settled at Carpentras nearby and there Francesco began his studies under the modest direction of Convenevole da Prato. In 1316, in obedience to his father's wishes, he went to Montpellier to study law. To this period. although they were certainly revised later. belong the earliest poems that have survived, those on the death of his mother (1318 or 1319: Epistolae *metricae,* i, 7). In 1320 he moved to Bologna and unwillingly continued his legal studies there until 1326. His knowledge and love of the classics increased and he was able to develop his acquaintance with the new vernacular poetry, perhaps even to experiment for himself. In 1326 he returned to Avignon, gave up his legal studies and took minor orders (which would allow him to enjoy benefices and canonries nithout ecclesiastical obligations).

For some years he enjoyed the life of the Avignon court where he soon made a name for himself thanks to the elegance of his culture and his first poetic attempts in Latin and the vernacular. His early youth. nhich had been mainly influenced by his love of God and virtue and his realization of the transitory nature of human affairs. was followed by a period of dissipation which coincides with the beginning of his most famous love affair (*Secretum meum,* iii, 6–7).

On April 6. 1327, in the church of Sta Chiara, he first saw Laura, the lady nho was to dominate his poetry, though not all his norks and still less his life. as the romantics would have us believe Such critics. followed by the positivists, have consistently tried to give a face and a name to the "lady" of the *Canzoniere* (she has been identified with Laura di Audiberto di Noves who married Ugo di Sade, Laura di Sabran, Laura di Chiabau, Laura Colonna, etc.). The reaction is seen in the opposite tendency to see in Laura a pure symbol or *senhal* (in the language of Provençal poetry), a personification of intellectual beauty and truth. But neither the particular images that are woven into the *Rime* nor the accepted transfigurations and poetic structure imposed by literary tradition are able to reduce her to a symbol or an allegory. Yet it is useless to try and find out who she really was since Petrarch maintained silence about everything that concerned her civil status, as though he considered it of no importance. Laura

lives only in his verse even though Petrarch drew his inspiration from a woman whom he had really known and loved.

At the invitation of Giacomo Colonna, a friend of his Bolognesi years, who had been appointed bishop of Lombez, Petrarch passed the summer of 1330 in that little Gascon town, "a most heavenly summer owing to the gaiety of the bishop and his companions," and then entered the service of Giacomo's brother, Giovanni, Cardinal Colonna, where he was to remain until 1347, "not serving a master, but rather a father or better still a most affectionate brother" (*Posteritati*). These were decisive years, crowded with travel alternating with periods of austere retirement, years of ambition but also of unpretentious, unremitting study and literary activity, particularly in the field of classical Latin (up to 1328). In 1333, he journeyed through France, Flanders, Brabant and the Rhineland. In Paris, thanks to a gift from Father Dionigi of Borgo San Sepolcro (his faithful friend and discreet confidant in spiritual matters) he was introduced to the *Confessions* of St. Augustine, a book which he was to use more and more as the breviary of his spiritual life; at Liège he transcribed, among other things, the Ciceronian oration *Pro Archia,* that great manifesto of the nature of poetry. These events seem almost to symbolize his mission as a stubborn advocate of the continuity between classical culture and the Christian message (as between a rich promise and its divine fulfillment) which justifies his position as founder and representative of European humanism and which can already be discerned in his two most ambitious and significant Latin works of this period, the *De viris* and the *Africa* (begun 1338 or 1339). And even before 1336 he had already begun to select, revise and copy those vernacular poems which he had been composing with increasing care during the preceding ten years.

The Mature Years.—Early in 1337 his dreams and aspirations which had been resolutely directed toward classical civilization found fulfillment in a visit to Rome. It was perhaps this deep emotional experience, which confirmed him in his faith, and the moral and religious doubts which had dramatically assailed him the previous year on his ascent of Mt. Ventoux with his brother Gherardo, that made him, when he returned to Provence, seek a refuge far from the restless, corrupt life of Avignon, full of memories of his most dissipated years (in 1337 his natural son Giovanni had been born). A few miles to the east he found the solitude of Vaucluse which was to serve as a retreat sacred to meditation and to poetry: his Helicon.

In Sept. 1340 there reached him simultaneous invitations from Paris and Rome to be crowned poet laureate, an honour which he had sought, not only from ambition but also in order that the rebirth of the cult of poetry might be celebrated after 1,000 years. For this reason he had no hesitation in preferring the Capitol to the Sorbonne and it was in the Capitol, on April 8, 1341, that he received a laurel wreath which he deposited as a symbolic gesture on the tomb of St. Peter.

From May 1341 until Feb. 1342 Petrarch was in Parma and later in the nearby solitude of Selvapiana; he then returned to Provence till the autumn of 1343. It is generally believed that at this time he passed through a "crisis" which, after a further period of dissipation in Avignon (his natural daughter Francesca was born in 1343), led him to a better-regulated life in which his spiritual need found expression in an intense concern for literary as well as moral problems. His inner torment, increased perhaps by his brother's decision to enter a Carthusian monastery, can be reduced to a conflict between his religious faith and his inability to adapt his own life to it: this is the situation so lucidly set out in the *Secretum* (42–43: "many times I thought to have shaken off my former yoke but it has bitten deep down to my bones . . . I shall die in my sin if help does not come from on High . . .").

It was therefore an evolution, both moral and literary, rather than a crisis, which made him realize that his love for Laura was wrong in spite of its purity and although it inspired him to do good, because it made him love his Creator for what he had created (and not the creature as the work of God) and was proof, therefore, of his attachment to this earth; an evolution which led him to break through the barriers of his too exclusive admiration for antiquity and to admit other and more authoritative voices. In the *De vita solitaria* (1346) the antinomy between classical and Christian culture appears almost completely resolved: "solitude," that great literary myth bequeathed by Petrarch to the humanist and modern worlds, becomes the point of contact between the *otium literatum* of the ancients and Christian asceticism; classical writers and heroes mingle with the prophets, saints and holy fathers, to such an extent that the first plan for the *De viris* was enlarged to include material from sacred as well as secular history.

Events which are fundamental to his biography as a man and a writer befell Petrarch during these years. He became sympathetically, even enthusiastically, interested in the efforts of Cola di Rienzo to realize the dream of popular government in Rome (an attitude which divided Petrarch ever more sharply from the curia at Avignon and in 1347 caused a break with Giovanni Cardinal Colonna). The terrible plague of 1348 caused the death of many friends including Laura herself (with poetic coincidence she died on April 6): the news reached Petrarch in Parma on May 19 and he noted it in his Virgil so that he might see it often and be reminded of the decay of all earthly goods. He met Boccaccio in Florence, a very important meeting, awakening in Petrarch a consciousness of his cultural and moral mission. He made a pilgrimage to Rome for the jubilee year (visiting his birthplace and discovering Quintilian) in 1350, the year to which Petrarch assigns his final renunciation of the pleasures of the senses.

Between these landmarks, his life unfolded, crowded with diplomatic missions and dedicated to study during periods of meditation: in the autumn of 1343 he was in Rome and then in Naples on a mission to Queen Joanna on behalf of the Colonna family; from Dec. 1343 until Feb. 1345 he was again at Parma (where he wrote the *Rerum memorandarum*) and then at Bologna and Verona (where he made his great discovery of Cicero's letters *Ad Atticum, Ad Quintum, Ad Brutum*); toward the end of 1345 he returned to Avignon and took refuge in his beloved Vaucluse for two years of great spiritual and literary activity (*Bucolicum carmen, De vita solitaria, De otio religioso*); in Nov. 1347 he left for Italy, probably on a mission in favour of Cola (whom the May revolution had placed at the head of the Roman republic) but the fall of the tribune made him change his plans; he went to Verona and then to Parma where, except for occasional visits and missions, he remained from March 1348 to March 1349 (in Aug. 1348 he was appointed archdeacon of the cathedral). He then made a more permanent home in Padua where the lord of the city, Giacomo Novello da Carrara, had obtained a lucrative canonry for him. But Giacomo was assassinated (Dec. 19, 1350) during Petrarch's jubilee pilgrimage to Rome and since he was prevented from returning to Parma by some disagreement with the bishop and the suspicious tyranny of the Visconti family, to whom the city had been ceded, he felt himself possessed anew by a longing for Vaucluse. Neither Boccaccio's visit in April nor the offer he brought of a chair in the university to be established in Florence under his guidance were able to hold him back. He left in May 1351, reached Avignon in June and went straight to Vaucluse. This fourth retreat was particularly productive: the arrangement of the *Canzoniere,* on which he had already resumed work in 1348 at Parma and Padua, began to assume a more definitive form; the idea of forming a corpus of his letters which had first come to him perhaps as early as 1345 and certainly by 1349 took shape in his plan for the first collection, the *Familiari;* he continued to work assiduously on his collection of *Metriche* begun in 1350; he embarked on his polemic against the doctors, the bitter enemies of humane letters; and he revised and rewrote various earlier works (*De viris, Secretum*).

The death of his closest friends, the suspicions of Pope Innocent VI (who had succeeded the friendly Clement VI in Dec. 1352), and his increasingly bitter differences with the curia at Avignon, finally decided Petrarch to leave Provence and to return to his own country. From the alpine frontier of Montgenèvre he addressed it with moving eloquence: "Hail O most sacred land, beloved of God, hail land whom the good can trust, the proud must fear . . . Eagerly I return to you after so many years to live with

you for ever; you will provide a haven of peace for my weary life." (Epistolae metricae, iii, 24). He found rooms in Milan where he remained, except for brief periods. during the next eight years (1353–61) in spite of harsh criticism for his acceptance of hospitality from ambitious tyrants and the enemies of Florence (the Visconti). Apart from the considerable missions entrusted to him by the Visconti (especially notable those to Venice in 1353 to negotiate peace with Genoa, to Mantua in 1354 and to Prague in 1356 where the emperor Charles IV accorded him royal honours, to Paris in the winter of 1361 on a visit to King John II after the peace of Bretigny), the Milanese period, the longest uninterrupted stay in one place during his whole lifetime, was one of the most fruitful. He completed the first proper edition of the Rime, applied himself with great fervour to the *Familiares,* made considerable progress with the De remediis, worked on the *Trionfi,* composed the Invectiva against Cardinal Jean de Caraman and the *Itinerarium* and revised and set in order with scrupulous care some of his earlier works.

Later Life.—During the spring of 1361, hoping to escape from the plague, he went to Padua on the invitation of Francesco da Carrara (son of his great friend Giacomo) remaining there until Sept. 1362 when, once more as a fugitive from the plague, he sought shelter in Venice, "the only stronghold in our times of liberty and peace and justice" (Senilium *rerum* libri, iv. 3). The *signoria* gave him a house on the Riva degli Schiavoni and Petrarch promised to bequeath all his books to the republic when he died. He was joined by his daughter Francesca with her husband the Milanese Franceschino da Brossano and their small daughter Eletta: the tranquil happiness of this little family gave great pleasure to their affectionate father. He was visited by his dearest and most famous friends (by the great chancellor Benintendi de' Ravegnani, by Paduan scholars, by Boccaccio, who in 1366 presented him with a long-desired Latin translation of the Homeric poems); he nas invited to play an honourable part in the life and politics of the city; he worked peacefully but with great concentration at the definitive versions of the *Rime,* the Familiares, the De *remediis* and the *Seniles.* Nevertheless the insult he received from four young Avverroists who called him "a good man . . . but illiterate and in fact an idiot" because he believed in Christian doctrines rather than those attributed to Aristotle, an insult which was ignored by Venetian public opinion, induced him to move back to Padua in 1367. He was to remain there until his death, dividing his time from 1370 onward between Padua and Arqui in the neighbouring Euganean hills where Francesco da Carrara had given him a little house, his last Helicon. He was still in demand as a diplomat: in April 1368 he accompanied the ruler and the bishop of Padua to meet the emperor Charles IV who aas on his way to Italy as an ally of the league against the Visconti; later he was in Pavia and Milan for the marriage of Violante. daughter of Galeazzo, to Lionello the second son of the king of England; in 1370 he was called to Rome by Urban V and he set off eager to see the fulfillment of his great dream of a new Roman papacy, but was halted at Ferrara by a stroke. Yet he did not stop working; in addition to revision he composed the De gestis Caesaris, the Invectiva against Jean Hesdin and the final sections of the Trionfi.

Petrarch died during the night of July 18–19, 1374, when he was working in his little study at Arqui, and was found the next morning, his head resting on a manuscript of his beloved Virgil.

WORKS

Petrarch's literary production as poet. historical moralist and outstanding representative of the new culture is enormous. The chronology of his writings is somewhat complicated and uncertain and is made more so by the scrupulousness with which he revised and rewrote, often very extensively. Included here is a summary list with notes and. when they exist, a reference to better editions than those in his collected works (Opera, 1554 and 1581).

Latin **Works.**—*Epistolae Metricae.*—A collection in three books of 66 epistles in hexameters, dating from the verses on the death of his mother (1318 or 1319) and the earliest epistle of 1333 to the last letters composed between 1350 and 1354; he appears to have worked on the collection in three distinct phases, about 1350, 1357 and 1363. The subject matter is, naturally, very diverse. intimate confessions, autobiographical anecdotes, letters of consolation and exhortation. moral reflections, literary propositions and rhapsodies, descriptions, panegyrics, etc. (*Poemata minora,* edited by D. Rossetti, 1831).

Africa.—Petrarch began this work at Vaucluse in 1338 or 1339, pursued it with greater vigour at Selvapiana in 1341, returned to it frequently but intermittently after 1343 but never completed it: its various parts were gradually put together but its nine books (iv and ix are very incomplete) were published only after Petrarch's death, by Paolo Vergerio in 1396. It is an epic poem in hexameters which relates the history of the Second Punic War. The episode of Sophonisba, sacrificed to political expediency by her ardent lover King Massinissa, is both pathetic and dramatic; the famous lament of the dying Magone on the decay and misery of everything on earth (it was the only passage made available during the poet's lifetime) is strictly Petrarchan in inspiration; and this sentiment, together with a desolate perception of the fugacity of time. pervades the whole work, tempering with Christianity the Roman classicism of Livy and Cicero who are widely used as sources and at times with too heavy a hand. (Critical edition by N. Festa. 1926.)

De *viris illustribus.*—The original plan of this work, begun in 1338 or 1339 and continued in 1341–43 as a series of biographies of famous Romans or people closely connected with Rome, was considerably modified between 1351 and 1353 so as to include famous men of all times beginning with Adam, thus achieving Petrarch's aim of emphasizing the continuity between the ideals of the Old Testament, of classical antiquity and of Christianity. Later he wrote fuller lives of Scipio and Caesar and finally, when he was in Padua, he took up the work again with the title *Quorundam virorum illustrium epithoma,* limiting it to 36 characters whose effigies were to be placed in a hall of Francesco da Carrara's palace; but he did not get further than the preface (the rest is the work of his disciple Lombardo della Seta who also completed the *Compendium* or Breve compendium of which Petrarch wrote only the first 14 biographies). (Edited by L. Razzolini, 1874–79.)

Secretum meurn.—This autobiographical treatise was composed between the autumn of 1342 and the winter of 1343 and revised between 1353 and 1358. Not intended for publication, it is a fundamental work for the understanding of Petrarch's inner life. It consists of three dialogues between Petrarch and St. Augustine in the presence of Truth: in the first, Petrarch's secret infirmity is identified with a sickness of the will which makes him aspire to a nobler life while lacking the knowledge and will power to achieve it; in the second, Petrarch examines his conscience with regard to the seven deadly sins and finds himself guilty of all of them except envy, but especially of accidia (the theological definition of the sickness of the will discussed in the first book); in the third, Petrarch convinces himself of the sinfulness both of love (even when pure and directed towards a chaste woman) and of the desire for glory: that is. of the two great passions of his life. But he wearily declares himself unable to reform. The work constitutes a self-analysis of pitiless sincerity and precise autobiographical references at one of the decisive moments of his life. (Edited by E. Carrara, in Petrarca, Prose, 1955.)

De vita solitaria.—Written in 1346 and later revised and enlarged (one addition is definitely of 1371), the treatise, in two books, provides the theoretical basis and the description of one of Petrarch's essential myths, that of the "solitary life," in which man is able to enjoy the consolations of nature and study together with those of prayer. (Edited by G. Martellotti, in Petrarca, Prose, 1955.)

De otio *religioso.*—Written in 1347 it was revised and considerably enlarged in 1357. It is a treatise in two books on the advantages of the contemplative monastic life. It takes up the theme of De vita solitaria from a more strictly devout attitude and is tinged with a sharp nostalgia for purity and spiritual peace (Edited by G. Rotondi, 1958.)

Familiarium rerum libri xxiv.—The idea of this collection of letters goes back to 1345 or more probably to 1349. The real

work of arrangement was begun between 1351 and 1353 (up to book viii) and the final version was completed between 1359 and 1360 (up to book xix); in 1363–64 Petrarch returned to it, adding four books, and continued to work on it until 1366. It consists of a selection of 350 letters (the earliest dated 1325, the latest 1366, although the collection is supposed to end at 1361) which are of great importance for an understanding of Petrarch's life, both spiritual and active, and for the history of his decisive influence on European culture. As Martellotti has observed, these collections of letters represent the final stage of that progress from the contemplation of the world of antiquity as a means of escape from unpleasant realities to an intense preoccupation with the present, and the study of antiquity as foreshadowing the moral truths of Christianity. (Critical edition by V. Rossi and U. Bosco, 1933–42.)

De renzediis *utriusque fortunae*.—This vast work, a part of which had been begun in 1354, had reached an advanced stage by 1360 and was finished in Oct. 1366 and published immediately. Petrarch probably returned to it later. It consists of two books containing 122 and 131 treatises, or discussions, between Reason, Pleasure and Hope and between Reason. Sorrow and Fear which contain respectively advice on how to attain good fortune and the remedies for bad, and which demonstrate the inconsistencies of pleasure and pain in a tone of bitter pessimism.

Senilium rerum libri.—Petrarch began his collection of the Senili after 1361 but never made a definitive arrangement as he did for the *Familiari*. The collection comprises 125 letters from 1361 to 1374 in 17 books.

Posteritati.—The first draft must be dated before 1367; there were important additions between 1370–72. It is an interesting autobiography in the form of a letter addressed to posterity. left unfinished and in draft form (it only goes up to 1351); it was to have formed the conclusion to the Senili. (Edited by E. Carrara and P. G. Ricci in Petrarca, Prose, 1955.)

De sui *ipsius* et *multorum ignorantia*.—Written 1367, published 1371, this is directed against the critics of Venice. Following St. Augustine Petrarch tries to show that rhetoric and poetry are the best spurs to moral action. (Edited by L. M. Cappelli, 1906.)

Other Latin *Works:* Prayers (1335–38). *Epistole* sine *nomine,* written 1342–58; collected 1359–60. (Edited by P. Piur, 1925.) *Rerum memorandarum* libri, 1343–45. (Crit. ed. by G. Billanovich. 1945.) *Bucolicum carmen,* 1346–48; definitive version 1364. (Edited by A. Avena. 1926.) *Salmi penitenziali,* 1347. (Edited by H. Cochin, 1929.) *Invectivarum* contra *medicum quendam* libri, 1352–55 (Edited by P. G. Ricci, 1950). *Invectiva* contra *quendam magni status hominem,* 1355. (Edited by P. G. Ricci, 1949.) *Itinerarium* breve de Janua *usque* ad Jerusalem, 1358 et seq. *Invectiva contra eum* qui *maledixit* Italiae, 1373. Epistole varie; 65 letters not included by Petrarch in his collections.

Italian Works.—Rerum *vulgarium fragmenta*.—This was Petrarch's title for the definitive collection of his Italian verse. his Rime. It consists of 366 compositions (317 sonnets, 29 *canzoni*, 9 sestine. 7 *ballate,* 4 madrigals) divided into two parts (263 poems described as in vita Laura; 103 in morte *Laura*). Naturally the first stage in the production of this work was the actual composition of the single poems (he did not include in the collection those written earlier than 1330); the second, before 1336, his first idea of making a selection; the third, between 1342 and 1347, the arrangement of the selected poems according to a certain criterion; the fourth, after the death of Laura, their division into two parts and the project of illustrating the story of his own soul (perhaps 142 lyrics on the period before Laura's death plus 29 after); the fifth, the first proper edition of the Canzoniere sent to Azzo da Carreggio in 1360 (about 174 plus 41); the sixth. a second edition in Jan. 1373 sent to Pandolfo Malatesta; the seventh, the definitive edition which is preserved in the Cod. Vat. Lat. 3195, partly autograph, partly transcribed by Giovanni Malpaghini under the poet's supervision. The choice of poems and the arrangement of the collection are governed by a most rigorous and exclusive standard of aesthetic taste, by a preference for an approximately chronological arrangement and by the poet's ever growing urge to express, through these verses which are chiefly concerned with his love for Laura, the story of his own soul, from the description of his falling in love to his anxious invocation to the Virgin; from his "youthful errors" to his realization that "all worldly pleasure is a fleeting dream"; from his love for this world to his final trust in God. The theme of his Canzoniere therefore, goes beyond the apparent subject matter, his love for Laura. For the first time in the history of the new poetry, lyrics are not considered as *nugae* or occasional verse as they had been from the troubadours to Boccaccio: Petrarch, in spite of frequent doubts and many changes of mind, still felt that the *schedulae* containing his verses were the threads holding together a marvelous new tapestry possessing its own unity and similar to that which he was constructing, on the Ciceronian model, from his letters. By selecting all that was most polished and at the same time most vigorous in the neo-Latin lyric tradition of the preceding two centuries, and filtering it through his new appreciation of the classics, he not only bequeathed to humanity the most limpid and yet passionate, precise yet suggestive, expression of love and grief. of the ecstasies and sorrows of man, but also created with his marvelous sensibility the form and language of the modern lyric. In fact, the history of the European lyric could be recounted in terms of action and reaction in the face of the Petrarchan experience. (Edited by G. Contini, 1949; commentaries by G. Carducci and S. Ferrari, 1899 and, 6th ed., 1957; edited by E. Chiorboli, 1924.)

Rime disperse.—This title (or sometimes Extravaganti) is used for those verbs which Petrarch did not include in his main collection, either because they nere not good enough or because they were not addressed to Laura. The authenticity of many is doubtful, in some cases no longer accepted. (Edited by A. Solerti, 1909.)

Trionfi.—A poem in *terza* rima probably conceived and begun in 1351 in imitation of Boccaccio's *Amorosa* visione and possibly of Dante's Divine Comedy. It was written in sections and continually revised during the following years (the earliest certain dates, 1356–60, are of the *Trionfo d'Amore*, the latest, Feb. 1374, is written in the margin of the Trionfo *dell'Eternità*). Petrarch left it unfinished and it was published posthumously. It is an historical and symbolical vision of the great theme of the *Canzoniere* raised from the autobiographical to the universal, that is, from the story of one man alone, Petrarch, to that of man in himself, or rather of the whole of humanity in its progress from earthly passion to fulfillment in God. Love triumphs over the greatest men, but is captured by Chastity; which in its turn, in the person of Laura. is overcome by Death; which is conquered by Glory; which is itself annihilated by Time: only in God does everything of beauty and everything of value, love for Laura and love for glory, shine eternally beyond all space and time, and heaven and earth are reconciled according to Petrarch's noble and constant dream. (Critical edition ed. by K. Appel, 1901; to be read in conjunction with the new sections, *Un* inedito petrarchesco, edited by R. Weiss, 1950.)

Conclusion.—This summary of the essential events of his life and sketch of the chronological and spiritual development of his works will have sufficed to show the exceptional importance of Petrarch in the poetry and culture of modern and Christian Europe; never before, perhaps. has a writer had so rapid, so decisive and so far-reaching an influence. This "presence" was so effective because it made itself continuously felt, through his spoken and written conversations with his friends and disciples, and his prodigious achievement as the discoverer of so many of the treasures of classical learning and beauty, both in those texts which he actually found and in those which he re-established by his sensitive and accurate interpretation. Through his sublime poetry, and his profound spiritual and moral meditations, his historical visions and reconstructions and in the devoted work for humane studies by which he solved the age-old problem of the reconciliation of the classical with the Christian world, Petrarch shows how in the substantial identity of human souls God provides the opportunity for meetings and contacts, for the affirmation of the same truths in different ages and under different skies. The words of his beloved St. Augustine which, during the ascent of Mt.

Ventoux, flashed before his mind's eye, "And men go to admire the high mountains and the immensity of the ocean and the course of the heavens . . . and neglect themselves," are truly symbolical of Petrarch's mission in life, of his thought and of his art. Never, since the great teachers of antiquity and the greatest fathers of the church, has man had so enthusiastic and sensitive an interpreter of his sorrows and his greatness, so subtle and so sympathetic an interpreter of his eternal uncertainty outside fulfillment in God. "I always feel a sense of unfulfillment in my heart," he wrote with Augustinian inspiration in the *Secretum*. It is for this reason that the figure of Petrarch towers over that age, from Boccaccio to Erasmus, which took its name from man. the age of humanism; for this reason that, from Bembo to Michelangelo and Ronsard, from Gongora and Milton to Klopstock, from Shelley and Heine to Leopardi, to Heredia, to D'Annunzio, the art which, better than any other, expresses with precision and yet with sensitivity the most constant and the noblest aspirations of man, sprang originally from the fount of Petrarchan inspiration.

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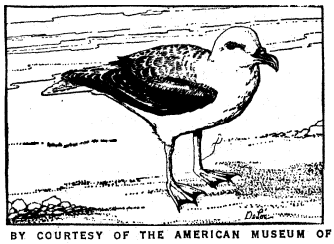
PETRE, SIR EDWARD (1631–1699), Jesuit confessor of King James II of England. was born in Paris, the son of Sir Francis Petre, Bart., of Cranham, and his wife Elizabeth Gnge. Educated at the Jesuit college at St. Omer, he entered the order under the name of Spencer in 1652, but did not receive the full orders till 1671, when he was sent on a mission to England. In 1679 he succeeded his brother in the title and family estates. On the accession of James II in 1685 he became confessor to the king. whom he encouraged in the policy which ended by producing the revolution of 1688. The king contemplated making him archbishop of York, as the see was then vacant, but the pope, Innocent XI, who was not friendly to the order, would not grant a dispensation to hold it, and even directed Petre's superiors to rebuke him for his excessive ambition. On the outbreak of the revolution, Petre fled, and had no further relations with James II. After a visit to Rome, he became head of the Jesuit college at St. Omer in 1693, from where he was transferred to Walten in Flandersin 1697. He died on May 15, 1699.

PETREL, group of birds whose name is derived from their apparent habit of walking on the water as St. Peter is recorded (Matt. xiv. 29) to have done. They form with the shearwaters (*q.v.*) and albatrosses (*q.v.*) the order Tubinares, the name denoting the tubular structure of their nostrils. There are two families, Procellariidae and Oceanitidae.

Petrels are archaic oceanic forms, with great powers of flight, dispersed throughout the oceans of the world; some species apparently never resort to land except for the purpose of nidification. During the breeding season many of them are nocturnal in their habits, passing the day in holes in which they generally nest, the hen laying a single white egg, sparsely speckled in a few species with fine reddish dots. Of those species that frequent the North Atlantic the stormy petrel, or Mother Carey's chicken, *Hydrobates pelagicus,* is the commonest. Other Atlantic forms are Leach's or the forktailed petrel, *Oceanodroma leucorrhoa,* a larger but less common bird and Wilson's petrel, *Oceanites oceanicus,* the type of the family Oceanitidae, which is common on the American side. In the southern ocean petrels are most abundant, both as species and as individuals. The Cape pigeon or Pintado petrel, *Daption capensis,* is one that has long been well known to mariners, while those who voyage to or from Australia meet with many more species, some, as *Ossifraga gigantea,* as large as albatrosses, and several called by names having reference to their strong smell of musk. The colouring of petrels is sooty black, gray of various tints and white.



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THE PETREL, AN OCEANIC BIRD THAT COMES TO LAND ONLY DURING THE BREEDING SEASON

PETRI, OLAUS and **LAURENTIUS,** two Swedish churchmen who played decisive roles in the reformation of the Swedish church. Born at Örebro in the diocese of Strangnas, OLAUS (or OLAVUS) PETRI (1493–1552) studied at Wittenberg (1516–18) and absorbed the reformed teaching of Luther and Melanchthon. When Gustavus Vasa was crowned king in 1523, Olaus had already attracted attention and criticism by his preaching. The Roman Catholic hierarchy were hostile to the king, who became a supporter of the reformed teaching. Laurentius Andreae, secretary and later chancellor to the king, was a friend of Olaus Petri, who preached the coronation sermon. Olaus rose in prominence and served briefly as chancellor (1531). Later he opposed the autocratic policy of the king, and both he and Andreae fell from favour and were condemned to death in 1540, the sentence being remitted for a heavy fine. Later he regained favour and was appointed pastor of Storkyrkan church in Stockholm where he died in 1552. Olaus provided most of the literature for the Swedish Reformation movement. including a Swedish New Testament (1526), hymnbook (1526), church manual (1529), the Swedish liturgy (1531) and many homiletical and polemical writings. His *Chronicle* is an important historical document.

LAURENTIUS PETRI (1499–1573) also studied at Wittenberg, returning to Sweden in 1527. He was appointed the first Protestant archbishop of Uppsala in 1531 and held this office until his death in 1573. His influence was very great, although he was less dynamic and forceful than his brother. The Swedish Bible of 1541, for which he was principally responsible, was as important for Swedish life and literature as Luther's German translation mas for the German-speaking peoples. His *kyrkoordning* (church order) of 1571 defined the practice of the church. particularly its relation to government, and went far toward establishing the independence of the church from the crown which has been characteristic of most of its history.

See C J I Bergendoff, *Olavus Petri and the Ecclesiastical Transformation in Sweden 1521–52* (1928); E. E Telverton, *An Archbishop uf the Reformation* (1959) (E. M. C.)

PETRIE, SIR (WILLIAM MATTHEW) FLINDERS (1853–1942), English Egyptologist, was born at Charlton on June 3, 1853, the son of William Petrie, C E.. and Anne, daughter of Captain Matthew Flinders (*q.v.*). He took an early interest in archaeological research, and between 1875 and 1880 studied ancient British remains at Stonehenge and elsewhere; in 1880 he published his book on Stonehenge. He mas much interested in

ancient weights and measures, and in 1875 published a work on *Inductive Metrology*. In 1880 he began a long series of important surveys and excavations in Egypt, beginning with the pyramids at Giza, following up his work there by excavations at the great temple at Tanis (1884), discovering and exploring the long-lost Greek city of Naucratis in the delta (1885) and the towns of Am and Dauhnae (1886), where he found important remains of the time when they were inhabited by the Pharaohs. Between 1888 and 1890 he was at work in the Fayum, opening up Hawara, Kahun and Lachish; and in 1891 he discovered the ancient temple at Medum. Much of this work was done in connection with the Palestine Exploration fund. By this time his reputation was established. He published in 1893 his *Ten Years' Digging in Egypt*, and was appointed Edwards professor of Egyptology at University college, London. In 1894 he founded the Egyptian Research account which in 1905 was reconstituted as the British School of Archaeology in Egypt. Perhaps the most important work of the school was at the site of Memphis (*q.v.*). Flinders Petrie was knighted in 1923. He resigned his professorship in 1933 and from 1932 to 1938 excavated in Palestine. Sir Flinders died July 28, 1942, at Jerusalem.

WORKS.—His chief general works on Egyptian subjects are: *Ten Years' Digging in Egypt* **(1893)**; *History of Egypt* (1894–1905); *Religion and Conscience in Ancient Egypt* **(1898)**; *Syria and Egypt* **(1898)**; *Hyksos and Israelite Cities* (1906); *Religion of Ancient Egypt* **(1906)**; *Arts and Crafts in Egypt* (1909); *Historical Studies* (1910); *Revolutions of Civilisation* (1911); *Eastern Exploration* (1919); *Prehistoric Egypt* (1920); *Social Life in Ancient Egypt* (1923); *Seventy Years in Archaeology* (1931); *Anthedon, Sinai* (1937); *Funeral Furniture and Stone and Metal Vases* (1937); *Egyptian Architecture* (1938); *Making of Egypt* (1939); *Egyptian Science* (1939). *A* principal work on Palestine is *Ancient Gaza* (5 vol., 1931–38).

PETROGRAD: *see* LENINGRAD.

PETROL: *see* GASOLINE (GASOLENE, PETROL).

PETROL ENGINE: see INTERNAL COMBUSTION ENGINES.

PETROLEUM. Petroleum exercises a deep influence on modern industrial civilization. Petroleum fuels power the engines of automobiles, buses. farm tractors and trucks as well as those of fishing craft, merchant ships, passenger liners and aeroplanes. Petroleum products lubricate engines. motors and machines, and petroleum cutting oils make possible much of the drilling and grinding basic to mass production. Petroleum fuels heat homes and buildings. Petroleum asphalt helps build modern highways. Either by self-consumption or by generating electricity. petroleum illuminants supply many people of the world with artificial light.

Products of petroleum are used to make synthetic fibres for clothing; synthetic rubber for tires and other uses; cleansing agents. such as soap and detergents; paints and plastics: and numerous ingredients used in fertilizers. insecticides, food processing and many medicines. Such peacetime applications of petroleum multiplied as scientists found new uses for the liquid's by-products. A whole new industry grew out of petroleum chemistry—the petrochemical industry.

Two world wars demonstrated petroleum's vital importance in war. World War I first focused attention on petroleum as a strategic material and World War II underscored its importance as a fuel and a lubricant. Petroleum also was made to yield toluol, an ingredient of T.N.T.; waterproofing greases essential to amphibious operations; inflammables for flame throwers, napalm, and fuel for rockets and jet engines.

Because of its importance in daily economic life and in war and national defense, oil became a significant factor in international politics. and petroleum development and the control of reserves over the world became important security measures.

Petroleum development. on the other hand. served to raise living standards in underdeveloped countries. Activity by pioneering companies was called a private Point Four. Underdeveloped countries found to be oil-producing were not the only ones to benefit. Greatly increased and more readily accessible proved oil reserves stimulated the building of refineries in many countries. This greater availability of the energy resource. petroleum, promised to play a dynamic role in the improvement of living standards for all peoples.

In this article petroleum will be considered in these separate sections:

I Origin and Characteristics
II. Methods of Production
III. Refining of Petroleum
IV. U S Petroleum Industry
V. World Oil Situation

I. ORIGIN AND CHARACTERISTICS

Most scientists believe oil was formed from the bodies of tiny plants and animals that lived in the sea hundreds of millions of years ago when the sea covered large areas of what are now land masses. The animals and plants lived and died by the billions, then sank to the bottom and mixed with mud and sand in layers called marine sediment.

Later, these sedimentary layers were covered by more mud and sand, which finally turned into rock. As ages passed. the sea withdrew, the earth's crust heaved and buckled and the heat and pressure caused by the overlying rock. together with decomposition of the organic life, is thought to have formed oil from the animals and plants in the deep-buried layers. Because of their mutual derivation from organic material, petroleum, natural gas and coal are known as fossil fuels.

Crude oil as it comes from the ground is a mixture of thousands of different chemicals. which range from extremely light gases to semisolid carbonaceous materials such as asphalt or paraffin wax. The gases are dissolved in the other components of the crude oil because of the extreme pressure to which petroleum is subjected in the ground.

Likewise, the paraffin wax is dissolved in the so-called paraffinic crudes but can be removed by combinations of refrigeration and filtration or by selective solvents. As a liquid, petroleum may be as thick and black as melted tar. or as thin and colourless as water, depending entirely upon the particular oil field from which it comes.

Chemically, crude oil is largely composed of hydrocarbons. compounds of hydrogen and carbon. In addition. crude oil often contains sulphur, either uncombined or present as a part of certain hydrogen-carbon-sulphur compounds.

II. METHODS OF PRODUCTION

Exploration.— Since oil is never found apart from marine sediments, oilmen first look for them. But they know that oil does not always stay where it was formed. The sediments are porous, and water or gas can push the oil through tiny holes in the rock or between grains of sand until it is trapped by nonporous rock. Oilmen look for these traps. which result from changes that have taken place in the earth's crust.

For about 40 or 50 years after the first commercial oil well was drilled in the United States (1859) little technical advice was sought in determining the location of well sites. Oil was discovered by drilling near seepages or other surface indications and by random drilling.

Scientific methods of search were later developed and used, though random drilling still yields occasional discoveries of considerable importance. About 1912, geologists started the mapping of rock outcrops to locate favourable places to drill. Within a few years most of the promising surface structures in the U.S. had been drilled to depths as great as possible with existing equipment and methods.

In the early 1920s the great era of subsurface exploration for oil began. Pit digging and core drilling were used in areas where identifiable key beds were not exposed sufficiently to permit surface mapping of underground structures. More careful logging of wells and improved methods of collecting and analyzing drill cuttings vastly increased the quantity and accuracy of available information. thereby permitting the geologist to extend his knowledge of structural conditions both laterally and vertically.

Palaeontologists effected a correlation of geological horizons between widely separated wells through a study of microfossils. In some regions mineralogists mere able to correlate the underground geological strata on the basis of the mineral content of the sediments.

Electrical. gamma-ray and neutron well logging all were of great

value to the geologist in correlations and in working out the details of subsurface structure. The great strides made in perfecting coring devices not only improved production and development techniques but also vastly increased the geologist's knowledge of deeply buried formations.

The many advances which were made along these lines. though not spectacular individually, cumulatively furnished a wealth of assistance to the geologist and served as the foundation of the study of subsurface geology.

Geophysical methods of exploration were introduced into the United States oil industry in the middle 1920s. (*See* GEOPHYSICAL PROSPECTING.) German scientists using the seismic method (setting off an artificial "earthquake" with a charge of dynamite and recording sound waves on a delicate seismograph instrument) were the first to use geophysical methods in oil finding successfully. They located the first salt dome in the U.S. Gulf coast area, these domes being favourable to the accumulation of oil in pools or reservoirs below ground. U.S. technicians greatly improved on the early instruments and methods and introduced several new methods until geophysical exploration became a routine field operation as well as a continuing major research project in the laboratories of the large oil companies. The seismic method has proved to be one of the most accurate.

Measuring magnetic force is another test for possible oil-bearing formations. This depends on iron. Some rocks contain more iron than others. The more iron a rock contains, the more magnetic it is. Generally. the sedimentary rocks. which may contain oil, are less magnetic than the harder rocks that never contain oil. Oilmen use a magnetometer in measuring the iorce of magnetism at the surface of the earth. This gives them a general idea of rock formations underground. They take many readings over a large area in order to find formations that might hold oil. Sometimes they tow a magnetometer behind an aeroplane. A navigation system based on radar tells exactly where the plane is at every instant. Thus the magnetometer readings can be pinpointed on a map. Airborne surveys cover large areas very quickly—on land or sea.

Gravity gives the same kind of help in the search for oii as magnetic force. The force of gravity varies from place to place, depending on the weight of rocks underneath. Sedimentary rocks are lighter than the others. Oilmen use an instrument called a gravimeter in measuring the pull of gravity at the surface. They plot the readings on a map in order to get a picture of rock formations far below.

During the early 1950s, laboratory and field work was being conducted on such projects as the mapping of geologic anomalies with radio waves and the adaptation of various physical instruments such as the electron microscope. the mass spectrograph and the X-rav to the detailed study of well samples and cores.

Highly specialized seismic techniques and equipment were developed to cope with the problems of exploration in the open waters of the continental shelf. It became possible to examine such an area with much greater rapidity than on land. much of this work utilizing radar. Gravity data mere obtained by placing the instrument in a diving bell or by recording the readings electrically. Substantial reserves of oil found off the coast of Louisiana and Texas on the flanks of salt domes were located by these methods.

Interpretation of geophysical data falls just short of being an exact science. It has been compared with the work of the medical diagnostician who bases his findings on the correlation of a number of laboratory tests including X-rays. The geophysicist assembles a series of scientific readings. These have been constantly improved but everything depends upon his experience and learning, his interpretation.

Despite great and continuing improvements in techniques, year by year oil is becoming harder to find. A study of United States wildcat wells over a period of years shows that the percentage of success has declined. It dropped from 13.16% in 1954 to 12.41% in 1955 even though 6j8 more exploratory wells were drilled during the latter year.

Early Production.— In the United States the subsoil is not owned by the government. as is the case in almost every other nation, but goes with the ownership of the land. The long-established law of oil and gas known as the "rule of capture" gives the owner of the oil-field land all the oil which he can reduce to his possession, whether or not all such oil originally underlay his particular tract. Upon discovery of a new field, therefore. in the early days every operator rushed to develop his property as rapidly as possible and produce it at maximum capacity so as to obtain the greatest possible share of the total oil recoverable from the field. Under such practices operators observed that the first wells obtained the highest recoveries. that unrestricted producing rates yielded higher recoveries and that more densely drilled tracts obtained more oil per acre than adjoining tracts with %-ider well spacing.

These observations led to the conclusions that rapid development, close well spacing and maximum producing rates resulted in maxi-

BY COURTESY OF CREOLE PETROLEUM CORP.

OFFSHORE OIL FIELDS. STORAGE TANKS AND WORKERS' HOUSES AT LAGUNILLAS ON LAKE MARACAIBO. VENEZ.

mum recovery. It was later established that these conclusions were unsound and that practices in vogue in the early years incurred gross economic waste and were detrimental to the maximum recovery of oil from the field as a whole. Therefore, regulations were provided on well spacing to protect the rights of the landowners and the public interest.

Underground Pressure.—Beginning in the mid-1920s geologists and petroleum engineers were able to piece together fragments of information which indicated a definite pattern of behaviour of gas, oil and water under the ground. They learned something about the accumulation of oil in porous strata. They learned how oil and gas were brought to the wells as a result of the natural reservoir energy of the gas and water which confined the oil under great pressures. The key element in modern conservation operations is the underground pressure which forces the oil through the oil-bearing strata to the bottom of the well, from which it may be lifted to the surface.

Because the natural gas that originally accompanies crude oil in the ground is under compression, it often can provide sufficient energy to move the oil through the porous rock to the bottom of the well, and sometimes up the well to the surface. Similarly, water associated with the oil may be under pressure and thus provide some of this energy.

Properly conserved, these two natural forces can expel a large amount of the oil in the formation. If these forces are inadequate, the oil may be moved to the surface by means of artificial lift, such as pumping. The proper use of the natural energy contributes greatly to the maximum production of oil. Its proper utilization, then, has become one of the primary steps in the U.S. conservation movement. In some naturally prolific fields, modern engineering methods will result in the production of more than 80% of the available oil.

In most cases, good engineering practices call for producing methods which do not permit the pressure in the reservoir to be reduced below a minimum amount. Sometimes pressure can be maintained by controlling the rate of oil withdrawal. but it is often necessary to use other means. Sometimes the produced gas is gathered and pumped back into the oil reservoir, where it helps to maintain pressure.

In some fields where a water drive exists, the injection of water into the reservoir provide5 an effective way of maintaining pressure and recovering more oil. Four mechanisms important in moving oil through the pores of the rock to the bottom of the well have been developed. (Some reservoirs may have a combination of these mechanisms, although generally one type predominates.) They are dissolved-gas drive, gas-cap drive, water drive and gravity drainage. When a field is active, application of such devices are said to relate to primary recovery, as distinct from secondary recovery methods applied after a field has practically stopped producing or has long since been abandoned.

Pumping.—Obviously, natural flow is the least costly way to produce oil. and the engineer does his best to keep the wells flowing. Under modern conservation methods. some fields are still flowing after 10 or 20 years of operation. However, when insufficient gas or water pressure is present to move oil from the reservoir to the surface, petroleum engineers and operators resort to pumping. This may occur in the first development of the field, or after most of the original energy has been depleted. At the beginning of 1954, there were 501,859 producing wells in operation in the United States. 442,394 of them utilizing artificial lift. More than 332,000, or about 66%, were classified as "stripper" wells. These are wells which are pumped infrequently, yielding on an average slightly over three barrels daily.

Secondary Recovery.—Some wells have ceased to produce or are producing at such a low rate that they are considered to be uneconomical. To recover some of the oil still remaining in the reservoir several methods, referred to as secondary recovery, are used. These consist of pumping water, gas or air into the producing formation, through what are known as service or input wells. This process supplements or restores the original reservoir pressure and re-establishes the energy drive. When this can be done, the oil moves toward the well bore.

Natural Gasoline and **Condensate.**—All crude oil is associated with natural gas in the ground. There are many fields. geologically similar to oil reservoirs. nhich contain natural gas with little or no oil. When there is oil, it is separated from the gas at the surface. Plants are built to recover from this gas a liquid known as natural gasoline or casing-head gasoline.

Many deep, high-pressure fields produce a substantial amount of straw-coloured oil knomn as condensate. This condensate is, in effect, a light crude oil, even though it is not a liquid in its underground state. Extensive research on methods of recovering this condensate has made it an important source of petroleum products.

Unitization.—Under U.S. property laws, each leaseholder has the right to produce his own property. Under many state conservation statutes, leaseholders are permitted to pool their interests. so that the reservoir can be produced as a unit. This practice, called unitization, is gaining wider acceptance throughout the oil industry.

Unitization is encouraged by federal regulations relating to the public domain and permitted by the laws of many states. It provides for the orderly, joint development of a field for the benefit of all. More oil is ultimately produced at less cost to the consumer. The landowner who leases his land to an oil company continues to receive his proportional share of royalties from oil produced from the entire field.

U.S. Interstate Oil Compact Commission.—Co-operating in effectuating state conservation measures in the U.S. is the Interstate Oil Compact commission, established by act of congress in 1935. This act enabled oil-producing states to co-operate in the exchange of information both in the production and in the conservation of their petroleum resources.

Estimates of Increases in Recoverable Reserves.—Water drive and gravity drainage proved the most efficient means for obtaining high recovery. One authority estimated in 1952 that modern production methods, as practised under the regulations of state conservation agencies, had resulted in an increase of 50% in the recoverable reserves. All authorities agreed that the figure is "very large," and that further improvements promise additional increases. A survey of Texas fields, made in 1954, estimated that fields of that state, which had produced 14,800,000,000 bbl. (much by early wasteful practices), had remaining reserves of about 26,200,000,000 bbl., 10,500,000,000 of which could be produced by secondary recovery. The survey also indicated that 53,400,000,000 bbl. left in the ground could not be recovered by knomn methods. The report suggested that the recovery for the state would average about 43%. Another study, published in 1955, covering the entire U.S., estimated 272,000,000,000 bbl. as the original oil content of the known commercial reserves. The sum of past production and primary and secondary reserves was given as 105,000,000,000 bbl., leaving 167,000,000,000 bbl. of oil unproducible by existing methods.

Conservation in East Texas.—One of the outstanding examples of conservation occurred in the fabulous east Texas oil field which in 1932 began to go to salt water and to lose its natural pressure. The field mas shut down and conservation methods devised, including the drilling of salt-water injection wells to bolster the pressure of the field. In 1956 there were 82 salt-water wells injecting over 400,000 bbl. daily into the field, and it was estimated that up to that time 1,947,300,000 bbl. of water had been injected back into the oil reservoir. Oil experts figured that the salt-water injection program had resulted in saving approximately 600,000,000 bbl. in the east Texas field alone.

Indeed. the majority of major fields in which the pressure was maintained reasonably close to the original pressure, either through conservation of the natural reservoir energy or through injection of gas or nater, recovered over 50% of their oil in place. Such recovery under efficient practice may be contrasted with the recovery of about 20% or 25% commonly expected from reservoirs depleted under inefiicient methods prior to 1930.

In fields that were produced by inefficient primary-recovery methods, secondary-recovery operations can be used to obtain substantial additional production. Ultimate recovery by primary and

secondary operations of 40%–60% is common under good secondary-recovery practice. Secondary recovery in depleted reservoirs is generally not so efficient as the equivalent fluid injection carried out as a pressure-maintenance operation in a ne field.

Difficulties Encountered. — Often practical considerations make it impossible to use the more efficient reservoir mechanisms. One of the most common problems is that the application of efficient reservoir-engineering methods generally requires unitization of the pool, or operation under conservation regulations that have substantially the same effect as unitization. In some oil fields in flush (natural-flowing) production it is virtually impossible to reconcile the interests of the various property owners so as to permit the adoption of a program for development and operation which would lead to maximum recovery from the whole field. As a last resort, the property owners may reach a satisfactory unitization agreement, but the arrangement of such agreements is sometimes extraordinarily difficult. Then too, there may be good economic reasons for not adopting pressure-maintenance operations in the early life of some fields.

In the case of smaller fields with reservoirs of poor quality, rapid production at the expense of high recovery may offer an acceptable pay out on the investment in the properties, whereas pressure-maintenance may result in too slow return of the capital tied up in the operation.

Finally, in many cases, technical reasons may make pressure-maintenance operations unattractive. For instance, in many reservoirs the viscosity of the oil is so high that only a small percentage of it can be displaced by the flow of any reasonable quantity of gas or water through the rock.

New Recovery Methods. — Although recovery varied greatly for individual fields, experts declared that many of the larger and more important fields in the U.S. discovered since 1930 were probably leaving little more than the residual oil unproduced. Most of the oil which mould not be produced under practices current in the latter 1950s was in older fields. Active research in laboratories and in the fields throughout the U.S. was being carried on to make greater recovery in these fields technically and practically possible.

Several methods of applying solvents in the field were under test. The use of LPG (liquefied petroleum gas) components to enrich injected gas gave results which suggested that under favourable conditions recoveries of the order of 80% might be obtained in practice. The possibility of using nonhydrocarbon solvents such as carbon dioxide were being studied. Vaporization of a part of the residual oil by gas injection at high pressure was also under test in the field.

Several thermal methods of increasing recovery were under investigation. Laboratory tests and theoretical studies demonstrated that any of these new recovery methods was capable of removing almost all of the oil from the rock through which it was operative. Only two barriers kept them from being widely used. One was the physical problem of controlling the fluid distribution in the reservoir in such a way as to operate throughout the productive section of highly complex and irregular reservoirs. The other was the high cost of the proposed methods compared with conventional producing methods.

Improved Drilling Methods. — Io 1925 the deepest well drilled was around 7,000 ft., and 5,000-ft. wells were uncommon. In 1952 a well 5,000 ft. in depth was considered relatively shallow, and many fields were producing from depths between 12,000 and 15,000 ft. In 1949 the first well to reach a depth of more than 20,000 ft. was drilled in Wyoming.

Early wells were drilled by the cable-tool system, and to reach depths of 3,000 to 4.000 ft. by this method was a slow and laborious process. Rotary-drilling methods were first used in 1901 in the Spindletop field near Beaumont. Tex. With the advent of better steels this method was greatly improved, and by the early 1920s it was the commonly used method for drilling nells.

The drilling of deeper wells was made possible by general improvements in the design. strength and power of drilling machinery; by metallurgical progress in the manufacture of alloy steels and advances in the fabrication of drill pipe, casing, tubing and pumping equipment; by scientific control of drilling fluids resulting in greater drilling speeds. drilling through formations previously impossible to penetrate with ordinary drilling muds and security from blowouts; and by improvements in cements and cementing practices and the development of techniques satisfactory under high subsurface pressures and temperatures.

The introduction of electrical well-logging equipment greatly assisted the correlation and evaluation of subsurface strata and consequently improved completion practices. The early techniques were applicable only before the casing was set, but later developments made logging possible through the casing and thus provided a means of evaluating formations behind the pipe in old wells.

Core-analysis equipment and techniques were perfected so that core samples of formations could be tested immediately upon their recovery at the surface and possible reserves recognized during the process of drilling. Complete truck-mounted laboratories provided this service at the well to any wildcatter, making available information as to porosity, permeability and fluid content of the core samples of the strata.

Examination of the drilling fluid under ultra-violet light and other special tests assisted in determining the fluid content of formations penetrated by the bit.

In 1956 the announcement of the securing by a U.S. concern of a licence to manufacture a turbodrill developed by Russian technicians created a stir among oilmen. Turbine drilling as compared with rotary drilling is faster and therefore cheaper, according to claims made by a Soviet engineer at the fourth Petroleum World congress at Rome in 1955. Efforts to perfect the turbodrill had been virtually suspended in the U.S. at the outbreak of World War II after years of testing. The Russians stated that 65% of Soviet drilling was by the turbine method.

In 1956 the world's deepest hole was reported to be the Richardson & Bass 1-L Humble-LL & E-State Lease 2414 in Louisiana, still drilling at 21,535 ft. The deepest producer was Shell Oil company's gas-condensate well at Weeks Island, La., producing from 17,558–84 ft. The deepest cable-tool well in the world was drilled in Chemung county, N.Y., by the New York State Natural Gas corporation to a depth of 11,145 ft. It was started June 8, 1948, and continued to June 3, 1953, when it was abandoned as dry. The drilling operation represented an expenditure of $195,000.

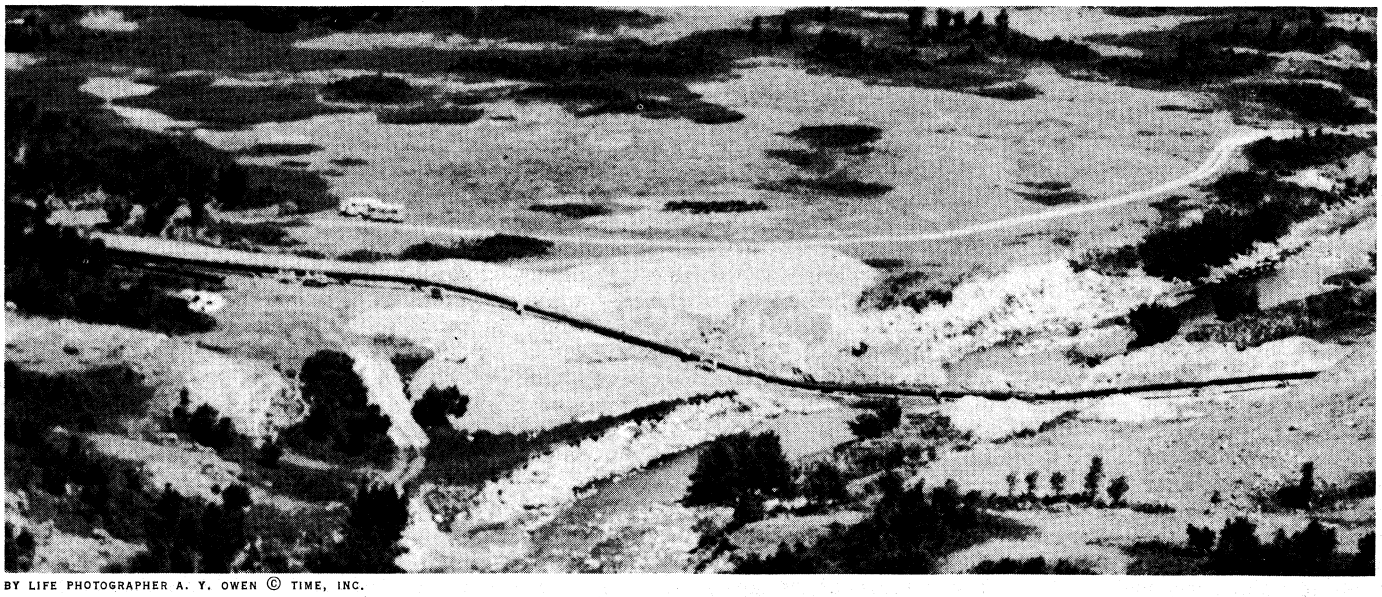
Offshore Drilling. — The opening up off the California coast of the pools of the continental shelf was made possible by the development of subsurface well-surveying instruments and directional-drilling techniques and their application to reserves under the deep coastal areas. The wells were drilled, from shore locations, on a slant to pools under water.

Drilling on the continental shelf in the Gulf of Mexico and experimentally in the Atlantic and in lakes, bays and shallow.-water areas of the Gulf roast and Venezuela was made possible by the development of suitable equipment for drilling from barges and special foundations. This opened the way to additional thousands of square miles of important prospective oil area and added substantially to crude-oil reserves.

The first discovery in the open waters of the Gulf of Mexico was the Creole field in 1938. World War II and litigation culminating in the supreme court decisions of 1947 and 1950 declaring the continental shelf federal property tended to restrict operations. Finally, in 1953, the federal Submerged Lands act restored to the states the title they previously had held and exercised. During this time, the industry poured $650,000,000 into the offshore fields of Louisiana and Texas. Gross revenue from all the oil and gas sold from the area was estimated at only $110,000,000. Yet this area from Brownsville, Tex.. to Key West, Fla., in water no deeper than 120 ft., constituted about 75,000 sq.mi. structurally promising for oil development.

For the drilling of wells in the Gulf tidelands, either exploratory or development, three general methods were used: the self-contained platform, the small platform-floating drilling tender and the mobile device. The small platform-floating drilling tender was most widely used.

To operate offshore, a base of operations on land must be provided. A permanent base is established in protected waters on



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SECTION OF THE TRANS-CANADA PIPELINE BUILT TO CARRY NATURAL GAS FROM ALBERTA OIL FIELDS TO CENTRAL CANADA

a navigable channel to the Gulf, and provided with an office, warehouse, communications centre. living accommodations, pipe racks and equipment and supply yard space, oil storage tanks and a slip. A complete offshore drilling unit requires three crew or personnel boats to transport up to 30 passengers and small supplies from the base to the rig. One boat is kept standing by the rig at all times for the evacuation of personnel in an emergency. Another is usually in transit and the third boat is kept in reserve at the base in case of a breakdown and for special unscheduled trips. A work boat is required.

In addition, tugboats are needed at certain times of the year, especially during the hurricane season, and also for short periods when equipment is being moved. Occasionally a deck cargo barge is used with the tug for carrying supplies and water. As an auxiliary to the drilling operation a dependable means of communication between the rig and the shore is necessary; therefore, each operation sets up its own FM radio and marine telephone facilities.

A survey of offshore operational costs published in 1952 showed that the investment made before drilling came to a minimum figure of $980,000 and a maximum figure of $4,050,000. Drilling costs were about $4,471 a day and about 100 days would be required. Tubular goods cost about $125,000 more. Drilling and production costs—estimated as about three to four times greater than uplands costs—were expected to be reduced materially as experience was accumulated in proving this vast potential oil reserve.

The Pipeline.— Not unlike the railways in operating technique, the modern pipeline system is an efficient, clocklike mechanism with dispatchers. district and division superintendents, "track-walkers" and section crews. Great improvements have been made in the pumping and power equipment at pumping stations. Diesel power is uidely employed for the powerful pumps, the performance is steady and continuous day and night, and the operation is almost automatic.

Since the early days. great changes have taken place in pipe material and in the joining of pipe. High-carbon steel was introduced. Methods were developed by which pipe was welded instead of joined by the ordinary screw couplings. In the gas fields, metallurgical science similarly enabled producers to pipe natural gas for long distances.

In the decade after 1927 the transportation of gas by pipeline was extended from a maximum distance of 250 mi. to distances of 1,000 mi. Electric arc welding, which permitted the handling of gas at high pressures; telescopic lines made up of sections of pipe of different diameters, the diameter increasing in the direction of flow as the pressure decreases; and automatic welding processes for field service, used in gas and oil fields, all came into vogue. The subsequent development of high tensile strength, thin-walled, large diameter pipe completely solved the problem of long-distance oil and gas transmission.

Coincident with the installation of gastight, long-distance natural-gas lines. pipeline systems were built to transport gasoline and distillates from the refineries to the main marketing centres. As in the case of natural-gas transmission, this was made possible by advances in metallurgy and in welding practices. Thus the pipeline began to supplement the railroad in the long-distance transportation of the refined products of petroleum. Large quantities of gasoline that would otherwise require the loading, hauling, unloading and return of hundreds of tank cars are moved in a continuous flow through pipes to market terminals.

III. REFINING OF PETROLEUM

Crude oil contains a very limited amount of the hydrocarbons which are suitable for immediate use as gasoline components. Therefore refiners must select other types of hydrocarbons from the crude oil and convert them to types which are desirable in gasoline. Tremendous investments in refining equipment are required to separate the types of hydrocarbons needed and to alter their chemical composition. To accomplish this, a wide variety of refining processes have been developed.

Cracking **of** Crude Oil.—The advent of the automobile in the early 1900s and its quick popularity caused a growing demand for gasoline which the refineries were hard put to supply. Petroleum chemists and technologists devised means of improving the refining processes, which enabled them to produce more gasoline from the crude oil, and thus relieved the tension on gasoline supply. They found the answer in 1915–20 in the thermal cracking of crude oil. Crude oil consists of hundreds of differenthydrocarbon compounds. Cracking is the dissociation or breaking down of the molecules and their rearrangement into a more useful form. In effect, the large molecules are literally broken down by high temperatures and pressures, and they are then regrouped to form the desired finished products. By this means the lo -boiling hydrocarbons, formerly useful only as fuel oil, could be converted into gasoline. Moreover, the quality of the cracked gasoline was found to be greatly superior to that produced by the old boiling or distillation (straight-run) method. Engine power was increased by the use of the improved gasoline, and the motorist got more miles per gallon of gas. The result was a tremendous contribution to the conservation of petroleum.

The next advancement was the development of catalytic cracking. In this operation a catalyst (some common catalysts are alumina. silica and certain clays such as bentonite) is introduced into the refining process to promote and expedite the cracking of the molecules.

Polymerization. — There were many other processes which made important contributions to the yield and quality of modern motor fuel. Polymerization came into use in the early 1930s. It catches petroleum refinery gases once largely wasted or used as fuel and converts them into liquid form. This process is the reverse of cracking. Whereas cracking breaks down the heavier molecules of fuel oil into the lighter ones of gasoline, polymerization combines the smaller molecules of certain gaseous by-products of refining into the chemical components of motor fuel. Installations for this purpose were numerous and polymer gasoline began to complement cracked gasoline.

Hydrogenation. — German technicians had developed a process for the conversion of coal into gasoline. called the hydrogenation process. Refiners in the U.S. began experiments to apply to petroleum a similar process brought there in the early 1930s. Before World War II commercial units were successfully using hydrogenation in making high-grade gasoline. diesel fuels and lubricants, special aromatic solvents and special-purpose pure hydrocarbons. In the process, petroleum fractions were subjected to the action of high-pressure hydrogen, at temperatures ranging from 500° to 1,000° F.. in the presence of catalysts.

The characteristics of the charging stock were altered chemically by this method. The refiner controlled the chemical composition of his final products.

Other **Processes.**—Alkylation was another development of the late 1930s and early 1940s. This process converts other gaseous constituents into high-quality gasoline. Involving a reaction between isobutane and various olefins, alkylation was not even considered possible a bare 15 years before; yet during World War II it was the backbone of the United States oil industry's tremendous production of 100-octane gasoline. Hydroforming, thermal reforming, catalytic reforming. aromatization, isomerization and many other additional chemical processes also came out of the oil industry's research laboratories. These processes lent considerable flexibility to refining and made possible an amazing manipulation of molecular groups.

Scientific development of the natural gasoline industry also added to the supply of high-grade motor fuel and aviation fuel. That development brought about efficient and economical means for recovering and stabilizing this volatile gasoline. Weathering could be dispensed with, thereby reducing waste and loss in storing and handling both the natural gasoline and the finished blended motor gasoline. The stabilization process also opened the way for the isolation and recovery of propane, butane, isobutane and other constituents of natural gasoline which formed the basis of a new fuel and chemical resource — liquefied petroleum gases.

Tetraethyl Lead and Octane Rating. — It had been discovered in 1922 that the addition to gasoline of a small quantity of tetraethyl lead would drastically reduce engine knock. Shortly afterward it was noted that a pure hydrocarbon known as isooctane would not knock in the highest compression engine that could then be built, and that another substance, normal heptane, would knock only under certain conditions.

These discoveries led to the formulation of an arbitrary octane-rating standard for motor fuel. A gasoline was called "87-octane," for example, if it produced the same knock as a mixture of 87% isooctane and 13% normal heptane. With standardized antiknock fuels (in 1956 even as high as roo-octane for premium fuel) automotive engineers could develop the high-compression engine which demanded, for satisfactory operation, what are known as high-octane fuels. Tetraethyl lead. therefore. enabled the automobile engineer to build more powerful and more efficient engines, resulting in economy in fuel consumption. Tetraethyl lead ranks along with the cracking process as one of the important factors in the conservation of crude oil.

Additives. — Tetraethyl lead was perhaps the chemical industry's first important direct contribution to the petroleum industry. As better and more powerful engines were developed and the need for better fuels and lubricating oils became more pressing, the chemical industry's contributions multiplied. In the latter 1950s the petroleum industry used millions of pounds of chemicals each year to improve the quality of its products.

These chemicals are used in two ways. First, in refining processes, chemicals are employed as catalysts in cracking up the molecules, or as solvents and acids (*e.g.*, sulphuric acid) for extracting undesirable fractions from lubricating oil stocks. Second, chemicals such as tetraethyl lead are employed as additives to improve highly refined gasoline and oil stocks. Other chemical additives, called oxidation inhibitors have reduced fuel gumming. which is responsible for loss of engine power and for carburettor clogging. Antioxidants and corrosion inhibitors supplied by the chemical industry are added to help motor lubricating oils withstand punishing heat. Detergents put in motor oils help keep engines clean. Pour-point detergents and depressants make oil flow readily in cold climates and help car starting in cold aeather. Viscosity index improver additives keep oil from thinning out when subjected to high temperatures of engine operation. Antiwear additives also are added to motor oils. It has been declared that these additives, plus rust-preventing additives, have doubled the life of automobile engines.

Jet and Rocket Energy From Petroleum Fuel. — The jet-propelled aeroplane, which uses a burning oil rather than gasoline, was a late development of World War II. and refining technologists developed a new fuel for it, as well as for high-speed jet- and rocket-propelled guided missiles. Co-operative fuel research between the petroleum and aviation industries was carried on, similar to that between the petroleum and automobile industries. As well as improving existing jet propellants, petroleum scientists extended their research into the field of rocket propellants made from certain petroleum and petrochemical products. In Feb. 1956 one company announced a potentially inexpensive propellant made of readily available ingredients — synthetic rubber, carbon black and a fertilizer grade of ammonium nitrate which is actually an extremely pure chemical.

The enormous energy output of jet engines made cooling the oil and bearings a major task, but the oil industry found a solution without which the development of supersonic aircraft powered with gas turbines would have been seriously impaired. As larger rockets were built. rnore powerful propellants and new types of motor Lubricating oils mere being developed for aeroplanes in continental and intercontinental travel, as well as for guided missiles and for the space ship of the future.

Automation in Refineries. — The first refineries were controlled by hand, even to hand firing of the stills with coal. Later refineries started using nonautomatic control devices with the controls adjusted manually. By the latter 1950s many refineries were equipped with instruments to continuously determine the composition of process streams and automatically make precise, immediate adjustments to the control devices. formerly reset by hand, mhich then automatically adjust the operating equipment to return the product to correct standards. Technologists identify these instruments by the properties measured, such as refractive index, specific gravity, dielectric constant and infra-red or ultra-violet light absorption.

Products of **Petroleum.**—A barrel of crude oil is generally considered to be composed of five constituent parts, or product groups. The lightest of these groups is made up of gases, and the successively heavier ones consist of the light, middle and heavy distillates and the residues. In the refining process, the lightest groups are distilled or "boiled off" first, and for this reason are referred to as being at the "top of the barrel." By beginning at the top of the symbolic barrel and working down, the order in which the essential petroleum products take form in the refinery can be traced.

A survey conducted by the American Petroleum institute showed a total of 2,347 petroleum products as classified in the following list:

Class of Product	Number of products
Fuel gas	1
Liquefiedgases	13
Gasolines:	40
Motor	19
Aviation	9
Other (tractor, etc.)	12

Gas turbine (jet) fuels	5
Kerosenes	10
Distillates (diesel fuels, light heating oils)	27
Lubricating oils (light and heavy, compounded and uncompounded)	1,156
White oils	100
U.S.P.	78
Technical	22
Rust preventives	65
Transformer and cable oils	12
Greases	271
Waxes (crystalline and microcrystalline)	113
Residual fuel oils	16
Asphalts (including road oils, tars, etc.)	209
Cokes	4
Carbon blacks	5
Chemicals and other (including solvents)	300
Total	2,347

Source: American Petroleum Institute.

The gases that are taken from the ground in association with crude oil are a source not only of gaseous products but of solid and liquid ones as well.

These include gas, used in refineries and factories for heat, light and power; liquefied petroleum gases, used extensively in rural areas for cooking and heating; carbon black, an ingredient of printing inks and synthetic rubber; and raw materials for making chemicals.

One of the most important of these chemicals is synthetic ethyl alcohol. which is valuable both as a solvent and in the manufacture of plastics and explosives. Another is isopropyl alcohol, used primarily as an antifreeze. Oil companies themselves manufacture 300 chemicals, while innumerable others are produced from petroleum intermediates by nonoil companies.

The best-known products of the light distillates are the gasolines. The production of gasolines alone amounts to about 1,250,000,000 bbl. a year, and represents 40 distinct types, each designed to do a specific job. Some are made for automobile engines, some for aeroplanes, some for tractors. Some are designed for summer, some for winter use. Some work best at high altitudes, some at low. Also, gasolines are components of jet fuel. Other light distillate products are the naphthas, from which are derived dry-cleaning fluids, rubber solvents and toluene, used in dyes and explosives.

In the middle distillates are the kerosenes used as fuels; light heating oils for commercial, industrial and home use; and diesel fuels. This group also furnishes a number of important products such as naphthenic acids.

The largest group of products — lubricating oils numbering more than 1,000 — are refined from the heavy distillates. These oils are employed in the moving parts of virtually every machine in existence — from turbines to watches, from the gears in a motorcar to the spindles in a textile mill. There are journal oils and transformer oils. switch oils, hydraulic oils and tempering oils. Each lubricating oil is designed for a clearly defined purpose.

Along with lubricating oils, the heavy distillates provide a wide range of white oils. petrolatums and paraffin waxes. White oils are the base for numerous medicines and cosmetics, for tree sprays and insecticides and the oils used in the manufacture of candy and in the packing of fruits and eggs. Petrolatums are used in preparing salves and creams, and in making rust preventives and rubber softeners. Waxes are important in the manufacture of paper and polishes and as sealers in home preserving.

Asphalts, coke and residual fuel oils are the chief products of the heaviest group, known as the residues. Asphalts provide roofing, paving and waterproofing materials. Coke serves as an industrial fuel and supplies the carbon for carbon electrodes. From the residual fuel oils come boiler fuels and wood preservatives.

The Petrochemical Industry. — In separating the chemical compounds of crude petroleum into their component parts. from light gases to heavy oily liquids, the refining industry supplies many of these parts — or intermediates made from these parts — to the chemical industry for the synthesis of entirely different materials. Because the end products bear no resemblance to petroleum itself. the role of these petroleum derivatives in industry and daily life is less known than that of the more direct products of refinery distillation. Yet petroleum has been the centre of a chemical revolution. Intermediate chemicals derived from petroleum sometimes are called petrochemicals, and products made with their help are referred to as petrochemical products. A whole new synthetic rubber industry grew with the help of the petrochemical butadiene. The array of plastics partly derived from petroleum may run, in finished form, from clocks and combs to nylon socks and acetate rayon neckties — or into the countless uses to which nylon is put in industries and other activities. Crease-resistant fabrics such as Dacron polyester fibre and Orlon acrylic fibre both are made from petroleum intermediates.

Paints, insecticides, detergents, cellophane and photographic film all utilize in their manufacture chemicals derived from petroleum. Polyethylene is another petroleum-derived product that has found many uses. for example. in refrigerator bags, nonbreakable tumblers, squeeze bottles and insulation for electric wires. Petroleum has made possible a revolution in the chemical industry. Some oil companies opened vast new plants, distinct from their refineries, for the manufacture of petrochemicals alone, while, as mentioned, nonoil companies — chemical concerns — made up the other part of the rapidly expanding petrochemical industry.

Petroleum and the Atomic Age. — Oil companies invested millions of dollars in atomic radiation laboratories where, at the beginning of 1956, over 160 atomic refining research projects were being conducted. The oil industry made wide use of radioactivity, especially of radioactive isotopes. Oil drillers gained knowledge of the subsurface by measuring the natural radioactivity of underground strata, or by measuring the reflections of artificial radiation from these rock layers. Flow problems of many kinds, involving both liquids and gases, were studied by means of radioactive tracers.

But in its new radiation laboratories, in the latter 1950s, the petroleum industry was studying applications of radioactivity that extended far beyond these uses of isotopes as tracers. Its major purpose was to explore the possibilities of using radiation to promote chemical reactions essential to oil refining and possibly useful in the production of petrochemicals. Petroleum atomic laboratories also were studying new oil products specifically related to the atomic age — for example, lubricants for atomic engines of the future.

IV. U.S. PETROLEUM INDUSTRY

The recognized birth of the U.S. petroleum industry occurred in the backwoods of western Pennsylvania, near Titusville. There, on Aug. 27, 1859, a former railroad conductor. Edmin L. Drake, struck oil in the first well actually drilled for petroleum. Before that wells were dug by hand or petroleum a-as recovered from seepages.

Investment in the U.S. Petroleum Industry. — By the latter 1950s, the U.S petroleum industry was one of the largest and most important parts of the country's economy. Its operating divisions utilized $37,500,000,000 of gross fixed assets, furnished direct employment to more than 2.000.000 workers and purchased vast quantities of steel, chemicals and other products. With sales of petroleum products. natural gas and chemical products at new levels and with some higher prices, it was calculated that the gross income of the entire industry in the United States, based on consumer prices, reached $19,800,000,000 in 1954. In terms of capital investment. the petroleum business was considered one of the largest in the country. It was estimated that the combined assets employed by the industry as a whole amounted to $47,000,000,000 at the end of 1954. The main components consisted of: gross fixed assets, 79.4%; current assets, 19.4%, other assets, 1.2%. Gross fixed assets amounting to $37,500,000,000 represented the industry's investment in property, plant and equipment. Distribution by departments was as follows. production 59.4%, transportation 11.5%, refining 17.1%, marketing and other facilities 12%. Gross investment of 35 important companies in property, plant and equipment on Dec. 31, 1954, both in domestic and foreign fields, aggregated $30,581,000,000 against which reserves of $14,496,000,000 were accumulated, leaving an indicated net value of $16,085,000,000. See Table I.

TABLE I.--Estimated Investment, Domestic and Foreign, of U.S. Petroleum Industry, Dec. 31, 1954
(in $000)

Department	Gross			Net		
	United States	Foreign countries	Domestic and breign	United States	Foreign countries	Domestic and foreign
Leases, wells, equipment— gasoline and cycling plants	14,097,775	2,117,815	16,215,590	6,803,212	1,101,326	7,904,538
Natural gas	256,266	10,916	267,182	183,850	10,474	194,324
Total production	14,354,041	2,128,731	16,482,772	6,987,062	1,111,800	8,098,862
Pipelines	1,980,422	217,320	2,197,742	1,156,635	137,971	1,294,606
Marine	617,326	398,458	1,015,784	333,045	261,442	594,487
Tank cars	42,420	292	42,712	12,373	15	12,388
Motor transport	49,823	1,243	51,066	27,886	651	28,537
Total transportation	2,689,991	617,313	3,307,304	1,529,939	400,079	1,930,018
Refineries and chemical plants	5,829,200	837,009	6,666,209	3,056,871	530,874	3,587,745
Marketing	2,981,410	656,105	3,637,515	1,831,498	349,033	2,180,531
Others	438,079	48,932	487,011	254,423	33,294	287,717
Total, all departments	26,292,721	4,288,090	30,580,811	13,659,793	2,425,080	16,084,873

Source: Frederick G. Coqueron, Financial Analysis *of 35* Oil *Companies for 1954.* (Chase Manhattan Bank)

U.S. Petroleum Production and Consumption. — In the latter 1950s the U.S. was by far the largest oil-producing country of the world. Annual crude-oil production increased from 209,000,000 bbl. in 1910 to 2,469,600,000 bbl. in 1955 (estimated). *(See* Table II for production figures covering the period 1940–55.)

TABLE II.—*Petroleum Production*
(in 000 bbl.)

Year	Crude oil	Natural gas liquids*	Total liquid petroleum
1940	1,353,214	58,867	1,412,081
1945	1,713,655	114,884	1,828,539
1946	1,733,939	117,809	1,851,748
1947	1,856,987	132,863	1,989,850
1948	2,020,185	147,079	2,167,264
1949	1,841,940	157,275	1,999,215
1950	1,973,574	182,119	2,155,693
1951	2,247,711	204,965	2,452,676
1952	2,289,836	223,897	2,513,733
1953	2,357,082	239,084	2,596,166
1954†	2,316,323	248,643	2,564,966
1955‡	2,469,600	262,700	2,732,300

*Natural gasoline and benzol. †Preliminary. ‡Estimated.
Sources: U.S. Bureau of Mines; American Petroleum Industry

The U.S. also was the largest oil-consuming nation of the world. and in 1955 over 3,000,000,000bbl. were used. This peacetime consumption represented an estimated 50% of total world consumption. Moreover, the U.S. had provided the bulk of the oil used by the Allied military establishments in World Wars I and II —90% and 69% respectively. Although there were recurring oil shortage scares. no oil famine ever materialized, but in later years the U.S. supplemented home production with imports on a larger scale than ever before. *See* Table III.

Texas was the principal oil-producing state of the U.S. in 1953,

TABLE III.—*Supply and Demand of Oil*
(in 000 bbl.)

Year	U.S. domestic supply	Imports	Exports	Year-end stocks	Domestic demand
1940	1,412,081	83,751	130,466	564,584	1,326,620
1945	1,828,539	113,619	182,983	463,579	1,772,685
1946	1,851,748	137,676	153,123	507,094	1,792,786
1947	1,989,850	159,389	164,477	502,053	1,989,803
1948	2,167,264	188,144	134,674	605,743	2,113,678
1949	1,999,215	235,559	119,376	602,891	2,118,250
1950	2,155,693	310,261	111,306	582,710	2,375,057
1951	2,452,676	308,194	154,052	634,109	2,569,827
1952	2,513,733	348,507	158,188	673,754	2,664,407
1953	2,596,166	377,499	146,591	725,507	2,775,321
1954*	2,564,966	383,909	130,021	714,933	2,829,428
1955†	2,732,300	451,100	136,133	709,700	3,052,500

*Preliminary. †Estimated.
Source: U.S. Bureau of Mines.

accounting for 43.4% of the total. Following were California with 15.4%; Louisiana, 10.8%; and Oklahoma, 8.5%. *See* Table IV.

There were 501,859 producing oil wells in the U.S. at the end of 1953 and over 57,000 wells were being drilled annually for oil and gas, representing almost double the number drilled in 1945. Of the total drilled in 1955, 21,100 nells or 36% were dry holes.

U.S. Reserves. — After World War II discovery of new oil fields continued in the U.S., with the result that proved reserves rose year after year, despite the mounting production. However, the net yearly increases in proved reserves grew small, and in 1955 were far below those for the immediate postwar years when they exceeded 1,000,000,000 or more barrels on at least six annual occasions. At the end of 1955 proved crude-oil reserves mere 30,012,170,000bbl. and natural gas liquids 5,438,565,000 bbl., making total liquid hydrocarbon reserves of 35,450,735,000 bbl., an increase of only 645,532,000 bbl. over 1954. *See* Table V.

Crude-Oil Prices. — Crude-oil prices were under government control during World War II. When price control was lifted they advanced and were again placed under control after the Korean war started. This control was lifted in April 1953. Oklahoma-Kansas 36 A.P.I. gravity oil sold at $1.02 a barrel in 1939,

TABLE IV.—*U.S. Crude-Oil Production, by State and Rank*

State	1953*			Year of 1 first 1 production
	Rank	Production (000 bbl.)	Per cent of total	
Texas	1	1,024,780	43.42	1889
California	2	364,933	15.46	1876
Louisiana	3	255,692	10.83	1902
Oklahoma	4	202,570	8.58	1891
Kansas	5	115,259	4.88	1889
Wyoming	6	84,918	3.60	1894
New Mexico	7	70,394	2.98	1913
Illinois	8	58,886	2.50	1889
Mississippi	9	35,425	1.50	1933
Colorado	10	32,331	1.37	1887
Arkansas	11	29,681	1.26	1920
Indiana	12	13,013	0.55	1889
Michigan	13	12,284	0.52	1900
Montana	14	11,630	0.49	1916
Kentucky	15	11,618	0.49	1860
Pennsylvania	16	10,669	0.46	1859
Nebraska	17	6,257	0.27	1939
North Dakota	18	5,183	0.22	1951
New York	19	3,800	0.16	1864
Ohio	20	3,550	0.15	1860
West Virginia	21	3,038	0.13	1860
Utah	22	1,807	0.08	1907
Alabama	23	1,694	0.07	1944
Florida	24	537	0.03	1943
Virginia	25	10	0.00	1943
Other states†	..	39	0.00	....
U.S. total	..	2,359,998	100.00	1859

*Preliminary. †Includes Missouri and Tennessee.
Source: U.S. Bureau of Mines.

TABLE V.— *U.S. Proved Reserves of Crude Oil and Natural Gas Liquids*
(in 000 bbl. of 42 U.S. gal.)

Item	Production during year	Estimated proved reserves as of end of year	Increase over previous year
Crude oil:			
1946	1,726,348	20,873,560	931,714
1947	1,850,445	21,487,685	614,125
1948	2,002,448	23,280,444	1,792,759
1949	1,818,800	24,649,489	1,369,045
1950	1,943,776	25,268,398	618,909
1951	2,214,321	27,468,031	2,199,633
1952	2,256,765	27,960,554	492,523
1953	2,311,856	28,944,828	984,274
1954	2,257,119	29,560,746	615,918
1955	2,419,300	30,012,170	451,424
Natural gas liquids:			
1946	...	3,163,219	...
1947	160,782	3,253,975	90,756
1948	183,749	3,540,783	286,808
1949	198,547	3,729,012	188,229
1950	227,411	4,267,663	538,651
1951	267,052	4,724,602	456,939
1952	284,789	4,996,651	272,049
1953	302,698	5,437,922	441,271
1954	300,815	5,244,457	(—)193,465
1955	320,400	5,438,565	194,108
Total liquid hydrocarbons:			
1946	...	24,036,779	...
1947	2,011,227	24,741,660	704,881
1948	2,186,107	26,821,227	2,079,567
1949	2,017,347	28,378,501	1,557,274
1950	2,171,187	29,536,061	1,157,560
1951	2,181,373	32,192,633	2,656,572
1952	2,541,554	32,957,205	764,572
1953	2,614,554	34,382,750	1,425,545
1954	2,557,934	34,805,203	422,453
1955	2,739,700	35,450,735	645,532

Source: American Petroleum Institute.

advanced to $1.17 in 1941 and remained pegged at that figure during World War II. In 1947 the price advanced to $1.62; in 1948 to $2.57. and in 1954 to $2.82 per barrel.

U.S. Refineries. — To convert crude oil into usable products, United States refineries processed 2,730,200,000 bbl. (estimated) in 1955, a record. This compared with 1,719,534,000 bbl. run in 1941 and 1,237,840,000 bbl. in 1939. Refinery capacity reached a new high, standing at 8,534,900 bbl. per day at the end of 1955, compared with 5,315,856 bbl. at the end of 1945. There were 337 petroleum refineries in 37 states at the beginning of 1954.

Transportation. — To carry the crude oil from field to refinery and refined products from refinery to market there were in the U.S., in 1952, 170,000 mi. of pipelines. The industry operated great fleets of tank trucks. In addition, there was an enormous movement of refined products (and a relatively small shipment of crude oil) by rail in petroleum tank cars which as of Jan. 1, 1953, numbered 121,871, most of them owned by the petroleum industry. A large oil tonnage also was carried by tank barge on inland waterways. And a vast tonnage of both crude oil and petroleum products was transported by tank vessels in coastwise and foreign trade by a world tanker fleet, which at the end of 1955 totalled 2,681 ships of 41,623,100 dead-weight tons, of ahich 490, of 7,989,500 tons, were under U.S. registry and 823, of 13,890,600 tons (all flags), were U.S. owned. *See* Table VI.

TABLE VI.—*World Tank Ship Fleet as of Dec. 31, 1955*
(ocean-going vessels, 2,000 gross tons and over)

Flag	No.	Dead-weight tons
Western Hemisphere:		
United States	490	7,989,500
Canada	16	193,600
Panamá	191	3,275,900
Others.		
Argentina	41	423,000
Brazil	14	225,400
Chile	3	26,200
Colombia	1	4,300
Costa Rica	2	22,300
Dominican Republic	1	3,200
Honduras	11	226,600
Mexico	20	193,100
Peru	3	15,000
Uruguay	2	32,900
Venezuela	33	210,400
Subtotal others	131	1,382,400
Total western hemisphere	828	12,841,400
Europe:		
Belgium	10	168,600
Denmark	49	810,800
Finland	14	196,900
France	110	1,905,100
Germany	32	463,200
Greece	16	233,600
Ireland	1	3,300
Italy	114	1,792,900
Netherlands	114	1,398,900
Norway	410	6,607,800
Poland	3	30,400
Portugal	8	105,300
Spain	31	280,000
Sweden	86	1,403,800
Turkey	6	73,200
United Kingdom	535	7,505,600
U.S.S.R.	38	358,100
Yugoslavia	3	25,700
Total Europe	1,580	23,363,200
Rest of world:		
Arabia	1	46,600
China	3	39,600
Egypt	2	25,600
Israel	2	21,800
Japan	67	1,058,200
Korea	4	16,900
Liberia	188	[illegible]
Morocco	2	15,200
New Zealand	1	3,300
Pakistan	2	14,300
Union of South Africa	1	24,600
Total rest of world	272	5,418,500
Total world	2,681	41,623,100
Total U.S. control, all flags	823	13,890,600

Source: Statistical Research Division, Sun Oil Company.

Motor Fuel. — Motor-fuel production in the U.S. in 1955 reached a high of 1,343,400,000 bbl. (estimated) compared with 793,431,000 bbl. in 1945. Motor vehicle registration also recorded a new high of 61,300,000 vehicles. compared with 31,000,000 in 1945. **See** Table VII. By 1953 state gasoline taxes ranging from four to seven cents per gallon were imposed by every state and the District of Columbia. In 1932 the federal government also began to tax gasoline.

TABLE VII.—*Motor Fuel Produced and Motor Vehicle Registration, U.S.*

Year	Fuel (000 bbl.)	Motor vehicles (000,000)
1940	616,314	32.5
1945	793,431	31.0
1946	775,816	34.4
1947	841,667	37.8
1948	919,723	41.1
1949	960,747	44.7
1950	1,024,181	49.1
1951	1,139,659	51.9
1952*	1,192,965	53.2
1953	1,266,376	56.2
1954†	1,269,152	58.0
1955‡	1,343,400	61.3

*Figures for 1952 and earlier include some motor fuel used as jet fuel components. †Preliminary. ‡Estimated.
Sources: U.S. Bureau of Mines and U.S. Bureau of Public Roads.

Of the 56,279,000 motor vehicles registered in 1953, 46,289,000 were passenger cars; 9,162,000, motor trucks; 141,000, buses; and the balance (consisting of publicly owned vehicles) were unclassified. The estimated average annual consumption of motor fuel by passenger cars (calculated by the American Petroleum institute) was 694 gal. in 1953 as against 503 gal. in 1945.

Distillates and Fuel Oil. — The increase in the production and use of distillates and residual fuel oil in the U.S. was no less substantial than that of motor fuels. Refineries had a record output of 602,100,000 bbl. of distillate in 1955, compared with 249,224,000 bbl. in 1945. Residual fuel oil output, however, was still substantially below the 1948 record. *See* Table VIII.

TABLE VIII.—*Distillate and Residual Fuel Oil Production*
(in 000 bbl. of 42 U S gal.)

Year	Distillate	Residual fuel oil
1935	100,235	259,826
1940	183,304	316,221
1945	249,224	469,492
1946	287,896	431,364
1947	312,173	447,795
1948	379,340	479,988
1949	340,825	424,909
1950	398,912	425,217
1951	475,801	469,377
1952*	520,378	453,807
1953	528,111	449,979
1954†	542,278	416,757
1955‡	602,100	417,800

*Figures for 1952 and earlier include some material used as jet fuel components. †Preliminary. $Estimated.
Source. U.S. Bureau of Mines.

Diesel-Oil Consumption. — Diesel-engine development began after World War I. The diesel engine displaced steam in many passenger vessels and freighters and also began to compete with the steam engine in powering railway locomotives. But, after World War II, U.S. railroads entered into a program of dieselization. which largely relegated the steam locomotive to the past. At the same time, dieselization of motor trucks, tractors and construction equipment occurred on a large scale.

Fuel-Oil Consumption in Homes. — The automatic oil burner for heating homes was introduced in the U.S. in 1917 and came into widespread use in the late 1920s. Its greatest gains, however, came after World War II. There were 6,992,000 automatic oil burners in U.S. homes at the beginning of 1954, more than double the 2,821,000 in use at the beginning of 1947 and more than six times the 1,152,123 in use as of Jan. 1. 1935. In addition there were millions of homes using space heaters which burned fuel oil distillate.

Use of Petroleum Products on the Farm. — By the latter 1950s farmers operated more than one-third of all the motor trucks in the U.S. The use of trucks to carry farm products to the market and manufactured products to the farm had grown into a great transportation system. The gasoline engine, the oil-fuelled diesel engine and the kerosene engine furnished the power for most farm machinery. As of Jan. 1953 there were 4,400,000 tractors in use on farms in the U.S. compared with 2,585,000 at the beginning of 1946 and 1,447,000 at the start of 1939.

Petroleum chemicals played an important role in modern farming practices, being used as fertilizers, soil fumigants and insecticides. Oil companies established agricultural laboratories which included experimental farms serving as proving grounds

for improved and new products.

Liquefied Petroleum Gases.—By the latter 1950s liquefied petroleum gases consisting of propane and butane were widely used in suburban and rural areas for cooking and for heating homes. These bottled gases also supplied motive power on the farms and were used for smoking meat, ripening vegetables. heating incubators and pasteurizing and sterilizing.

Bottled gas also was used to enrich manufactured gas, to heat industrial plants and as a component in synthetic rubber and chemical solvents. Estimated sales in the U.S. during 1955 totalled 6,006,000,000 gal., compared with 1,276,766,000 gal. in 1945 and 76,8 j5,000 gal. in 193 j.

Although house heating was the biggest single factor in the industry's phenomenal growth. by the latter 1950s LPG for motor fuel was one of the fastest growing uses. It was estimated that in 1955, 671,000,000 gal. were used in internal-combustion engines. an increase of 22.6% for the year and representing about 11% of total industry sales. The biggest users were trucks. tractors. buses. irrigation and drilling engines. The largest sales increase in any single category. however. was in the use of LPG in the manufacture of synthetic rubber components. an increase of 56.3% to a total of 481,000,000 gal.

V. WORLD OIL SITUATION

World Production of **Oil.**—Table IX gives the production of the principal oil-producing countries of the world in 1955. However. whereas U.S. production accounted for 71% of world production in 192 j and 63% in 1930, the figure was only 44.56% in 1955. These statistics strikingly revealed (1) the tremendous growth in world production; (2) the gradual recession of the U.S. from its dominant position. though it remained the world's foremost oil-producing country; and (3) a profound change in the traditional flow of oil in the world's markets. Table X reveals the extent of this change.

World Oil Reserves.—Estimated world crude-oil reserves as of mid-year 19 jj reached a total of 154,539,200,000 bbl. compared with 58,026,596,000 bbl. at the end of 1945, as shown in Table XI.

U.S. Operations Abroad.—The picture of world production and reserves as it relates to the position of the U.S., however, needs further explanation. The U.S. industry has become international in scope, operating in the main oil-producing areas which are not under the control of the U.S.S.R. In 1937 U.S. companies. according to private sources, accounted for about a third of the production in areas outside the U.S., exclusive of the U.S.S.R. and the satellites and in 1953 they were credited with close to half of this total.

The Middle East.—With the middle east accounting for 93,265,000,000 bbl. or over 60% of total world reserves (Wallace E. Pratt, U.S. geologist, early in 1956 placed the figure at 121,700,000,000 bbl. or about 70% of his estimated free-world total of 172,100,000,000 bbl.), a reshuffle of world markets occurred. The discovery and tapping of these reserves came only because of pressures related to Europe's relative dependence on foreign oil sources. The British government bought an interest in the Anglo-Persian Oil company (Anglo-Iranian Oil company, British Petroleum company) before World War I as a measure of insurance for a navy whose vessels were being converted to oil burning. Britain saw a middle east supply eventually promoting the end of its dependence on the U.S., which at that time produced about 80% of all world oil and perhaps accounted for as high a percentage of world refining capacity. The Anglo-Persian Oil company met with phenomenal success after World War I. opening up one of the world's greatest oil fields in Iran and building what became the world's largest refinery at Abadan on the Persian gulf. There was also an expansion of home refineries in Europe.

British, Dutch and French interests at the close of World War I took the next significant step in the middle east. With the breakup of the Turkish empire they exercised rights to explore various of the newly set up mandates and protectorates by taking over the Turkish Petroleum company, which had rights throughout the old Turkish sultanate.

Only after the U.S. state department protested the "closed door" policies involved was U.S. participation permitted in the Iraq Petroleum company. formed to supersede the old Turkish Petroleum company. In 1927 a great new field was opened in Iraq. Iraq became the second largest oil-producing country of the middle east. In 1956 Iraq Petroleum ownership was divided 23¾% each between Near Eastern Development (equally owned by the Standard Oil Company [New Jersey] and Socony-Vacuum Oil company), British Petroleum (54% British government owned). Royal Dutch-Shell (60% Dutch and 40% British capital). Compagnie Française des Petroles (35% French government owned), and 5% Participations and Investments Ltd. (formerly C. I. Gulbenkian).

TABLE IX.—World Crude-Oil Production, 1955 and Cumulative
(in 000 bbl. of 42 U.S. gal.)

Region and country	1955*	Cumulative total 1857–1955
North America:		
Canada	129,351	606,456
Cub?	366	2,178
Mexico	89,364	2.882.398
Trinidad	24,896	526.069
United States	2,484,521	52.614.561
Other North America	....	683
Total North America	2,728,498	56.632.345
South America:		
Argentina	30.495	596,107
Bolivia	2,790	11,722
Brazil	2,001	6,327
Chile	2,574	7,868
Colombia	39,668	702,490
Ecuador	3.588	64.278
Peru	17,157	484,309
Venezuela	787.438	8,956,709
Total South America	885,711	10,829,810
Europe:		
Albania†	‡	23.162
Austriat	‡	146,132
Czechoslovakia†	‡	8,109
England	403	6.815
France	6,140	32,028
Western Germany	22,431	185.916
Hungary†	‡	69.086
Italy and Trieste	1,532	6,926
Netherlands	7,141	43,917
Poland†	‡	286.781
Rumania	‡	1,439,578
U.S.S.R.†	470,400	8,414,168
Yugoslavia	‡	7,365
Other Europe†	114,400	115,404
Total Europe	622.447	10.785.387
Africa:		
Algeria	432	2.066
Egypt	12,571	228,496
French Morocco	764	4,773
Total Africa	13,767	235.335
Asia:		
Bahrein Island	10,981	175,866
Burma	§	§
China†	2,620	13,851
Formosa (Taiwan)	25	412
India	5,969§	367,555
Iran	120.035	2,675,404
Iraq	251.445	1,388,352
Japan	2,264	109,423
Kuwait	398.493	1,822,723
Indonesia!	89,855	1,640,959
Neutral zone	8.605	14,600
Pakistan	§	§
Qatar	41,520	165,277
Sakhalin†	1	123,672
Sarawak and Brunei	39.825	403,645
Saudi Arabia	352,241	2.306. 810
Turkey	1,209	2,269
Other Asia	....	....
Total Asia	1.325,087	11,210,818
Australia and New Zealand	....	103
Rest of world	....	870
World total	5,575,510	89.694. 668
Per cent produced by U.S.	44.56	58.66

*Preliminary. †Estimated. ‡Included in "other Europe." §Burma and Pakistan included with India. ||Includes New Guinea. ¶Sakhalin included with U.S.S.R.
Source: U.S. Bureau of Mines.

In the 1930s the Standard Oil Company of California and the Texas company jointly with their Bahrein Petroleum company and their Arabian American Oil company (Aramco) made sensational oil strikes on Bahrein Island and in Saudi Arabia. The Gulf Oil corporation and the Anglo-Iranian Oil company with their Kuwait Oil company had as notable results in the tiny sheikhdom of Kuwait. By the beginning of World War II it was evident that the middle east held a fabulous store of oil.

The war vitiated the "red line agreement" which prohibited owners of Iraq Petroleum from operating outside the old Turkish sultanate. This enabled the Standard Oil Company (New Jersey) and the Socony-Vacuum Oil company to share in Aramco's great expansion and in building a pipeline to the Mediterranean.

In June 1951 Premier Mohammed Mossadegh succeeded in ousting the Anglo-Iranian Oil company from Iran and setting up a government-owned company, the National Iranian Oil company. In 1954, after a costly three-year attempt at nationalization during which the oil fields and the great refinery were virtually shut down, a consortium of international oil companies was formed. As the result, from all-British sponsorship Iran's oil development became

TABLE X.— U.S. and World Production, 1940–55
(in 000 hbl of 42 U S gal.)

Year	U.S.	Per cent	Rest of world	Per cent	Total world
1940	1,353,214	62.94	796,607	37.06	2,149,821
1945	1,713,053	66.64	891,574	33.36	2,564,627
1946	1,733,939	63.16	1,011,491	36.84	2,745,430
1947	1,856,987	61.45	1,165,152	38.55	3,022,139
[illegible]					
[illegible]					
1950	1,973,574	51.90	1,829,421	48.10	3,802,995
1951	2,247,711	52.43	2,039,115	47.57	4,286,826
1952	2,289,836	50.78	2,219,120	49.22	4,508,956
[illegible]	2,357,082	49.40	2,414,580	[illegible]	4,771,662
1955†	2,469,638	44.74	3,050,000	55.26 53.59	5,519,600

"Preliminary. †Estimated.
Source: U.S. Bureau of Mines.

the responsibility of a number of nations under a holding company called Iran Oil Participants, Ltd.

Under the agreement, the Anglo-Iranian Oil company, which soon after changed its name to British Petroleum company, was to receive approximately $600,000,000 over a period of years from the other consortium members and, in addition, $70,000,000 from Iran over a ten-year period beginning in 1957 for a portion of its properties excluded from the consortium agreement and the net settlement of claims and counterclaims from the past.

TABLE XI.—World Oil Reserves
(in 000 bbl. of 42 U.S. gal.)

Region	June 30, 1955	Dec. 31, 1945
Western hemisphere:		
North America:		
United States	30,060,000	19,941,846
Canada	2,400,000	150,000
Mexico	2,000,000	870,000
Other	2,500	3,000
Total North America	34,462,500	20,964,846
South America:		
Venezuela	10,919,000	7,000,000
Other	1,458,500	1,336,000
Total South America	12,377,500	8,336,000
Total western hemisphere	46,840,000	28,300,846
Eastern hemisphere:		
Europe:		
U.S.S.R. and satellites	10,606,000	8,653,500
Other	778,000	186,650
Total Europe	11,384,000	8,840,150
Africa	115,000	75,500
Middle east:		
Iran	13,000,000	6,000,000
Iraq	14,500,000	4,750,000
Kuwait	27,500,000	4,000,000
Saudi Arabia	36,000,000	3,000,000
Other	2,265,000	750,000
Total middle east	93,265,000	18,500,000
Far east	2,934,200	1,310,000
Total eastern hemisphere	107,698,200	28,725,650
Total both hemispheres	154,538,200	57,026,496
Australia-New Zealand	1,000	100
Total world	154,539,200	57,026,596

Source: World *Oil*, Aug. 15, 1956.

The agreement, signed only after 11 months of negotiation, was designed to fulfil both the requirements of the consortium for proper business management and the spirit of the Iranian nationalization law. In return for permitting the consortium to operate its nationalized oil development and refining, the government was to receive about $400,000,000 over the first three years in addition to a large and continuous annual income thereafter based upon the volume of business transacted.

The National Iranian Oil company remained as its government's petroleum resources authority. The consortium set up two companies to operate in Iran, one concerned with exploration and production, the other with refining. The national company had two of seven directors on the board of each operating company. Payments to the national company and payment to Iran of income taxes were based on the consortium's participants getting Iranian oil on essentially the same fifty-fifty financial basis as in other middle east producing areas. The national company received a cash payment of 12½% of the price of crude oil, or might elect to take an equivalent of crude oil in kind.

Under the arrangement the national company obtained refined products for consumption in Iran at slightly above their cost and distributed them locally. It was directly responsible for such activities as employee transport, housing, medical services, operation of food supply systems, industrial and technical training. and was to be compensated by the consortium for these services to the extent that they were necessary to the oil operations. With the exception of certain limited rights of the national company as regards exploration and production solely for internal consumption, the consortium operating companies were given exclusive rights to conduct oil exploration and production operations in the area covered by the agreement. The life of the agreement was to be 40 years, including the provisions for three j-year extensions, and the arrangements included reduction of the area covered by the agreement at the end of stated periods. In the event of misunderstandings, procedures for arbitration were specifically stated. The agreement could not be annulled, amended, modified or interfered with through legislative or administrative acts of the Iranian government.

The companies, and the extent of their holdings, in Iran Oil Participants, Ltd., are British Petroleum 40%, Royal Dutch-Shell 14%, the U.S. consortium group of five (Standard Oil Company [New Jersey], Socony-Vacuum Oil company: Gulf Oil corporation, the Texas company and Standard Oil Company of California, 7% each) 35%, Cie. Française des Petroles 6%, and Iricon agency (a second U.S. group comprising Atlantic Refining company, Hancock Oil company, Pacific Western Oil corporation, San Jacinto Petroleum company, Signal Oil and Gas company, American Independent Oil company, Standard Oil Company [Ohio] and Tide Water Associated Oil company) 5%.

Shift to the "Open Door."—In many countries by the latter 1950s. new or amended petroleum laws made it easier for privately owned companies to engage in production operations. This distinct shift from nationalization and a closed-door policy made the path easier for private companies to engage in oil operations outside their own countries.

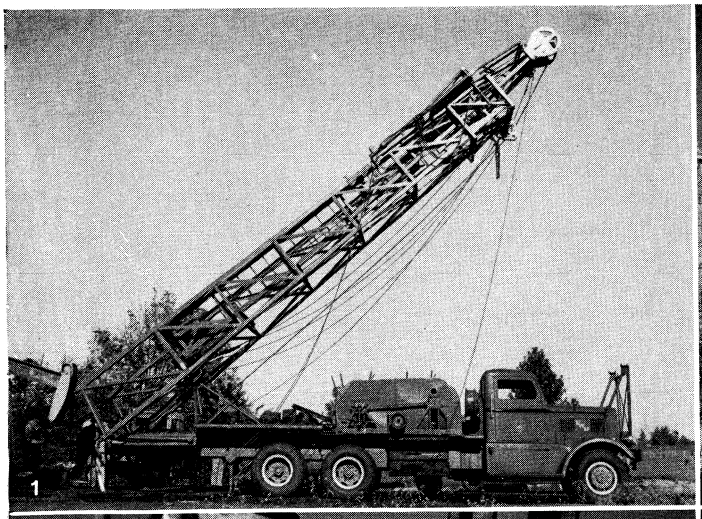
As a prelude, the pattern of concessions covering oil operations underwent profound change. Concessions by the latter 1950s were hard-bitten contracts indicating economic and social change in underdeveloped countries using, or seeking to employ, a rich natural resource to national advantage. An oil contract adhered not alone to a petroleum law, the passage of which almost invariably preceded the attempted development of the resource, but to existing labour laws.

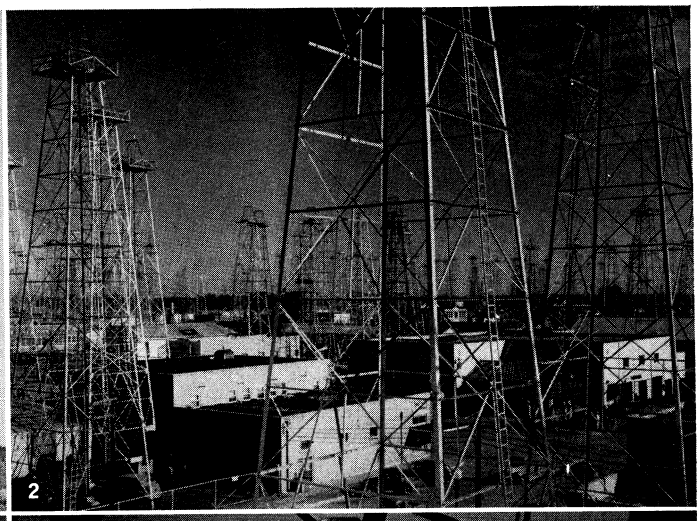
A concession might cover an entire nation or huge tracts running into millions of acres. On the other hand. it might comprise limited acreage as in Venezuela and Canada. Most, but not all, contracts called for the turning back of a part of the acreage to the government when production was found. Royalties varied in different countries and on different concessions in the same country. The trend in new petroleum legislation was toward a royalty of 12½%—as in Turkey, Libya and Guatemala. Laws in these countries were pointed to as models for nations serious about having foreign capital participate in developing their known or still to be proved oil resources.

A contract usually followed the provisions of the country's petroleum law as to royalty provisions, time limitation. percentage of nationals employed, refinery building obligations and profit participation—and often went further than the law. The contract followed the labour law as to wages, benefits, provision for schools, hospitals, housing, utilities and other services—and again, often went further than the law. For instance. companies voluntarily set up comprehensive employee training courses.

Thus foreign operations, projecting into social spheres of edu-

PETROLEUM



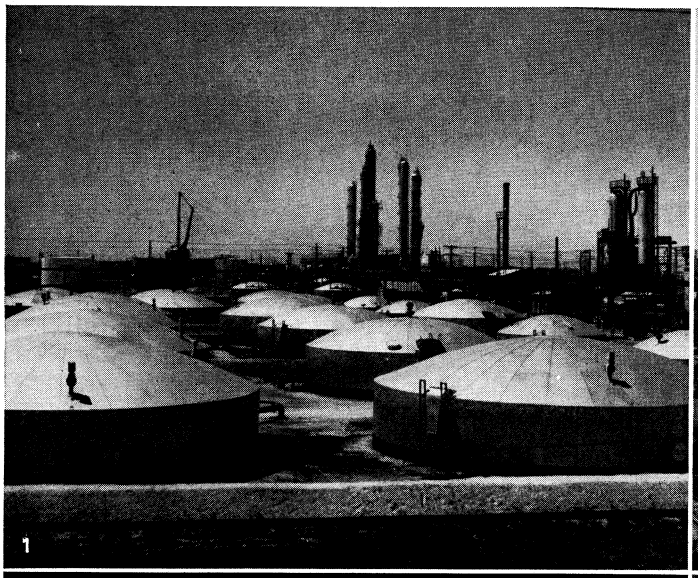


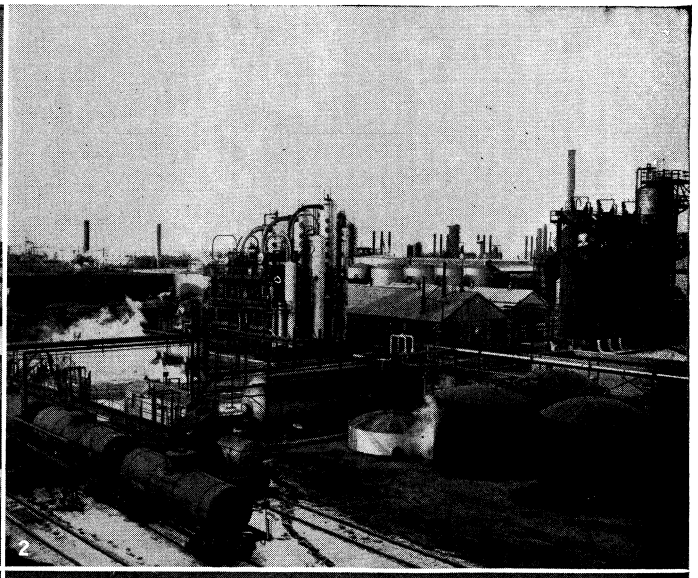
BY COURTESY OF (1) SHELL OIL CO. INC.; PHOTOGRAPHS, (2-5) MEISEL FROM MONKMEYER

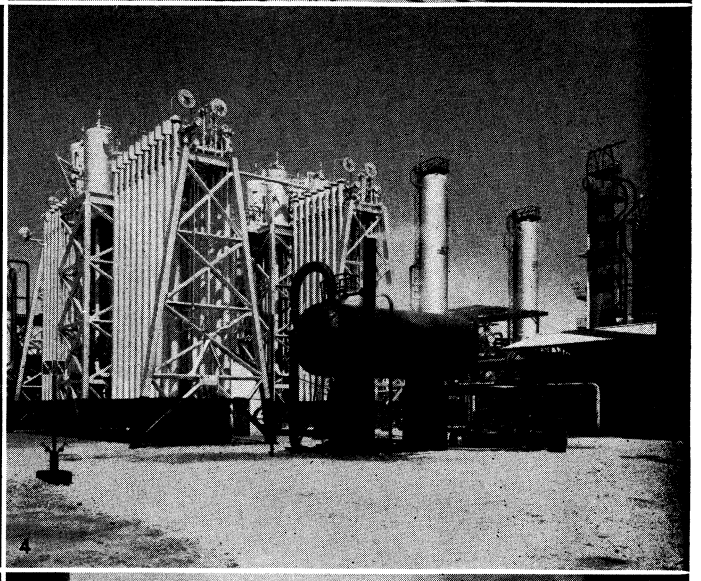
PETROLEUM: PROSPECTING, DRILLING, TRANSPORTING

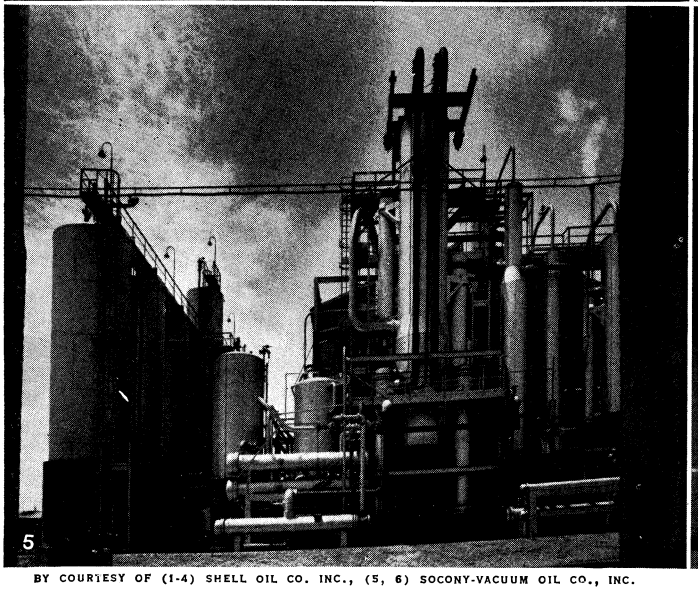
1. Unit drill which bores a hole in which dynamite is exploded to assist the seismograph crew in locating underground structures likely to contain oil
2. Oil derricks at Kilgore, in the East Texas field. Wells are drilled from 1,000 to 15,000 ft. deep
3. Drilling in a field near Houston, Texas
4. Roughneck adjusting a swivel in an oil derrick
5. Laying a pipeline to transport oil

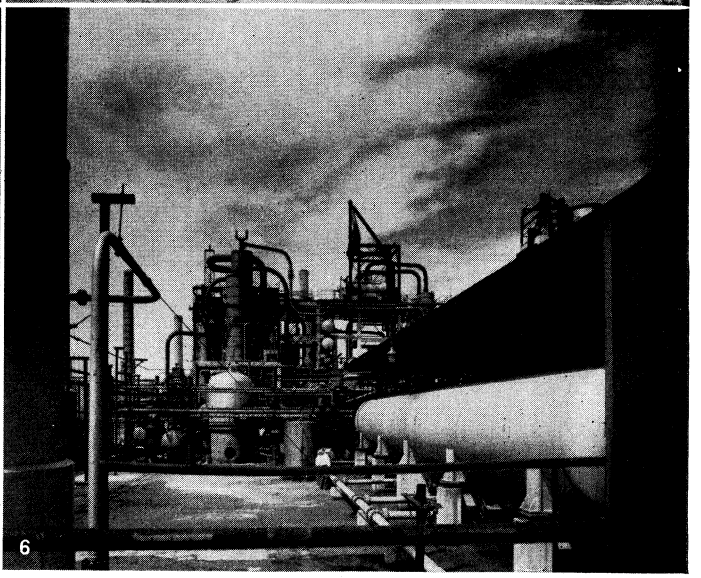
PETROLEUM











BY COURTESY OF (1-4) SHELL OIL CO. INC., (5, 6) SOCONY-VACUUM OIL CO., INC.

PETROLEUM: STORING, REFINING, PROCESSING

1. Storage tanks in a refinery
2. General view of a refinery
3. Alkylation unit of a refinery
4. Polymerization plant
5. Unit for solvent wax extraction
6. Clearosol refining unit

cation, health, housing and utilities, entailed expenses far beyond operational ones to which the U.S.—and largely the Canadian—operations were confined.

Fifty-Fifty Profit Sharing.— The general idea that government and company should share oil profits equally 'briginated in Venezuela in 1943 and acquired final form there in 1948 by invocation of an income-tax law in addition to the petroleum lam. By the latter 1950s most big producing areas accepted this general idea and wrote it into their contracts.

Implementation varied according to country. As applied to a nation, the basis of the fifty-fifty philosophy is that, in return for its share. the government will open its natural resources to development, provide physical protection to operators and their workers and guarantee the normal protection of its laws. On the part of the companies. it means that. in return for their share, they will provide the initial risk capital, the technical knowledge and access to markets.

Old concessions were modified, or new ones written, to embrace the fifty-fifty principal in Saudi Arabia, Iraq. Kuwait, Qatar and in the consortium agreement with Iran—all profitable oil-producing countries. New legislation of Turkey, Libya, Israel and Guatemala —small-producing or nonproducing countries—while adopting fifty-fifty sharing, recognized that such sharing can only be attained gradually.

Such laws provided that the concessionaire can take home not only what he invests but his earnings. There was recognition that an investing concern must know its financial obligation in advance and also have assurance that such obligation will not be increased during the life of the concession. Another trend was recognition of the incentive value of percentage depletion, this being a part of all the above-mentioned new laws. Then, too. more emphasis has been given to tax and foreign exchange provisions aimed toward nondiscrimination.

"Sowing the Petroleum." — The phrase, "sow the petroleum," refers to the practice of plowing back petroleum revenue into public works and into projects designed to stimulate agriculture and diversification of industry—to equalize the imbalance of an oil economy. In Venezuela. where, by the latter 1950s, 60% of the government's revenue came from oil, a large percentage of the income was used to improve public housing and to build highways, ports, schools and hospitals, and to improve agriculture. In Iraq 70% of all oil revenue received by the government, by law, had to be turned over to the Iraq Development board, which used the money for such purposes as irrigation, drainage projects. road construction, mechanization of agriculture and the extension of electrification. Using revenues from oil royalties, the Saudi Arabian government financed the many projects which were serving to raise the country's standard of living. Similarly, petroleum was being "sowed" in Bahrein and Kuwait with notable results. Employment, vocational training, general education, modern housing and health facilities—all on a substantial scale—have also resulted from oil operations in underdeveloped countries.

In Venezuela, for example, the medical and health programs made possible by oil revenues cut deeply into the incidence of malaria and other diseases which formerly had been widespread. Hospitals and clinics brought modern medical care to great numbers of the Venezuelan people. Children who previously never hoped for even a smattering of formal education came to accept daily schooling as commonplace. Venezuela's highway-building programs in 15 years more than trebled the mileage of all-weather roads linking once-isolated communities.

In the middle east, in a relatively few years, revenue from oil investment brought to a desert people standards of living which normally represent the progress of centuries. Health standards were transformed. Water supplies were created by drilling wells which made it possible for once barren areas to produce more of their own food. Oil-company employees were taught not only the skills essential to their jobs at the drilling rigs or refineries, but also the "three R's," typing, bookkeeping, nursing and other subjects. Particularly promising employees were sent to universities. Doctors, engineers and teachers continued to come from these programs.

Following the consortium agreement of 1954, the government of Iran launched a seven-year plan organization to co-ordinate the development of the country and its resources. This would provide railroad and highway transportation facilities, cement factories, drinking-water supplies, irrigation projects, mining development and general improvement of communications as well as expansion of education and public-health facilities.

The evolution of "sowing the petroleum" showed the oil companies spearheading the movement toward better living in underdeveloped countries and justifies an expressed evaluation of their efforts as a private Point Four program. The capital investments of all the oil companies in the middle east alone amounted to about $1,000,000,000 in the five-year period 1951–55. In 1950 the direct revenues to middle east countries from oil operations were equivalent to about $200,080,000. In 1955, oil provided about $880,000,000 in direct payments to governments, or more than four times the 1950 figure.

In the area of southeast Asia comprising the Malayan peninsula, British Borneo and Indonesia—Asia's principal oil-producing territory—"sowing the petroleum" was actively operative in the latter 1950s. (In Indonesia alone over $1,000,000,000 had been invested by foreign oil companies.) In these countries employment had been provided for tens of thousands, over 90% of whom were nationals. Because oil operations were usually in remote places, the companies created towns and maintained all such necessary facilities as houses, streets, water supply, sanitation, commissaries and power plants. Schools and on-the-job training for employees were established. Roads and harbour facilities were provided and expanded. Aided by petroleum revenues, southeast Asian nations put into operation programs emphasizing the improvement of agriculture, transportation and communications, power supplies and fundamental social services.

Early in 1956 the Venezuelan government indicated it would consider new or modified bids for new oil concessions. The second largest oil-producing country and the world's largest exporter of oil, Venezuela had not granted any new concessions for more than ten years. Venezuelan authorities gave two apparent reasons for the opening of new territory for exploration and development: first, a basic need to increase reserves in ratio to rising production and, second, a prospective plan for more oil revenue to finance an expanded industrial and social development program which Venezuela's government hoped would take the country out of the one-commodity class.

New Oil Areas.—Within practically all the established oil-producing countries, intensive post-World War II exploration resulted in the finding of important new productive areas. While the middle east led in uncovering fresh reserves, the U.S. continued to add to reserves despite heavy annual withdrawals. The same was true of Venezuela. In the western hemisphere, Canada scored outstanding results.

Canada's oil boom dates from the Leduc strike in the prairie province of Alberta in Feb. 1947. At that time Canada produced only 20,000 bbl. daily or less than 10% of its requirements. By the summer of 1949, so intensive and successful had been the search by U.S., Canadian and other companies which joined the rush, an estimated 1,000,000,000 bbl. of reserves justified starting the first pipeline—this to the head of the Great Lakes. Potential daily production had increased from 50,000 bbl. in 1949 to 375,000 bbl. by 1954.

However. during the same period Canadian consumption increased from 314,000 to 560,000 bbl. daily, which meant that, though capable of producing much more than its 1949 consumption, Canada was still able to produce only about 65% of its requirements. In 1955 actual production amounted to about 304,000 bbl. daily and represented 57% of Canadian demand for crude oil.

In the mid-1950s it was estimated that since 1947 the Canadian petroleum industry had spent $1,500,000,000 in developing crude-oil and natural-gas reserves. Over 3,200 mi. of trunk pipelines were built and refinery capacity was more than doubled, at an estimated cost of $1,000,000,000. In 1956 crude-oil and natural-gas pipelines, building and in prospect, represented a further invest-

ment of hundreds of millions of dollars.

Between 1946 and 1954 the use of oil in Canada increased more than twice as fast as in the C.S., the most rapid rise being in distillates chiefly for home heating. which accounted for more than a quarter of Canadian oil requirements. Canadians, per person, were the second highest consumers of petroleum in the world; Canada, as a nation, was the third largest. By the latter 1950s one-third of all homes were heated by oil; there was one motor vehicle for every four Canadians, and there were three tractors for every four occupied farms.

But Canadian production was not confined to domestic markets. It was being piped into the U.S. northwest and middle west. Estimated proven reserves in western Canada approximated 3,000,000,000 bbl. at the end of 1955. Authorities believed that by 1980 the figure would be from 23,000,000,000 to 30,000,000,000 bbl. Oil development improved Canada's balance of payments by reducing the need for imported oil supplies and stimulating diversified investment.

Canada's oil development began as early as that in the U.S. (1859), perhaps earlier. Nevertheless, until the Leduc discovery well in 1947 the country was essentially a have-not nation as far as oil was concerned. Other essentially have-not nations, which for generations starved for want of oil, had begun by the latter 1950s to produce volumes promising to their economies. Among them were west Germany, France: the Netherlands and Italy. The search in other countries such as Great Britain and Australia continued unflaggingly, with promise of ultimately successful results. At the core of the notable discoveries in the middle east, in Canada and in Europe, was not, as it might seem. merely skill and improved techniques. At the root was inexorable social change — the pressure of nations and peoples to improve their economies by developing their own energy resources.

Between 1927 and 1955 Russia doubled its crude-oil production. In 1955 Russia and its satellites were credited with estimated reserves totalling 10,606,000,000 bbl., compared with 8,653,500,000 bbl, in 1945. In 1953 Russia began making barter agreements with other nations using its supposed surplus of oil products. The Soviet's oil development proceeded. with a military purpose primarily, if not solely, in mind, while civilian uses were excluded completely or severely restricted. In 1956 the free world topped Russia and its satellites in oil reserves by 14 to 1. But the U.S.S.R.'s indicated inferior position was more apparent than real. for the petroleum industry was being run by the state on a basis dictated by the needs of the army, navy and air force. Also. the Russians had built up sources of oil in all strategic parts of the country.

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PETROLOGY is the branch of geology concerned with the investigation of the composition, structure and history of the rock masses building up the accessible portions of the earth's crust (Gr. *petros*, "rock"). Rocks are usually defined as aggregates of minerals without reference to their state of cohesion. Loose sands, clays, gravels or soils are included among rocks as being mineral masses playing an important role in field geology. On the other hand, the less soluble parts of the skeletons of animals and plants may form a considerable portion of rocks as. for example, in the case of coral limestone, lignite and chalk. Lastly. rocks may be built up almost wholly of noncrystalline material such as obsidian, pitchstone or tachylyte, representing liquids so rapidly chilled that consolidation has occurred in the glassy state. Rocks are the units with which the geologist deals in investigating the structure of the earth's crust, and some varieties cover enormous areas. Granite, sandstone and schist often form whole provinces and build up lofty mountains, while other rock types are of such rare occurrence that they are known only in one or two localities in far-removed parts of the earth's surface.

Broadly speaking, rocks are divided into three great classes, igneous. sedimentary and metamorphic. In this article discussion is confined to the nature, composition, classification and origin of igneous rocks and the methods by which they are examined. For the other groups. *see* SEDIMENTARY ROCKS and METAMORPHISM. *See* also MINERALOGY.

Following are the main subdivisions of this article:

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I. TREATMENT OF THE SUBJECT

Below is a brief survey of that part of the science of petrology which concerns igneous rocks, with the headings under which particular subjects are treated (each italicized item has a separate article).

Igneous rocks occur as intrusions or extrusions. The plutonic or deep-seated intrusive rocks which cooled far below the surface occur as *batholiths, bosses, laccoliths* and *veins (see* ORE DEPOSITS), and include *granite, syenite, diorite, gabbro* and *peridotite:* related to the granites are *aplite, greisen, pegmatite* and *schorl;* to the syenites, *borolanite, nzonzonite, nephelite-syenite* and *ijolite;* to the diorites, *tonalite;* to the gabbros, *napoleonite, pyroxenite* and *theralite,* and to the peridotites, *picrite* and *serpentine.* The hypabyssal intrusive rocks occur as *sills, veins, necks,* etc., and are represented by *porphyry* and porphyrite, *diabase* and *lamprophyre;* to the porphyries belong *felsite* and *quartz-porphyry.* The extrusive rocks are volcanic and found typically as lava flows; they include *obsidian, perlite, pitchstone* and *rhyolite, phonolite* and *traehyte, andesite, dacite* and *basalt* (with the related *spilite, tachylyte* and *variolite*), *nephelinite* and tephrite.

Intermediate between the sedimentary and igneous rocks comes the group of rocks known as pyroclastic or fragmental volcanic rocks. These include *agglomerate,* some types of *breccia* and *tuff (see* also VOLCANO). The agencies which affect igneous (among

other) rocks and modify them are discussed under GEOCHEMISTRY, METAMORPHISM, METASOMATISM and VOLCANISM.

1. Composition of Igneous Rocks. — Though the number of recognized minerals approximates 1,500, comparatively few of these are important as rock formers, more especially if the subdivisions into which the common species are broken up are disregarded. The vast majority of the igneous rocks are built up of less than a dozen groups of minerals. These are: (1) quartz; (2) feldspars; (3) pyroxenes; (4) amphiboles; (5) micas; (6) olivines; (7) nepheline; (8) leucite; (9) iron ores; and (10) apatite. To this list, for sedimentary rocks. may be added chlorite, kaolin, montmorillonite, calcite, dolomite and a few other minerals. Metamorphic rocks are built up largely of the same minerals as igneous rocks but include special species which are foreign to the latter, partly on account of their composition and partly because they appear to require special physical conditions (stress) for their production. The mineralogical nature of a rock is primarily dependent on its chemical composition, but other factors are of first importance in determining the paragenesis of rock-forming minerals. principally the mode of origin of the rock or the physical conditions prevailing during its formation. Two rock masses may have very much the same bulk composition and yet differ fundamentally in their mineralogical assemblages. Thus, certain lamprophyres rich in biotite have much the same composition as certain leucite-basalts, a hornblendite may be similar in composition to a camptonite and so on. Igneous rocks of identical chemical composition but dissimilar mineralogical constitution are said to be heteromorphous. The governing factors are the physical conditions attending consolidation of the rock.

All crystalline rocks have consolidated from solution or from fusion. A granite arises by the consolidation of a liquid at high temperatures and great pressures; a metamorphic rock like mica-schist, on the other hand, represents the recrystallization product of a clay rock under the influence of heat and stress. Throughout this conversion the rock has been essentially solid. recrystallization taking place in the presence of minor amounts of interstitial liquid. Other crystalline rocks, like rock salt, gypsum, anhydrite, etc., have been deposited from solution in water, mostly as a result of evaporation on exposure to the air. The majority of sedimentary rocks, however, consists of a mechanical aggregate of crystalline particles; such are sandstone, clay, etc. The structure of these sedimentary and all pyroclastic rocks is referred to as fragmental.

2. *Magma.* — All igneous rocks have solidified from a state of liquidity, the liquid that finally consolidates as rock being technically referred to as magma (Gr. magma, from *massein*, "to knead"). Rock magma is a complex silicate solution carrying gases; the most important part of the solution is water, which may constitute 5% to 6% of the mass. The greater part of the clouds given off by active volcanoes consists of steam, with which are associated minor amounts of other gases, the chief being carbon dioxide, carbon monoxide, hydrochloric acid, sulfur vapour, oxides of sulfur, hydrogen sulfide, hydrogen fluoride, ammonia, methane, chlorine, fluorine, hydrogen and nitrogen. When the magma consolidates the major part of these volatile constituents usually escapes. With very rapid cooling, however, the magma may solidify without crystallization as a volcanic glass, at the same time retaining much of its water. Analyses of pitchstone show not infrequently a content of 5% to 6% of water, and even higher values are recorded; on the other hand unaltered crystalline igneous rocks seldom show a water content greater than 2%. Here there is almost direct confirmation of the conclusion that the water content of the magma before crystallization is greater than the water content of the rock formed from it.

From what source is igneous magma derived? In the older conception of the earth a volcano was pictured as a safety valve for a molten interior, but a close study of igneous action, past and present, clearly negates any such interpretation. The active vents of Mauna Loa and Kilauea, Hawaii, though only about 20 mi. apart, have the summits of their lava columns at a difference of level of 10,000 ft. Yet liquid lava is erupted more frequently and in greater quantity from the higher column. Clearly these two outlets are not directly connected with a common liquid reservoir. Again, neighbouring vents, as those of the Lipari Islands north of Sicily, erupt widely different products, and each may maintain its independent behaviour regardless of what is happening to its neighbour. The conclusion is enforced that each distinct eruptive centre possesses its own reservoir, and the presence of a number of independent magma chambers underlying an eruptive region is indicated. At greater depth these are no doubt connected with some magmatic reservoir of much larger dimensions. In some such common source the close community of petrographic character revealed in the succession of liquids erupted or intruded throughout any given igneous cycle is to be traced.

II. METHODS OF INVESTIGATION

A. ANALYTICAL

1. Macroscopic Characters. — The macroscopic (Gr. *makros*, "large") characters of rocks, those visible in hand specimens without the aid of the microscope, are extremely varied and difficult to describe accurately and fully. The geologist in the field depends principally on them and on a few rough chemical and physical tests; and to the practical engineer, architect and quarrymaster they are all-important. Although frequently insufficient in themselves to determine the true nature of a rock. they usually serve for a preliminary classification and often give all the information really needed for a particular purpose. With a small bottle of acid to test for carbonate of lime, a knife to ascertain the hardness of rocks and minerals and a pocket lens to magnify their structure, the field geologist is rarely at a loss in deciding to what group a rock belongs. The fine-grained species may be indeterminable by these means, and the minute mineral components of all rocks can usually be ascertained only by microscopic examination; but it is easy to see that a sandstone or grit consists of more or less rounded, natern orn sand grains, and if it contains dull. weathered particles of feldspar, shining scales of mica or small crystals of calcite, these also rarely escape observation. Shales and clay rocks generally are soft, fine-grained. often laminated, and they not infrequently contain minute organisms of fragments of plants. Limestones are easily marked with a knife blade, effervescereadily mith weak cold acid and often contain entire or broken shells or other fossils. The crystalline nature of a granite or basalt is obvious at a glance, and while the former contains white or pink feldspar, clear vitreous quartz and glancing flakes of mica the other will show yellow-green olivine, black augite and grey striated plagioclase.

2. *Microscopic Characters.* — When dealing with unfamiliar types or with rocks so fine-grained that their component minerals cannot be determined with the aid of a lens, the geologist is obliged to have recourse to more delicate and searching methods of investigation. With the aid of the blowpipe (to test the fusibility of detached crystals), the goniometer (to measure crystal angles), the magnet, the magnifying glass and the specific gravity balance the earlier investigators attained surprisingly accurate results. Examples of these may be found in the works of Leopold von Buch, G. P. Scrope, Charles Darwin and many others. About the end of the 18th century D. G. S. de Dolomieu examined crushed rock powders under the microscope and P. L. Cordier in 1815 crushed, levigated and investigated the finer groundmass of igneous rocks. His researches are models of scrupulous accuracy, and he was able to announce that these rocks consisted essentially of such minerals as feldspar, augite, iron ores and volcanic glass and did not differ in nature from the coarser grained rocks. W. Nicol, whose name is associated with the discovery of the Kicol prism, seems to have been the first to prepare thin slices of mineral substances, and his methods were applied by H. Witham (1831) to the study of plant petrifactions.

Petrography. — This method, subsequently of such far-reaching importance in petrology, was not immediately used for the systematic investigation of rocks, and it was not until 1858 that H. C. Sorby pointed out its value. The great work of this investigator was the production of very thin sections of rocks and their systematic examination under the high powers of the microscope. The densest, blackest rock can be made to yield a section of $\frac{1}{1,000}$

in. in thickness, so thin and transparent that fine print can be easily read through it and transmitting light so clearly that the most high-powered objectives of the microscope can be used to discern and study its minutest structures with the same facility that they can be employed upon sections of organic material prepared by the microtome. The introduction of this powerful weapon of research inaugurated a new era in petrology — that of petrography or the descriptive branch of petrology. The optical study of sections of crystals had been advanced by Sir David Brewster, Nicol and other physicists and mineralogists and it only remained to apply their methods to the minerals visible in rock sections. The pioneer workers who brought quantitative methods into the optical side of the problem were A. des Cloiseaux, H. Rosenbusch. F Zirkel, M Schuster, F. Frouqué and A. M. Lévy.

By the second half of the 20th century optical methods for determining minerals with the petrographic microscope were highly developed

Optical *Constants*.—Although rocks at mid-20th century were studied principally in microsections, the investigation of fine crushed rock powders which was the first branch of microscopic petrology to receive attention, was still in use. A mineral whose optical properties are known can be accurately determined by immersing its ponder in liquid media whose indices of refraction are known. and determining the optical constants In the hands of a skilled petrographer the principal optical constants of a single grain of a mineral can be determined in half an hour. The chief fundamental constants measured are the principal indices of refraction, the crystallographic orientation of the directions of light vibration corresponding to those indices and the amount of absorption of light vibrating in these directions, all for one or more standard nave lengths of light. The double refraction, optical character optical axial angle, dispersion of the optic axes and bisectrices and extinction angle are all fixed by the fundamental constants and can be estimated under the microscope.

The immersion media cover a range of optical refraction from that of aater (1.333) to that of a selenium-arsenic selenide melt (3.17). The liquids are chiefly organic substances — acetone. alcohol cinnamon oil. menobrom-naphthalene and methylene iodide. Most minerals have refraction constants ranging in the interval 1.450–1 870, and their refractive indices may therefore be matched by a set of liquids whose refractions cover this range. The modern rotation apparatus whereby thin sections may be tilted irom the horizontal so that the axis of the microscope passes through them at different angles has been of inestimable value in measuring accurately the optical constants of a single grain in a rock slice, and is aidely used for the determination of feldspar and other mineral species of variable composition. A few measurements on a selected section of a mineral permit the determination of its exact chemical composition and the crystallographic orientation of the section itself. The technical methods employed for the determinations referred to above are largely founded on the use of polarized light.

3. Mechanical Separation of Constituents. — The separation of the constituents of a crushed powder in order to obtain pure samples suitable for analysis is also extensively practised. The two principal methods adopted involve either the electromagnet or heavy liquids

By the use of an electromagnet the component minerals of a rock may be separated by varying the strength of the current. A weak magnetic field attracts magnetite, then hematite arid ilmenite. Silicates containing iron will follow in definite order, augite. hornblende. tourmaline, olivine and biotite being successively attracted. The degree of attraction is not, however, proportional to the iron content. The colourless nonmagnetic minerals — quartz, feldspar, muscovite, nepheline. etc.—remain. In the modern laboratory, processes using automatic magnetic separators supplement or replace magnetic separation by hand. Electrostatic and dielectric methods of separation have also been brought into use in the isolation of mineral particles of rocks.

Separation by means of water is not much used in petrographic work. However, a preliminary "panning" as practised by miners is often useful as a means of concentrating rare minerals occurring in very small quantity in the rock before the application of the methods next to be described. Methods of separation of minerals by which they are sorted according to their specific gravities by means of heavy fluids have an extensive application. The fluids used are those which do not attack the majority of the rock-forming minerals.

Of the many liquids used. methylene iodide (sp.gr. 3.32) and bromoform (sp.gr. 2.86) are perhaps the most convenient. For more dense minerals. Clerici's solution — an aqueous solution of thallium formate — is best adopted. By concentration the specific gravity can be raised to 4.32 at 60° C. so that even the heavier rock minerals can be separated without difficulty. By dilution with water, or, in the case of methylene iodide, dilution with bromoform or benzol, successive crops of minerals may be separated in appropriate separating funnels. In this way a granite may be successively fractionated into its component minerals, biotite (sp.gr. 3.1), muscovite (2.85), quartz (2.65), oligoclase (2.64) and othoclase (2.56). All these minerals float in methylene iodide; on dilution with benzol they are precipitated in the order given. Rocks like eclogite containing heavier minerals, such as ilmenite (sp.gr. 4.84), garnet (4.20) and diopside (3.29), may be similarly separated by means of a thallium formate-water solution. Mineral isolation using heavy liquids is commonly carried out with high-speed centrifuges, which greatly hasten settling, especially of the finest particles, and effect a more thorough separation of the minerals.

4. Microchemical Methods. — Chemical methods are frequently of great use. Weak hydrochloric acid will dissolve calcite irom a crushed limestone, leaving dolomite and silicate minerals, and hydrofluoric acid may be used to extract the glassy base of, volcanic and hypabyssal rocks from the pyroxenic minerals. Of much wider use, however, are microchemical methods for distinguishing minerals under the microscope. They are of special value in discriminating alkali minerals like nepheline, haüyne, nosean, analcime and sodalite in the groundmass of igneous rocks. The methods depend on selective attack by acids, the formation of distinctive precipitates and the staining of gelatinous residues. Quartz and ieldspar in fine-grained rocks may be differentiated by etching with hydrofluoric acid; quartz remains clear while the surface of the feldspar grain becomes cloudy, being altered to aluminum fluosilicate. and may be stained by an aniline dye. This method is particularly useful in discriminating quartz and feldspar in fine-grained metamorphic rocks in which the feldspar is without crystal form, is untwinned and shows lack of cleavage.

5. X-ray Methods. — X-ray diffraction methods of identification have also come much into use; they may be applied to single crystals, isolated by the procedures already outlined, or to the finest aggregates. using then the technique of X-ray powder photography. See MINERALOGY: X-ray Diffraction; X-RAYS.

6. Chemical Analysis. — The ultimate chemical composition of a rock is of fundamental importance in determining its nature, and the chemical analysis of rocks is now widely carried out. In rock analysis of the better class as many as 25 constituents are determined and recorded. The most abundant or major constituents are stated as oxides. and any rock analysis of good quality records the content of at least nine or ten of these. They are silica, alumina, ferric and ferrous oxides, magnesia, lime, soda, potash and water. These nine oxides make up about 98% of the igneous rocks. Two other oxides are usually determined, TiO_2 and P_2O_5, as they are represented in the common minor constituents — ilmenite and apatite — titanium being also present in some pyroxenes, amphiboles and micas. Such a chemical analysis is usually sufficient to determine to which of the two great classes, igneous or sedimentary, a rock belongs and, if it is igneous, the position to be assigned to it in any of the conventional classifications. In the case of metamorphic rocks it often establishes whether the original mass was a sediment or of igneous origin.

7. Specific Gravity. — By the balance and the pycnometer the specific gravity of rocks is determined in the usual way. It is greatest in those rocks rich in iron, magnesia and the heavy metals, and least in rocks rich in alkalis, silica and water. Eclogites (sp.gr. 3.5) are among the heaviest of the silicate igneous rocks,

while the vitreous lavas of high silicity like obsidian (sp.gr. 2.35) are among the lightest.

B. Rock Synthesis

The methods of investigation described above may be grouped together as analytical, in contradistinction to the synthetic investigation of rocks, which proceeds by experimental work to reproduce different rock types and thus to elucidate their origin and explain their structures.

1. Pioneer Investigations. — Though the experiments of H. B. de Saussure (1740–99) on the fusion of granites and porphyries may be said to mark the earliest beginnings of experimental petrology, the era of rock synthesis should be dated from the time of the researches of Sir James Hall (1761–1832) on the fusion of dolerites found in the neighbourhood of Edinburg. This investigator shom-ed convincingly that crystalline diabase (British dolerite or whinstone) could be fused and consolidated, according to the rate of cooling, either as black glass resembling natural pitchstone or as crystalline aggregates of minerals much like the diabase from which they came. Hall's most famous experiments, however, were conducted with limestones. Powdered chalk, by being heated in gastight gun barrels, mas converted into a crystalline mass of calcite, thus supporting the contention of James Hutton that heat and pressure had consolidated limestones and converted them into marbles. A lapse of almost 90 years had occurred before the experiments of Hall mere substantiated, when in 1878 the French petrologists F. Fouqué and Michel Lévy began their extensive researches on the synthesis of minerals and rocks by pyrogenetic methods. They succeeded in producing, by the use of a gas furnace and a nitrogen thermometer, such rocks as porphyry, basalt and diabase, at the same time obtaining the characteristic textures — porphyritic. ophitic, etc.—by modifying the conditions under which the melts were cooled. With the more siliceous or acid rocks their experiments were much less successful. They advanced for the first time in a convincing manner the explanation that for the crystallization of these rocks the gases, never absent in natural rock magmas, were indispensable mineralizing agents (mineralizers). Later, it became known that the formation of many minerals is facilitated, or can only be accomplished, in the presence of volatile constituents such as water, borates. chlorides, fluorides, etc. Not only do these assist in promoting the fluidity of the liquid and facilitate crystallization, but they form essential constituents of some of the important minerals occurring in acid igneous rocks (micas, tourmaline, topaz, etc.).

Among the pioneers in synthetic petrology may also be mentioned H. E. Ste.-Clair Deville, H. de Senarmont, P. Berthier, L. Bourgeois, P. G. Hautefeuille, K. Chrustschoff, C. Doelter, J. Morosewicz and J. H. L. Vogt. To Vogt is owed the first comprehensive essay toward bringing the crystallization of igneous rock magmas definitely under the known lams of solution. Beginning a study of a large series of silicate slags, more or less comparable in composition with igneous rocks, he brought together a large body of information throwing light on the order of crystallization, the composition of the eutectics and the lowering of freezing points of the minerals in slag mixtures. these results being directly applied to the elucidation of the crystallization processes in natural magmas.

2. Geophysical Laboratory. — Up to this period the synthetic work, involving as it did the measurement of the melting point of minerals and the succession of crystallization in more or less complex mixtures, though very suggestive, lacked the strictly quantitative element. Experiments were carried out on materials always containing impurities or foreign substances, and the methods adopted for the determination of fixed thermal points such as melting points, inversion points or heat changes were of doubtful precision. In 1904. with the establishment of the Geophysical laboratory at Washington, D.C., synthetic or physicochemical petrology entered upon a new quantitative era. The work of this laboratory was undertaken in order to enter upon a quantitative study of rock formation which should include those minerals and rocks which are geologically important and those which are economically useful, and those formed directly from the magma and those formed by subsequent alteration. The individual problems are in reality problems for physics and physical chemistry; but the delay in attacking them resulted from the fact that the measured relations established by the exact sciences were scarcely of adequate scope to meet the needs of large petrological questions. The great body of physical and physicochemical measurements was confined to a temperature region below 100° C. while processes operating in rocks may have occurred at temperatures up to 1,400° C., an enormous range over which to stretch the application of ordinary methods and one in which the common forms of apparatus not only fail but are themselves threatened with destruction. The initial work of the Geophysical laboratory was primarily to extend the methods of accurate temperature measurement to include the entire field of rock formation from 0° to 1,600" C. The electric pyrometer reached such precision that an error of one or two degrees is all that need be expected in measuring temperatures up to 1,600' C.; moreover. these temperatures can be maintained quite steady for days or weeks at a time. Calorimetric measurements were improved; specific heats can be determined with great accuracy even at the highest temperatures. At the same time petrographic methods were advanced so that the crystallographic and optical constants of the very minute crystals obtained in silicate melts could be accurately measured. The investigation of mineral substances under high pressures and high temperatures combined, and in the presence of volatile constituents, also became a subject of study.

With these methods of precision available for the study of rock materials, examination of simple mineralogical systems was prosecuted. An understanding of the chemistry of the common oxides of rocks and of their combinations is essential to the progress of petrology. Experimental work was conducted on the combinations of the oxides lime, magnesia. alumina, silica; the six possible binary systems were fully n-orked out and the four possible ternary systems thoroughly studied, while portions of the quaternary system were successfully explored. These equilibrium studies were further extended by investigations on silicate systems containing ferric and ferrous oxide, soda and potash and by exploration of some important systems containing water. Much light was thereby thrown on the processes taking place during the consolidation of igneous magmas which, though much more complex in their constitution, yet clearly show by petrographic examination closely similar phenomena, such as are revealed in the crystallization behaviour of these simpler systems. The application of these laboratory investigations to the elucidation of the origin and evolution of igneous rock types will be considered hereafter (see *Plutonic Cornplexes,* below). *See* also Mineralogy: *Experimental Mineralogy.*

III. CLASSIFICATION OF IGNEOUS ROCKS

Igneous rocks are subdivided into many groups according to their composition, chemical and mineralogical, their structures and textures and their mode of occurrence. Between allied rocks there are, however. no hard and fast boundaries, for by increase or decrease in the proportions of their constituent minerals, they pass by every gradation one into the other. Similarly the distinctive textures of one kind of rock may often be traced gradually merging into those of another. Hence the definitions adopted in establishing rock nomenclature merely correspond to more or less arbitrarily selected points in a continuously graduated series. This is frequently urged as a reason for reducing rock classification to its simplest possible terms and using only a few generalized rock designations.

The earliest attempts at the classification of rocks on modern lines are to be found in the works of K. C. von Leonhard (1823) and Alexandre Brongniart (1827). These and other efforts, principally by K. F. Naumann (1850), Bernhard von Cotta (1855) and Justus Roth (1861), while being built on the criteria of composition and structure of rocks, were largely developed from purely macroscopic investigation or ultimate chemical analysis. The pioneer work of H. C. Sorby (1858) in preparing transparent microsections of rocks opened the way for the discovery of the mineral constituents and textures of the finer grained igneous rocks, and

rapid advances in the knowledge of the constitution of igneous rocks followed. The classifications of F. Zirkel (1873) and H. Rosenbusch (1877) were the first products of the application of the new method of petrographic research, and in these mineral constitution was accorded first place as a basis of subdivision. The effect of microscopic study was to stress the importance of mineralogical and textural characters of rocks to the neglect of other characteristics. Rosenbusch in particular, influenced by the contention principally of K. A. Lossen (who urged the significance of the geological relations of igneous rocks, their occurrence and manner of formation). further developed his classification to express the relationship of geological occurrence and texture, and introduced in the second edition of his *Mikroskopische Physiographie* a fundamental change.

This classification is based first on geological position, then on texture and finally on mineral and chemical composition. Igneous rocks are divided thus into three great groups: (1) deep-seated rocks; (2) dike rocks; and (3) effusive rocks. Like others before it, this classification is still essentially qualitative, and at mid-20th century was the one most commonly adopted by petrographers. An exposition of Rosenbusch's classification is set forth in his *Elemente der Gesteinslehre,* revised by A. Osann (1923).

IV. HABIT OF IGNEOUS ROCKS

Igneous rocks occur essentially in two different ways; *i.e.,* either as lavas or as intrusions.

1. Lavas or Effusive Types.—The lavas have been poured out at the surface and have consolidated after ejection, under conditions which are fairly well understood, seeing that they may be examined at active volcanoes in many parts of the world; the intrusive rocks. on the other hand, have been injected from below into cracks and fissures in the strata and have cooled there beneath masses which conceal them from view until exposed by denudation at a subsequent period. The members of these two groups differ from one another in many respects, so that it is often possible to assign a rock to the one group or to the other on mere superficial inspection. The lavas (or effusive rocks), having cooled rapidly in contact with the air, are as a rule finely crystalline or have at least a fine-grained groundmass representing that part of the viscous semicrystalline lava flow which was still liquid at the moment of eruption. At this time they were exposed only to atmospheric pressure, and the steam and other gases, nhich they contained in great quantity, were free to escape. Many important modifications arise from this, the most striking being the frequent presence of numerous steam cavities (vesicular structure) often drawn out to elongated shapes subsequently filled up with minerals by infiltration (amygdaloidal structure). As crystallization was going on while the mass was still creeping forward over the surface of the earth, the latest formed minerals (in the groundmass) are commonly arranged in subparallel ainding lines following the direction of movement, and the larger early minerals which had previously crystallized may show the same arrangement. The first generation of crystals generally forms before the lava has emerged to the surface, that is to say, during the ascent from the subterranean depths to the crater of the volcano. It has frequently been verified by observation that freshly emitted lavas contain large crystals borne along in a molten, liquid mass. The large. well-formed. early crystals are generally admitted to be porphyritic; the smaller crystals of the surrounding matrix or groundmass belong to the posteffusion stage. More rarely lavas are completely fused at the moment of ejection; they may then cool to form a nonporphyritic, finely crystalline rock, or if more rapidly chilled may in large part be noncrystalline rock, or glassy (vitreous rocks such as obsidian, tachylyte, pitchstone). A common and easily recognized feature of glassy rocks is the presence of rounded bodies (spherulites: Gr. *sphaira,* "ball") consisting of fine divergent fibres radiating from a centre; these divergent fibres consist of imperfect crystals of feldspar, mixed with quartz or tridymite; similar bodies are often produced artificially in glasses which are allowed to cool slowly. Rarely these spherulites are hollow or consist of concentric shells with spaces between (lithophysae: Gr, *lithos,* .'stone"; *physa,* "bellows"). Perlitic structure, which is also found to be common in glasses. consists in the presence of concentric rounded cracks as a result of contraction on cooling *(see* PERLITE ; SPHERULITE).

The phenocrysts (Gr. *phainein,* "to shon"; *krystallon,* "a crystal") or porphyritic minerals are not only larger than those of the groundmass; as the matrix was still liquid when they formed they were free to take perfect crystalline shapes, not being interfered with by the pressure of adjacent crystals. They seem to have grown rapidly. as they are often filled with inclusions of glassy or finely crystalline material like the material of the groundmass. Microscopic examination of the phenocrysts often reveals that they have had a complex history. Very frequently they show successive layers of different composition, indicated by variations in colour or other optical properties; thus augite may be green at the centre and various shades of brown outside this; or it may be pale green centrally and darker green with strong pleochroism (aegirine) at the periphery. In the feldspars the centre is usually more basic and richer in lime than the surrounding faces, and successive zones may often be noted, each less basic than those nhich lie within it. Phenocrysts of quartz (and of other minerals), instead of sharp, perfect crystalline faces, may show rounded corroded surfaces, aith the points of the crystals blunted, and irregular tonguelike projections of the matrix into the substance of the crystal; it is clear that after the mineral had crystallized it was partly again dissolved or corroded at some period before the matrix solidified. Corroded phenocrysts of biotite and hornblende are very common in some lavas; they are surrounded by black rims of magnetite mixed with pale green augite. The hornblende or biotite substance has proved unstable at a certain stage of consolidation and has been replaced by a pseudomorph of augite and magnetite nhich may be partially or completely substituted for the original crystal but still retains its characteristic outlines.

2. Plutonic or Abyssal Types.—The characteristics of a typical deep-seated rock similar to granite or diorite will now be considered. That these are clearly igneous is proved by the manner in nhich they have burst through the superincumbent strata, filling the cracks with ramifying veins; that they were at a very high temperature is equally clear from the changes which they have induced in the rocks in contact nith them. But as their heat could dissipate only very slowly, because of the masses which covered them, complete crystallization has taken place and no vitreous, rapidly chilled matter is present. As they have had time to come to rest before crystallizing they are not fluidal. Their contained gases have not been able to escape through the thick layer of strata beneath which they were injected, and may often be observed occupying cavities in the minerals; they have also occasioned many important modifications in the crystallization of the rocks. Because their crystals are of approximately equal size, these rocks are said to be granular; there is typically no distinction between a first generation of large \\ell-shaped crystals and a fine-grained groundmass. Their minerals have formed, however, in a definite order, and each has had a period of crystallization which may be very distinct or may have coincided nith or overlapped the period of formation of some of the other ingredients. The earlier have originated at a time when most of the rock was still liquid and are more or less perfect; the later are less regular in shape because they were compelled to occupy the interspaces left betneen the already formed crystals which pressed on them. The former are said to be idiomorphic (*i.e.,* having their own characteristic form, Gr. *idios,* meaning belonging to one's self), the latter are allotriomorphic (Gr. *hallotrios,* meaning belonging to another). There are also many other characteristics nhich serve to distinguish the members of these tno groups. Orthoclase. or microline, for example, is the typical feldspar of granite. while its modification, sanidine, occurs in lavas of similar composition; leucite is common in lavas, very rare in plutonic rocks; muscovite is confined to the intrusives. These differences shon the influence of the physical conditions under which consolidation takes place. Fundamental studies on the thermal behaviour and polymorphism of the group of minerals and on the

variable inversion temperature of rock-forming quartz shed new light on the long-known mineralogical differences between feldspars and quartz found in acid volcanic rocks and the same minerals found in plutonic rocks. The differences were interpreted as due to changes brought about in these constituents of the plutonic rocks during cooling by processes of inversion, unmixing and recrystallization from an initial character similar to that of the feldspars and quartz of the corresponding volcanic rocks. These conclusions necessitate some revision of ideas of "order of crystallization" and of the origin of mineral textures in deep-seated igneous rocks of this mineralogical character (*J. Geol.*, vol. 58. pp. 489–511 [1950]; vol. 60, pp. 107–124 [1952]). See FELDSPAR.

3. Intrusive or Hypabyssal Types.—There is a certain class of intrusive rocks which have risen upward toward the surface but have failed to reach it, and have solidified in fissures as dikes and intrusive sills at no great depth. To this type the name hypabyssal is often given in distinction from the plutonic (or abyssal) which formed at greater depths. As might be expected, the hypabyssals show structures intermediate between those of the effusive and the plutonic rocks. They are very commonly porphyritic, not rarely vitreous and sometimes even vesicular. In fact many of them are indistinguishable petrologically from lavas of similar composition. The attempt to form a special group of hypabyssal (intrusive and dike) rocks has met with much criticism and opposition. Such a group certainly cannot rank as equally important and equally well characterized with the plutonic and the effusive. But there are many kinds of rock which are not found to occur normally in any other manner. As examples the lamprophyres, the aplites and the porphyries might be cited. These never occur as lava flows or as great plutonic bosses: if magmas of the same composition as these rocks occur in either of these ways they consolidate with different assemblages of minerals or different structures.

In subdividing the plutonic, the hypabyssal and the effusive rocks, the principle is followed of grouping those together which resemble one another in mineral constitution and in chemical composition. In a broad sense these two properties are interdependent.

V. CHEMICAL CHARACTERS

1. Rock Elements.—Twelve elements (oxygen, silicon, aluminum, iron, calcium, sodium, potassium, magnesium, titanium, phosphorus, hydrogen and manganese) constitute about 99.6% of the earth's crust. Of these oxygen is the most abundant and constitutes 46.59% of the igneous rocks of the crust, the elements given above being placed in their order of abundance. These petrogenic or rock elements occur typically as oxides, simple silicates, aluminates. fluorides, chlorides and sulfides. In rock analyses they are stated as oxides. From a computation based on 5,159 analyses. H. S. Washington and F. W. Clarke arrived at the following as the average percentage composition of all igneous rocks: silica, 59.12; alumina. 15.34; ferric oxide, 3.05; ferrous oxide. 3.80; magnesia, 3.49; lime, 5.08; soda. 3.84; potash, 3.13; water, 1.15; titanic oxide, 1.05; phosphorus pentoxide. 0.3; manganous oxide. 0.12; inclusive 0.5. (See GEOCHEMISTRY: *Chemistry of the Earth: Abundance and Origin of Elements.*)

2. Range of Composition.—The known igneous rocks show a vide but limited range of composition. As the most abundant and essential rock minerals are either silica or silicates, silica shows the highest maximum and the widest range of these oxides. In some magmatic ores its content falls to zero but it rises to 78% in some acid granites; alumina varies normally between 10% and 20%, and some corundum-bearing rocks contain much more, being probably not of pure magmatic origin; iron oxides have a general range from 15% to less than 1% and magnesia from 25% to less than 1%. In some olivine rocks (dunite) it reaches a value of 48%. Lime is highest in some pyroxenites and anorthosites (20%–22%), but its general range is from 15% to zero. Soda reaches a maximum of 18%–20% in almost pure nepheline rocks (urtite) but has a general range frorn 15% to nearly zero. Potash usually varies from 10% to zero. Water in fresh crystalline igneous rocks seldom reaches more than 2%, but pitchstones may contain up to 10%.

3. Common Minerals and Associations.—The commonest minerals of igneous rocks are the feldspars, pyroxenes and amphiboles, quartz and the micas. From a statistical examination of 700 igneous rocks an average composition has been calculated as follows: feldspars 59.5%, pyroxenes and amphiboles 16.8%, quartz 12.0%. micas 3.8%, other minerals 7.9% (apatite 0.6%, titanium minerals 1.5%). This estimate however is clearly only an approximation. Rock minerals have been classified empirically into two groups. according as they are capable or incapable of existing in the presence of free silica; *i.e.*, into saturated and unsaturated minerals. The former group includes such minerals as the feldspars, pyroxenes, amphiboles and micas; and the latter olivine, nepheline, leucite and other feldspathoid minerals.

Certain minerals are as a matter of common observation not found together in igneous rocks. Olivine (except fayalite) and quartz do not occur in association, but are represented by rhombic pyroxene. The associations nepheline and quartz, leucite and quartz, pyroxenes or amphiboles and muscovite are almost unknown among magmatic crystallizations; on the other hand, certain mineral associations or parageneses occur frequently; thus aegirine and arfvedsonite, nepheline and nosean, common hornblende and titanite are well known as faithful companions in igneous rocks. Again some minerals are restricted to particular magmas; melanite, melilite and certain rare zirconium-titanium minerals are almost entirely confined to the alkali igneous rocks. By inspection of a rock analysis it is frequently possible to state approximately what minerals the rock will contain, but there are numerous exceptions to any rule which can be laid down. The minerals which crystallize from an igneous magma may depend largely on the physical conditions under which the liquid consolidates; accordingly. rocks of almost identical chemical composition with widely different mineralogical constitution are found. Such rocks, as already noted, are referred to as heteromorphous. Some familiar examples of assemblages of this character are mica syenite and leucite basalt, minette and leucite basalt, hornblendite and websterite.

Certain minerals are practically confined to deep-seated rocks, *e.g.*, microcline, muscovite, diallage and almandine garnet; on the other hand, leucite is very rare in plutonic rocks, as is also anorthoclase and the variety of potash feldspar known as sanidine. Some of these peculiarities are readily explicable, as they depend on the pressure, temperature or concentration of volatile constituents in the crystallizing magma. Others still represent a problem for solution. The subject will be referred to again in a later part of this article.

4. Acid, Basic and Alkali Rocks.—In the classification generally adopted by petrographers, the silica content of the magma forms a basis of further subdivision of igneous rocks. The division of volcanic rocks into acid, intermediate and basic was devised in the first place by W. H. Abich (1841). When this division is applied to igneous rocks in general, those which contain most silica and which if crystallized yield free silica as quartz are erected into a group designated the acid rocks in allusion to the assumed role of silica in the mineral kingdom. Those which have low silica percentages and are rich in magnesia, lime and iron—so that quartz is absent while olivine, pyroxene or calcic feldspar are usually abundant—form the basic group. The intermediate rocks include those characterized by the general absence of both quartz and olivine.

An important subdivision of the intermediate as well as the basic group contains a very high percentage of alkalis (soda or potash or both), and consequently has minerals such as nepheline, nosean, analcime or leucite, minerals not common in other rocks. This group is often referred to as the alkali rocks. Lastly, members of a small subgroup rich in olivine (peridotite, dunite), pyroxene (pyroxenite) or calcic feldspar (anorthosite) have been called the ultrabasic rocks. They have low percentages of silica but much iron, magnesia or lime. With the exception of the last group, including also such ultrabasic lavas as augitite and limburgite and a few related rocks such as monchiquite, melitite

basalt and alnoite, practically all igneous rocks contain feldspar or feldspathoid minerals. In the acid rocks the common feldspars are orthoclase, with perthite, microcline and oligoclase, all having much silica and alkalis. In the basic rocks labradorite, bytownite and anorthite prevail, being rich in lime and poor in silica, potash and soda. Augite and olivine are the common ferromagnesian minerals of the basic rocks, but hornblende and biotite are on the whole more frequent in the acid rocks.

5. Mineralogical Constitution. — The classification in the two tables below is based essentially on the mineralogical constitution of the three great groups of igneous rocks. The alkali rocks containing nepheline and leucite are treated separately, for, though they show transitions into the corresponding intermediate and basic rocks (syenites, diorites, gabbros, etc.), they contain many minerals which are unknown in other rocks. In a purely formal classification such as is outlined here they are more conveniently considered as a distinct series. Their genetic relations among themselves and with the other rock types are considered later.

The lamprophyres form a peculiar group of hypabyssal rocks not included in the tables. They usually occur as dikes in association with granites, syenites. diorites and gabbros, and are basic differentiates of these parent rocks. Thus the minettes, vogesites and kersanites *(see* LAMPROPHYRE) occur in association with granitic or quartz diorite masses, while camptonites, monchiquites and alnoites may be found commonly as satellites of alkali plutonic masses like nepheline-syenite or essexite.

TABLE I.—Alkali Rocks Containing Nepheline and Leucite

Commonest minerals	Alkali feldspar Nepheline or leucite Augite Hornblende Biotite	Plagioclase (limesoda) Nepheline or leucite Augite Hornblende (Olivine)	Nepheline or leucite Augite Hornblende (Olivine)
Plutonic . . .	Sepheline syenite Leucite syenite	Essexite Theralite	Ijolite Urtite Missourite
Hypabyssal . .	Nepheline syenite —porphyry Tinguaite	Essexite and Theralite } Diabase	Nepheline dolerite
Volcanic . . .	Phonolite Leucitophyre	Tephrite Basanite	Nepheline basalt Nephelinite Leucite basalt

The classificatory scheme here adopted is admittedly artificial, for it subdivides rocks aithout particular reference to their genetic relationships. Even regarded as a classification for a utilitarian end it has many imperfections; the subdivisions are of unequal value and transitional types are not included. The latter, however, can be accommodated by further subdivision. Many of them have received special names. The quartz syenites may be interposed between granite and syenite, the tonalites between granite and diorite and so on.

The question may be asked: When is a rock entitled to be recognized as belonging to a distinct species or variety and deserving a name for itself? It must, first of all, be proved to occur in considerable quantity at some locality or, better still, at a series of localities, or to have been produced from different magmas at more than one period of the earth's history. In other words, it must not be a mere anomaly. Moreover, it should have a distinctive mineral constitution. differing from that of other rocks, or something individual in the characters of its minerals or of its structures. It is often surprising how peculiar types of rock, believed at first to be unique. turn up with identical features in widely scattered regions; alnoite, for example, occurs in Norway, Scotland, Montreal. British Columbia, New York and Brazil, tinguaite in Scotland, Norway, Brazil, Montana, Portugal, etc. This indicates that underlying all the variations in mineralogical, structural and chemical properties there are definite relationships which tend to repeat themselves, producing the same types whenever the same conditions are present.

6. Quantitative Classifications. — Various attempts have been made to introduce a quantitative element into igneous rock classification. These have followed either chemical or mineralogical lines. The principal of these is the quantitative chemical classification introduced by a group of U.S. petrographers. The chemical composition of an igneous rock is here regarded as its fundamental characteristic and a series of subdivisions is erected on this basis. Other criteria are relegated to the background. The completed rock analysis is first interpreted in terms of an ideal set of minerals which constitutes the norm, but which in reality seldom corresponds to the actual composition (mode). The rocks are then divided into groups strictly according to the relative proportions of these ideal minerals to one another. The details of the classification need not be described here as they are fully set forth in a treatise specially devoted to this classification (W. Cross *et al., Quantitative Classification of Igneous Rocks* [1903]; see *Bibliography).*

A quantitative element is introduced in other systems by subdividing rocks into groups by arbitrary lines based on mineral percentages: a complicated system framed on these lines was devised by A. Johannsen (J. *Geol.*, 1917, 1919). In another the prime divisions are erected on so-called "principle of silica-saturation" *(S.* J. Shand, *Eruptive Rocks* [1947]), while a third combines some of the features of both the quantitative chemical classification and the Johannsen system with the larger groups of the Rosenbusch system (P. Niggli. *Schweiz. Min. Petr. Mitt.* [1931]). In all, the effect of the introduction of the quantitative element has been to increase the artificiality of the system and by this means to obscure the genetic relations existing between rock types. For this reason these systems are unlikely to supplant the qualitative classification in general use. It is indeed largely to the influence of "quantitative classifications" that the bewildering and unnecessary multiplicity of igneous rock names must be ascribed.

VI. PETROGRAPHICAL PROVINCES

As long ago as 1872 H. Vogelsang had noted that the igneous rocks of certain districts possessed textural or mineral characters in common, serving to distinguish them from the rocks of other districts. The researches of J. W. Judd (1886) and J. P. Iddings (1892) further substantiated this observation and showed that this community of petrographic character applied to the igneous rocks erupted or intruded during a particular period of igneous activity within the region. To such regions Judd gave the name petrographical provinces and Iddings employed the term consanguinity to express the genetic relationship irnplied in these resemblances among associated rocks. Excellent examples of such petrographical provinces or comagmatic regions, as they were termed by H. S. Washington, are the Oslo region of southern Norway, characterized by Permian alkali intrusions and extrusions;

TABLE 11.—Acid and Basic Rocks

Commonest minerals	Acid	Intermediate		Basic	Ultrabasic
	Quartz Orthoclase (and oligoclase) Mica Hornblende Augite	Little or no quartz		No quartz	Augite Hornblende Olivine (Basic plagioclase)
		Orthoclase Hornblende Augite Biotite	Plagioclase Hornblende Augite Biotite	Plagioclase Augite Hypersthene Olivine	
Plutonic	Granite	Syenite	Diorite	Gabbro Norite	Prridotite Pyroxenite Hornblendite (Anorthosite)
Hypabyssal	Quartz-Porphyry	Orthoclase Porphyry Orthophyre	Porphyrite	Diabase	Picrite
Volcanic	Rhyolite Obsidian	Trachyte	Andesite Dacite	Basalt Tachylyte	Limburgite Augitite

the Roman region, characterized by rocks rich in potash; the alkali province of central Montana; and the Tertiary calc-alkali province of Hungary. On a larger scale the volcanoes which girdle the Pacific (Andes, Cordillera, Japan, Philippines, etc.) and those which occur on the volcanic islands of the Atlantic illustrate the same phenomena. The consanguinity in the igneous series of a petrographical province implies that the whole assemblage is derived from some common deep-seated magma, during a period which, while necessarily prolonged, was not of vast duration in a geological sense. The assemblages of a province may and often do show a wide diversity of rock type embracing intrusions and extrusions. Prolonged eruption have in a few cases a somewhat monotonous character as a result of the predominance of one kind of rock. Thus the lavas of the Hawaiian Islands are mostly basaltic, as are those of Oregon, Washington and the Deccan, India, all of which form geological masses of enormous magnitude. In the Oslo district, on the other hand, the assemblages comprise (among the intrusive rocks) a wide range of type—hornblendite, essexite, larvikite, lardalite, nordmarkite, soda, and potash granites.

A. Differentiation

The process by which a magma is split into a variety of partial products is known as differentiation. Its importance from the standpoint of theoretical petrology is very great; it is, in point of fact, the fundamental problem of petrogenesis. The differentiation may appear as a variation either in a single rock body or in an associated series of separate intrusions or extrusions. In the first case a single intrusion shows variation in different parts of its mass, the extreme varieties being usually connected by gradual transition. The contrasted parts are frequently arranged symmetrically with reference to the borders of the mass forming concentric zones in bosses or laccoliths suggestive of a differentiation *in situ* connected with the cooling of the mass. Excellent examples of variation of this kind are provided by the laccolithic intrusions of the Highwood mountains of Montana. The best-known of these—the Shonkin Sag laccolith—has a chilled edge phase, a leucite basalt porphyry (or mafic phonolite) representing a quenched sample of the intruded magma. followed inward by a thick zone of shonkinite which forms an envelope to a central horizontal layer of alkali syenite.

Variation in an associated series is exemplified by the succession of lavas emitted from a volcanic focus. These may differ considerably from one another. Thus in the Berkeley hills near San Francisco, Calif., the volcanic succession is a repeated series of andesites, basalts and rhyolites. In other cases the lavas emitted are much more varied and, while no significant relations in the succession can be discerned, it is to be remembered that a significant order may be obscured by the overlapping of the flows from nearby volcanoes. In the simpler cases the order of eruption is one of increasing divergence from an initial type.

B. Plutonic Complexes

A series of plutonic rocks intimately associated and localized at a centre constitutes a plutonic complex. Such complexes often contain a great diversity of petrographical types ranging from peridotite and gabbro through diorite to acid granite. The succession of these intrusions follows an order of decreasing basicity, the later and more acid rocks usually occupying the greater part of the complex. the earlier and more basic being subordinate in amount and restricted to the borders of the mass. Excellent examples of such plutonic complexes are provided by the early Devonian intrusions of newer granites of the Scottish Highlands (*e.g.*, Garabal hill, Loch Lomond). What then are the operative factors which led to differentiation?

1. Unmixing.—The possible processes leading to heterogeneity in a magma may be considered under (1) those occurring in the liquid prior to crystallization (liquid $\leftrightarrows$ liquid equilibrium); and (2) those incident on crystallization (crystal $\rightleftarrows$ liquid equilibrium). In the first group comes the process known as liquation or unmixing. Many liquids, homogeneous at high temperatures. separate with falling temperature into two or more nonconsolute fractions, and the hypothesis that igneous magmas form such immiscible fractions has been favoured by some petrologists, notably Rosenbusch. H. Backstrom and R. A. Daly. From his own studies Vogt concluded that the rock-forming silicates are freely miscible. The only known case among magmas for which immiscibility can be claimed is that of sulfide-containing silicate melts. Such a magma unmixes at a temperature above the region of crystallization of the usual sulfides, and liquid sulfides, especially those of iron, are separated as liquid drops. These, because of their greater density, sink to the floor of the magma, collecting as a distinct sulfide layer or. in some cases, the liquid layer may be injected into the surrounding rocks. These sulfide aggregates form important ore deposits (*q.v.*). It is among lavas which as a group show the various stages of quenching of liquid magmas that the evidence for immiscibility might be expected; the absence of lavas containing glassy globules of composition distinct from that of the main mass of lava goes far to show that immiscibility is not an operating factor in petrogenesis.

Experimental evidence of immiscibility in silicate liquids was indeed obtained, but the composition range of liquids which show it is unlike that exemplified by rock magmas. This limited miscibility is found in mixtures of silica with any of the oxides (lime, magnesia. ferrous oxide, alumina), but in a region of very high silica content. The minimum temperature for the existence of two liquids is in each case only a little below the melting point of silica. or in the vicinity of 1,700" C. The oxides (soda, potash, alumina) show no such immiscible region in their silica mixtures, and moreover it requires only a small proportion of any of these miscible oxides to render miscible with silica the oxides which are themselves immiscible with silica. No natural magmas are known which approximate in composition to the region of immiscibility in these melts. It is true that natural magmas contain, in addition, water, but accumulating experimental studies in hydrothermal systems had up to 1960 given no reason to believe that fields of immiscibility extend into the composition region of natural magmatic systems.

2. Fractional Crystallization.— The second group of processes referred to above involves a crystal $\rightleftarrows$ liquid equilibrium and comprises crystallization and its converse. the assimilation of crystalline material. Knowledge of the crystallization of silicate magmas is derived from long-sustained observations of igneous rocks themselves and mas greatly augmented by high-temperature experimental research on silicate melts. The great body of evidence thus accruing leads to the belief that fractional crystallization is to be recognized as a fundamental process in igneous rock differentiation—the derivation of igneous rocks of diverse but related character. Either the localization of crystallization or the localized aggregation of crystals is sufficient to produce heterogeneity in a rock magma. The first phenomenon, the localization of crystallization, was at one time thought competent to explain those cases of differentiation *in situ* exemplified by the basic marginal phases of intrusive masses. Examination of igneous rocks early showed that minerals crystallize in a more or less definite order. In general, olivine, hypersthene and other minerals prominent in ultrabasic rocks are among the earliest minerals to separate; then follow augite, calcic plagioclase, hornblende, biotite, potash feldspar and quartz. plagioclase continuing to separate and becoming at the same time more sodic. This is the so-called normal order of crystallization, the validity of which, despite exceptions, has long been recognized. When the rule is expressed in this way the more basic minerals precede the less basic: in a somewhat modified form it was early known as Rosenbusch's law of decreasing basicity. Accordingly. it was supposed that at a cooling boundary there is a precipitation of minerals of early crystallization (basic minerals), the continued growth of many crystals being maintained by diffusion. The completion of this process results in a crystalline mass with a border phase enriched in the minerals of early crystallization.

The rate of diffusion in silicate melts has been the subject of laboratory study and the results obtained show that the possible effects are incompetent to account for the formation of border phases about large intrusions. The marginal phase indeed appears

to represent rather a chilled phase having a composition close to that of the original magma, the more acid phase which it enclosed representing a differentiate formed by much slower cooling of the remainder of the magma. The relative movement of crystals with respect to the liquid from which they separated may be of two kinds: (1) movement under the influence of gravity — sinking or floating of crystals; and (2) movement by straining off or squeezing out of residual liquid by earth movement. Both of these processes can be invoked to explain the more important case of differentiation exemplified by an associated series of intrusions or extrusions. In a crystallizing magma (provided viscosity does not inhibit the free movement of crystalline material) as the first formed crystals are denser than the molten material in which they form. they should sink under the influence of gravity in the liquid. The lower regions of the rock mass into which the crystals sink become enriched, the upper regions impoverished, in the constituents of which they are formed. The sinking of crystals in silicate melts has been both experimentally verified in the laboratory and observed in nature. Darwin (1844) suggested that this process was a potent factor in producing diverse rock types. If the evidence of consolidated rock masses themselves be taken, intrusions are found in which such gravitational segregation is indubitably exemplified. Thus the concentration of early formed olivine crystals near the base of sheet- or sill-like intrusions has been observed in the case of the quartz-dolerite sill of the Palisades (Hudson river) and of the picrite-crinanite sill of the Shiant Isles (western Scotland). The Permian picrite-teschenite sills of central Scotland, while exhibiting similar phenomena of settling of olivine in place, provide, in the main, evidence of injection of crystal-charged magma of picrite following closely upon intrusion of a more liquid teschenite which now margins the sills. The role of fractional crystallization in the production of a series of related rock types within a great magma chamber is spectacularly illustrated in some of the largest intrusive complexes laid bare by erosion. These complexes occur at widely scattered localities in the world in the form of sheets of basic igneous rock of great thickness, showing a layered (banded) structure with systematic types of variation within them. Such are the intrusions of the Bushveld. Transvaal; Duluth, Minn.; Sierra Leone, west Africa; Stillwater, Mont.; and Skaergaard. east Greenland — stratiform structures often several miles thick which, despite much diversity in detail, show broad features of similarity in that systematic variation observed within them.

The interpretation of the petrologic structure of these sheets usually assumed either (1) that the complex is the result of successive sheet intrusions varying in composition; or (2) that they represent the product of crystallization of a single body of magma nith gravitative sorting. Detailed examination of the Skaergaard mass made clear that this layered structure arose from fractional crystallization of a magma occupying a deep inverted cone chamber, solidification proceeding from the base upward, the solid phases accumulating like a sediment on the floor. The intrusion consists of basic rocks and comprises a marginal rock group and a central layered group. The marginal rocks show fluxion structures and banding parallel to the steeply dipping contacts. The layered group is exposed to a thickness of three kilometres, the whole of this consisting essentially of plagioclase, olivine and pyroxene, their composition as solid solution series changing gradually from the lower to the upper horizons. At the lower horizons the plagioclase is bytownite, in the upper it is an andesine-oligoclase. Olivine in the lower horizons is poor in iron, but at the top of the series is fayalite, and the pyroxenes show similar enrichment in iron in their phases as they are traced upward.

The separation of the rocks of the intrusion into marginal and layered groups and the differentiation of the latter may be explained by the fact that the liquid magma was sufficiently mobile to allow a convective circulation and equilibrium, the temperature gradient attained. however. being much less than the downward increase in the average crystallizing temperature, because of the increasing hydrostatic pressure (freezing-point gradient). Data which are available for the silicates give the approximate magnitude of these effects as ½° C. per kilometre for the convective gradient and 3° C. for the freezing-point gradient. Accordingly, although cooling would take place from the top and flanks of the intrusion and the temperature at these points would be cooler, the solid phases would separate near or at the bottom and would gradually accumulate on the floor.

In the Skaergaard mass only the upper portions of the intrusion are laid bare, the rock types ranging from hypersthene olivine gabbros to ferrogabbros and fayalite ferrogabbros with a final residual granophyric differentiate close to the roof. The remarkable correlation in detail of the composition of crystals of solid solution series with their position in the layered mass and the ordered sequence of rock product so yielded, present in all a convincing picture of the results of fractional crystallization of a once homogeneous magma. It is not unlikely that the mechanism thus clearly made manifest for the Skaergaard intrusion characterizes other layered sheets (*e.g.,* Stillwater), although the history of some of these may be further complicated and its tracing blurred by the intervention of intimately associated intrusions.

3. Application of Laboratory Investigations. — The trend in mineral composition revealed in layered series of rocks such as that already described is illuminated by experimental laboratory study of phase equilibriums in silicate systems of related composition. The main contributions in such synthetic studies have come from the Geophysical laboratory at Washington, D.C. (see Rock Synthesis, above). Systems which approach in their complexity some of the simpler types of igneous rocks were explored, and the results obtained justify the conclusion that the fusion and solidification phenomena of igneous rocks are capable of systematic treatment. Starting with pure chemical substances, the melting points, dissociation temperatures and inversion points of numerous rock-forming minerals were determined and the equilibrium phenomena of two- and three-component systems involving the commoner oxides of igneous rocks were quantitatively elucidated.

This study embraced the binary and some of the ternary systems of the oxides lime, magnesia, ferrous oxide. alumina, soda. potash and corundum with silica, and was extended to the exploration of certain plane sections of four- and five-component systems. The investigation of mineral inversions provided data throwing light on the temperature of igneous magma. Such of these inversions as are enantiotropic. or reversible, and take place without appreciable lag can be appropriately used as geological thermometers.

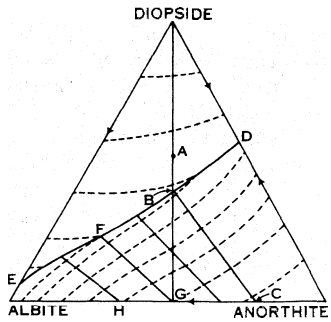
The study of binary and more complex systems has shown that the eutectic relation — for so long given a pre-eminent role in discussions of the crystallization of igneous rocks — is but one of several relations that may obtain between two or more components. Crystallization processes are normally complicated by solid solution and incongruent melting. The former phenomenon is widespread, for most of the major constituents of igneous rocks — feldspars, pyroxenes, olivines, amphiboles and micas — are members of complex solid solution series. (See MINERALOGY: *Nature of Minerals: Solid* Solution.)

In systems of three components the crystallization phenomena are often complex: occurrence of inversion points in one or more of the components, the formation of binary or ternary compounds with congruent or incongruent melting, and the formation of isomorphous mixtures, limited or unlimited, among the phases, are some of the many complications met with in the silicate systems investigated. Ternary systems that have been studied include those mixtures from which the phases plagioclase, pyroxene, olivine, silica and the alkali alumina silicates, potash-soda feldspars, leucite and nepheline, are precipitated.

The crystallization phenomena in a system involving the first two of the phases indicated above — diopside-albite-anorthite — may be taken as an example. The equilibrium diagram is shown in the accompanying figure. The crystallizing phases are diopside and plagioclase. These mixtures are therefore comparable with simple basaltic or gabbroic magmas on the one hand and simple dioritic (augitediorite) magmas on the other, according to the nature of the plagioclase.

Consider the crystallization of a liquid whose composition is represented by the point A (50% diopside, 50% plagioclase—Ab_1An_1).

Crystallization begins with a separation of diopside (supposed to be a simple mineral and not an isomorphous mixture, as it would usually be in rocks) at about 1,275" C. At 1,235° C. the excess of diopside (B) has separated out, and feldspar begins to crystallize. It has about 80% anorthite (C). Thereafter diopside and feldspar both crystallize, but as the composition of the liquid travels along the line DBE from B to F the composition of the feldspar changes from C to G (if it is supposed that all the early feldspar which is unduly rich in anorthite is stage by stage resorbed). The resulting rock has the mineral composition above stated; but if resorption of feldspar is incomplete the last-formed feldspar is richer in albite and has a composition H. The feldspar crystals in that case are zonal with basic centres. If at any time crystallization is suddenly brought to an end a glassy groundmass will be formed, which is richer in soda and silica than the original magma and contains zoned feldspar crystals. This is exceedingly like what takes place in many basaltic lavas. Again, if the original mixture had been richer in feldspar, so that the composition point lay below the line DE, feldspar would have crystallized out first. Original compositions near B then yield early both diopside and plagioclase phases and quenching at this stage would show both enveloped in a glassy base. This is in keeping with observations on glassy basalts which exhibit plagioclase and pyroxene of early crystallization set in preponderant glass.



EQUILIBRIUM DIAGRAM OF CRYSTALLIZATION PHENOMENA

The separation of liquid from crystals can be accomplished not only by zoning but also by the sinking of crystals from the upper layers of the liquid. The resulting liquid is enriched in albite and, under favourable circumstances, the final liquid may approach the albite-diopside eutectic of composition 97% Ab, 33% diopside. The analogy with the differentiation course of gabbroic magma is clear. A mixture rich in diopside and anorthite-rich plagioclase, corresponding to an anorthite-rich gabbro or eucrite, may pass to an assemblage rich in more acid plagioclase with subordinate diopside, corresponding to an augite-diorite.

4. **Discontinuous-Reaction** Series.—The continuous-reaction relation between crystals and liquid in the systems just studied is of fundamental importance in the crystallization history of magmas. This reaction is common to all solid solution series, and such solid solutions are called continuous-reaction series. Very similar effects, however, are produced by another type of crystallization phenomenon revealed in synthetic melts. In this case an early precipitated phase reacts at a certain temperature with the surrounding liquid and a new phase is precipitated, a reaction process of a discontinuous kind. This reaction is illustrated in the system forsterite (olivine)-silica. Here there are three solid phases, forsterite, protoenstatite ($MgSiO_3$) and cristobalite (SiO_2). The orthorhombic pyroxene, protoenstatite, has an incongruent melting point and dissociates at 1,557° C. into forsterite and liquid. From all melts of composition between Mg_2SiO_4 and $MgSiO_3$, the first phase to crystallize is forsterite, which continues to separate until the temperature of 1,557° C. is reached, when the olivine reacts with the liquid to form protoenstatite. When equilibrium is established the resulting crystalline mass consists wholly of olivine and pyroxene. If, however, the opportunity for reaction is inhibited, either by the sinking of olivine crystals or by their enclosure in the reaction product, the course of crystallization is extended and the third phase, silica, is precipitated giving a mass composed of residual olivine, pyroxene and silica.

A reaction relation of this type may effect a series of compounds in a crystallizing melt. These, arranged in their order of succession, constitute a discontinuous-reaction series. The combined effects of discontinuous and continuous reaction are revealed in the related ternary systems diopside-forsterite-silica. Here the magnesia pyroxene forms a complete series of solid solutions (monoclinic pyroxenes) with diopside; they form a continuous-reaction series, the crystals in equilibrium with the liquid being relatively enriched in the magnesian end member ($MgSiO_3$). The effect of hindering the reaction relations is now twofold, the residual liquid (or upper layers of the liquid if sinking of crystals prevails) is enriched in silica and the diopsidic pyroxene, 2s a result of the offset in composition.

The lowest point of formation of liquid in the system (there is no ternary eutectic) is the binary eutectic diopside-silica. In ternary silicate systems containing ferrous oxide, *e.g.,* in the system MgO-FeO-SiO_2, fractional crystallization effects a concentration of iron in the residual liquid which for some initial compositions may yield, according to the degree of fractionation, crystalline aggregates of ferriferous pyroxene and silica or ultimately iron-rich olivines and silica.

5. Natural Magmas.—That reaction processes of these kinds operate in natural magmas is clearly demonstrated. They are seen among minerals in zoned crystals of solid solutions like the plagioclase feldspar and the complex pyroxene phases, or in the resorbed borders of magnesian olivines with their pyroxenic mantles; their cumulative effects may be revealed in the graded sequences in mineral compositions in a layered intrusion, such as that of Skaergaard, crystallizing upward from its base, or in the association of related but contrasted rock types, whether these be the contrasted parts of gravitationally differentiated sills or the contrasted separate intrusions of a plutonic complex.

The normal calc-alkali magma, more complex in composition than the synthetic melts investigated, contains other components, including water, and from these natural melts mineral phases such as amphiboles and micas with constitutional hydroxyl are precipitated. Petrographic data make it clear that these too take part in the reaction process.

The principal minerals of these igneous rocks can in fact be arranged as reaction series, such that any member is produced from the preceding member by reaction with liquid magma, as already instanced by the reaction pair, olivine-pyroxene. The plagioclase feldspars together with potash feldspar form one series and the olivines, pyroxenes, amphiboles, micas and quartz constitute another. Inspection of this order will reveal that it is in essence the "normal order" already recognized in the rule formulated long ago by Rosenbusch.

A basic magma quickly cooled may give rise simply to basic plagioclase and pyroxene or yield by fractional crystallization a differentiation chain embracing all the minerals enumerated above, the continual offset in composition of the residual liquid in which water accumulates being accomplished by appropriate removal of crystals through gravitative settling, squeezing out or filtering off of interstitial liquid by earth movement during crystallization.

6. Hydrothermal Systems.—The extrapolation of experimental equilibrium studies based on data obtained from anhydrous silicate systems, such as the foregoing, to natural rocks, led to great advances; nevertheless the evidence that many igneous rocks have crystallized in the presence of water vapour and in fact contain hydrous mineral phases made clear the limited applicability of the experimental results, directly to the interpretation of the crystallization history of the more siliceous and alkaline rock assemblages. Experimental attack on hydrothermal systems followed later and an outline of the scope of these researches is now presented.

Before World War II quantitative phase equilibrium studies in silicate systems containing volatiles, particularly water, had been few. G. W. Morey and C. N. Fenner had worked out the system H_2O-K_2SiO_3-SiO_2 (report, 1917) and at a later date R. W. Goranson had demonstrated the solubility of water in a liquid of granite composition (report, 1931). During and immediately after the war the great interest in certain crystalline phases, especially quartz, had stimulated a great deal of hydrothermal work and radically new equipment was developed. The first systematic study of a silicate system comparable with a natural assemblage—the system MgO-SiO_2-H_2O—was completed in 1949. This study opened a new era of conquest of the wet mineral silicate and in

many respects laid the ground work for much of the later investigations in the hydrothermal field. This work demonstrated that no liquid appeared in the ternary system even at 1,000° C. and at a water vapour pressure of 40.000 lb./in.², thus throwing new light on the problem of emplacement of peridotites and serpentines in the upper crust. Most of the postwar hydrothermal studies were in fact carried out under PT conditions below that at which a liquid (melt) phase appears and above the critical temperature of water. These studies are therefore largely concerned with crystal ⇄ vapour equilibrium. Examples of such subsolidus studies were those of SiO_2-H_2O, CaO-SiO_2-H_2O, MgO-Al_2O_3-SiO_2-H_2O, and numerous researches dealing with the synthesis and stability of individual mineral groups — feldspars, garnets, micas, amphiboles. nepheline-kalsilite, analcime and several carbonate systems. These investigations proved of particular importance in the study of rock metamorphism (*q.v.*) and some had their application also in the interpretation of phase relations in the cooling history of the igneous rocks.

The most significant liquidus studies related to the petrographically important system of the alkali feldspars ($NaAlSi_3O_8$-$KAlSi_3O_8$) and of these with SiO_2—*see* especially O. F. Tuttle and N. L. Bowen, "Origin of Granite in the Light of Experimental Studies in the system $NaAlSi_3O_8$-$KAlSi_3O_8$-SiO_2," *Geol. Soc.* Amer. Mem. 74 (1958). These are the systems which approach in composition the great group of natural rocks, the syenites and granites. The outstanding feature of the researches was the evidence found to support the indications that a complete series of solid solutions existed betneen potash and soda feldspars at elevated temperatures. but that in the subsolidus region a solvus existed with two feldspars existing side by side. Homogeneous synthetic feldspars thus exsolved at lower temperatures in confirmation of the accepted theory of most natural perthites. In the ternary system with silica at high water-vapour pressures the liquidus has a thermal trough near the centre toward which all liquids moved on crystallization.

This minimum had a composition in the range common for granites, a result in harmony with a long-held view of the magmatic origin of this rock type. The investigation of more basic assemblages of simple gabbroic or eucritic composition, *e.g.*, the system diopside-anorthite, under high water pressure revealed a marked lowering of the liquidus and a change in the composition of the binary eutectic, with the implication that water is markedly soluble in gabbroic magma, as had been shown earlier for the granitic liquid system.

7. Magmatic Assimilation. — Heterogeneity in a magma may derive through a crystal liquid equilibrium not only by the spontaneous process of fractional crystallization and reaction but also by reaction of liquid magma with its wall rock or with what foreign inclusions it may incorporate. This process. known as assimilation, may lead to the development of a diversity of rock type and is to be recognized as an important factor in petrogenesis.

It seems probable that the heat effect connected with the solution of solid rock by a liquid magma is always negative, solution being accompanied by absorption of heat, usually of the order of the latent heat of melting. Simple solution would then demand large amounts of heat. which are only available if the liquid possesses great superheat. Intruding magmas, however, can scarcely be at a temperature much above their crystallization range. Such effects of magma upon its enclosures as are observed must therefore be attributed to processes of reaction and precipitation.

The concept of the reaction series finds fruitful application in the study of this problem. Enclosures of rock fragments in a magma may be divided broadly into two classes, those of igneous and those of sedimentary origin. The first class is built normally of minerals which are members of the reaction series. The magma itself, saturated with a given member of such a series, is effectively supersaturated with all earlier members of that series. If the inclusion is built of these earlier members the magma cannot in consequence dissolve them. It can, however, react with them and transform them into the member with which it is saturated, often by passing through other members of the series as intervening

These changes effected by subtraction of material from the magma induce withdrawal precipitation of the phase with which the magma is saturated. In the course of the reaction the inclusion itself is often disintegrated and may come to be completely incorporated in the liquid.

With an inclusion built up of members of the reaction series later than that with which the magma itself is saturated, the process is one of reactive solution — the inclusion becoming part of the liquid at the expense of precipitation of the magma saturated phase. On the liquid, the resultant effect is a pushing onward along the normal course which fractional crystallization in the process of cooling might accomplish. In these reactions no phase foreign to the reaction series is normally precipitated, and there may result locally rock types scarcely distinguishable from types derivable by fractional crystallization. Plutonic complexes with their range of associated intrusions — basic to acid — often show clear evidence of extensive hybridization by reaction of a later (more acid) magma upon an earlier (more basic) consolidated product, the rock types found near the border approximating in composition and structure to a range of igneous rocks of a normal differentiation series while being in fact the result of hybridization brought about by action of liquid (acid) magma upon a basic (gabbroic) rock.

The monzonitic and tonalitic margins of granitic masses of some igneous complexes may be traced to the hybridizing influence of acid magma on an earlier plutonic rock of basic or ultrabasic composition of which all superficial traces may have disappeared. The newer granite complexes of Scotland provide convincing demonstration of hybridizing processes of this nature. The effects of reaction of igneous magmas upon sediments set a more difficult problem, since sedimentary material may not belong to the reaction series

In many cases the incorporation of sediments in a magma, mhile yielding adjustments in the composition and reiative proportions of existing phases, may effect but little modification in the general course of fractional crystallization. On the other hand, extended incorporation of certain types of sedimentary material may lead to the precipitation of new mineral phases not normally met with in igneous rocks.

Gabbro magma assimilating shales or slates may pass first into norite by precipitation of rhombic pyroxene and basic plagioclase, at the expense clinopyroxene, and eventually yield cordierite norites. Rocks of this character are well developed in Aberdeenshire and elsewhere. Basaltic magma, through assimilation of limestone, may give products rich in melilite and wollastonite and yield, at least locally, an alkali fraction from which nepheline is precipitated. Whether basic magma through this mechanism can generate alkali rocks on a large scale is a question yet to be determined. That their production is not limited to this mechanism. however. is clearly attested by the geological environment and petrographical relations of many examples of this group of rocks.

Assimilation processes clearly play a significant role in the development of some rock assemblages, and among these are to be expected rock types which exhibit in both composition and structure the characteristics of normal igneous rocks. The full contribution of these processes has yet to be evaluated though a limit to their action is prescribed if magmas in general possess little superheat.

8. Palingenesis. — The apparent dominance of granodiorites and granites in orogenic belts led some petrologists to entertain the view that these particular rocks have been derived by remelting of the granitic layer and the intrusion of the resulting liquid to higher levels. This possibility cannot be denied; yet it is to be remembered that a granitic differentiate as a late residual liquid subject to filter pressing during mountain building might well come to dominate in volume the upper regions of a magmatic tract laid bare by erosion. It is conceivable, however, that some granites may have their immediate origin in such refusion and perhaps also that a process of partial refusion may affect siliceous sediments subject to deep burial in the cores of geosynclines. As distinct from the juvenile granites derived by fractional crystal-

lization, granites supposedly originating in this way have been referred to as palingenetic and the process of refusion as palingenesis. The genetic link between granitic and basic (basaltic) material remains, for the dominantly mafic character of the crust makes it evident that the sial or granitic layer must ultimately have been derived from such basic material.

9. Granitization.—The aqueous and alkali-bearing residual liquids emanating from granitic magma during its later consolidation stages are known to penetrate into the surrounding rocks. Where these rocks are argillaceous, metasomatism by the alkali solutions acting upon the micaceous minerals of the sediment may result in the feldspathization of such pelitic rocks, transforming them into assemblages analogous in composition to the parent rock from nhich these solutions came. This is the process of granitization. With such processes there is frequently a merging of the parent intrusive with an igneous-looking rock which is metasonlatic in origin

In the more speculative accounts of the process the parent intrusive itself has been regarded as formed in the same manner and the existence of a genuine igneous intrusive denied, but such an extreme view seems unlikely to be correct. A survey of the problems of granite emplacement with special reference to North America was made by A F. Buddington (Bull. Geol. *Soc. Amer*, vol. 60. pp. 671–747 [1959]).

VII. GEOGRAPHIC DISTRIBUTION OF IGNEOUS ROCKS

A study of the geographical distribution of igneous rocks has shown that the earth's surface may be mapped out into more or less definite petrographical provinces, each with its own community of petrographical characters. Strongly contrasted provinces may exist almost side by side, as is seen in the Tertiary Bohemian and Hungarian provinces standing on either side of the Carpathian range, the one characterized by a suite of igneous rocks rich in alkali, the other comprising an assemblage relatively rich in lime, magnesia and iron oxide. The chain of volcanoes that fringes the shores of the Pacific from Tierra del Fuego to Alaska and thence by Japan and the Philippines to Java and Sumatra represents a province of a larger order, characterized by rocks which have so much similarity in many important features that they are certainly of allied origin. These rocks are all of Tertiary and Recent age; their eruptions began in Eocene or Miocene times and have continued with more or less frequent intermissions up to the present day. The igneous rocks of the Atlantic islands from the Azores to Tristan da Cunha comprise an assemblage of types strikingly different from the igneous rocks of the eastern Pacific borderland. Each of these magmas has been taken as a type, and they are referred to as the Pacific and Atlantic magmas. Chemically the Atlantic (or alkali) rocks are characterized by high percentages of alkalis (potash and soda) in relation to silica and alumina, and mineralogically by the presence of alkali minerals, especially feldspathoids (nepheline. sodalite, analcime. etc.). The Pacific (subalkali or calcic) rocks, on the other hand, show relatively more abundant lime, magnesia and iron oxides.

Certain suites of rocks characterized by high potash content and mineralogically, by the presence of leucite or abundant potash feldspar and micas, have been separated from the Atlantic suite, though they are perhaps not of co-ordinate importance. Rocks of this character are illustrated by the Quaternary province of the Roman region: Vesuvius belongs to a line of volcanoes (extending from Lake Bolsena to the Phlegraean fields) that have poured out lavas of this character. They are sometimes known as the Mediterranean suite.

When one turns to the igneous rocks of older geological periods the same contrasted suites can be recognized. The midland valley of Scotland has been the theatre of igneous action both in Lower Devonian and Carboniferous times. The igneous assemblages of the two periods show. however, a striking contrast. The earlier lavas are distinctly of the Pacific type, including andesites, basalts and rhyolites. while the Carboniferous extrusions and dike rocks include trachytes teschenites, picrites and monchiquites—an Atlantic assemblage. Petrographical provinces are therefore clearly not permanent.

Study of the geological relations of igneous rocks clearly reveals that there is a general correspondence in both time and space between igneous action and movements of the earth's crust, whether these be simply vertical movements of elevation and depression or tangential movements of folding and overthrusting which build up great mountain chains. As in crustal movements so in igneous action, periods of activity have alternated with periods of quiescence. The movements of compression which led to the folded mountain chains fringing the Pacific were accompanied and followed by widespread volcanism, and the movements of depression which in Tertiary times led to the formation of the Great Rift valley of east Africa were attended and followed by a great suite of volcanic eruptions. The interdependence of igneous action and crust movement is even of a still more intimate kind, for not only the distribution of igneous rocks, but the distribution of different kinds of igneous rock is seen to stand in unmistakable relation to the great tectonic structures of the earth. The examples referred to above are illustrative of this conclusion. The volcanoes of the Pacific cordillera erupted calcic andesites and basalts, and are associated with granodiorite and quartz-diorite intrusions; the eruptions associated with the African Rift valley are in contrast, being of alkali type and including soda trachytes, phonolites and related alkali lavas. Whether attention is confined to Tertiary igneous rocks or extended to those of earlier date, the conclusion is enforced that rocks of the Pacific suite are closely associated with folded mountain chains and appear in regions subject to movements of compression and lateral thrust, and that the Atlantic or alkali suites are associated with regions of subsidence, subject to tension and faulting. The volcanic rocks of oceanic islands are dominantly olivine basalts and with these, though in minor development, are associated typical Atlantic differentiates—trachyte and phonolite. More siliceous lavas have not been frequently reported, but their occurrence with basalts and trachytes in an oceanic environment attests an intimate genetic relationship and adds support to the theory that granitic differentiate can derive from parental basaltic magma. Quartz trachyte or alkali rhyolite have been thus recorded in the inner Pacific at Easter Island and in Tutuila (Samoa), in the south Atlantic (Bouvet Island) and in the Indian ocean (Kerguelen archipelago).

The tectonic environment of rocks of the Mediterranean suite is less clearly defined. In general their spatial arrangement in relation to the Pacific and Atlantic suites reflects their intermediate position. They are characteristic of the region lying between the orogenic zones and the forelands or regions of subsidence. The position of the potassic Roman province in relation to the Alpine orogenic zone and the alkali (Atlantic) basin of the west Mediterranean illustrates this association clearly.

Between many calcic, sodic and potassic suites no sharp line of division is to be recognized, and in their relative distribution upon the face of the globe may be seen the influence of tectonic processes as an external factor exerting a profound influence on the trend of differentiation. See also Index references under "Petrology" in the Index volume.

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PETRONIUS ARBITER (GAIUS or ? TITUS PETRONIUS) (d. A.D. 66). Roman voluptuary, poet and the reputed author of the first western European novel. Tacitus gives a graphic account (*Annals*, xvi, 18–19) of his character and the manner of his death. He was an able man, who distinguished himself as governor of Bithynia and consul; but his chief talent lay in the pursuit of pleasure, in which he displayed such exquisite refinement as to earn the unofficial title of the emperor Nero's "arbiter of elegance" *(arbiter elegantiae)*

Being suspected of conspiring against the emperor, he was ordered to commit suicide; his last hours were passed in amusements, social pleasures and the composition of a scurrilous catalogue of Nero's debaucheries. The identification of this Petronius with the author of the *Satyricon* is, notwithstanding all that has been urged to the contrary, reasonably certain. The atmosphere of the work and the internal evidence point to the Neronian period, and it seems unlikely that two different men of the same name and so similar in character and outlook can have existed at the same time.

The *Satyricon* (properly perhaps *Satyrikon liber*, "Book of Satyrlike Adventures") is a "picaresque" romance. It relates the wanderings and escapades of a disreputable trio of adventurers, the narrator Encolpius ("Embracer"), his friend Ascyltos ("Scot-free") and the boy Giton ("Neighbour"—a euphemism). The surviving portions probably represent about one-tenth of the complete work. Some semblance of unity is imparted to the episodic narrative by a wrath motif recalling the *Odyssey* and the *Aeneid:* the narrator is pursued by the enmity of Priapus, whose divinity he apparently offended in a lost portion of the work. The *Satyricon* has obvious affinities with the later Greek prose romances, particularly in the rhetorical flavour which pervades it, but its immorality, or rather amorality, sets it in a class apart from them. Its tone recalls the notorious predilection of Nero and his court for low life and suggests that it may have been composed specially for their amusement. Its literary ancestry is complex and can only be guessed at. The loose narrative framework encloses a number of detached tales of the so-called "Milesian" type, the ancestor of the smoking-room story, a classic instance being the famous "Widow of Ephesus" *(Satyricon*, ch. 111–112); in this the *Satyricon* resembles the later *Metamorphoses* of Apuleius. Other features, however, recall the "Menippean" satire (represented in Latin by M. Terentius Varro): namely, the mixture of prose and verse in which it is composed; and the digressions in which the author airs his own views on various topics having no connection with the plot.

The most remarkable of these digressions, which are the only parts of the work which may properly be called satire, is the passage relating to contemporary epic poetry (ch. 118); it is followed by a hexameter poem of 295 lines on the civil war between Caesar and Pompey, apparently intended as a criticism (not a parody) of Lucan. Whether Petronius had a Greek model or whether the fusion of genres represented by the *Satyricon* was his own invention must, in the present state of the evidence, remain uncertain.

The longest and the best episode is the so-called *Cena Trimalchionis* or "Banquet of Trimalchio" (ch. 26–78), a description of a dinner party given by Trimalchio, an immensely rich and vulgar freedman (former slave) of oriental origin, to a group of friends and hangers-on. Its length appears disproportionate even to the presumed original size of the *Satyricon* (though the story of Cupid and Psyche in Apuleius offers a partial analogy), and it has little or no apparent connection with the plot. The scene is a Greco-Roman town in Campania, possibly Puteoli (Pozzuoli), and the guests, mostly freedmen like their host, are drawn from what corresponded to the *petit bourgeois* class. Trimalchio is the quintessence of the parvenu, a figure familiar enough in ancient satirical literature, but especially so in the 1st century A.D., when freedmen as a class were at their most influential. The setting exemplifies a literary form stemming from Plato's *Symposium* and already employed for satirical purposes by Horace *(Satires*, ii, 8).

Two features distinguish Petronius' *Cena* from other ancient examples: its extraordinary particularity and realism and the figure of Trimalchio. It is obvious that the table talk of the guests in the *Cenu* is based on personal observation of provincial societies. The speakers are beautifully and exactly characterized and their dialogue, quite apart from the invaluable evidence for colloquial Latin afforded by the vulgarisms and solecisms in which it abounds, is a humorous masterpiece. Trimalchio himself, with his vast wealth, his tasteless ostentation, his affectation of culture, his superstition and his maudlin lapses into his natural vulgarity, is more than a typical satirist's figure. That some of his idiosyncrasies are taken from life is proved by Seneca's description of Calvisius Sabinus *(Epistles*, xxvii, 5); and, if due allowance is made for comic exaggeration, little about him is actually incredible. As depicted by Petronius, however, he is one of the great originals of literature, fit company for Shakespeare's Falstaff or R. S. Surtees' Jorrocks. Development of character for its own sake was hardly known in ancient literature: the emphasis was always on the typical, and the classical rules as expounded by, for instance, Aristotle and Cicero, laid down that character was secondary to more important considerations such as plot. Petronius, in his treatment of Trimalchio, transcended this almost universal limitation in a way that irresistibly recalls Dickens, and much else in the *Cenu* is Dickensian—its exuberance, its boisterous humour (rare in ancient literature, where wit predominates) and its loving profusion of detail.

The rest of the *Satyricon* is hardly to be compared with the *Cenu.* It offends not so much by its indecency as by the selfish and flippant hedonism which colours it throughout (a debased Epicureanism: *see* the poem at the end of ch. 132). This, allied to a Latin of unmatched grace and elegance, earned for Petronius (from Justus Lipsius) the title *auctor purissimae impuritatis*, "writer of the purest impurity." The few poems transmitted separately from the *Satyricon* under Petronius' name do nothing to

enhance his reputation. To the middle ages he was known as the author of moral maxims, preserved in fragmentary excerpts; his popularity in modern times dates from the publication in 1664 of the previously unknown *Cena Trimalchionis,* discovered in a manuscript at Trau (Trogir) in Dalmatia.

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PETROPAVLOVSK, (1) a town in the Kazakh *oblast* of the Kazakh Soviet Socialist Republic, U.S.S.R., in 55° N. and 69° E., on the left bank of the Ishim river, where the Trans-Siberian railway crosses it. Pop. (1959) 35,000. The town is a centre for caravan trade from the Kirghiz steppe in corn, cattle, furs, tea, wool and cotton and has an Asiatic appearance.

(2) A port on the eastern shores of Avacha bay in the Kamchatka *oblast,* of the Russian Soviet Federated Socialist Republic, U.S.S.R., in 53° 16' N., 159° E. Pop. (1959) 86,000. The inhabitants are mainly Russians, Japanese, Chinese, Koreans and natives. and the town, which has been growing rapidly, is a centre for the fur trade.

There are summer sailings to Vladivostok and Japan, but the harbour is frozen from November to May. There is a wireless station, linking it with Vladivostok and with the fish canneries in the north of Kamchatka.

The Russian Pacific fleet was stationed there for a time and defeated a combined attack by the French and English during the Crimean War. It was transferred in 1854 to Nikolayevsk-on-Amur and, ultimately to Vladivostok.

PETROPOLIS, a city of the state of Rio de Janeiro, Brazil, in an elevated valley of the Serra de Estrêla or dos Orgãos mountains, 2,634 ft. above sea level, is 27 mi. N. of Rio de Janeiro, with which it is connected by railway and highway. It was founded in 1845 by Julius Frederick Knoeller, and was sponsored by Dom Pedro II, the Brazilian emperor for whom it was named. The emperor was attracted to the city's relatively cool climate—9° F. lower than Rio de Janeiro during the summer—and held court there during the warmer months, attended by public officials and members of the diplomatic corps.

The ornate royal palace, surrounded by luxuriant gardens, houses the Museu do Imperio (Museum of the Empire) that contains many of the possessions of João VI of Portugal, who resided in Brazil for several years, and of the two Brazilian emperors, Dom Pedro I and Dom Pedro II. The cathedral of the town is of 13th-century French Gothic design. There is a variety of manufacturing industries in the city and a short distance away are rich farm lands. Pop. (1950) 61,011 (city); 108,307 (mun.). Quitandinha palace, a leading resort centre, is about 3 mi. S. of Petrópolis on the highway to Rio de Janeiro. (J. J. J.)

PETROVARADIN (German **PETERWARDEIN**), a former town and fortress of Croatia-Slovenia, Yugos., situated on a promontory formed by a loop of the Danube; occupied by the axis in 1941. After the return to Yugoslavia it was annexed to the city of Novi Sad.

The fortifications consist of the upper fortress, on a lofty serpentine rock rising abruptly from the plain on three sides, and of the lower fortress, rising from the river on the northern base of the rock.

The fortress is believed to represent the Roman Acumincum, and received its present name from Peter the Hermit, who in 1096 marshaled the levies of the first crusade there. It was captured by the Turks in 1526 and was retained by them for a period of 160 years.

PETROZAVODSK, the chief town in the Karelian Autonomous Soviet Socialist Republic of the Russian Soviet Federated Socialist Republic, U.S.S.R., in 61° 41' N., 34° 20' E., on the west shore of Lake Onega, and on the Leningrad-Murmansk railway. Pop. (1959) 135,000.

PETRUS AUREOLI (*c.* 1280–1322), otherwise PIERRE AURIOL (or ORIOL. D'ORIOL), French Franciscan, theologian and philosopher known honorifically as *Doctor facundus,* "the eloquent teacher," was born near Gourdon in Quercy. Having studied in Paris and taught in Bologna and Paris, he became provincial of his order for Aquitaine (*c.* 1320) and archbishop of Aix-en-Provence (1321). Criticizing both Thomas Aquinas and Duns Scotus, he promoted an individualistic empiricism, supported by a nominalistic-conceptualistic doctrine of universals which in some ways anticipates William of Occam.

His *Commentary on the Sentence:* was first printed in Rome, 2 vol. (1596–1605).

See A. Teetaert, "Pierre Auriol," in *A.* Vacant (ed.), *Dictionnaire de théologie catholique,* xii (1934). (L. M.-Po.)

PETTENKOFER, MAX JOSEPH VON (1818–1901), German chemist and hygienist whose name is most familiar in connection with his work in practical hygiene and nutrition, which he put on a scientific basis, was born on Dec. 3, 1818, at Lichtenheim, near Neuburg.

He studied pharmacy and medicine at Munich (Ph.D., 1843), and after working under Justus von Liebig at Giessen was appointed chemist to the Munich mint in 1845. Two years later he was chosen professor of chemistry in the medical faculty at Munich, and in 1865 he became professor of hygiene. He was ennobled in 1883. In 1894 he retired from active work, and on Feb. 10, 1901, he committed suicide at Munich.

The reaction known by his name for the detection of bile acids was published in 1844.

PETTIE, JOHN (1839–1893), Scottish painter, was born in Edinburgh on March 17, 1839. At 16 he entered the Trustees' Academy in Edinburgh, working under Robert Scott Lauder. His first exhibits at the Royal Scottish Academy were "A Scene From the Fortunes of Nigel"—one of the many subjects for which he sought inspiration in the novels of Sir Walter Scott—and two portraits in 1858. To the Royal Academy in 1860 he sent "The Armourers"; and in 1862 he settled in London, where he joined W. Q. Orchardson. In 1866 he was elected A.R.A., and in 1874 R.A.

Pettie died at Hastings on Feb. 21, 1893.

John Pettie, R.A. (1908), by his nephew Martin Hardie, gives the story of his life, a catalogue of his pictures and 50 reproductions.

PETTIGREW, RICHARD FRANKLIN (1848–1926), U.S. senator, whose amendment to the Timber Culture act of 1891 established the right of the president to reserve public forest lands by proclamation. He was born on July 23, 1848, in Ludlow, Vt. In 1854 the family moved to Wisconsin, first to Dane county and shortly thereafter to Evansville, where he attended the public school and academy. He entered Beloit college in 1864, taught school a year, and in 1867 entered the University of Wisconsin (Madison), where he studied law. In 1869 he went to the Dakota territory as a U.S. deputy surveyor and settled in Sioux Falls (later South Dakota). He was admitted to the bar in 1871 but continued his surveying and dealt in real estate until 1875.

He was elected to the house of representatives of the territorial legislature in 1872 and to the territorial council in 1877, 1879 and 1885. He served as delegate to the 47th U.S. congress from the territory, 1881–83, being elected as a Republican, and in 1889 when South Dakota and North Dakota were admitted to the union, he was chosen a senator for South Dakota. He was re-elected in 1895. Politically independent, he was a single taxer, opposed to the private ownership of land, and believed railroads and telegraph systems should be public utilities. He broke with his party when, as a delegate to the national convention of 1896, he walked out after the defeat of a free silver resolution. He supported the Democratic candidate, William Jennings Bryan, in the following campaign. He was defeated for re-election to the senate in 1900.

He practiced law in New York city before returning to Sioux Falls, where he died on Oct. 5, 1926. His house and his collections of Indian and frontier relics and of specimens of birds, snakes and animals native to South Dakota were bequeathed to the city as the Pettigrew museum.

PETTY, SIR WILLIAM (1623–1687), English political economist and statistician, one of the founders of economic thought and demographic and economic statistics, was born at Romsey, Hampshire, May 26, 1623. Having studied medicine at the universities of Leyden, Paris and Oxford, he was in turn seaman, medical student, physician, professor of anatomy at Oxford, professor of music in London, inventor, surveyor and landowner in Ireland and a member of parliament. He died in London on Dec. 16, 1687.

A protagonist of the empirical scientific doctrines of the newly founded Royal society, of which he was a founder-member, Petty was one of the leading pioneers of political arithmetic; *i.e.*, "the art of reasoning by figures upon things relating to government." His various *Essays on Political Arithmetick* and *Political Survey or Anatomy of Ireland* (1672) presented population estimates and rough calculations of social income. His methods seem crude and audacious by modern standards, but Petty was not unaware of their limitations. His ideas on monetary theory and policy, including the quantity theory, were developed in *Verbum Sapienti* (1665) and *Quantulumcunque concerning Money, 1682* (1691). But his main contribution to political economy was *Treatise of Taxes and Contributions* (1662), in which he expounded what should be the main economic functions of the state. In doing so he touched on the fundamental problem of the theory of value, treating the labour necessary for production as the main determinant of exchange value and seeking a standard of value in the necessary sustenance of a man for a day. Petty—an advocate of religious toleration—favoured allowing scope to the natural forces of individual self-interest and "rather complying with the motions of nature than contradicting it with vehement administratives." But unlike liberals after Adam Smith he considered the maintenance of a high level of employment by monetary and fiscal policies and by public works to be a duty of the state.

See Economic Writings of Sir William Petty, ed. by C. H. Hull, 2 vol. (1899). (T. W. H.)

PETUNIA, a genus of popular garden plants of the nightshade family (Solanaceae), comprising perhaps 15 species, mostly from Brazil and Argentina. The group has been much hybridized and the origin of the common garden sorts is doubtful. Petunias are divided into three main divisions: (1) erect types, 7–15 in high, used for bedding; (2) sprawling or weak-stemmed types, often called balcony petunias, useful for window boxes; and (3) dwarf types. 4–6 in. high, also used for bedding. Modern petunia varieties have typically funnel-shaped flowers, only slightly unsymmetrical, and variously crisped, fringed or ruffled; double varieties have also been developed.

All the petunias are annuals and are not frost-hardy. They may be started from seed sown indoors and just barely covered with fine-grained soil eight to ten weeks before outdoor planting is safe. When warm weather has arrived the seedlings can be planted outdoors in almost any ordinary garden soil. They do particularly well along the seaboard of the Atlantic, and especially so along the coast of Oregon, Washington and northern California, but may be grown in almost any temperate locale. They can be started outdoors directly from seed in the warmer parts of the United States and in southern England.

Amply watered and in a sunny location, these showy plants will bloom profusely all summer, yielding blossoms of pure white through various shades of red violet to deep violet. Some of the large-flowered types are easily beaten down by rain and so should be staked. (N. TR.)

PETWORTH, a town of West Sussex, Eng., 14 mi. N.E. of Chichester by road. Pop. (1951) 2,729. Petworth (Peteorde in Domesday Book, Puetewurth in 1181) is named in a grant by Eardwulf, king of Northumbria (d. 810) to St. Peter's church. Under Edward the Confessor it was an alodial manor, held by his queen, Edith, and in 1086 Robert Fitz-Tetbald held it of Roger de Montgomery, earl of Shrewsbury. Standing in a large park is Petworth house (National trust) with a 13th-century chapel; the manor house was almost wholly rebuilt between 1688 and 1696 by the duke of Somerset. The south front was rebuilt in 1869–72. It is remarkable for its magnificent collection of pictures and its wood carvings by Grinling Gibbons and Jonathan Ritson (1776?–1846).

PEUTINGER, KONRAD (1465–1547), German humanist and antiquarian, was born at Augsburg. In 1497 he was town clerk of Augsburg, and was on intimate terms with the emperor Maximilian. He was one of the first to publish Roman inscriptions, and his name remains associated with the famous *Tabula peutingeriana*, a map of the military roads of the western Roman empire, discovered by Konrad Celtes. Peutinger also edited the *Historia Gothorum* of Jordanes and the *Historia gentis Langobardorum* of Paulus Diaconus.

The *Tabula peutingeriana* was first published as a whole by F. de Scheyb (1753); later editions by E. Desjardins (1869–74) and C. Miller (1888); *see* also *E.* Paulus, *Erklärung der Peutinger Tafel* (1867); Teuffel-Schwabe, *Hist. of Roman Literature* (Eng. trans., 1900).

PEVENSEY, a village in the Hailsham rural district of East Sussex, Eng., 38 mi. E.N.E. of Brighton by road. Pop. (1951) 1,686. It was the landing place of William the Conqueror and became the head of the rape (*q.v.*) of Pevensey, granted by William to the earl of Mortain. It subsequently became the honour of the Eagle. Some time before the reign of Edward I the town of Pevensey was made a limb of the Cinque Port of Hastings and shared the liberties of the Cinque Ports. By an act of 1883 it ceased to exist as a borough. The decline of Pevensey was caused by the silting up of the Pevensey levels, once a shallow bay but by 1700 almost completely reclaimed, leaving Pevensey about 1 mi. inland. Pevensey castle's outer wall. with towers, is Roman, the remains of the powerful fortress of Anderida. Within are the ruins, principally of the 13th century but in part Norman, of the castle proper, with a keep.

PEW, a term, in its most usual meaning, for a fixed seat in a church, usually enclosed, slightly raised from the floors and composed of wood framing. mostly with ornamented ends. Some bench ends are certainly of Decorated character, and some have been considered to be of the Early English period. They are sometimes of plain oak board, 2½ to 3 in. thick, chamfered and with a necking and finial generally called a poppy head; others are plainly panelled with bold cappings; in others the panels are ornamented with tracery or with the linen pattern, and sometimes with running foliages. The large pews with high enclosures, known familiarly as "horse boxes" and common in English churches during the 18th and early part of the 19th centuries, have nearly all been cleared away. The church of Whitby, in Yorkshire, is perhaps the best surviving example of an unaltered interior.

At common law all seats in a parish church are for the common use of all the parishioners, and every parishioner has a right to a seat without paying for it. As against the assignment and disposition of seats by the ordinary, acting through the church wardens, two kinds of appropriation can be set up: (1) by the grant of a faculty by the ordinary; and (2) by prescription, based on the presumption of a lost faculty. Such faculties are rarely granted now, they were formerly common; the grant was to a man and his family "so long as they remain inhabitants of a certain house in the parish." The letting of pews in parish churches became common in the 16th century, but there are some earlier instances of the use, for example at St. Ewens, Bristol, in 1455.

See A. Heales, *History and Law of Church Seats and Pews* (1872); Phillimore, *Eccles. Law*, ii, 1424 *sq.* (1896).

PEWTER, an alloy, the basis of which is tin. Modern pewter is a tarnish-resistant alloy composed of approximately 91% tin, 7.5% antimony and 1.5% copper; the best grades contain no lead. The copper adds ductility and desirable working properties while antimony serves to whiten the alloy and to impart a hardness unknown to old pewter. Old pewter, first used nearly 2.000 years ago by the ancient orientals and Romans contained sufficient lead to cause the surface to darken with age. There are two schools of thought among pewter collectors: some prefer the dark satin-

PEWTER

English pewter cup, cast in relief; early 17th century

Large salver, Temperantia dish, cast in relief by François Briot of Alsace-Lorraine; *c.* 1580–90

Salver cast in relief and set with a plaque of Limoges enamel. Outer rim shows scenes from the parable of the prodigal son. French, 1550–70

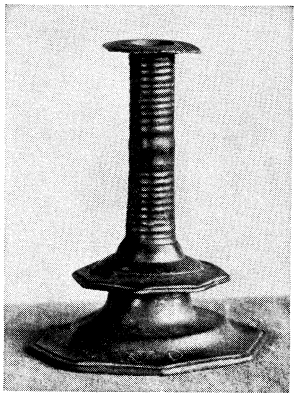
South German plate cast in relief. Marked with the arms of Nürnberg and the initials I. H.; dated 1628

16TH AND 17TH CENTURY PEWTER

BY COURTESY OF VICTORIA AND ALBERT MUSEUM; PHOTOGRAPH, (BOTTOM RIGHT) C. H. CANNINGS

PEWTER

South German plate, dated 1619. Marked with the arms of Nürnberg and the initials B. O. (Paul of Oham)



English candlestick, late 17th century

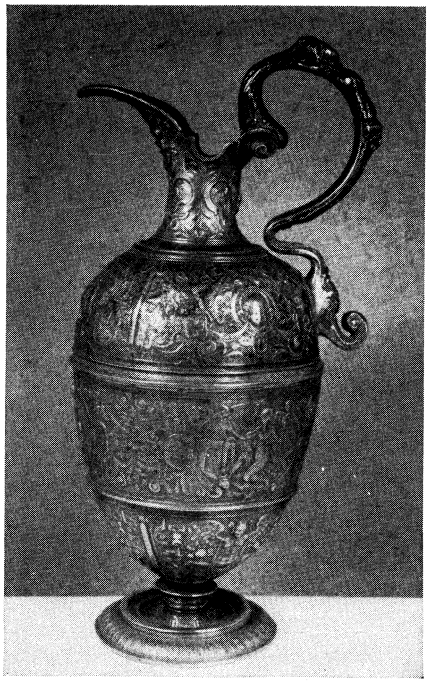
Embossed tankard with cover, the sides decorated with medallions showing allegorical figures. French, late 16th century

U.S. tankard by Frederick Bassett (1740–1800)

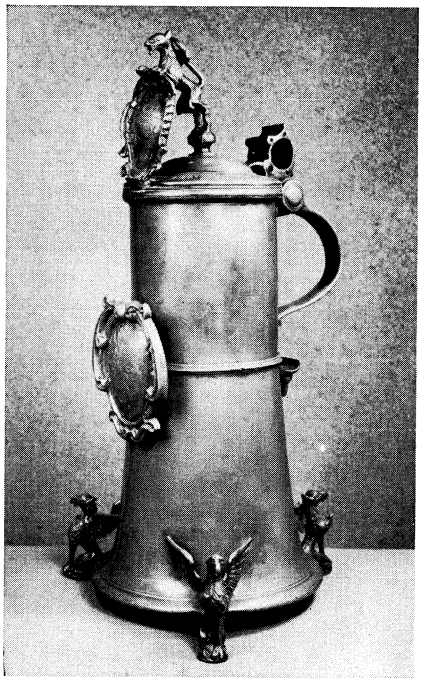
English candlestick bearing the arms of the Pewterers' company and the maker's name; 1616

U.S. mug by Joseph Danforth of Middletown, Conn.: between 1781 and 1788

Large flagon, a guild tankard of silvered pewter cast in relief; probably Swiss, second half of the 16th century



Temperantia ewer by François Briot of Alsace-Lorraine; c. 1580–90

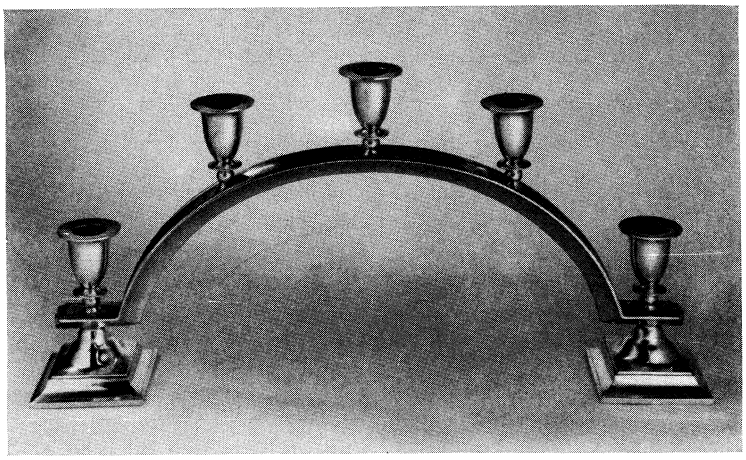


German guild flagon, 17th century

EUROPEAN, ENGLISH AND U.S. PEWTER, 16TH TO 18TH CENTURIES

BY COURTESY OF (TOP LEFT TOP CENTRE TOP RIGHT, CENTRE BOTTOM LEFT BOTTOM CENTRE, BOTTOM RIGHT) VICTORIA AND ALBERT MUSEUM, (CENTRE LEFT) THE METROPOLITAN MUSEUM OF ART N Y. ROGERS FUND. 1939 (CENTRE RIGHT) SMITHSONIAN INSTITUTION; PHOTOGRAPH, (BOTTOM RIGHT) C. H. CANNINGS

Vegetable dish and cover. French



Five-light candelabra. Danish

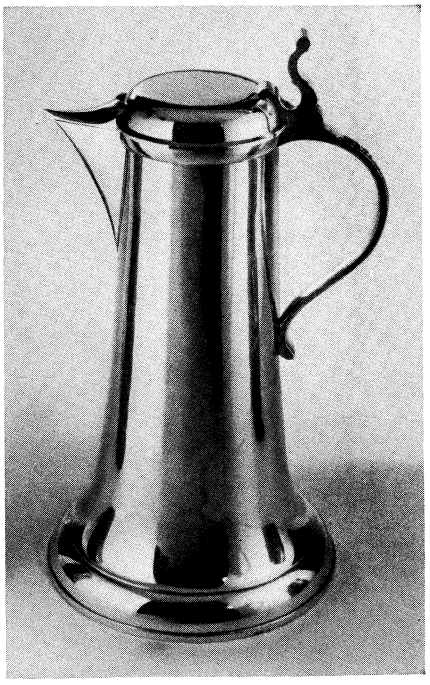
Miniature galleon. Swedish

Etched plate with zodiac inscriptions. German

Cocktail shaker. Norwegian

Tankards. Left to right: English, Norwegian, English. U.S., U.S., German. Malayan

Water lugs. Left to right: U.S., English, U.S., U.S., Dutch, U.S.



Wine can. German

20TH CENTURY PEWTER

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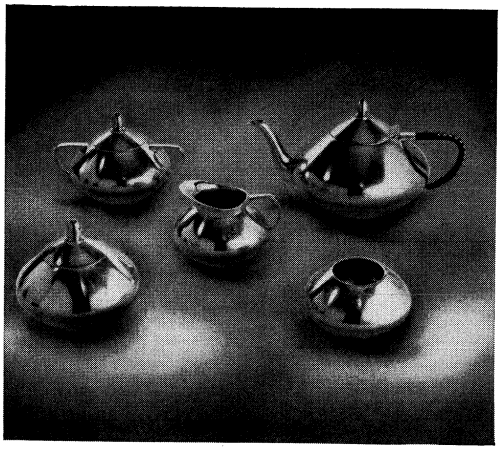
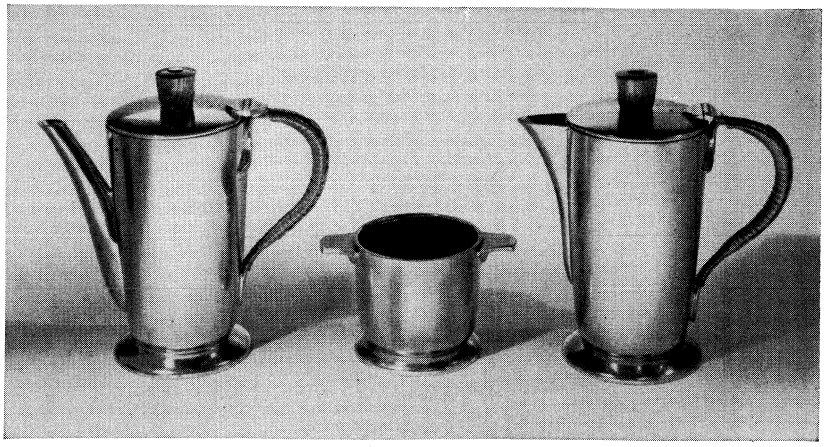
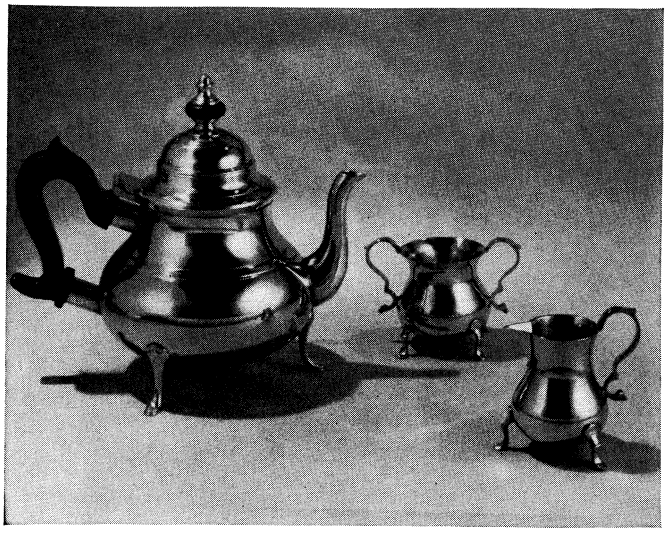
PEWTER



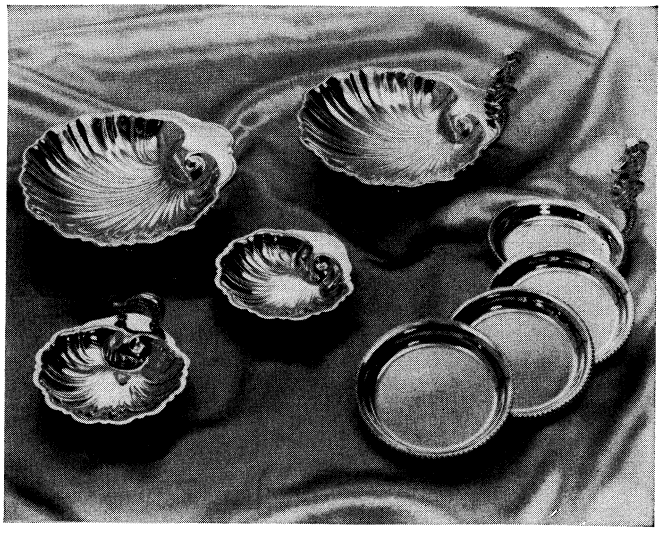
Tea service. Dutch



Coffee pot, sugar basin and hot milk jug. English

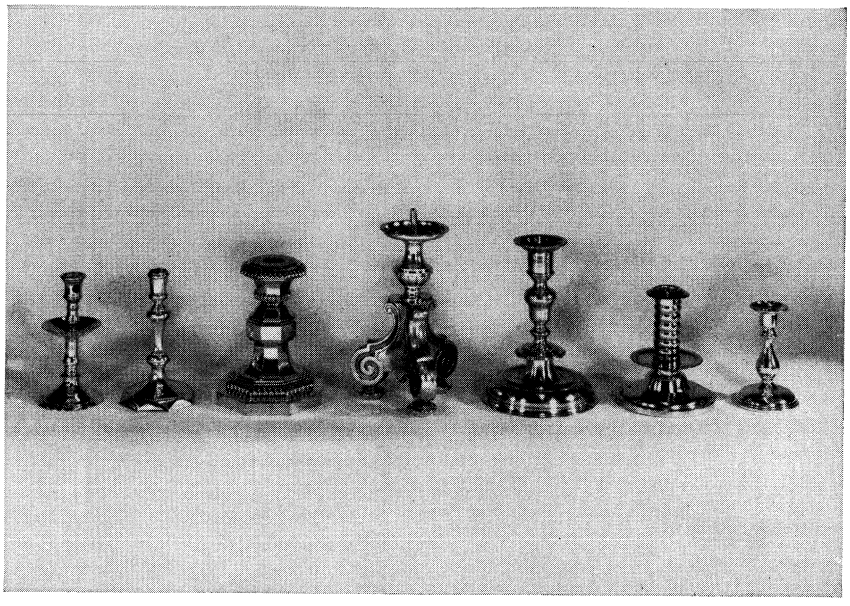


Teapot, sugar and creamer. U.S., Williamsburg design



Ashtray and bonbon dishes. U.S.

Coffee and tea service with tray. U.S.



Candlesticks. Left to right: French, U.S., French, Swedish, English, U.S., U.S.

20TH CENTURY PEWTER

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like sheen of old pewter while others prefer modern pewter which retains its brightness indefinitely and lends itself to a whole gamut of finishes from a crisp bright finish to a soft satin sheen.

Pewter played an important part in the development of civilization as a medium for artistic expression and as a material from which domestic utensils were fashioned. Pewter exceeds most other metals in ductility and ease of working. It may be stretched, compressed and bent into almost any desired shape; and it does not harden or stiffen sufficiently on coldworking with tools for annealing to be necessary. Modern methods of manufacture differ considerably from those of the early craftsmen, which involved casting, turning and hammering. Much of the flat and hollow ware is spun on a lathe instead of being cast; the stamping press is used frequently to produce unique shapes such as oval trays and gravy boats. Casting methods are still essential for making handles, feet, knobs, hinges and for heavy ornamental pieces. Pewter articles can be hammered into shape, the surface can be raised or stretched, surface lines can be emphasized by chasing and embossing and decorative effects can be achieved by etching. Machine methods for polishing have added interesting possibilities in new and artistic finishes.

Modern Pewter.--Modern pewter is somewhat softer than brass or bronze. In spite of its softness, it must be classed as one of the most durable metals and as one which will resist oxidation almost indefinitely. Utensils made from pewter have a high resistance to almost all weak acids: food and drink may be served in them without fear of chemical action.

Modern pewterware falls into two types: antique and modern. For the person who prefers antique pewterware, there are reproductions of early masterpieces of the American colonial period. For instance, a complete line of Williamsburg reproductions are available, some of which are actually cast from original molds. For those who desire modern pewterware, there is a wide variety of articles such as coffee and tea services, plates, trays, water jugs. tankards, candelabras, serviette rings, bowls, flasks, cigarette and jewelry boxes, spoons, trophies, ship models, pepper and salt shakers. ashtrays and communion cups. Most modern manufacturers in adapting original designs or producing new designs, have kept the bold simple lines which are the chief charm of pewter.

The revival of interest in pewter can be attributed to several factors. For example, the public has become educated to the charm and beauty of nontarnishing pewter; contemporary craftsmen are using pewter in new ways and in striking designs. Pewter has been introduced as an important activity in industrial arts courses in the schools and the home workshop.

Historical Background.— The historical background of old pemter is extensive and many historical collections can be seen in museums throughout the world. Famous collections are on display in the Victoria and Albert museum in London, the Smithsonian institute in Washington, D.C., and the University of Copenhagen, Den. There are more than a dozen large pemter collections in the United States. (*See* list of museums, B. N. Osburn and G. O. Wilber, *Pewter,* 1947.)

England.--Specimens of Roman pewter excavated in England leave no doubt that pewterware was made in England by the Roman legions. From the Renaissance, the use of pewter in England had been firmly established in the church and for domestic purposes. Pewter chalices had replaced wooden vessels before the end of the 11th century; until the 15th century it was customary to bury a pewter chalice with the priest. After the Reformation and throughout the 17th and 18th centuries, a large number of pewter vessels were found, especially flagons, alms dishes and collection plates. It was customary for every pewterer to strike his '(touch" or mark: these marks were made with a steel die into which some ornamental design with the initials of the maker had been cut. The mark indicated membership in a guild called the Worshipful Company of Pewterers, chartered by the crown in 1503. Records of touch-plates were destroyed in the great fire of 1666. The activities of the company prospered and pewterware became an important household item. Plates, saucers, tankards, mugs, candlesticks and mustard pots are excellent examples of some commonly used articles in English homes until the period when china and porcelain appeared. During World War I and II many valuable pieces of pewter relegated to the attic were sold for scrap and lost forever. It is surprising that so much pewter has survived and that it is possible to form a representative collection of pewter items from at least the late 17th century to the middle of the Victorian era.

Holland.— Much fine pewterware was made in other parts of continental Europe. The earliest known date on a pewter article made in Holland is 1331. In the 17th century, pewter played an important part in middle-class homes and in the inns.

The modern pewter industry continues the old tradition. Century-old, well-tried models are still being made but craftsmen have given new shapes to the classic material by harmoniously combining usefulness and beauty. Dutch pewterware is plentifully available and is exported to all countries into which importation is allowed.

Sweden.— The manufacture of pewterware began in Sweden before the end of the 13th century. Guild rules existed as early as 1485 when pewterers were required to stamp their wares. A rose-and-crown mark, much in evidence in the 17th century, denoted the highest quality. The artistically brilliant period of pewter in Sweden was the 18th century when it served widely for table wares and candlesticks. The decline occurred as in other countries but manufacture was revived in 1924.

Germany.--Germany had established a pewter industry at Augsburg and Nuremberg in the 14th century. During the next four centuries, pewter was the most versatile metal available and wares of every kind were made. The treatment of pewter in relief was quite common as, for example, the plates with portraits of emperors or medallions of Biblical scenes. German hostels afforded much in the way of tankards and drinking vessels. After World War II, the pewter industry in Germany had revived strongly in the towns of Regensburg, Wurttemburg, Diessen and Nabburg.

France and Belgium.— The rise of pewter in France and Belgium was contemporary with that in other European countries. In France the most interesting period was the 16th century. Highly ornamented pieces have been found which were associated with the name of François Briot, the greatest of French pewterers. His well-known Temperantia salver and ewer are covered with ornament in relief. On the ewer are figures of the cardinal virtues, while on the dish are figures of Minerva and the seven arts, with the four elements and Temperance in the centre. Fine examples of his work are preserved in the Cluny museum, Paris. Little of the ancient pewter remains in Belgium because so much has disappeared during the repeated wars and invasions.

Colonial America.—Pewter was used much in the households of colonial America. The earliest pewterers came from England, bringing their traditional styles with them. The period which marked its greatest production was the 150 years between 1700 and 1850. Boston, New York and Philadelphia were the main centres of manufacture. Every kind of utensil mas made which was in any way requisite for domestic purposes: plates, bowls, spoons, tankards, candlesticks and lamps were made in enormous quantities. With the advent of cheap pottery, particularly plates, the pewterers turned their efforts to the manufacture of coffee pots and these became the mainstays. In the 20th century, there came a revival of interest in colonial period pewter; several firms took up the manufacture of antique reproductions and then branched into new designs which found favour. It is apparent that in spite of other available materials, pewter retained its hold and popularity upon American taste long after it had ceased to interest the European public. During World War II and for a number of years thereafter, the manufacture of pewter was not allowed because tin was reserved for essential purposes. Restrictions were removed in 1953 and manufacturers made up lost ground by leaps and bounds. Since then, the world production of modern pewterware has exceeded the amount of pewter produced in any similar period in the history of the industry. *See* also ANTIMONY; *TIN*.

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(R. M. MacI.)

PEYOTISM is the use by American Indians of peyote (*Lophophora williamsii*), a spineless cactus which grows in northern Mexico and in Texas. The word "peyote" seems to be a Spanish version of the Nahuatl term *peyotl*.

The properties of the cactus are such that, when eaten, it produces extraordinary physiological and psychological effects. These effects seem to vary with the social and psychological conditions under which peyote is taken. Scientific observations have been made upon white persons only under laboratory conditions; the effects reported are distinctly different from those observed upon Indians taking peyote under ritual conditions.

There are two major forms of peyotism, the old peyote complex and the peyote religion.

The old peyote complex is the earlier form of peyotism, which flourished prior to the 20th century. Peyote was used by persons primarily as a medicine and to obtain visions for purposes of supernatural revelation. The plant was used collectively as an auxiliary in tribal dancing rites, the purpose of the peyote evidently being to induce a trance state during the dance. Little is known about the preconquest (1521) origin and distribution of the old peyote complex; all that can be stated is that peyote is depicted on pre-Columbian archaeological remains in Mexico. Documents from the 16th century to the 18th report the distribution of the old peyote complex in Mexico and the United States within the area between 18° and 36° N. lat. and between 92° and 114° W. long. In the 20th century the old peyote complex exists in Mexico, with diminished importance.

The peyote religion is a syncretistic form of peyotism which developed during the second half of the 19th century. The peyote religion is practised by a voluntary religious organization, whose rite is one of prayer and quiet contemplation, centred on peyote both as a symbol of the spirits being worshipped and as a sacrament.

The fully developed peyote religion probably originated among the Kiowa and Comanche on their reservation in Oklahoma, about 1885, out of an earlier Apache peyote rite. From 1891 on the religion spread rapidly and became the most widespread indigenous Indian religion, extending from the Great Lakes to the Rocky mountains in both the United States and Canada. Groups practising the peyote religion were incorporated in 1918 as the Native American Church.

Peyotism has the basic traits found in all religions: a doctrine, ethics and ritual. Most peyotists consider themselves to be Christians, for they conceive peyotism to be the Indian version of Christianity. Their proof of this is that they accept the Christian Trinity and Christian ethics.

Doctrine of the Peyote Religion.—Peyotist doctrine, or religious theory, consists of a belief in the existence of power, spirits and incarnations of power.

Power.—"Power" is the Indian equivalent of what the Greek New Testament calls *pneuma* (Holy Spirit, Holy Ghost) and anthropologists mana. It is an immaterial and invisible supernatural force, which produces characteristic effects in things influenced by it and can be transferred from one thing to another under the proper ritual conditions. Man needs power to be successful and healthy; without it he becomes unsuccessful and ill.

Spirits.—Spirits are immaterial personifications of power. The peyotist pantheon consists of what may be called white and Indian spirits.

White Spirits: the Trinity.—God is equated with the Great Spirit. He is universally acknowledged to be the supreme being and the ultimate source of all power; therefore He controls the destiny of everything in the universe, including man. Whether He is the creator spirit as well depends upon the tribe. Jesus plays various roles. In some tribes He is the culture hero (often equated with the traditional culture hero) who gave the white version of Christianity to the whites and peyotism to the Indians. In other tribes He is a guardian spirit who, rejected by the whites who murdered him, now looks after the equally rejected Indians. Another of Jesus' roles is that of intercessor spirit between God and man. The Holy Ghost has been adopted as part of the Trinity.

Indian Spirits.—Waterbird is usually identified as the water turkey (Anhinga nnhinga). Some equate Waterbird with the traditional Indian Thunderbird, others with the white Christian dove. Most often it has the role of a messenger spirit that carries man's prayers to God.

In many tribes peyote itself is personified as Peyote spirit. In general, the role of Peyote spirit is similar to that of the guardian spirit aspect of Jesus in white Christianity; he is a compassionate being, always benevolent, sympathetic and helpful.

Incarnations.—Incarnations are material embodiments of power, and peyote is the prime incarnation. It was given to the Indians by God because he took pity on them for being a subject people—poor, weak, helpless and ignorant. God made the peyote and put some of his power into it in order to help the Indians. Therefore when one eats peyote he absorbs the power inherent in it, which he can then utilize. Thus it is a sacrament like the bread and wine of white Christians, which are consumed in order to absorb the Holy Spirit inherent in them.

The characteristics of the plant are such that when taken internally it produces remarkable physiological and psychological effects. From the supernaturalistic viewpoint of Indian peyotists, these properties consist of the power within the peyote; when the sacramental plant is taken internally, this power is absorbed and affects the individual's spiritual and physical state. From the viewpoint of scientists, these properties consist of alkaloids; when the alkaloids are taken internally they affect the central nervous system.

The next most important incarnation of power is the water drunk during the rite at midnight and in the morning. Water is needed by all living things, and therefore all water is sacred. In addition, the water used in the rite is prayed over and "blessed" so that it acquires additional power. The morning water is particularly sacred because it is brought in and prayed over by the wife or other close female relative of the leader. She represents womanhood as the source of human life (she symbolizes "the mother of us all") and in some tribes also Peyote Woman to whom the rite was revealed.

The foods used in the morning communion breakfast (usually corn, game and fruit) also contain power, for they represent the important classes of foods man needs for life.

Ethics and Eschatology.—The peyotist ethical code constitutes a way of life called the Peyote Road, and conforming to the ethic is "following the Peyote Road." This ethic has four main parts.

Brotherly Love.—Members should be honest, truthful, friendly and helpful to one another. This is conceived as a spelling out of the Golden Rule (Matthew vii, 12; Luke vi, 31).

Care of Family.—Married persons should not engage in extramarital affairs and should cherish and care for one another and their children. Money should be spent on the family as a whole, rather than selfishly.

Self-Reliance.—Members should work steadily and reliably at their jobs and earn their own living.

Avoidance of Alcohol.—There is a maxim, "Peyote and alcohol don't mix."

Ritual.—Characteristically, but not always, the rite (called a meeting) is held in a Plains-type tepee. It is an all-night ceremony, usually lasting from about 8 P.M. on Saturday to 8 A.M. on Sunday. Essentially the rite has four major components: prayer, singing, eating the sacramental peyote and contemplation.

The reasons for choosing peyote as a sacrament can best be explained in terms of the fourth component of the rite; namely, contemplation. After eating peyote each worshipper spends most of his time in contemplation; any given person spends relatively little

time in solo singing. What does he contemplate about, and why does he need peyote to help him do so?

As in the case of any other sacrament, the worshipper eats peyote under the proper ritual conditions in order to obtain power to commune effectively with God and the other spirits. Perhaps the most important element in contemplation is concentration on such communion. For in all religions the purpose of communion is to lift the worshipper from the commonplace level of mundane existence to the exalted level of spiritual sublimity. In the culture areas under consideration, the traditional Indian means of obtaining the power needed for a successful and healthy life was through the vision quest. The individual went off in isolation. subjected himself to ordeals so that he would be pitied, and prayed for assistance until some spirit appeared in a vision and gave him personal power. Peyotism changes the traditional pattern somewhat. The individual participates in a collective rite, but he spends most of the time in contemplation—he is in a collective isolation. as it were. Two features exist which are peyotist equivalents of the traditional ordeal. Most persons do not find peyote pleasant to take: "It is hard to eat peyote." In addition, they find it difficult to sit on the ground all night in one position: "It is hard to sit through a meeting." The prayer for assistance is important; one prays that God and the other spirits will take pity on him and help him, through peyote. But this is elaborated in peyotism, so that it becomes necessary to be in the proper spiritual and psychological state when eating peyote. Spiritually, one must put away all evil thoughts. Psychologically, one must be conscious of his personal inadequacy. humble, sincere in wanting to obtain the benefits of peyote, and concentrate on it.

When taken under the proper conditions, peyote causes the worshipper to experience a revelation that in most cases takes the form of a vision, in uhich he sees or hears a spirit. In some cases the revelation takes the form of a mystical state, the unification of all immediate experience with God. In either circumstance the individual has a vividly direct experience of what has been revealed, qualitatively different from inference or hearsay. which is so characteristic of revelation in all societies. Therefore the peyotist is an individualist and an empiricist; he believes only what he himself has experienced: "The only way to find out about peyote is to take it and learn from peyote yourself." It may be interesting to know what others have to say; but all that really matters is what one has directly experienced—what has been revealed to him personally by peyote.

The traditional visions brought personal power; by contrast, peyotist revelations afford insight. This should be obvious for mystical states, but some explanation may be in order in the case of peyote visions. Usually the visions consist of God, Jesus or some other spirit presenting a revelation depending upon the personality and problems of the individual. The following are typical: He may be comforted by seeing or hearing some previously unexperienced item in the peyote doctrine or departed loved ones now in a happy existence. He may be guided on the one hand by being shown the way to solve some problem in daily life; on the other hand, he may be reproved for evil thoughts and deeds and warned to repent.

Peyote is also eaten as an aid to contemplation; through it one obtains increased powers of concentration and introspection. (1) The worshipper concentrates on communion and revelation in order to obtain the maximum from them. (2) On behalf of himself and others, he prays silently or aloud, concentrating as hard as he can in order to procure the attention and acquiescence of the spirits to whom the prayer is directed.. (3) Peyote heightens introspection and sensitizes the conscience. The worshipper examines his life meticulously to see where he has strayed from the Peyote Road because of evil thoughts and deeds. He then confesses his sins and promises to repent and discipline himself.

Peyotists express these results of contemplation as "learning from peyote." Used properly in this way, peyote is an inexhaustible teacher. A stock statement is, "You can use peyote all your life, but you'll never learn all there is to know about peyote. Peyote is alnays teaching you something new."

Another important use of peyote is as a medicine. It is believed to be a catholicon, or universal panacea. Other medicines, both Indian and white, are good for particular diseases, but peyote is good for all ills, spiritual as well as bodily. The peyotist etiology is based upon traditional Indian beliefs. Disease is produced either by insufficient power or by a foreign object. Sickness can therefore be cured in three ways. First. the sick person eats enough peyote to absorb the amount of power needed to restore health. Second, in more serious cases one prays to God and other spirits to give the patient added power, over and above that which is obtained from eating the peyote; the invalid may do this for himself, but in the most serious illnesses a doctoring meeting is held so that others can help pray for the required power. Third. the sick person may vomit as a result of eating peyote. In this way the foreign object which caused the disease is ejected from the body; the patient then eats more peyote in order to obtain the power necessary to restore health. (Vomiting also purges one of spiritual uncleanness.)

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PFAFF, JOHANN FRIEDRICH (1765–1825), German mathematician, was born on Dec. 22, 1765, at Stuttgart. He studied at Gottingen and Berlin.

From 1788 to 1810 Pfaff was professor of mathematics in Helmstedt; from 1810 till his death, April 21, 1825, he held the chair of mathematics at Halle. His researches bore chiefly on the theory of series, to which he applied the methods of the so-called combinatorial school of German mathematicians. and on the solution of differential equations. His two principal works are *Disquisitiones analyticae maxime ad calculum integralem et doctrinam serierum pertinentes* (vol. i. Helmstedt. 1797) and a memoir on partial differential equations in *Abh. d. Berl. Acad.* (1814–15). His method of integrating partial differential equations of the first order with any number of variables led Jacobi to introduce the term "Pfaffian problem."

PFALZBURG: *see* PHALSBOURG.

PFEFFER. WILHELM (FRIEDRICH PHILIPP) (1845–1920), German physiological botanist whose work on osmosis marked an epoch in investigations on the properties of semipermeable membranes and water solutions *(see* SOLUTIONS: *Osmotic Pressure)*. He was born in Grebenstein near Kassel on March 9, 1845. After earning a degree in botany and chemistry from Gottingen university in 1865, he spent the next several years studying botany and pharmacy at Marburg university. He continued his botanical studies as a private assistant to Nathanael Pringsheim at Berlin (1869–70) and to Julius von Sachs at Würzburg university (1870–71). In 1871 he returned to lecture at Marburg as a *Privatdozent* ("official but unpaid lecturer") and in 1873 was appointed *Extraordinarius* at Bonn university. In 1877 he accepted a professorial appointment at Basel university and later similar positions at the universities of Tiibingen (1878) and Leipzig (1887).

He also made significant contributions in the following areas of plant physiology: respiration, photosynthesis, protein metabolism, tropic and nastic movements. In 1881 he published the first part of his *Handbuch der Pflanzenphysiologie* (Eng. trans. by A. J. Ewart, *Physiology of Plants*, 3 vol., 1906) which prevailed for many years as an important text. He died, Jan. 31, 1920, in Leipzig. He published more than 100 papers and books. (W. J. McI.)

PFEIFFER, IDA LAURA (1797–1858), Austrian traveler, daughter of a merchant named Reyer, was born at Vienna on Oct. 14, 1797. In 1820 she married Pfeiffer, a lawyer of Lemberg, who subsequently incurred official persecution and was reduced to poverty. In her later life Mme. Pfeiffer devoted her limited means to extensive travel. Her last journey was in 1846 to Madagascar. Becoming involved in a plot to overthrow the government, she was expelled from the country. She died at Vienna, Oct. 27, 1858.

Her travels are described in *Reise einer Wienerin in das Heilige Land* (Vienna, 1843); *Reise nach dem Skandinavischen Norden und der Insel*

Island (Pest. 1846); *Eine Frauenfahrt um die Welt* (Vienna, 1850); *Meine Zweite Weltreise* (Vienna, 1856); *Reise nach Madagascar* (Vienna, 1861, with a biography by her son).

PFLANZER-BALTIN, KARL, FREIHERR VON (1855–1923), Austro-Hungarian general, was born at Pecs in Hungary in 1855. On the outbreak of World War I he mas charged with the defense of Transylvania, but when the Russians crossed the Carpathians, Pflanzer-Baltin, with an improvised division, attacked this enemy. After fighting with varying success in the southern part of eastern Galicia and in the Bukovina, the 7th army under his command was driven back by Brussilov's offensive in June 1916, whereupon he was relieved of his command. In the summer of 1918. entrusted with the command on the Albanian front which was yielding before the attack of the entente army, Pflanzer-Baltin won back, after a brief and powerful attack, the old positions southward of Fjeri and Berat.

PFLEIDERER, OTTO (1839–1908), German Protestant theologian, was born at Stetten near Cannstadt in Württemberg on Sept. 1, 1839. From 1857 to 1861 he studied at Tübingen under F. C. Baur; and afterward in England and Scotland. He then entered the ministry, became a tutor at Tiibingen and for a short time held a pastorate at Heilbronn (1868). In 1870 he became chief pastor and superintendent at Jena and soon afterward professor ordinarius of theology, but in 1875 he was called to the chair of systematic theology at Berlin, having made his name by his *Der Paulinismus,* published in 1873 (2nd ed., 1890; Eng. trans., *Paulinism,* 2 vol.. 1873, etc.).

Other important works are: *Das Urchristentum, seine Schriften und Lehren, in geschichtlichem Zusammenhang beschrieben* (1878; enl. ed., 1902; Eng. trans., 1906); *The Development of Theology Since Kant, and Its Progress in Great Britain Since 1825* (1890), written for publication in England; *Religionsphilosophie auf geschichtlicher Grundlage* (1878; Eng. trans., *The Philosophy of Religion on the Basis of Its History,* 1886–88); *Die Entstehung des Christentums* (1905; Eng. trans., 1906); *Religion und Religionen* (1906; Eng. trans., 1907); and *Die Entwicklung des Christentums* (1907). Pfleiderer was Hibbert lecturer in London in 188j and Gifford lecturer at Edinburgh in 1894. He died on July 18, 1908. In New Testament criticism Pfleiderer belonged to the school of F. C. Baur, but showed a greater disposition to compromise than the early Baur school.

PFLÜGER, EDUARD (1829–1910), German physiologist, was born in Hanau and studied under J. P. Müller and Du Bois Reymond at Bonn. In 1868 he founded the *Archiv fur die gesamte Physiologie,* and ten years later opened the new Institute of Physiology at Bonn. His *Untersuchungen uber die Physiologie des Electrotonus* (1859) marked the beginning of his lifelong researches on metabolism, embryology and respiration. He experimented with cross-fertilization of the eggs of different species of frogs and became interested in the cleavage in the development of the eggs. He was able to show that the seat of respiration is not in the blood or lungs, but in the tissue.

PFORTA or SCHULPFORTA, formerly a Cistercian monastery dating from 1140, afterward a German public school. It is in the Prussian province of Saxony, on the Saale, 2 mi. S.W. of Naumburg. The remains of the monastery include the 13th-century Gothic church, restored, the Romanesque chapel (12th century) and other buildings later used as dormitories, lecture rooms, etc. There is also the Fiirstenhaus, built in 1573. Schulpforta was one of the three *Fürstenschulen* founded in 1543 by Maurice, duke and later elector of Saxony, the others being at Grimma and at Meissen. Pforta passed to Prussia in 1815.

PFORZHEIM, a town of Germany, formerly in the *Land* of Baden, after 1945 in Baden-Württemberg, at the confluence of the Nagold and the Enz, on the margin of the Black forest, 19 mi. S.E. of Karlsruhe by rail. Pop. (1950) 54,143. Pforzheim is of Roman origin. From about 1300 to 1565 it was the seat of the margraves of Baden. It was taken by the troops of the Catholic league in 1624, and was destroyed by the French in 1689. It has the old palace of the margraves of Baden, and the Schlosskirche, the latter an edifice of the 12th–13th centuries. Pforzheim became the chief centre in Germany for the manufacture of gold and silver ornaments and jewelry.

PHAEDO, Greek philosopher, founder of the Elian school, was a native of Elis, born in the last years of the 5th century B.C. In the war of 401–400 between Sparta and Elis he was enslaved in Athens. He became a pupil of Socrates, who conceived a warm affection for him. It appears that he was intimate with Cebes and Plato, and he gave his name to one of Plato's dialogues. Athenaeus relates, however, that he resolutely declined responsibility for any of the views with which Plato credits him, and that the relations between him and Plato were the reverse of friendly. Aeschines also wrote a dialogue called *Phaedo.* Shortly after the death of Socrates Phaedo returned to Elis, where his disciples included Anchipylus, Moschus and Pleistanus, who succeeded him. Subsequently Menedemus and Asclepiades transferred the school to Eretria, where it was known as the Eretrian school and is frequently identified (*e.g.,* by Cicero) with the Megarians. The doctrines of Phaedo are not known, nor is it possible to infer them from the Platonic dialogue. His writings, none of which are preserved, were in the form of dialogues.

See Wilamowitz, *Hermes,* xiv, 189 *seq.*

PHAEDRA, in Greek legend, daughter of Minos and Pasiphae. With her sister Ariadne she was carried off by Theseus to Athens, and became his wife. On the way to Eleusis she met Hippolytus (*q.v.* for the rest of the legend).

PHAEDRUS (fl. 1st century A.D.), Roman fabulist of uncertain date. whose work, though ignored by classical Roman writers, was apparently the first of its kind in Latin and attained great popularity in the middle ages. It seems probable that he was born *c.* 15 B.C. and lived at least until the reign of Claudius. His birthplace was Thrace, whence he went early to Italy and received the customary training in Greek and Latin, studying among other authors, Euripides. Simonides, Ennius and Virgil. A slave by birth, he became a freedman in Augustus' household, but, as the prologue to book iii of his *Fabulae Aesopiae* states, later fell foul of Tiberius' minister Sejanus and was prosecuted and punished. "The fable," wrote Seneca *c.* A.D. 43, "has not been tackled by the Roman genius." If one presses the word "Roman" and recollects Phaedrus' foreign extraction, this statement need not imply ignorance of Phaedrus. The Phaedrus mentioned by Martial (iii, 20, j) has been identified, but on uncertain grounds, as the fabulist. Fables are placed by Quintilian (i, 9, 2) on the curriculum of the young, but. though "Aesop" is named, Phaedrus is not. Unless Martial's Phaedrus is the same man, the earliest reference to him is in the works of Avianus, who about the end of the 4th century composed 42 fables in undistinguished elegiacs.

Though Ennius, Lucilius and Horace had introduced fables into their poems, Phaedrus was the first writer to latinize whole books of fables. His contribution consists of free versions in iambic metre of Greek prose fables then circulating under the name of "Aesop." His iambic senarius, or six-foot line, conceivably influenced by that of Publilius Syrus, is nearer the rough vigour of Plautus than the monotonous artificiality of Seneca: spondees frequently replace iambs in the second and in the fourth feet. Phaedrus' latinity, apart from a few instances of slipshod syntax and vulgar speech, is close to the Augustan norm. Abstract expressions (*e.g., majestas ducis* = "the emperor") smack of the Latin of the silver age. Original poetic imagery is wanting, and epithets are mainly conventional. Phaedrus plumes himself on his brevity; for this as for his simplicity he merits praise.

The popularity, both in Europe and in the east, of the literary beast fable needs no emphasis. (*See* FABLE.) Even the ubiquitous moral tag subtracts little from enjoyment of such favourites in the Phaedrian corpus as "The Fox and the Sour Grapes," "The Wolf and the Lamb," "The Lion's Share," "The Two Wallets" and "The Pearl in the Dung-heap." Phaedrus considers himself a genuine artist, the pioneer of a genre unattempted by his Roman predecessors, whose poems, combining charm with a serious didactic purpose (*utilitas),* are assured of immortality. His stories are enlivened by various references to contemporary Roman society, and some could be interpreted, especially if the cap fitted, not merely as social but as political satire.

The Recovery of the Text.—Avianus states that Phaedrus

wrote five books of fables only; and the first printed edition of Phaedrus, published by Pierre and François Pithou at Troyes in 1596, in fact had its contents divided into five books. At the beginning of the 18th century, however, there was discovered at Parma a manuscript of Nicolaus Perottus (Niccolò Perotto or Perotti; d. 1480), the humanist archbishop of Siponto, containing 64 fables of Phaedrus, of which 30 were new. These new fables were published by G. A. Cassitto in 1808 and next, more correctly, by C. Jannelli in 1809; but these editions were superseded by the discovery of a much better preserved manuscript of Perottus in the Vatican, published by Angelo Mai in 1831. The authenticity of these new Phaedrian fables was for some time disputed. but is now generally accepted, though it is impossible to assign them to their original places in the five books. They are usually printed as an appendix.

Knowledge of Phaedrus' works, meanwhile, can be further extended by a careful investigation of the prose versions of his fables current in the middle ages. Of these the oldest collection existing seems to be that known as the *Anonymus Nilanti*, so-called because first edited by J. F. Nilant (at Leiden in 1709). For his edition Nilant used a manuscript of the 13th century, but the collection itself is associated with a little-known writer called Romulus and may have been made in the Carolingian period or even earlier. Later such collections are the Adhemarian, made by Adhémar de Chabannes; and the Weissenburg, from the monastery of SS. Peter and Paul at Wissembourg in Alsace. After a detailed examination of these three medieval collections, Carl Magnus Zander *(see* bibliography) restored 30 more fables to the iambics of Phaedrus.

BIBLIOGRAPHY.—There are editions of the *Fabulae Aesopiae* by J. P. Postgate (1920), by L. Havet (1895; annotated ed. 1923) and by A. Brenot (with Fr. trans., 1924). *See* further C. M. Zander, *Phaedrus solutus* (1921). (H. H. HY.)

PHAER (PHAYER), **THOMAS** (1510?–1560), English writer, best known for a translation of Vergil's *Aeneid* (1558) which is less medieval in tone than those of Gavin Douglas (1553), and the earl of Surrey (1557). Educated at Oxford and at Lincoln's Inn. London, Phaer was a doctor (M.D. 1559) and lawyer as well as a writer and describes himself as "solicitor to the king and queen in the marches of Wales." He translated. with original additions, a medical text by Jehan Goeurot under the title *The Regiment of Lyfe* (1544). He also contributed to *A Myrroure for Magistrates* (1559) and has been credited with *Ratura Brevium Newly Corrected in Englisshe* (1532) and *A Newe Book of Presidentes* (1543). *Seven First Bookes of the Eneidos of Virgill Concerted in Englishe meter* appeared in 1558; it was extended to nine books in 1562. The task, left unfinished at his death (Aug. 1560 at Kilgerran. Pembrokeshire) was completed by Thomas Twyne (1584).

(H. H. Ds.)

PHAETHON, in Greek mythology. was the son of Helios, the sun-god, and the nymph Clymene (Gr. *phaethon,* "shining." ('radiant"). He persuaded his father to let him drive the chariot of the sun across the sky, but he lost control of the horses and, driving too near the earth, scorched it. To save the world from utter destruction Zeus killed Phaethon with a thunderbolt. He fell to earth at the mouth of the Eridanus, a river of northern Europe (identified in later times nith the Po), on the banks of which his weeping sisters. the Heliades, were transformed into poplars and their tears into amber.

The story is most fully told in the *Metamorphoses* of Ovid (i. 750, ii, 366, and Nonnus, *Dionysiaca,* xxxviii). The fall of Phaethon is a favourite subject, especially on sarcophagi. as indicating the transitoriness of human life

See G. Knaack, "Quaestiones phaethonteae" in *Philologische Untersuchungen* (1885); Wilamowitz-Möllendorff and C. Robert in *Hermes,* xviii (1883); Frazer's *Pausanias,* ii, 59, which gives interesting parallels; S. Reinach. *Revue de l'hist. des religions,* lviii (1908).

PHAGOCYTOSIS is the orocess bv which living cells ingest or engulf other cells or particles. The phagocytic cell may be a free-living. unicellular organism, such as an amoeba, or one of the body cells such as a leucocyte (white blood cell). The particles commonly phagocytized include bacteria tissue cells (usually dead). protozoa. various dust particles pigments and other minute foreign bodies. In the simpler forms of animal life, such as amoebae and sponges. phagocytosis is a means of feeding; in higher animals phagocytosis is chiefly a defensive reaction against infection.

To Elie Metchnikoff is due the chief credit for recognizing the importance of phagocytosis in protecting the body against infectious agents. In man and in vertebrates generally, the most effective phagocytic cells are the macrophages (large phagocytic cells) and the granular leucocvtes (small phagocytic cells). The macrophages occur especially in the liver, spleen and lymph nodes, where their function is to free the blood and lymph of bacteria and other particles. Macrophapes are also found in all tissues as wandering amoeboid cells. and a cell related to the macrophage is found in the blood (*q.v.*). The smaller type of phagocyte (granular leucocyte) is carried along by the circulating blood until it reaches an area of infection, where it crawls through the blood vessel wall, being directed toward the invading bacteria by means of substances given off by the bacteria.

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PHAGOCYTOSIS OF TUBERCLE BACILLI BY A MACROPHAGE

This directed movement is known as chemotaxis.

Before phagocytosis is accomplished, the phagocyte and particle must adhere to each other, and whether this is possible depends largely on the chemical nature of the surface of the particle. On less virulent bacteria ordinary proteins from the blood form a surface film to which leucocytes adhere, and phagocytosis follows. But virulent bacteria are ingested with more difficulty. Leucocytes. instead of adhering to them, succeed only in pushing them away. If, however, the leucocytes succeed in pushing them against a firm surface. such as the lining of a blood vessel. the bacteria may not be able to slip away and are ingested. This process is known as "surface phagocytosis." Other virulent bacteria may not be phagocytized until their surfaces are coated with peculiar globulins (proteins) formed by the body in response to the presence of that kind of bacterium. Such globulins are called antibodies. and antibodies are of great importance in establishing immunity (*q.v.*) of the body to diseases. In the treatment of infections by penicillin, phagocytosis may be an important auxiliary in stopping the growth of bacteria.

The manner in which a phagocytic cell ingests a particle varies somewhat with the size of the particle. Small particles. such as bacteria or minute grains of charcoal. seem to be ingested in an instant. At one moment they appear through the microscope to be adherent to the surface of the phagocyte: at another moment they are inside it. Larger objects such as clumps of bacteria or tissue cells are phagocytized by a more prolonged response of the leucocyte. The cell flows around the object until it has been completely engulfed.

The results of phagocytosis are digestion and destruction of the particle by means of ferments inside the phagocyte. This is the chief means by which the body gets rid of bacteria and other microorganisms. If the particle is indigestible. however, as is a grain of carbon, it eventually may be ejected by the phagocyte. Also, ingested living organisms. such as tubercle bacilli, may be resistant to the intracellular digestive ferments and not only survive but multiply within the phagocyte. In moving about. the phagocyte may then carry such bacteria into other parts of the body and therefore actually assist in the spread of disease instead, as is more usual, of defending the body against infection.

It is possible to mimic phagocytosis by means of a demonstration of nonliving models. A drop of chloroform is suspended in water and a bit of clean thread of glass is placed in contact with the chloroform. Under these conditions, the glass is not taken up by the chloroform. Then the glass thread is coated uith shellac and,

since the chloroform is able to spread on the shellacked surface, the drop of chloroform phagocytizes the glass thread. Finally the chloroform dissolves the shellac and then ejects the uncoated glass thread.

See also BACTERIAL AND INFECTIOUS DISEASES; INFLAMMATION.

See Stuart Mudd, Morton McCutcheon and Balduin Lucké, "Phagocytosis," Physiol. Rev., 14:210–275 (1934); J. Berry and T. T. Spies, Medicine, Baltimore 28:239 (1949); M. R. Smith and W. B. Wood, Jr., *J. Exp.* Med. 103:509 (1956). (M. McC.)

PHAGOTUS, a curious reed instrument, developed by Afranio Albanesi of Pavia (16th century) from the ancient Serbian bagpipe or piva. It was shaped like the letter H, the upper part of each side pillar containing the sound-producing tubes, pierced with finger holes, and the wind supply being provided by an attached air reservoir in the form of a bag, and bellows.

REDRAWN FROM a PHOTOGRAPH, N.Y. ZOOLOGICAL SOCIETY

VULPINE PHALANGER (TRICHOSURUS VULPECULA)

PHALANGER, a name applied to the members of the diprotodont marsupial family Phalangeridae (see MARSUPIALIA).

Phalangers are small or medium-sized woolly coated animals, with long, often prehensile tails, large claws and opposable, nailless, first hind toes. They are nocturnal in habit and feed on fruit, leaves and blossoms, though a few are insect eaters. Several possess gliding membranes between the fore and hind limbs.

The ring-tailed phalangers (Pseudocheirus) of Australia and New Guinea are the most generalized forms. Allied to them is the Australian "flying squirrel" (Petauroides volans), ranging from Queensland to Victoria. Another flying genus is Petaurus, with several species on the Australian continent, Aru Islands and New Guinea. A third parachuting form is the minute Acrobates *pygmaeus* of eastern Australiz.

The cuscuses (Phalanger) are arboreal animals, the size of cats. They inhabit the Solomon Islands, ranging thence to Timor and Celebes, being the only old world marsupials found west of New Guinea. The fur is woolly and the tail prehensile. Nearly allied to these are the Australian forms of which the brush-tailed phalanger (Trichosurus *vulpecula*), about the size of a small fox, is the best known. Other species are T. *fuliginosus* of Tasmania and T. canina of South Queensland and New South Wales. These animals are locally known as "opossums."

PHALANX, the name, in Greek history, of the arrangement of heavy-armed infantry in a single close mass of spearmen (Gr. phalanx, of unknown origin) (see ARMY).

PHALARIS, tyrant of Acragas (Agrigentum) in Sicily, c. 571–555 B.C., was responsible for the building of the temple of Zeus Atabyrius in the citadel. and took advantage of his position to make himself despot (Aristotle, Politics, v, 10). Under his rule Agrigentum seems to have attained considerable prosperity; its splendid planning, with a row of temples along the line of the wall and spacious quarters within the walls. belongs probably to his time. He fought wars against the Sicans, and the people of Himera on the north coast of the island entrusted themselves to him in spite of the warnings of the poet Stesichorus (Aristotle, Rhetoric, ii, 20). Late authors call him master of the whole island. He was overthrown in a general rising headed by Telemachus, the ancestor of Theron (tyrant c. 488–472), and, it is said, burned in his brazen bull.

Later ages have held up Phalaris to infamy for his cruelty. In his brazen bull, devised by Perilaus (Perillus) of Athens, the tyrant's victims were roasted alive, their shrieks representing the bellowing of the bull. Perilaus himself is said to have been the first victim. The bull is referred to briefly by Pindar (Pythians, i, 95–96). No doubt the bull is derived from Rhodes, the mother city of Agrigentum, together with the worship of Zeus Atabyrius; connection with the human sacrifices of the Phoenicians has been suspected. but is problematical. The Carthaginians carried away a brazen bull from Agrigentum, which was restored by Scipio.

The sophists represented Phalaris as a naturally humane man and a patron of philosophy and literature; and the famous letters bearing his name (148 in number) no doubt have their origin as a rhetorical exercise. They are now chiefly remembered for the crushing exposure they received at the hands of Richard Bentley (*q.v.*) in his controversy with Charles Boyle (later earl of Orrery), who had published an edition of them in 1695. The first edition of Bentley's Dissertation on *Phalaris* appeared in 169; in W. Wotton's Reflections on Ancient and Modern Learning, and the second edition, replying to the answer which Boyle published in 1698, came out in 1699. Bentley proved that the letters were written by a sophist or rhetorician (possibly Adrianus of Tyre. died c. A.D. 192) hundreds of years after the death of Phalaris. Suidas admired the letters and before their exposure by Bentley they were highly thought of, *e.g.,* by Sir William Temple in his Essay on Ancient and Modern Learning (1692), though others, as Politianus and Erasmus, perceived that they were not by Phalaris. An edition of the Epistles by R. Hercher appeared in *Epistolographi* Graeci (Paris, 1873), and Bentley's Dissertation was edited by W. Wagner (with introduction and notes, London, 1883).

See R. C. Jebb. *Bentley* (London, 1882).

PHALAROPE, the name given to a family of shore birds with three genera, *Phalaropus, Steganopus* and Lobipes. The phalaropes are allied to the sandpipers (*q.v.*), from which they differ in their swimming habits and the lobed membranes that fringe their feet and by the close nature of the lower plumage. They are aquatic birds, spending the winter on the open sea. The male is less brightly coloured than the female and performs the duties of incubation.

The red-necked phalarope (*Lobipes lobatus*) breeds in the Hebrides and Ireland. and the group as a whole is arctic. *Steganopus* tricolor is exclusively American. (K. P. S.)

PHALLICISM or PHALLISM, an anthropological term applied to that form of worship in which adoration is paid to the generative function symbolized by the phallus, the male organ (from Gr. *phallos*). The same principle is at the root of the nature worship of Asia Minor, whose chief deity. the Great Mother of the Gods (*q.v.*), is the personification of the earth's fertility. Similarly in India worship is paid to divine mothers; the phallus is called *linga* or *lingam,* with the female counterpart called *yoni;* the *linga* symbolizes the generative power of Siva, and is a charm against sterility. The rites classed together as *Sakti* puja represent the adoration of the female principle.

Phallic emblems are found in many parts of the world. The tendency, however, to identify all obelisklike stones and tree trunks. together with rites like circumcision. as remains of phallic worship has met with much criticism, and the best modern view is that phallicism never developed into an organized cult; *e.g.,* Robertson Smith, Religion of the *Semites,* 3rd ed., pp. 456 and 688.

PHALSBOURG, a town of France, in the *département* of Moselle: stands on a plateau (1,080 ft.) above the main road from Saverne to Nancy and Metz, 25 mi. N.W. of Strasbourg by rail. Pop. (1954) 1,798.

The principality of Phalsbourg, of which this town was the capital, originally a part of Luxembourg, afterward belonged in turn to the bishop of Metz, the bishop of Strasbourg and the duke of Lorraine, and passed to France in 1661.

The town commands the passes of the Vosges, and was strongly fortified by Vauban in 1680. Of these fortifications only the Porte de France and the Porte d'Alsace remain.

PHALTAN, a town and taluka (subdivision) of Satara North district. Bombay state! India. The town (pop. [1951] 12,142) is about 50 mi. S.E. of Poona.

PHALTAN TALUKA (pop. [1951] 99,781) corresponds with the former princely state of that name (area 391 sq.mi.; pop. [1941] 71,437), controlled in British days through the Deccan and Kolhapur agency and merged with Bombay on March 8, 1948. Area of modern taluka is 456 sq.mi.

PHANARIOTES, a name derived from Phanar, the chief Greek quarter at Stamboul, where the ecumenical patriarchate

is situated. and applied to those members of families resident in the Phanar quarter who bet een the years 1711 and 1821 were appointed hospodars of the Danubian principalities; that period of Moldo-Wallachian history is also usually termed the Phanariote epoch. The active part taken by the Greek princes in the revolt of 1820–21 induced the Porte to revert to the appointment of native princes.

PHANGNGA, a small Thai *changwat,* borders the Andaman sea on the west side of peninsular Thailand. It is sparsely populated. Area 1,530 sq.mi.; pop. (1947) 60,335. The *changwat* is forested, hilly and mountainous with shallow and poor soils. There is more fertile soil in the southern part of the *ckangwat,* between the rough terrain and the sea, but that area is comparatively inaccessible. Phangnga is noted for tin production.

Phangnga, the capital, is about 45 mi. N.E. of Phuket. The population of the city of Phangnga was 14,250 in 1947.

(T. F. B.)

PHANIAS (PHAINIAS) (*fl. c.* 300 B.C.), Greek philosopher, of Eresus on the island of Lesbos, was a pupil of Aristotle and a friend of Theophrastus, whom he joined in the Peripatetic school. He is mentioned as the author of works on logic, in which he probably followed Aristotle's doctrine; he also wrote, as Theophrastus did, on botany; and there are remains of works by him on poets, on the Socratic philosophers and on history. His *Prytaneis* of *Eresus* was a history in which events in the Greek world in general were included, the chronology being determined by the series of the successive magistrates of his native place. In his *Tyrants of Sicily* he seems to have dealt with western history against a Panhellenic background.

See the texts ed. by Carl Müller, *Fragrnenta historicorurn graecorum,* vol. ii (1848); also R. Laqueur, article *s.v.* "Phainias," in Pauly-Wissowa, *Real-Encyclopädie der classischen Altertumswissenschaft,* vol. xix (1938). (F. Wi.)

PHANTASMAGORIA, a name invented by a certain Philipstal in 1802 (from Gr. *phantasma,* "phantasm," "apparition"; and *agora,* "assembly") for a show or exhibition of optical illusions produced by means of the projecting lantern. The word was later applied to any rapidly or strikingly changing scene, or disordered phantasy.

PHARAOH, the Hebraized title of the king of Egypt (*q.v.*), in Egyptian Per-'o; Pheron in Herodotus represents the same. Its combination with the name of the king, as in Pharaoh Necho, Pharaoh Hophra, is in accordance with contemporary native usage; the name of the earlier Pharaoh Shishak (Sheshonk) is rightly given without the title. In hieroglyphic a king bears several names preceded by distinctive titles. In the 4th dynasty there might be four of the latter: (1) identifying him with the royal god Horus: the name is commonly written in a frame representing the façade of a building, perhaps a palace or tomb, on which the falcon stands; (2) connecting him with the vulture and uraeus goddesses, Nekhabi and Buto of the south and north; (3) a hawk on the symbol of gold, signifying the victorious Horus; (4) the old titles of the rulers of the separate kingdoms of upper and lower Egypt, to be read *stni,* "butcher(?)" and *byti,* "beekeeper(?)." The personal name of the king followed (4), and was enclosed in a cartouche apparently symbolizing the circuit of the sun which alone bounded the king's rule. Before the 4th dynasty the cartouche is seldom found: the usual title is (1), and (3) does not occur. In the jth dynasty the custom began of giving the king at his accession a special name connecting him with the sun; this was placed in the cartouche after (4), and a fifth title was added: (j) Si-re, "son of the sun-god," to precede a cartouche containing the personal name. The king was briefly spoken of by his title *stni* (see 4). or *hnm-f,* "his service," or *Ity,* "liege lord." These titles were preserved in the sacred writing down to the latest age. An old term for the royal palace establishment and estate was Per-'o, "the Great House," and this gradually became the personal designation of Pharaoh. (F. Ll. G.)

PHARISEES, a Jewish sect of the second commonwealth. Its origins and the etymology of its name are obscure. According to rabbinic tradition, the Pharisees were in the direct line of transmitters of the oral law from Ezra and the Men of the Great Synagogue. Modern scholars too detected some antecedents in the Old Testament, especially in Malachi iii, 16. Their more immediate ancestors a-ere the pietistic group of Hasidim who, in the middle of the 2nd century B.C., helped spearhead the Maccabaean revolt (I Macc. ii, 42) (*see* MACCABEES). They gradually disappeared as a distinct movement after the fall of Jerusalem in A.D. 70, only because virtually the whole Jewish people accepted their ideology. Many hypotheses have been advanced for their name. Later suggestions that it stemmed from *Parsaah* (Persian) because of their acceptance of Parsee angelology (Thomas Walter Manson), or that they had been called "heretics" by their opponents and subsequently adopted that designation (Louis Finkelstein), seem less likely than their ancient equation with "separatists" because of their self-imposed separation from the nations and, in some respects, also from the masses of less observant Jews.

Religious Teachings. — In his extensive descriptions of the Jewish sectarian conflicts, Flavius Josephus (A.D. 37–9j?) stressed particularly dogmatic differences. Addressing himself to a Graeco-Roman audience, the Jewish historian undoubtedly exaggerated the importance of these theoretical controversies, and gave them an excessively Greek philosophic colouring. But he was undoubtedly right that, in contrast to the Sadducees, the Pharisees believed in retribution after death and personal resurrection, and also espoused a combination of free will and predestination. "Everything is foreseen, but nevertheless freedom of [individual decision] is given," although recorded only in the name of R. Aqiba (Mishnah Abot iii, 1j), represents the long-accepted doctrine of the Pharisees. Far more important, however, was the Pharisees' insistence on the binding nature of oral law which, in their opinion, had been revealed to Moses simultaneously with the written Torah and had co-ordinate authority with it. In that law were reflected traditions and practices which had developed in the preceding centuries, often without direct scriptural backing. To supply such scriptural links the Pharisees developed a ramified system of hermeneutics, seven major rules of which were formulated by their great leader Hillel (*q.v.*).

Political Struggles. — In the overheated religious atmosphere of the second commonwealth, political controversies were immediately translated into sectarian differences and vice versa. The Pharisees as such were nonpolitical. In fact, for them religious values towered so high above all other concerns that they were ready to submit to foreign domination rather than to an impious government of their own. On one occasion, three successive Pharisaic delegations appeared at great personal danger before Mark Antony, pleading for the removal of Herod. During the great war with the Romans both their leader. Johanan ben Zakkai, and another prominent member, Josephus, made peace with Vespasian. But because of the deep interlocking of politics and religion, their leaders became constantly embroiled in the struggle with the Maccabaean kings John Hyrcanus and Alexander Jannaeus (135–78 B.C.) and later with the Herodian dynasty and the predominately priestly and landowning Sadducees. Only during the short reign of Salome Alexandra (78–69 B.C.) did they control the government, In these struggles, the Pharisees enjoyed increasing backing by the masses. Although their leaders sometimes looked askance at the religious laxity oi many "people of the land" and, for the sake of greater ritualistic strictness, organized themselves in special fraternities (*haburot;* hence their members were called *haberim),* they enjoyed wide popular following. In Josephus and the New Testament they appear as the spokesmen of the overwhelming majority of the population. For this reason religious reformers wishing to overthrow the existing religious order attacked them severely. The polemical utterances in the Gospels (for instance, Matthew xxiii, 15; Mark vii. 6), apparently aimed at the more rigid faction of the house of Shammai, created the image of the Pharisees as religious hypocrites — an image from which only modern research was able to free them.

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PHARMACOLOGY. In the broadest sense, pharmacology is the study of the changes produced in living animals by chemical substances (except foods); the animals may include any species from a microorganism to man.

The term pharmacology is used sometimes, in a more restricted sense, to refer to the study of the action of drugs, that is, agents used to treat diseases. This represents the most important application of pharmacology and explains its place among the medical sciences. It is clearly distinguished from pharmacy, the art of preparing drugs for use, but is closely related to therapeutics, the application of drugs to the treatment of disease, and to toxicology, the study of poisons and poisonings; both of these may be considered to be specialized applications of pharmacology. In a practical sense, pharmacology is the experimental science on which therapeutics is based, since the safe and effective use of drugs in the treatment of diseased patients is possible pnly after careful observations of their effects in the laboratory.

Origins of Pharmacology. — Attempts to use drugs to alleviate disease are as old as the history of man, but until the last century they were based mainly on superstition, magic, religion or at best on trial and error. European medicine before A.D. 1500 was characterized by rigid adherence to the medical doctrines of the ancient Greeks — principally those of Galen (A.D. 131–201), whose prolific writings, about a hundred volumes in all, represented some original observations, many elaborate recipes for prescriptions and a great many dogmatic "explanations." The writings of Galen were accepted as absolute authority for more than a thousand years, to such an extent that original observations and experimentation were not only discouraged but often actually forbidden. The first among many successful rebels against Galenism was Paracelsus (Aureolas Theophrastus Bombastus von Hohenheim, A.D. 1493–1541), a truly bombastic iconoclast who wandered through northern Europe, always in trouble with the local authorities, but overcoming the objections of his contemporaries by his therapeutic successes. He was an original thinker and daring innovator who introduced many new remedies and advocated simple prescriptions with one or a few ingredients rather than the dozens handed down from Galen.

In the next 300 years. there was a steady accumulation of information on the structure and functions of the body both in health and disease. However, therapeutics remained an "art" rather than a science, and, although the term "Pharmakologie" was used in 1692 by S. Dale in London, it meant merely the description of substances used in medicine. The *pharmacopoeias* (official volumes containing descriptions and outlining standards for drugs) included such remedies as dried vipers, foxes' lungs, and moss from the heads of criminals who had been hanged in chains, along with some herbs of real value. The concept of systematic laboratory investigation of drug action did not arise until about 1850; it was not until then that the public was made aware of the necessity for animal experimentation (by François Magendie. the French physiologist). Observations of the action of chemicals on the animal body became possible only after the new physiologists developed sensitive methods for the measurement and recording of changes in the function of the body, An equally important contribution was the striking development of chemistry. It was difficult to experiment with the crude drugs and extracts available because their potency varied from one batch to another. The situation began to change during the first half of the 19th century, when the new chemists in France and Germany isolated many active substances — morphine, strychnine, atropine, quinine and many others — from their crude plant sources.

As these pure chemicals became available (and later, as thousands of new chemical compounds were synthesized in the rapidly expanding German dye industry). more and more studies of drug action were made. The first students of pharmacology were physiologists who became curious about the effects of the substances on heart rate, respiration or other of the physiological functions they were studying — or who used the compounds as tools to study physiological problems. The first laboratory devoted exclusively to experimental pharmacology was that of Rudolph Buchheim at Dorpat in 1846–47; he contributed the idea that the effects of drugs on the body should be explained as well as described.

Pharmacology as an independent experimental science was really founded and firmly established by the German Oswald Schmiederberg (1838–1921). He defined its purpose — the study of the damage brought about in living organisms by chemically acting substances (except foods, whether used for therapeutic purposes or not). He wrote a textbook of pharmacology, helped to found the first journal devoted to reports of pharmacological experiments, and, most important, headed a school at Strasbourg which attracted students from all over the world. His school was the nucleus from which independent departments of pharmacology were established in universities all over the world.

Methods and Purposes of Pharmacology. — The work of pharmacologists is closely related to that of other biological scientists. In order to understand the changes produced in living animals. pharmacologists must understand, and be able to measure. the normal operations of the animal body — physiology. They must also understand pathology, the study of changes in structure and function resulting from injury or disease. The recognition and description of such changes may require not only gross observations on living animals, but also microscopic examination of tissues or cells, or chemical determinations on body fluids or excretions. If pharmacologists study the effectiveness of such drugs as antiseptics or antibiotics, they must use the concepts and methods of bacteriology. If they are attempting to find the ingredients responsible for the actions of crude plant drugs, they may find themselves involved both in chemistry and botany. Their work is often related to biochemistry (chemistry of living things), since they study effects of foreign substances on cells or chemical systems of the body.

During the earlier years of the new science, its workers became aware that a relation exists between the chemical structure of a compound and the effects it produces in the body. Since that time, increasing emphasis has been placed on this phase of pharmacology and many studies describe the changes in action resulting from small changes in the chemical structure of the drug. Since most agents of medical interest are organic chemicals (complex structures containing carbon atomsj, pharmacologists who engage in such studies must have a considerable understanding of organic chemistry.

The development of atomic resources for peacetime uses after World War II brought pharmacologists into a new area of investigation. One of the major problems of pharmacology has always been the difficulty of determining the fate of foreign compounds in the body. The doses of most potent drugs and poisons are small, and when they are distributed in large volumes of body fluids. they become almost impossible to detect or measure by ordinary chemical means. However, it is highly desirable to trace minute amounts of the compounds in the bloodstream or in the organs of the body in order to determine whether they are concentrated in any organs or cells and to establish how long they remain and how they are excreted. This was made possible by the availability for scientific investigation of radioactive isotopes (chemical elements having almost exactly the same chemical properties as the normal, but capable of being detected by Geiger counters or similar instruments). Since 1945, pharmacologists have been tracing the passage of some compounds through the body by incorporating radioactive atoms into the compounds they wish to study. The small amounts of radioactivity are not harmful to the animals; in fact, in some carefully controlled studies such determinations have been made on human volunteers. The tracer compounds are usually synthesized chemically, but where this is difficult or impossible, they have been prepared by exposing plant

or animal sources to radioactive materials in such a way that radioactive atoms are incorporated into the desired compounds as the living plant or animal manufactures them; the radioactive substances are then isolated and purified to be used in experiments.

In general. pharmacologic investigations are directed toward describing completely the interaction between the body and the drug. This includes describing fully the sequence of physiological changes that occur and describing what happens to the drug itself. It includes also explanations for the observed changes, at least in terms of physiology, and preferably in terms of chemistry or physics. Chemical explanations of mechanisms of action have been established for a number of chemical substances. These explanations have much more than academic interest; they tend to increase our knowledge of physiology and other biological sciences; they make it possible to use drugs more effectively; and by showing what characteristics are necessary for therapeutic action they stimulate the search for more effective new agents, without the undesirable side effects possessed by many available drugs. Such information is also sought for poisonous compounds used in the home (bleaches, insecticides, etc.), in industry or in agriculture (pesticides) in order to minimize health hazards (see *Pharmacology in Public* Health, below).

Pharmacology in Medical Education and Research.—Since pharmacology is a part of the curriculums of medicine, dentistry, veterinary medicine and pharmacy, departments of pharmacology are usually associated with educational institutions in these fields; the programs usually include training and study at the graduate level as well as the required courses of instruction. Such departments. especially in medical schools, are traditionally devoted to the study of basic problems in pharmacology and to the application of basic principles to the solution of speci'fic medical problems. Research in pharmacology is conducted also in many hospitals and foundations, either publicly or privately supported.

Pharmacology in the Drug Industry.——Important basic research is carried out in the research laboratories of pharmaceutical and chemical companies. After 1930, this area of pharmacological research expanded rapidly. particularly in the United States. The utilization of the financial kesources of industry, together with the contributions of universities, hospitals and foundations, resulted in the solution of many complicated problems in a surprisingly short time. Many new therapeutic agents were developed (*e.g.*, sulfa drugs, antibiotics, cortisone, "tranquilizing" drugs and many others), and a great body of fundamental knowledge was accumulated.

The work of pharmacologists in industry deals also with the exhaustive tests that must be made before promising new drugs can be introduced into medical use. Detailed observations of effects on all systems and organs of experimental animals are necessary before the physician can accurately predict effects of the drug on his patients, but their principal purpose is to disclose any potential toxicity to man. It must be emphasized that, except under unusual circumstances, the pharmacologist does not test the effects of drugs in patients; this is done only after complete tests on animals and is usually conducted by physicians to determine the clinical effectiveness of new drugs.

Constant testing is also required for the routine control and standardization of drug products. Those which contain only pure active ingredients can be tested by chemical means, but a few still remain that consist of relatively crude mixtures of plant or animal products (digitalis and pituitary, for example). These can be standardized (adjusted to standard strength) only after the pharmacological potency of each batch is determined by comparing its effect on some species of animal with the effect of a standard sample of drug. This process of testing is known as bioassay, and the entire process of standardization is known as biological standardization.

Pharmacology in Public Health.—The public welfare is obviously dependent on adequate pharmacological examinations of new products, but the development of new compounds and new processes throughout industry is also associated with potential health hazards for workers. The study of such hazards is termed industrial toxicology and the concepts and experimental methods are those of pharmacology, adapted for special conditions. Another application of pharmacology (or, more specifically, of toxicology) is in the study of the poisons used in agriculture to control plant pests and animal parasites. Here pharmacological or toxicological studies are undertaken to discover how the agents act to destroy pests; this makes it possible to use the agents more efficiently. and to develop more satisfactory new ones. Attention is also focused on the evaluation of potential health hazards and on the development of antidotes and methods of treatment to be used in cases of accidental poisoning. See also PHARMACY; PHARMACOPOEIA. (V. E.)

PHARMACOPOEIA, a book published by a government, or otherwise under official sanction, to provide for a specific political area, standards of identity. quality and strength for those medicinals which represent the best practice and teaching of medicine. The primary function of a pharmacopoeia is to describe each drug of the approved list in such a way that whenever dispensed it meets the standards of quality and strength established for it. The provisions of the pharmacopoeia in force (*i.e.*, the one that is "official") are binding upon all who produce drugs and those who dispense them. The pharmacopoeia is a fundamental safeguard to public health.

The task of compiling most pharmacopoeias is carried out without compensation by experts in the professions of medicine, chemistry and pharmacy at the request of the agency undertaking the compilation, usually that responsible for matters of public welfare. Most programs are financed from government funds, but the British *Pharmacopœia* and the United States *Pharmacopeia* are written by private, nonprofit organizations with the sanction of their respective governments. In the case of these pharmacopoeias, the proceeds of their sale support the work of revision.

The oldest record in the form of a pharmacopoeia is a stone tablet of ancient Babylonia, believed to have been inscribed about 1700 B.C. The first true pharmacopoeia to appear in Europe mas the Florentine Nuovo *Receptaris* (1498). The Danish Pharmacopoeia (established 1772) is the oldest in continued existence. The following countries established pharmacopoeias (the dates indicate the latest edition or [italics] supplement or reprinting): Argentina (1957), Austria (1906), Belgium (1930, *1953*), Brazil (1929, *1947*), Chile (1941), China (1953), Czechoslovakia (1954, *1958*), Denmark (1948, *1954*), Egypt (1953), Finland (1956), France (1949, *1954*), Germany (1926, *1951*), Greece (1924), Hungary (1954), India (1955), Italy (1940), Japan (1951), Mexico (1952), Netherlands (1958), Norway (1939, *1953*), Paraguay (194j), Poland (1954), Portugal (1946), Rumania (1956), Spain (1954), Sweden (1946), Switzerland (1933, *1954*), Turkey (1948), U.S.S.R. (1952, *1952*), United Kingdom (1958), United States (1955, *1958*), Venezuela (1942), Yugoslavia (1951).

Most countries not having a national pharmacopoeia adopted that of one or more other nations or in rare cases adopted the International Pharmacopoeia (see below).

The pharmacopoeial standards form the basis for enforcement of laws on the quality of drugs made available within the country concerned. Thus. the standards established have a vital bearing on the level of public health and the practice both of medicine and pharmacy. Actual enforcement of the standards is generally a function of an agency separate from that which creates them, but there are exceptions to this, notably in Canada, where the same department both establishes and enforces the standards. Enforcement involves collection and analysis of drug samples purporting to be of pharmacopoeial quality; when the analytical findings do not substantiate the label claim, legal action may be taken. This form of control varies greatly from one country to another. Where the central government is strong, the control is generally on a uniform national scale, as in the Americas and most of Europe. Where the local government is strong, as in the case of the cantons of Switzerland, enforcement is mainly on a local scale. These inter- and intra-national differences result in variations in the strength and quality of drugs, which cause confusion for both travelers and medical practitioners and are not in the best interests of public health. Travelers benefit especially from uniform drug standards. For example, a diabetic who travels must depend

largely upon local sources for the insulin that makes the difference for him between good health and dangerous illness. Insulin is prepared from the pancreatic glands of cattle and its potency must be standardized by assays on rabbits or mice. Furthermore, it deteriorates if not kept cold. However, thanks to the acceptance of uniform pharmacopoeial standards, good insulin is available almost everywhere.

International Pharmacopoeia. — Efforts to eliminate international differences in drug standards date to 1865, but the first practical move was made in 1902 by the Belgian government in sponsoring an international conference in Brussels. This resulted in the Brussels agreement of 1906, which proposed uniform nomenclature and standards of strength for many important drugs, particularly those which were being dispensed in the form of tinctures and infusions. A second conference in 1925 went still further toward establishing uniformity in pharmacopoeial standards among nations. These agreements were limited in scope, since they applied to only a few of the drugs in use.

The problem became more acute with the increase in international travel and in international trade in medicinal products after 1925. and received the attention of the Health Organization of the League of Nations, which created a Technical Commission of Pharmacopoeia1 Experts. The original seven-member group undertook to prepare an international pharmacopoeia, but this was interrupted when the League went out of existence. However, the work was resumed almost immediately upon creation of the World Health organization, a specialized agency of the United Nations which is the successor to the Health Organization of the League. The newly formed Expert Committee on the Unification of Pharmacopoeias (which later became the Expert Committee on the International Pharmacopoeia and Pharmaceutical Preparations) succeeded in compiling the first volume of the *Pharmacopoea Internationalis* for publication in 1951. A second, complementary volume appeared in 1955, and a supplement was added in 1958. The WHO published the texts in English, French and Spanish, but translations into German and Japanese were undertaken privately under WHO authority. The WHO planned to revise the standards periodically toward the end of providing model specifications for all of the important drugs.

The *Yharmacopoea Internationalis* was put forward by the WHO only as a recommendation aimed to minimize or eliminate entirely variations among national pharmacopoeial standards. Some nations among those without their own pharmacopoeia, for example, Ethiopia and Israel, made the International Pharmacopoeia official for use within their borders.

The four Scandinavian countries and Iceland provided a notable example of international co-operation toward uniformity in drug standards. Jointly, they formed the Scandinavian Pharmacopoeial council, which laid the foundation for publication of a single pharmacopoeia in four languages (Danish, Finnish, Norwegian and Swedish) to supersede the existing national pharmacopoeias of those countries as the binding authority on the identity, quality and strength of drugs.

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PHARMACY is the science and art concerned with the collection, preparation and standardization of drugs. Its scope includes the cultivation of plants that are used as drugs and the synthesis of chemical compounds of medicinal value. It further includes the analysis and standardization of medicinal agents. The pharmacist is responsible for the manufacture of the dosage forms of drugs, such as tablets, capsules and sterile solutions for injection. As a dispensing pharmacist, he compounds physician's prescriptions for drugs. Pharmacology (*q.v.*) is the science that embraces all knowledge of drugs with special reference to their mechanism of action in the treatment of disease. Obviously this broad science has many subdivisions, such as toxicology (the study of poisons) and therapeutics (the use of drugs in the treatment of disease). Pharmacy, according to the foregoing description, is one of the subdivisions or specialties of pharmacology.

Historical Development. — The beginnings of pharmacy are lost in the mists of antiquity. When early man expressed a juice from a succulent leaf to apply to a wound he was practising this ancient art. In the book of Exodus, Moses was directed by the Lord to prepare "an ointment compound after the art of the apothecary." In the Greek legend, Aesculapius, the God of the healing art, delegated to the beautiful Hygeia the duty of compounding his remedies. She was his apothecary or pharmacist. The physician-priests of Egypt were divided into two classes, those who visited the sick and those who remained in the temple and prepared the remedies for the patients.

In ancient Greece the art of healing recognized a separation between the duties of the physician and those of the pharmacist, and this separation prevailed also among the Roman practitioners. During the middle ages in Europe the separation of the two groups became less distinct. Many physicians undertook 'the preparation of their own medicines. The Moorish influence in Europe brought about the practice of separate duties for the pharmacist and physician again. The trend of specialization is exemplified by a law enacted by the city council of Bruges. Belg., in 1683, forbidding physicians to prepare their own remedies.

The distinct role of the pharmacist as separate from that of the physician is evidenced by the establishment of the office of apothecary general in the army of France during the middle of the 18th century. In America, Benjamin Franklin took an important step in keeping the two professions separated when he appointed an apothecary to the Pennsylvania hospital.

Education. — The history of pharmaceutical education has followed in the wake of medical education. As the training of the physician underwent the change from the apprenticeship system to formal educational courses, so did the training of the pharmacist. The first college of pharmacy was founded in the United States in 1821 and is now known as the Philadelphia College of Pharmacy and Science. Other institutes and colleges were established in the U.S., Great Britain and continental Europe. Later many universities organized schools and colleges of pharmacy within their courses of instruction. Colleges of pharmacy as independent organizations or as schools of universities operate in most countries of the world.

The course of instruction leading to the degree in pharmacy (bachelor of science in pharmacy) extends over four academic years. Many institutions, however, offer graduate courses in pharmacy and cognate sciences leading to the degrees of master of science and doctor of philosophy. These advanced courses are especially intended for those who are preparing for careers in research, manufacturing or teaching in the field of pharmacy.

It is clear that since the medication of the sick with drugs encompasses a wide field of knowledge in the biological and physical sciences, an understanding of these sciences is necessary for an adequate pharmaceutical training. The basic four-year curriculum in the colleges of pharmacy of the United States embraces physics, chemistry, biology, bacteriology, physiology, pharmacology and many other specialized courses such as dispensing pharmacy. In addition, subjects of a general educational character such as languages and mathematics are included. As the pharmacist is engaged in a business as well as a profession, special training is provided in merchandising, accountancy and pharmaceutical jurisprudence. After 1960 one year of college work in addition to high school was required for entrance to colleges of pharmacy in the United States.

Legislation. — Before he is permitted to practise pharmacy, an applicant must be qualified by graduation from a recognized college of pharmacy, meet specific requirements for experience and pass an examination conducted by a board of pharmacy appointed by the government. The passing of this board examination confers upon the person the legal right to practise pharmacy. In the United States he is then designated a registered pharmacist.

The pharmacy laws include the regulations for the practice of pharmacy, the sale of poisons, the dispensing of narcotics and the sale and labeling of dangerous drugs. The pharmacist sells and dispenses drugs within the provisions of the food and drug laws of the country in which he practises. These laws recognize the national pharmacopoeia as the standard for drugs *(see* PHARMACOPOEIA). The pharmacopoeias of the different nations are compiled and published according to the respective legal national procedures. For example. the publication of the *British Pharmacopoeia* is regulated by sec. 47 of the Medical act, 1956. Subsection (1) of this section, which reproduced similar provisions in earlier acts, is as follows:

47.—(I) The General Council shall, at such intervals as they may determine, cause to be published under their direction new editions of the *British Pharmacopoeia,* containing such descriptions of and standards for, and such notes and other matter relating to. medicines. preparations, materials and articles used in the practice of medicine, surgery, or midwifery, as the council may direct.

Pharnzacopeia of the United States is prepared and published by the U.S. Pharmacopoeia1 convention. The League of Nations in 1925 proposed an international pharmacopoeia. The World Health organization of the United Nations assumed the task of the League after World War II and published the *Pharmacopoea Internationalis* in 1951. English, Spanish and French editions were later published. The purpose of the *Pharmacopoea Internationalis* is to standardize, as far as possible, the medication with drugs throughout the world.

Furthermore, the *Pharmacopoea Internationalis* provides standards for drugs for smaller nations that have no national pharmacopoeia.

Organizations. — There are numerous national and international organizations of pharmacists. In Britain the Pharmaceutical Society of Great Britain, established in 1841, is typical of the pharmaceutical organizations. In the United States the American Pharmaceutical association, established in 1852, is a society that embraces all pharmaceutical interests. Some of the other organizations in the United States are the American Drug Manufacturers' association. the Federal Wholesale Druggists' association and the National Association of Retail Druggists. Among the international societies is the Fédération Internationale Pharmaceutique, founded in 1912 and supported by 35 national societies, for the advancement of the professional and scientific interests of pharmacy. The Pan American Congress of Biochemistry and Pharmacy includes the pharmaceutical societies in the various countries in the western hemisphere.

There are also other international societies in which history, teaching and the military aspects of pharmacy are given special emphasis.

Ethics of Pharmacy. — The code of ethics of the American Pharmaceutical association sets forth the ethical code under which pharmacy in the United States is to be practised. Since the code is applicable to the profession in all parts of the world, certain excerpts are given here:

The primary obligation of pharmacy is the service it can render to the public in safeguarding the preparation, compounding and dispensing of drugs and the storage and handling of drugs and medical supplies. . . . The pharmacist willingly makes available his expert knowledge of drugs to the other health professions. . . . The pharmacist refuses to prescribe or to diagnose; he refers those needing such service to a properly licensed practitioner. . . . The pharmacist compounds and dispenses prescriptions carefully and accurately, using correct pharmaceutical skill and procedure.

Research. — Pharmaceutical research is conducted mainly in the schools of pharmacy and in the laboratories of the pharmaceutical manufacturing houses. It embraces the organic chemical synthesis of new chemical agents for use as drugs and is also concerned with the isolation and purification of plant constituents that might be useful as drugs. Research in pharmacy also includes methods for assay and standardization of medicinal agents. These phases of research in pharmacy are primarily an application of the science of chemistry to drug products, but the pharmacist also engages in research that is peculiar to the profession. This research involves formulation of dosage forms of medicaments, a study of their palatibility, methods of standardization and their stability. The researches of pharmacy are usually published in journals, such as the *Journal of Pharmacy and Pharmacology* (London), the *Journals* of the American Pharmaceutical association (Scientific Edition and Practical Edition) (Washington), the *American Journal of Pharmacy* (Philadelphia) and the *Pharnzaceutica Acta Helvetiae* (Ziirich). *See* also APOTHECARY: PHARMACOLOGY; PHARMACOPOEIA.

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PHARNABAZUS, Persian soldier and statesman, the son of Pharnaces, belonged to a family which from 478 B.C. governed the satrapy of Phrygia on the Hellespont. from its headquarters at Dascylium. Pharnabazus first appears as satrap of this province in 413, when he entered into negotiations with Sparta and began war with Athens. After the war he came into conflict with Lysander *(q.v.; see* also PELOPONNESIAN *WAR),* who tried to keep the Greek cities under his own dominion. A letter sent by Pharnabazus to the ephors at Sparta was one of the causes of Lysander's overthrow.

When in 399 the war with Sparta broke out Pharnabazus again tried to conduct it strenuously. With the help of Conon and Evagoras of Salamis he organized the Persian fleet, and while he was hard pressed on land by Agesilaus he prepared the decisive sea battle which was fought in August 394 at Cnidus under his and Conon's command and completely destroyed the Spartan fleet. He sent support to the allies in Greece, by which the walls of the Piraeus were rebuilt. But in the war on land he struggled in vain against the lethargy and disorganization of the Persian empire; and when at last, in 387, in consequence of the embassy of Antalcidas to Susa. the king decided to conclude peace with Sparta and to enter again into close alliance with her. Pharnabazus, the principal opponent of Sparta, was recalled from his command in high honours to marry Apame, a daughter of the king.

In 38j Pharnabazus was one of the generals sent against Egypt, and in 377 he was ordered to prepare a new expedition against the valley of the Nile. The gathering of the army took years, and when in 373 all was ready, his attempt to force the passage of the Nile failed. A conflict with Iphicrates, the leader of the Greek mercenaries. increased the difficulties; at last Pharnabazus led the army back to Asia.

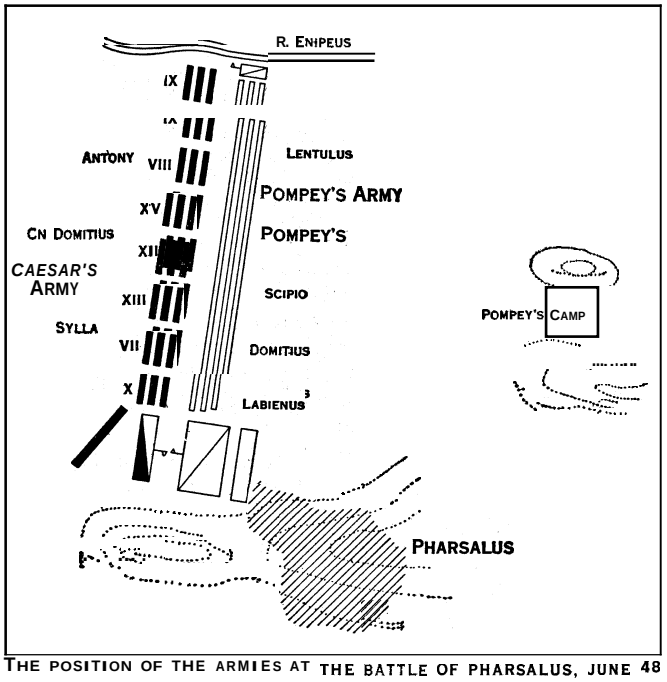
When Pharnabazus died is not known. (ED. M.)

PHARSALUS, BATTLE OF (48 B.C.). The defeat sustained by Julius Caesar at Dyrrachium in May 48 B.C. in no way disheartened him, but it compelled him to change his plan, and that at once. The task before him was a difficult one. namely, to retire before a victorious enemy and cross two bridgeless rivers, the Genusus and Apsus. Leaving 15 cohorts and 300 vessels to guard Dyrrachium, Pompey set out toward Heraclea, while Caesar made his may to Aeginium in Thessaly, where he was joined by Cnaeus Domitius and two legions; this brought his force up to nine ––about 24,000 men. He moved eastward and camped northwest of Pharsalus in the plain on the left bank of the Enipeus. There he awaited his enemy. whose army numbered 50,000 infantry, 7,000 cavalry and a large number of light troops. Pompey felt certain of victory, but he overlooked the personal factor and forgot that Caesar *was* his army and that, as one writer says: "The whole body was instinct with his purpose." The battle was fought on June 7 (Julian calendar).

Pompey planned to hold Caesar's front with his infantry and mass his cavalry. largely outnumbering Caesar's, on his left wing in order to envelop Caesar's right wing and attack it in the rear. Pompey's right wing rested on the river Enipeus and was protected not only by the steep banks but by a force of about 600 horsemen, as Caesar saw. It was under the command of Lentulus, and was composed of Cilician and Spanish troops—good soldiers. His left wing numbered the I and III legions and was accompanied by Pompey in person. Scipio held the centre with two Syrian legions and the bulk of the cavalry. slingers and archers, under Labienus were massed on the outer flank of the

left wing.

Caesar drew up his legions in three lines of cohorts, four in the first, three in the second and three in the third; his men stood eight deep. On the right he placed the X. legion and on the left the



THE POSITION OF THE ARMIES AT THE BATTLE OF PHARSALUS, JUNE 48 B.C. WHEN JULIUS CAESAR DEFEATED THE ARMY OF POMPEY

IX. Antony commanded the left, Sylla the right and Cn. Domitius the centre; he himself took up his position opposite Pompey. Thus far his order of battle was normal, but he had noticed the large force of cavalry massed on his enemy's left. Recognising that this mass was intended to outflank him, he drew up a fourth line of chosen cohorts, taken from the third line, and placed six of these cohorts and his small force of horse on his right, telling them that on their courage would depend the results of the battle. The third line he proposed to hold in reserve, and the first and second he ordered not to charge until he required it to. The trumpets were then sounded, and the battle cry of "Venus Victrix" raised, to which the Pompeians answered: "Hercules Invictus."

Pompey had ordered his men to await the enemy's assault, for he considered that when the two forces clinched his troops would be the fresher; but Caesar realising that this was a sign of weakness ordered his legions forward, trusting as he did to the impetus of the charge inspiring them with courage. Mid-way his men paused to regain breath, then advanced again, and when within range the front rank men hurled their javelins and drawing their swords rushed forward, and the two lines clinched. Immediately Pompey launched his cavalry and archers against his enemy's right flank, driving Caesar's cavalry from the field. Then the fourth line came into play, and in place of casting their javelins they closed on the horsemen with the sword "striking at the horses' breasts, and the men's legs and faces." In spite of their numbers the horsemen turned and fled, and the fourth line falling upon the archers and slingers drove them back, then, wheeling to the left, they struck Pompey's front, now locked in battle, on its flank and rear. At once Caesar galloped to his third line and ordered it to advance. This it did, breaking through Pompey's front. When Pompey saw his cavalry routed, despairing of success, he fled to his camp, possibly to rally the fugitives. The camp was eventually assaulted and taken, whereupon Pompey and 30 horse fled to Larissa and embarked for Egypt, where later on he was assassinated by Ptolemy Auletes, or rather by his tutor the eunuch Photinus, for Ptolemy was but a boy of ten. In this battle Caesar lost 30 centurions and 200 men killed, and Pompey 15,000 killed and 24,000 prisoners.

Caesar for political reasons showed great clemency by proclaiming a general pardon. He then organised his prisoners into two new legions and sent them to Asia.

BIBLIOGRAPHY.—Caesar's *Commentaries;* the *Catiline* of Sallust; the *Pharsalia* of Lucan; and the histories of Appian, Dio Cassius and Velleius Paterculus; T. Mommsen, *History of Rome* (New York, 1911); A. Holm, *History of Greece;* Col. Stoffel, *Histoire de Jules César; guerre civile* (1887); T. A. Dodge, *Caesar* (New York, 1892); J. A. Froude, *Caesar, a Sketch* (1896); G. Ferrero, *Greatness and Decline of Rome* (New York, 1907); W. W. Fowler, *Julius Caesar* (1909).

(J. F. C. F.)

PHARYNGITIS, [illegible] sillar areas. The causes are those of inflammations in other regions. and the sequels are also analogous. There may be local pain and discomfort with fever in the more acute cases.

(*See* INFLAMMATION; THROAT. DISEASES OF; RESPIRATORY SYSTEM, DISEASES OF.) (F. L. A.)

PHARYNX, in anatomy, the cavity into which the nose and mouth lead and which serves as a passage for both food and air. *See* THROAT.

PHASES. The different luminous appearances presented by the moon (*q.v.*) and several of the planets, the variety of the amount of surface visible from the earth being termed phases.

PHATTHALUNG is one of two small landlocked *changwats* of peninsular Thailand. Most of Phatthalung's surface water and products move eastward to Thale Sap, Songkhla and the South China Sea on the east side of the [illegible] for navigation. Rice, coconuts, betel nuts! oilseeds and rubber are grown on Phatthalung's fertile plain. Area (1956 survey) 1,262 sq.mi.; pop. (1960 census) 228,863. Phatthalung, the capital (1947 census, 75,838), on the west shore of Thale Sap and 45 mi. N.E. of Songkhla. is on the peninsular trunk railroad and the transpeninsular highway connecting Songkhla and Phuket. (T. F. B.)

PHEASANT, the bird, according to legend, introduced by the Argonauts into Europe from the banks of the Phasis (now Rion) in Colchis, and later supposedly first introduced into England by the' Romans. This bird. *Phasianus colchicus,* is the type of the family *Phasianidae,* and is reared in England for shooting. Ring-necked pheasants were first successfully introduced in America in 1881, when birds from eastern China (*P. c. torquatus*) were liberated in Oregon; later, hybrid birds from England (*P. c. colchicus* × *P. c. torquatus*) were released in New England. They are now well established in extreme southern Canada and throughout the northern United States, where they breed in late April and early May, lay 7 to 13 olive-buff eggs in a nest, on the ground hidden by a tussock of grass or small bush. The male is a handsome bird with brilliant plumage and red wattles; the female protectively coloured in mottled brown. The wings are short; the tail is long. The birds are polygamous; they feed on grain. seeds, shoots and insects, and both fly and run well. Pheasants will cross with numerous other gallinaceous birds. including the common fowl; the offspring in this case is called a *pero.* The true fowl-like game birds, family Phasianidae, include turkeys of North America. guinea fowl of Africa, the grouse and prairie chickens, the quail and partridges of the northern hemisphere, and the chicken-like birds of the subfamily Phasianinae. Among the latter are some 48 genera and 149 species: which include the peafowl of southeastern Asia, francolins of Africa and southern Asia, old world quail, and particularly the Asiatic jungle fowl or wild chickens and their close relatives the pheasants, likewise natives of Asia. The pheasants number 20 genera and 48 species, some represented by several geographical races, as many as 42 being recognized in *Phasianus colchicus,* which ranges across central Asia from the Black sea to Japan and Formosa. Reeves' pheasant (*Syrmaticus reevesii*) from northern China has a very long tail. The golden pheasant (*Chrysolophus pictus*), Amherst's pheasant (C. *amherstiae*) and the silver pheasants (*Gennaeus* spp.) are even more beautiful. They are all Chinese birds and are well known in aviaries. The lovely Argus pheasants (*Argusianus*) of Malacca and Siam may measure 6 ft. from the beak to the tail in the male; the secondaries of the wings (which are longer than the primaries) have metallic spots resembling

PAINTED FOR THE ENCYCLOPÆDIA BRITANNICA BY HELEN DAMROSCH TEE-VAN

PHEASANTS AND THEIR ALLIES

This family contains, besides the Pheasants, the Peacock, most magnificent of birds, and the Jungle Fowl, whose domesticated descendants are very useful to mankind. Most of the males are brilliantly coloured, while many are adorned with magnificent tails. Their original homes are in Asia, from the Caucasus to Japan and the East Indian Islands

1. Reeves' Pheasant (*Syrmaticus reevesii*). 2. Lady Amherst Pheasant (*Chrysolophus amherstiae*). 3. Golden Pheasant (*Chrysolophus pictus*). 4. Indian Peacock (*Pavo cristatus*). 5. Silver Pheasant (*Gennaeus nycthemerus*). 6. Red Jungle Fowl (*Gallus gallus*). 7. Germain's Peacock Pheasant (*Polyplectron germaini*). 8. Impeyan Pheasant (*Lophophorus impejanus*). 9. Satyr Tragopan (*Tragopan satyra*). 10. Malayan Crested Fireback Pheasant (*Lophura rufa*). 11. Eastern Chinese Ring-necked Pheasant (*Phasianus colchicus torquatus*)

eyes. The monals (*Lophophorus*) inhabit the Himalayas. The peacock pheasants (*Chalcurus* and *Polyplectron*) inhabit Burma, Siam, Indochina, and the Malay region; the plumage is ornamented with metallic eyespots. The adornments of male pheasants are strikingly displayed in courtship. *(See* COURTSHIP OF ANIMALS.)

See Tegetmeier, *Pheasants; their Natural History and Practical Management;* Beebc, *Monograph of the Phasianidae* (1918–22).

PMEIDIAS: *see* PHIDIAS.

PHEIDON (8th or 7th century B.C.), king of Argos. According to tradition he flourished during the first half of the 8th century B.C. He was a vigorous and energetic ruler and greatly increased the power of Argos. He gradually regained sway over the various cities of the Argive confederacy, the members of which had become practically independent, and (in the words of Ephorus) "reunited the broken fragments of the inheritance of Temenus." His object was to secure predominance for Argos in the north of Peloponnesus. Pheidon assisted the Pisatans to expel the Elean superintendents of the Olympian games and presided at the festival himself. The Eleans, however, refused to recognize the Olympiad or to include it in the register, and shortly afterwards, with the aid of the Spartans, who are said to have looked upon Pheidon as having ousted them from the headship of Greece, defeated Pheidon and were reinstated in the possession of Pisatis and their former privileges. Pheidon is said to have lost his life in a faction fight at Corinth, where the monarchy had recently been overthrown. He made changes in the existing system of weights and measures in the Peloponnese, and his system was in use at Athens before Solon (Arist. *Ath. Pol.* x, 2), but Ephorus' statement that he first coined silver money seems unlikely.

His date is disputed. Pausanias assigns the Olympiad at which he presided to 748, but the balance of modern authority is in favour of the first half of the 7th century.

See Hcrodotus vi, 127; Ephorus in Strabo viii, 358, 376; Plutarch, *Amatoriae narrationes,* 2; Marmor parium, *ep.* 30; Pollux ix, 83; Nicolaus Damascenus, frag. 41 (in C. W. Muller's *Frag. hist. graecorum,* iii); G. Grote, *History of Greece,* pt. ii, ch. 4; B. V. Head, *Historia Numorum* (1887); F. Hultsch, *Griechische und römische Metrologie* (1882); G. Rawlinson's *Herodotus,* appendix, bk. i, note 8. On the question of Pheidon's date, *see* J. B. Bury, *History of Greece,* ii, 468 (1902); J. P. Mahaffy, *Problems in Greek History,* ch. 3 (1892); J. G. Frazer's note on Pausanias vi, 22, 2; and especially G. Busolt, *Griechische Geschichte* (2nd ed., 1893), ch. iii, 12. C. Trieber, *Pheidon von Argos* (Hanover, 1880), and J. Beloch, in *Rheinisches Museum,* xlv, 595 (1890), favour a later date, about 580.

PHELPS, EDWARD JOHN (1822–1900), American lawyer and diplomat, was born on July 11, 1822, at Middlebury, Vt. He graduated from Middlebury college in 1840, was a schoolmaster for a year in Virginia and was admitted to the bar in 1843. From 1851 to 1853 he was second controller of the U.S. treasury, and then practised law in New York city until 1857, when he returned to Burlington. He was one of the founders of the American Bar association, and was its president in 1880–81. From 1881 until his death he was Kent professor of law in Yale university. He was minister to Great Britain from 1885 to 1889, and in 1893 served as senior counsel for the Cnited States before the international tribunal at Paris to adjust the Bering sea controversy. His closing argument, requiring 11 days for its delivery. was an exhaustive review of the case.

Phelps lectured on medical jurisprudence at the University of Vermont in 1881–83, and on constitutional law at Boston university in 1882–83, and delivered numerous addresses. among them that on "The United States Supreme Court and the Sovereignty of the People" at the centennial celebration of the federal judiciary in 1890 and an oration at the dedication of the Bennington Battle monument. unveiled in 1891 at the centennial of Vermont's admission to the union.

In politics Phelps was always conservative, apposing the anti-slavery movement before 1860, the free-silver movement in 1896, when he supported the Republican presidential ticket, and after 1898 becoming an ardent "antiexpansionist."

He died at New Haven. Conn., on March 9. 1900.

See his *Orations and Essays,* edited by J. G. McCullough, with a "Memoir" by J. W. Stewart (1901); and the memorial address by M. H. Buckham, in *Proceedings of the Vermont Historical Society* (Burlington, Vt., 1901).

PHELPS, OLIVER (1749–1809), U.S. public official and merchant. who is remembered chiefly for his land speculations after the American Revolution, was born near Poquonock. Conn.. on Oct. 21, 1749. He entered the mercantile business at an early age and soon became a prosperous trader. During the Revolution. he was in charge of army purchases in Massachusetts and he served in the lower house of the state legislature, 1778–80, and later in the senate. 178j.

Phelps also served at the constitutional convention, 1779–80, and was a member of the governor's council in 1786.

In April 1788 Phelps and Nathaniel Gorham, who was also a merchant and was president of the Continental congress in 1786, purchased pre-emptive rights—the right of first purchase from the Indians—to about 6,000,000 ac. of land in western New York. Massachusetts had received those rights under the treaty of Hartford with New York in 1786. The partners, however, soon encountered financial difficulties. They failed to sell sufficient shares in the speculative enterprise to meet their obligations to Massachusetts and the original cost, moreover. was increased by a rise in the value of Massachusetts currency. with which the debt was to be paid. They thus were unable to make their first payment and in 1790 returned most of the land, known as the Genesee country, to the state.

Phelps's later speculations in lands on the lower Mississippi river and elsewhere, based chiefly on credit, also eventually led to financial disaster. He retired to the Genesee, where he retained minor holdings. and died on Feh, 21, 1809.

PHELPS, SAMUEL (1804–1878), English actor and manager, was born at Devonport on Feb. 13. 1804.

He was early thrown upon his own resources, and worked in various newspaper offices. Shortly after his marriage in 1826 to Sarah Cooper (d. 1867), he accepted a theatrical engagement in the York circuit at 18s. a week. and afterward appeared in south of England towns in prominent tragic roles. attracting sufficient attention to be spoken of as a rival to Edmund Kean.

He made his first London appearance on Aug. 28, 1837, as Shylock at the Haymarket. After a short season there. he was with William Macready for about six years at Covent Garden, the Haymarket and Drury Lane successively.

In 1844 he became colessee of Sadler's Wells theatre with Thomas L. Greenwood and Mary Amelia Warner (1804–54). Greenwood supplied the business capacity. Phelps was the theatrical manager and Mary Warner was the leading lady. Phelps spent 20 years at Sadler's Wells theatre, during which time he raised the Sadler's Wells house to an important position and himself appeared in an extensive and varied repertory.

Thirty-four of Shakespeare's plays were presented there under his direction. In 1861 Greenwood retired from the partnership, and Phelps, unable to cope with the business of management, retired from it in the following year.

For the next 15 years he acted under various managements, achieving considerable success in some of Andrew Halliday's dramatic versions of Sir Walter Scott's novels. such as *The Fortunes* of *Nigel* and *Ivanhoe.* His last appearance was in 1878 as Cardinal Wolsey in *Henry VIII.* He died on Nov. 6. 1878.

He was a sound and capable actor rather than one of any marked genius; and. in spite of his predilection for tragedy, was most successful in such characters of comedy as called for dry humour. Perhaps Sir Pertinax Macsycophant in Charles Macklin's *The* Man *of the World* was his finest impersonation. He published an annotated edition of Shakespeare's plays (2 vols., 1852–54).

BHELPS, THOMAS STOWELL (1822–1901), U.S. naval ofiicer and surveyor, was born at Buckfield, Me., on Nov. 2, 1822. At the age of 17 he entered the U.S. navy and as part of his training as a midshipman served with the Mediterranean and Brazil squadrons. He was made passed midshipman in 1846 and promoted through the grades to rear admiral by the time of his retirement in 1884.

Phelps was on duty with the U.S. coast survey for a number of

years before he served on the sloop-of-war "Decatur," which defended the northwest coast against Indians, 1855–56. He later participated in the successful Paraguay expedition, 1858–59, which the U.S. sent to gain redress for a military Paraguayan action in 1855 against a U.S. ship.

During the Civil War Phelps surveyed the Potomac river and conducted other surveys in preparation for federal military actions. At the second naval attack on Fort Fisher (near Wilmington, N.C.), Jan. 13–15, 1865. he commanded the sloop "Juanita."

Phelps commanded the South Atlantic station. 1883–84. He published *Sailing Directions for the Straits of Magellan, Reminiscences of Seattle . . .* (1881). dealing with his service on the "Decatur." and various articles on historical topics. He died in New York city on Jan. 10, 1901.

PHELPS, WILLIAM LYON (1865–1943), U.S. teacher and author, did much to popularize the teaching of contemporary literature. Born on Jan. 2. 1865, in New Haven, Conn., he attended Yale university (B.A. 1887, M.A. 1891) and Harvard university (Ph.D., 1891). He taught at Harvard for a year. and then returned to Yale where he was for 41 years a member of the English department and Lampson professor from 1901 until his retirement in 1933. For years his students voted him Yale's most inspiring professor and thronged to his classes on contemporary drama, in the teaching of which he was a pioneer, and on Tennyson and Browning. In 1895 he taught the first U.S. college course in the modern novel, doing much to introduce Russian novelists to U.S. readers. A popular lecturer and critic, his literary essays in *Scribner's Magazine* and other periodicals and his syndicated newspaper column. "A Daily Thought," brought him an audience estimated in the millions.

As a critic he helped make the popular reputation of Thornton Wilder. An object of the scorn of H. L. Mencken, he endorsed Mencken's *Prejudices*. He died on Aug. 21, 1943, in New Haven.

His numerous books were devoted chiefly to English literature. His *Autobiography with Letters* was published in 1939.

See also F. *H*. Barber's *Fellow of Infinite Jest* (1949).

PHELPS, WILLIAM WOODWARD (1869–1938), U.S. naval officer, was born on Nov. 26, 1869, in Baltimore. Md. Graduated from the U.S. Naval academy in 1889, he was commissioned an ensign in 1891 and promoted through grades to rear admiral on Dec. 31, 1921. During World War I he commanded the fast transports "Great Northern" (1917–18) and "Leviathan" (1918–19). He commanded the "Arizona" (1920–21) after service as chief of staff at the Naval War college (1919–20).

He became commander of the Yangtze river patrol and of the U.S. Asiatic fleet from July 1922 to Nov. 1923. He also served as a member of the general board of the navy (1924–26), commander of the fleet base force, U.S. fleet (1926–28), commandant of the Portsmouth, N.H., navy yard (1928–31) and from 1931 until his retirement in 1933 commandant of the Brooklyn navy yard.

He died in New York city on May 11, 1938.

PHELYPEAUX, a French family of Blésois. Its two principal branches were those of the seigneurs of Herbault, La Vrillière and St. Florentin, and of the comtes of Pontchartrain and Maurepas.

RAIMOND PHELYPEAUX, seigneur of Herbault and La Vrillière (d. 1629), was treasurer of the *Épargne* in 1599, and became secretary of state in 1621. His son LOUIS succeeded him in this latter office and died in 1681.

BALTHAZAR PHELYPEAUX, marquis de Châteauneuf (d. 1700), and LOUIS, marquis de La Vrillibre (d. 1725), respectively son and grandson of Louis, were also secretaries of state.

LOUIS PHELYPEAUX (1705–77), comte de St. Florentin and afterward duc de La Vrillibre (1770), succeeded his father as secretary of state; became minister of the king's household in 1749, a minister of state in 1751, and discharged the functions of minister of foreign affairs on the disgrace of Étienne François duc de Choiseul (1770). He incurred great unpopularity by his abuse of *lettres de cachet*, and had to resign in 177j.

RAIMOND BALTHAZAR PHELYPEAUX, seigneur du Verger, a member of the La Vrillière branch, was sent as ambassador to Savoy in 1700, where he discovered the intrigues of the duke of Savoy, Victor Amadeus II, against France; and when war was declared he was kept a close prisoner by the duke (1703–04). At the time of his death (1713) he was governor general in the West Indies.

The branch of Pontchartrain-Maurepas was founded by PAUL PHELYPEAUX (1569–1621), brother of the first-mentioned Raimond, he became secretary of state in 1610.

PHEMISTER, DALLAS BURTON (1882–1951), **U.S.** surgeon, was one of the first to show that surgical shock was due to loss of blood and was also noted for devising a procedure to equalize bone growth in children. Born on July 15, 1882, in Carbondale, Ill., he took his M.D. degree from Rush Medical college, Chicago. Ill., in 1904 and established his practice in Chicago in the same year. From 1917 to 1919 he served with the American expeditionary forces as a major in the medical corps.

Phemister established the department of surgery at The University of Chicago medical centre, and was chief of surgery at the centre from 1925 until his retirement in 1945.

He served as president of the American College of Surgeons from 1948–49 and of the American Surgical association. He was a member of the Society of Clinical Surgery and of the Chicago Surgical society. He died on Dec. 28, 1951, in Chicago.

PHENACETIN, a drug contained in both the U.S. and British pharmacopoeias, in the former under the name of acetophenetidin. It is also a common ingredient of patent headache and "pain-killing" remedies. Phenacetin is a useful analgesic and antipyretic for headaches, colds, muscular pains and rheumatic conditions.

The drug crystallizes from water in colourless plates, melting at 135° C. It is soluble in about 70 parts of hot and in about 1,400 parts of cold water. It is prepared by acetylating paraphenetidine, or by heating paraacetylaminophenol and potassium ethyl sulphate with alcoholic soda to 150° C. Paraphenetidine is prepared by treating the sodium salt of paranitrophenol with ethyl iodide, and reducing the nitrophenetole to paraphenetidine or aminophenetole.

The yield may be doubled by diazotizing paraphenetidine, coupling with phenol, ethylating and reducing.

PHENACITE, a rare mineral consisting of beryllium orthosilicate, occasionally used as a gem stone. In general appearance it is not unlike quartz, for which indeed it had been mistaken, and was for this reason named from the Greek meaning a deceiver.

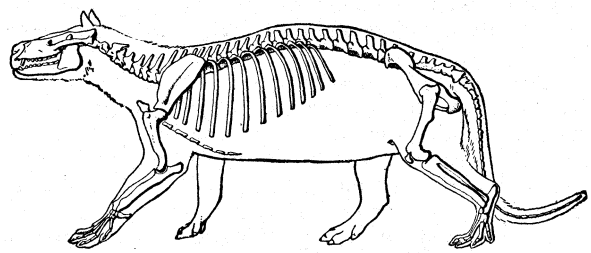
For gem purposes the stone is cut in the brilliant form but it is not in general use; fine examples are seldom seen outside of private or museum gem collections. The indices of refraction are higher than those of quartz, beryl or topaz; a faceted phenacite is consequently rather brilliant and may sometimes be mistaken for diamond.

Phenacite has long been known from the emerald and chrysoberyl mine on the Takovaya stream, near Sverdlovsk in the Urals, where large crystals occur in mica schist. It is also found with topaz and microline in the granite of the Ilmen mountains in the southern Urals and of the Pikes peak region in Colorado. Large crystals of prismatic habit have been found in a feldspar quarry at Kragero, Nor., and clear lenticular crystals are abundant at San Miguel de Piricicaba in Minas Gerais, Braz.

The formula of phenacite is Be_2SiO_4. It occurs as isolated crystals, which are rhombohedra1 with parallel-faced hemihedrism and are either lenticular or prismatic in habit. There is no cleavage, the fracture is conchoidal, and the crystals are sometimes perfectly colourless and transparent, but more often grayish or yellowish and only translucent. The hardness is high, being 7.5–8; the specific gravity is 2.98. (CL. F.)

PHENACODUS, a primitive and generalized hoofed mammal of the Lower Eocene, now extinct. The two best-known species are represented by complete skeletons found in the Bighorn basin of Wyoming in 1881. They are of the size respectively of a pig and of a fox, and typically of the family Phenacodontidae of the order Condylarthra. The teeth of *Phenacodus* are very short-crowned, uith low rounded cusps, the dentition unreduced, the premolars smaller than the molars and of simple pattern. The feet are five-toed but the first and fifth digits are considerably re-

duced; the small flattened hoofs resemble those of the tapir. The arrangement of the wrist bones is serial, the upper row directly overlying the lower ones, as in *Hyrax* and the elephant, instead of alternating as with other hoofed animals.



FROM SCOTT. "LAND MAMMALS OF THE WESTERN HEMISPHERE" (MACMILLAN)

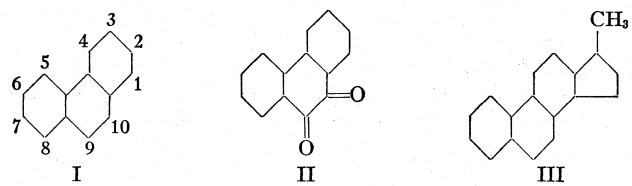
SKELETON OF PHENACODUS, IN THE AMERICAN MUSEUM OF NATURAL HISTORY. NEW YORK CITY

The astragalus in the hind foot is like that of Carnivora with distinct neck and convex rounded head. This character distinguishes the Condylarthra from the higher ungulates as the primitive construction of their teeth distinguishes them from the variously specialized ungulate tooth patterns. The brain was small and of inferior structure. (W. D. M.)

PHENANTHRENE, an aromatic hydrocarbon (first discovered in 1872) having the same composition, $C_{14}H_{10}$, as anthracene (*q.v.*) and found with the latter in coal-tar distillates boiling between 270° C. and 400° C. Pure phenanthrene, I, melting point 100° C.–101° C. and boiling point 340° C., is obtained from this mixture by fractional crystallization by virtue of its greater solubility than anthracene, the chief other component. Final traces of anthracene are removed by oxidative treatment, taking advantage of the greater ease of oxidation of anthracene. Phenanthrene is readily oxidized to the orange phenanthraquinone, II, a typical orthoquinone (*see* QUINONES).

Degradation of this quinone eventually yields diphenic acid and ultimately biphenyl. compounds which serve to establish the structure of phenanthrene.

The completely or partly hydrogenated phenanthrene nucleus is present in a wide variety of important natural products including certain alkaloids (notably morphine), resin acids (*see* ABIETIC



I II III

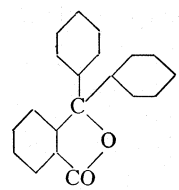
ACID), sterols, bile acids, sex hormones, heart poisons and saponins. The structures for many of the sterols, bile acids and sex hormones were established readily after the correct formulation of Diel's hydrocarbon, III, a product obtained from these substances by selenium dehydrogenation. as 3'-methylcyclopentenophenanthrene, III, was proved by synthesis (1934). Many cancer-producing hydrocarbons contain the phenanthrene nucleus. Many methods for the synthesis of phenanthrene and related substances were developed.

See L. F. Fieser, *The Chenzistry of Natural Products Related to Phenanthrene,* 2nd ed. (1937). (M. S. N.)

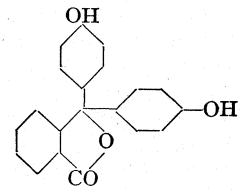
PHENIX CITY, a city of eastern Alabama, U.S., in Russell county, on the Chattahoochee river, is opposite Columbus. Ga., of which it is a residential and industrial suburb. Manufactured products include lumber. caskets and embalming supplies.

In 1923 the legislature extended the corporate limits of Phenix City to include the town of Girard but it did not alter the county boundaries. In 1927, a branch courthouse was established, in that part of Phenix City which had formerly been Girard, to maintain jurisdiction over the northern division of Russell county. The county boundaries were finally altered in 1932, to include all of Phenix City in Russell. The legislature in 1943 provided for the transfer of all records from the old county seat, at Seale, to Phenix City. For comparative population figures *see* table in ALABAMA: *Population.* (P. A. B.)

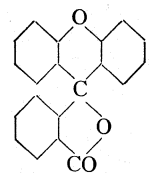
PHENOLPHTHALEIN, an organic compound of the aromatic series which has two uses: (1) as an indicator for acids and bases in volumetric analysis; (2) as a purgative drug. The



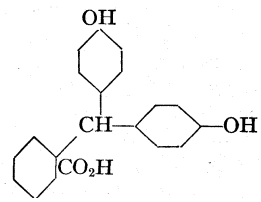
Diphenylphthalide



Phenolphthalein



Fluorane



Phenolphthaline

phthaleins are prepared by condensing phenols with phthalic anhydride, phenol itself giving rise to phenolphthalein together with a small quantity of fluorane, while resorcinol under similar conditions yields fluorescein (q v.).

Phenolphthalein is obtained when phenol and phthalic anhydride are heated with concentrated sulfuric acid. It crystallizes in colourless crusts (m.p. 250°–253° C.) and is nearly insoluble in water, but dissolves in dilute alkaline solutions with a fine red colour, because of the formation of the red disodium salt. It may be reprecipitated from these solutions by the addition of an acid. It is to this remarkable colour change that its use as an indicator is due. It dissolves in concentrated caustic alkalies to a colourless solution which contains the colourless trisodium salt.

Phenolphthalein has extended use as a purgative under such synonyms as purgen, laxoin, laxans, etc. Phenolphthalein is dissolved in the bile and intestinal fluid, which are slightly alkaline, and being irritant to the intestine it causes intestinal peristalsis and evacuation.

PHENOLS, a large class of organic substances of which phenol is the parent compound. They are characterized by the presence of at least one hydroxyl group attached to the benzene ring.

Phenol or carbolic acid was discovered in 1834 by F. F. Runge, who separated it in crude form from coal tar and called it *Karbolsäure.* In 1841 *A.* Laurent produced the pure substance, again from coal tar, and named it *hydrate* de *phényle* or *acide phénique.* The term "phenol." which was later used, was introduced by C. F. Gerhardt. He prepared the substance in 1843 by the dry distillation of salicylic acid in the presence of lime. In 1867 A. Wurtz and A. Kekulé discovered the synthesis from benzene, a process still of commercial importance involving the fusion of a strong alkali with the alkali salt of benzene sulfonic acid.

Phenol is found in coal tar, in wood tar and in many other products derived from the pyrolysis of animal and vegetable matter. In small quantities it is also present in Galician and Caucasian petroleum. It is a product of animal metabolism and, bound to other substances, it occurs in the urine of many mammals.

The commercial manufacture of phenol began in 1860. Originally this substance was obtained solely from coal tar. In the early years of the 20th century, and particularly during World War I, the demand exceeded the supplies available from coal tar, and production was augmented by the commercial synthesis of phenol from benzene.

As a result of the rapid rise of the plastics industry, which absorbed increasing amounts of phenol in the making of Bakelite and epoxide resins, production by synthesis outgrew the volume recovered from coal tar, and by the mid-1950s less than 5% of

the total annual U.S. production of about 500,000,000 lb. came from coal tar and more than 90% was made synthetically.

Uses.—Although in the 19th century phenol was used extensively because of its antiseptic properties, its use in the operating room was discontinued because of its irritating action. It also lost its important position among disinfectants where it was largely supplanted by its higher-molecular-weight homologues, by its derivatives and by other chemicals. But it is still used as a standard in the evaluation of disinfectants.

The great demand for phenol during World War I can be attributed to the extensive use of its trinitro derivative (see PICRIC ACID) as an explosive. Although made by some of the Allies during World War II, it did not compare in importance with explosives such as trinitrotoluene.

The increasing demand for phenol at mid-20th century was caused principally by the expanding plastics industry. which absorbed about two-thirds of the total production. There phenol is treated with formaldehyde to make the infinite variety of Bakelite-type resins used for molding purposes, for laminating of paper, cloth and wood, for adhesives, protective coatings, paints and many other uses. For the epoxide-type resins, phenol is reacted with acetone to form bisphenol [2,2-bis (4-hydroxyphenyl) propane] uhich in turn is condensed with epichlorohydrin. Roughly one-fourth of the output went to the chemical and pharmaceutical industries for conversion into such derivatives as salicylates, chlorophenols, alkyl phenols, phenyl phosphates, nitrophenols and phenolsulfonic acids. The production of salicylic acid was one of the best-known outlets for phenol. From it many medicinals (*e.g.*, aspirin), flavours and dyes were prepared. The chlorophenols are important as bactericides, fungicides, selective herbicides (2,4-dichlorophenoxyacetic acid) and starting materials in the production of pharmaceuticals and photographic chemicals. The alkyl phenols are useful as oxidation inhibitors (di-tert butylphenol). starting materials for drying-oil-soluble varnish resins (paratertiary butylphenol) and as reagents in the manufacture of synthetic detergents. Triphenyl phosphate is a plasticizer used in cellulose acetate film and phenolsulfonic acids find application principally in the production of synthetic tanning agents. The remaining production was used as selective solvent in the refining of lubricating oils, the extraction of aromatic fractions (toluene) from petroleum distillates and for many other purposes.

Properties.—Phenol is closely related to benzene, having, in place of one of the six hydrogen atoms present in the benzene ring, a hydroxyl group which is the combination of one oxygen and one hydrogen atom. Its formula is $C_6H_5.OH$. Thus it stands in the same relation to benzene as methyl alcohol, $CH_3.OH$, does to methane. CH_4.

Although it has some properties which resemble those of the aliphatic alcohols, in particular of the tertiary alcohols, phenol cannot be classified as an alcohol. It is characterized by its acidic nature and its readiness to form salts with strong bases. Phenol is the prototype of the hydroxylated members of the benzene series.

Phenol has a molecular weight of 94.11. At atmospheric pressure it boils at 182° C. It solidifies at 41° C. into colourless needles. At 25° C. its density is 1.072 and its refractive index at 41° C. is 1.5425. It has a characteristic pungent odour and in dilute water solution a sweetish taste. In more concentrated form it is poisonous and produces burns on the skin. At room temperature phenol is sparingly soluble in water. If more than 8% by weight of phenol is present, two phases appear in the solution, a bottom layer consisting of phenol with some dissolved water and a top layer of water containing about 8% phenol. As the temperature is elevated. the mutual solubility increases, until above 66° C. phenol and water become soluble in all proportions. Phenol is readily soluble in alcohol, ether. chloroform, carbon disulfide, glacial acetic acid and the hydrocarbons of the aromatic series. It is less soluble in the liquid hydrocarbons of the aliphatic series. Because of its acidic nature, it dissolves readily in solutions of alkalies with the formation of alkali-metal salts. These salts are readily decomposed by the addition of acids. Similarly to ordinary alcohols, phenol can be esterified with carboxylic acids, although the reaction does not proceed with the same ease and often requires the action of the chloride or anhydride of the carboxylic acid or an alkali-metal salt of phenol. It can be converted into an ether by treating its sodium or potassium salt with an alkyl halide. such as methyl iodide, or by treating it under elevated temperature and pressure with acetylenes in the presence of alkaline catalysts.

As a derivative of benzene, phenol can be sulfonated, nitrated and halogenated. The presence of the hydroxyl group enhances the reactivity of the benzene ring, so that milder conditions are indicated to control the reactions. Halogenations proceed quantitatively to the trihalide stage, a fact that is useful in the analysis for phenol. Substitutions take place principally in positions ortho and para to the hydroxyl group. Hydrogen, in the presence of active catalysts. will add to phenol to form cyclohexanol or. under more drastic conditions, cyclohexane. Of great commercial importance is the readiness nith which phenol reacts with aldehydes, in particular formaldehyde, to form condensation products of high molecular weight.

Preparation.—Natural phenol is recovered at coal-tar-distillation plants from a distillate fraction boiling between 160° C. and 230° C. To extract the phenol together with its homologues—the various cresol (methyl phenols) and xylenol (dimethyl phenols) isomers—from this fraction, it is washed with dilute aqueous sodium hydroxide solution. To "spring" the acids out of the aqueous solution the extract is purified and treated with an acidic material, such as carbonic acid which is often available in stack or kiln gases. The thus liberated acids are withdrawn. purified, and finally fractionally distilled under vacuum to yield phenol in various grades of purity followed by the cresol and xylenol cuts.

Synthetic phenol is produced from benzene mainly by three general procedures which may be classified according to the main process steps as follows:

1. Sulfonation process, which consists in the treatment of benzene with sulfuric acid and subsequent fusion of the resulting benzenesulfonic acid with sodium hydroxide to form sodium phenoxide, which is dissolved in acids to liberate phenol.
2. Chlorination process, which consists in the treatment of benzene with chlorine and subsequent hydrolysis of the resulting chlorobenzene with steam or with aqueous alkaline solutions to form phenol or alkali phenoxide solutions, the latter being treated with acids to liberate phenol.
3. Cumene process, which consists in the reaction of benzene with propylene to form cumene, (monoisopropylbenzene); oxidation of the cumene with air to make cumene hydroperoxide; and, finally, cleavage of this hydroperoxide to produce phenol and acetone.

In the sulfonation process benzene is caused to react with an equivalent amount of concentrated sulfuric acid to form monobenzene sulfonic acid according to the equation

$$C_6H_6 + H_2SO_4 \longrightarrow C_6H_5SO_3H + H_2O$$

Since the reaction slows down as the reactant sulfuric acid becomes diluted with the water of reaction, the process is often carried out by passing benzene vapour through a sulfuric acid bath, maintained at a temperature above 100° C.. in such a way that only a portion of the benzene reacts while the rest escapes as vapour together with the water formed in the reaction. The vapours are condensed, the water is separated and the benzene is returned to the sulfonation bath. At the end of the cycle there is obtained in the bath benzene sulfonic acid which is essentially free of sulfuric acid and which can be used directly in the fusion step without the laborious intermediate steps necessary if appreciable quantities of free sulfuric acid remain dissolved in the sulfonation product. The second. so-called fusion step in the process, proceeds according to the reaction

$$C_6H_5.SO_3H + 3NaOH \longrightarrow C_6H_5.ONa + Na_2SO_3 + 2H_2O$$

In practice this operation is carried out in cast-iron vessels. Caustic soda in excess of the theoretical requirement is first charged and heated to about 300° C. Then the benzene-sulfonic acid or its sodium salt is pumped into the molten mass. After about six hours the reaction mixture is plunged into aqueous-process liquors in which sodium sulfite crystallizes out because of its low solubility in strongly alkaline solutions. The solution is filtered, and the fil-

trate, containing sodium phenoxide and residual free caustic soda. is treated with sulfuric acid to liberate the phenol and to convert the soda into sodium sulfate. A final distillation of the phenol removes water and furnishes the marketable product.

In the chlorination process, benzene is treated with chlorine to form monochlorobenzene according to the equation

$$C_6H_6 + Cl_2 \rightarrow C_6H_5.Cl + HCl$$

The reaction is carried out in cylindrical vessels. Iron is added to the charge as a catalyst. To repress the formation of the more highly substituted polychlorobenzenes. an excess of benzene is maintained in the reaction zone. The resulting crude chlorination product is treated with a dilute caustic-soda solution to free it of by-product hydrogen chloride.

After settling, the product is subjected to fractional distillation to separate from it the nonconverted benzene and to purify the monochlorobenzene. The more highly chlorinated products remain in the still bottoms. The conversion of monochlorobenzene into phenol is commercially accomplished by any one of fhe following reactions:

(1) $C_6H_5Cl + H_2O \rightarrow C_6H_5.OH + HCl$
(2) $C_6H_5.Cl + 2NaOH \rightarrow C_6H_5.ONa + NaCl + Hz0$
(3) $C_6H_5.Cl + Na_2CO_3 + H_2O \rightarrow C_6H_5OH + NaCl + NaHCO_3$

Reaction 1, in the presence of a catalyst, proceeds in the vapour phase at about 500° C. and atmospheric pressure. Reaction 2 is carried out in the liquid phase at high pressure and temperature in corrosion-resistant autoclaves. The resulting sodium-phenoxide solution is treated with the by-product hydrogen chloride from the chlorination step to liberate the phenol. Reaction 3 is utilized in the Dow Chemical Co. process in which chlorobenzene and soda-ash solution are pumped through long copper coils at a pressure of 3,000 lb. per square inch and at about 320° C. After cooling the mixture, the pressure is released and free phenol separates from the bicarbonate solution. Diphenyl ether appears as the product of a side reaction. Fortunately, its formation can be suppressed by returning some of it to the mixture entering the hydrolysis step. For final purification the phenol is subjected to a fractional distillation under vacuum.

Since the vapour-phase hydrolysis (reaction 1) furnishes hydrogen chloride, economies could be realized if this by-product were utilized as a source of chlorine in the chlorination of benzene. This has been accomplished by the Raschig process, which combines the principle of the Deacon process—the preparation of chlorine from hydrogen chloride and oxygen—with the chlorination of benzene and the subsequent vapour-phase hydrolysis of chlorobenzene. The process uses air as the source for oxygen and is operated on a large scale. The individual reactions can be summarized by the equation

$$C_6H_6 + \tfrac{1}{2}O_2 \rightarrow C_6H_5.OH$$

In the cumene process (used commercially since 1950), benzene is treated with gaseous propylene in the presence of an acidic catalyst such as aluminum chloride or phosphoric acid on a clay support. After neutralization the resulting reaction mixture is distilled to separate monoisopropylbcnzene (called cumene) from polyisopropplbenzene and unconverted benzene. The cumene is then subjected to air oxidation until about one-third is converted to cumene hydroperoxide. The excess cumene is removed from the oxidation mixture by distillation at reduced pressure and recycled. The residue contains the concentrated cumene hydroperoxide and is contacted with a strong acid whereupon it decomposes into phenol and acetone. These reactions are shown by the equations:

$$C_6H_6 + C_3H_6 \rightarrow C_6H_5\text{-}CH(CH_3)_2$$
$$C_6H_5\text{-}CH(CH_3)_2 + O_2 \rightarrow C_6H_5C(CH_3)_2OOH$$
$$C_6H_5C(CH_3)_2OOH \rightarrow C_6H_5OH + (CH_3)_2CO$$

The final products, phenol and acetone, are separated by fractional distillation. (E. W. V.)

PHENOMENALISM (from the Greek *phainomenon*, "appearance": see PHENOMENON), a philosophical theory of perception and the external world. Its essential tenet is that propositions about material objects are reducible to propositions about actual and possible sensations. or sense data, or appearances. According to the phenomenalists. a material object is not a mysterious something "behind" the appearances which we experience in sensation. If it were. the material world would be unknowable; indeed, the term "matter" itself would be unintelligible unless it could somehow be defined by reference to sense experiences. In a phenomenalistic analysis of material-object propositions, it is of course essential to mention possible sensations and not merely actual ones. The wall which someone sees just in front of him is hard and rough. though he is not at the moment touching it. But it is still true that, if he were to stretch out his hand. he would experience tactual sensations of hardness and roughness. These tactual sensations are possible, though not at the moment actual. Moreover. material objects continue to exist at times when they are not being observed at all. For instance, there is a fire burning in the next room: though no one at present sees or feels it. But it is still true that. if there were an observer in the next room. he would experience bright. flickery, yellowish colour-patches. and he would feel warmth. Moreover. the precise character of the visual sensations which he would experience and. likewise, the degree of warmth which he would feel would vary with the point of view which he occupied in the room. In speaking about a material object, then. we must be referring to a very large group or system of many different possibilities of sensation. Whether actualized or not. these possibilities continue during a certain period of time. When the object is observed. some of these possibilities are actualized, though not all of them. So long as it is unobserved, none of them are actualized. In this way. the phenomenalist claims! we can give an "empirical cash-value" to the concept of matter, by analyzing it in terms of sensations.

It must be emphasized that the term "possible sensation," as phenomenalists use it. is a kind of shorthand for a hypothetical ("if . . . , then . . .") proposition. When it is said that a visual sensation of such and such a kind is possible. though not actual, the meaning is that a colour sensation of that kind would occur if there were an observer at such and such a place where there is in fact no observer.

Some of the classical difficulties of phenomenalism arise directly from the central part which these hypothetical propositions play in the phenomenalist analysis. The phenomenalist claims to analyze all material-object expressions in terms of actual and possible sense experiences. But it is difficult for him to avoid using material-object expressions in his if-clauses, and this would make his analysis circular. In the example just given, "an observer" (*i.e.*, an animate human organism) is a material-object expression, and so is "in the next room." No doubt we might attempt to analyze each of these material-object expressions in terms of other possible sense experiences. "The next room." for instance, might be resolved into the visual and other sensations which an observer would have if he opened the door or looked through the window. Expressions referring to an observer might be analyzed in terms of the sensations which another observer would have if he were to look in a certain direction. But now the same difficulty arises again about these new if-clauses. A second and even more important objection is this: it is very difficult to believe that categorical propositions about material objects (*e.g.*, "there is a fire in the next room") can be analyzed without remainder into sets of hypotheticals; *i.e.*, that a statement about what there actually is can be reduced to a set of statements about what there would be if certain (nonexistent) conditions were to be fulfilled.

BIBLIOGRAPHY.—George Berkeley, *Principles of Human Knowlrdge*, sections 3, 58, 59 (1710); J. S. Mill, *Examination of Sir William Hamilton's Philosophy*, 3rd ed., ch. 11 and appendix to ch. 12 (1866); M. Schlick, *Gesammelte Aufsätze*, ch. 5 (1938); A. J. Ayer, *Foundations of Empirical Knowledge*, ch. 5 (1940) and *Philosophical Essays* (1954); R. J. Hirst, *Problems of Perception* (1959). (H. H. PE.)

PHENOMENOLOGY, a term used in philosophy and psychology to denote a study of the varying forms in which something appears or is manifested. as opposed to studies of causal origins, real constitution, significance, etc., which go beyond what is apparent. The word was used by Hegel in his Phenomenology of *Spirit* (1807) to stand for a study of the forms assumed by mind

or spirit in its development toward complete self-consciousness. It is also much used in contemporary psychology to cover descriptions of direct, personal experience, as opposed to accounts based on an observation of behaviour. Thus a typical modern phenomenological study is David Katz's *Der Aufbau der Farbwelt* (1930; original ed., *Die Erscheinungsweisen der Farben,* 1911; Eng. trans,, *The World of Colour,* 1935), which deals with the varying ways in which colours appear to the percipient; *e.g.,* as spread over surfaces, as filling space, as lustrous, as a property of the lighting, etc. The term was also used by Edmund Husserl (*q.v.*), professor of philosophy at Gottingen and Freiburg, who made it stand for an a priori psychological discipline which, in studying the ways in which objects appear to the mind, should provide a foundation for all empirical psychologies. Husserl's methods were subsequently widened so as to apply to other scientific disciplines and so as to develop into a universal phenomenological philosophy. The present article will confine itself to the phenomenological teaching of Husserl.

The phenomenology of Husserl is a lineal descendant of the "psychognosy" of Franz Brentano (*q.v.*), under whom Husserl studied in Vienna in 1884–86. This psychognosy was an attempt to delimit the subject matter of psychology, by laying down certain basic features which entitle us to call a phenomenon psychical (or mental) and by classifying psychical phenomena into certain fundamental types. The most important result of these psychognostic investigations is that mental states are all characterized by intentionality or direction to objects (the term was borrowed by Brentano from the schoolmen): "In a presentation something is presented, in a judgment something is acknowledged or rejected, in love something is loved, in hate hated, in desire desired, etc." *(Psychologie vom empirischen Standpunkte,* 1874). Brentano maintained that the intentional inexistence of objects in experience was the peculiar feature of the psychical (mental): no physical phenomenon showed anything comparable. Further. he divided "psychical phenomena" into the basic class of presentations, in which an object is simply set before consciousness, and the more complex classes of the judgment and of the phenomena of love and hate, which are built upon and presuppose the former. He held, further, that every mental state reveals its existence and character to an attendant state of inner observation or perception, which is part of itself: it is by exercise of this inner perception that our psychognostic studies must proceed.

The term phenomenology first becomes prominent in Husserl's early masterpiece, *Logische Untersuchungen* ("Logical Investigations"; 1900–01). In this work Husserl is concerned to refute psychologism, a view which makes the subject matter of logic and mathematics psychological, which regards them as dealing with our mental acts of judging, counting, adding, inferring, calculating, etc., and which also makes their validity depend on the contingent make-up of the human mind. As opposed to such psychological interpretations, Husserl proposes to build up a phenomenological account of our mental approaches. both in the logico-mathematical and in other fields. This phenomenological account will not concern itself with the actual states of mind of men and animals of which there is empirical evidence; it will deal abstractly and generally with the sorts or kinds of experience in which certain sorts of object are set before us. It will seek to analyze such directed experiences and to discover the relations to objects (and to other experiences) that are implied by their being the sort of experiences that they are. Such an investigation will be intuitive, in that one will not be able to give reasons for the particular analyses that one adopts; one may also call it descriptive, since it will be in many ways like the description of objects given in sense perception. But though intuitive and descriptive, it will also be non-sensuous and a priori: the kinds examined and analyzed will be "there" only for abstraction and for reflection, and whatever is laid down about them will be true of necessity or "grounded in their essence," and not merely found to go with them in experience. Such phenomenological analyses of our mental approaches will also involve a treatment of the various sorts of object that are set before our minds: though such objects are distinct from our mental approaches, it is nonetheless part of the description of the latter that they should "terminate on" or "be directed toward" certain objects. The phenomenologist is concerned, however, not with the actual existence or real character of such objects, but only with their status as objects, as phenomena for consciousness. Hence an abstract, incomplete, merely possible or even impossible object will be as important for his researches as one that is actual. The phenomenologist will, in fact, consider objects (like experiences) only as abstract types or kinds: this abstraction will reach a peak in the logicomathematical sciences where he will only deal with them as "somethings-or-other" or as objects in general. Logic and mathematics together constitute for Husserl a *mathesis universalis* or study of things-in-general. Though not themselves psychological or phenomenological studies, they have a foundation in the latter, insomuch as their objects enter into reality only as part of the description of certain abstract and generalizing intentions.

Apart from its first volume of antipsychologistic *Prolegomena* (which, read in isolation, gives a wholly misleading impression of Husserl's philosophy), the *Logische Untersuchungen* comprises six important studies. The first, *Ausdruck und Bedeutung* ("Expression and Meaning"), deals with the "meaning-conferring" acts which lie behind the significant use of linguistic expressions. The second, *Die ideale Einheit der Spezies und die neueren Abstraktionstheorien* ("The Ideal Unity of Species and Modern Theories of Abstraction"). deals penetratingly with the accounts of abstraction given by Locke, Berkeley, Hume. Mill and others and distinguishes the pure contemplation of abstract kinds or essences from selective attention to the "moments" or abstract aspects of objects. The third study, *Zur Lehre von den Ganzen und Teilen* ("Toward a Doctrine of Wholes and Parts") deals with this very problem of the "moment" or abstract aspect of an object, which is incapable of existing apart from its whole. The fourth study, *Der Unterschied der selbstandigen und unselbstandigen Bedeutungen* ("The Distinction Between Independent and Dependent Meanings"), deals with the intentional background of the distinction betueen categorematic and syncategorematic expressions. In the fifth study, *Über intentionale Erlebnisse und ihre "Inhalte"* ("On Intentional Experiences and Their 'Content' "), Husserl criticizes and develops Brentano's notion of intentionality as the distinguishing feature of the mental. He puts forward his own notion of the conscious "act," (which he explicitly disassociates from connotations of activity and agency) and draws elaborate distinctions between what he calls the quality of acts, the manner in which they approach their objects. and their matter (*Materie*), the side of them that determines what object they deal mith. It may be noted that Husserl, like Brentano, does not make the object of a mental act an actual part of it: to be concerned in thought with the god Jupiter is not to have that god as an actual element in one's concern. Nor does concern mith an object entail its extramental existence anywhere: its status may be merely intentional, it may be merely the case that we have ideas of it. Intentionality is no relation between a mental act and something lying outside of it: concern with an object is something self-sufficient and complete, to live through it is to have its object before one, whether that object has any further real status or not. It will be observed how Husserl, by the radical originality of these concepts, avoids many of the pitfalls into which his Cambridge contemporaries fell. The last study in the book, *Elemente einer phanomenologischen Aufklarung der Erkenntnis* ("Elements of a Phenomenological Elucidation of Knowledge"), is probably the most characteristic and valuable of all Husserl's writing. He here develops the distinction between the act of mere meaning (*Bedeutungsintention*), the object of which is not actually present, and the experience of fulfillment of meaning (*Bedeutungserfüllung*), in which what is referred to is also itself directly given. Obviously it is basic to thoughts, whether in the theoretical or in the practical sphere, that they should be capable of existing empty or unfulfilled and that they should also be capable of being realized carried out, executed, fulfilled in one manner or another. In the theoretical field it is in our passage from an unfulfilled to a fulfilled reference that all that is called knowledge arises; *e.g.,* when I expect something to be black and

also find it to be black. In this connection Husserl's thought comes near to adopting something like the modern verification principle. a meaning for him is always correlative to some fulfilling intuition. Only he is willing to widen the notion of intuition to cover the case of abstract and even of synsemantic meanings; we can be brought face to face with the meaning of an "and," an "or" or a "but" or other syntactical connectives. There is a categorial intuition of ideal objects and of their a priori relationships. which is quite distinct from sensuous intuition.

Husserl's more mature views of the task of phenomenology, together with an actual attempt to carry out his phenomenological program, are to be found in his later work *Ideen zu einer reinen Phänomenologie und phanomenologischen Philosophie* (bk. i, 1913, bk. ii and iii in the posthumous *Husserliana*, 4 and 5, 1950–52; Eng, trans. of bk. i by W. R. Boyce Gibson. *Ideas: General Introduction to Pure Phenomenology*, 1952). Phenomenology is here ranged among a large body of eidetic disciplines, each of which works out an ontology for a peculiar region of objects and sets forth the types and the axioms applying to objects of that kind. There is one such eidetic science dealing with colours, sounds and the sensible qualities generally, another with spatiality, another with temporality, another with material thinghood, and so forth. Logic and mathematics together constitute an eidetic science the categories and axioms of which apply in all regions and which is consequently without a proper region of its own; it may, however, with due reserve, be said to govern a formal or analytic region. These regional sciences are arrived at by abstraction and by an examination of essence, but phenomenology (which is the eidetic science of the region of experiences) is not arrived at merely in this manner; it requires, in addition, that one should practise a sort of Cartesian doubt in regard to all common-sense beliefs, that one should put them all in brackets, subject them all to a transcendental suspension or *epoche*. Without ceasing to believe in them. one should put one's belief in them out of action. In this suspension of conviction, consciousness itself will become highlighted, the mere appearance of houses, trees, men, etc., being tantamount to the existence of one's awareness of them. Consciousness itself is thus immune from the *epoche* which dissolves its objects. In connecting our suspension of conviction in regard to the natural-empirical world with our inner perception of our own conscious dealings with it, Husserl is adding depth to Brentano's notion of inner perception: it no longer merely means a sort of secondary empirical perception of our own mental acts, which is tacked on to those mental acts themselves. And once consciousness has thus been made manifest to our inner perception, it can be subjected to the same generalizing abstraction and examination of essence that have been applied to its objects. In this way one supplements one's regional ontologies with a pure phenomenology which explains how their objects appear or are given.

Husserl, however, passes on to certain theses which would seem to involve the abandonment of his original *epoche* and a complete surrender to metaphysical idealism. For he holds that, while appearances and acts of consciousness exist absolutely, their natural-empirical objects can be said to exist only for consciousness: their being is by its nature intentional. Even the transcendent objects of physics enjoy a transcendence which is only constituted in and by consciousness, their whole function being to provide a satisfactory account of experienced things. Husserl goes further and maintains that the existence of a pure self or ego, the point of unity of our mental acts. is guaranteed by our inner perception: those acts then become its spontaneous activities. Husserl is here going back on the teaching of the *Logische Untersuchungen*, which refused to see in the self anything more than the systematic unity of our mental acts and which disjoined its notion of act from suggestions of activity. The act of perceiving X means no more for the *Logische Untersuchungen* than that *X* appears or is given: in his later work it involves a transcendental subject and its activities. It would appear, then. that the *Logische Untersuchungen* is more strictly phenomenological, more chary of going beyond the appearances, than are the works in which Husserl's phenomenological program is most loudly proclaimed.

Husserl's actual carrying out of his program is to be found in the latter portions of the *Ideen* (and elsewhere). Here only a few points can be mentioned. While accepting Brentano's general position that concern with objects is the distinguishing mark of the mental. Husserl accepts into his mental realm factors which, though not themselves intentional, nonetheless serve as the stuff for our sense-making, interpretative references. The data of sense as well as certain primitive feelings are such hyletic constituents of experience. Husserl also draws a distinction between the noetic and the noematic aspects of our conscious experiences. We consider an experience noetically when we study the way in which it approaches its objects, whether attentively or inattentively, believingly or unbelievingly, approvingly or disapprovingly, and so on; whereas we consider the same experience noematically when we consider the intentional objects that come to light in it. Hardly, however, has Husserl drawn this distinction than he puts forward a principle which does much to obliterate it. he holds that to every noetic aspect of experience there is always a corresponding noema. that to every mode of our conscious approach there is an answering feature in the object approached. All consciousness is, in short, implicitly presentative. The noematic correlate of an approach need not, however, come to light in that approach itself: it may require another subsequent act to elicit it. Thus, when I deny something of an object, I am concerned simply with that object and not with its lack of an attribute: its lack of a given attribute is, however, the noematic correlate of my act and can itself become the object of a subsequent act. In the same way, if I surmise or desire a state of affairs, I am concerned with that state of affairs and not with its probability or its desirability; the latter are, however, the ideal noemata corresponding to my act, which can be made the objects of a subsequent awareness. Phenomenologically, Husserl holds, there is all the difference in the world between experiencing a denial, a surmise or a wish and contemplating the absence, the likelihood or the desirability which are their respective objective correlates. Husserl gives interesting phenomenological analyses of outer and inner perception. of attention. of our consciousness of time, of belief, surmise and supposal: he also deals with the experiences (classified under the heading of *Vernunft* or reason) which provide justifying evidence for our other attitudes. He then goes on, in later books of the *Ideen*, to give phenomenological accounts of external nature; of the space and time nhich are its structure; of the sense-qualities which qualify its objects; of its various lifeless, living and conscious inhabitants; and of the personal and social arrangements and cultural activities of these last. Though phenomenology suspends belief in the natural empirical order, it can nonetheless deal with that order in bracketed fashion. No thing or feature in that order need escape its net of essence: it can always deal with it as an object of consciousness or as an instance of certain ideal possibilities. Husserl's followers Max Scheler, Martin Heidegger (*qq.v.*), Fritz Kaufmann, Oskar Becker and Gerhart Husserl developed a concrete phenomenology of the emotional, aesthetic, ethical, religious, social and juridical spheres.

By the middle of the 20th century it was still not possible to pass a balanced judgment on Husserl's contributions to philosophy: a thinker of such originality and such difficulty would obviously take a long time to make his full impact on philosophical thought and to engender a comprehending and comprehensive reaction. Part of the difficulty is linguistic: Husserl's idiom, though entirely sober and suited to its material, is by no means easy to master. It becomes even harder in translation. It may, however, be suggested that Husserl's fundamental contributions are much simpler than they at first sight appear to be; thus there is little more to his transcendental *epoche* and examination of essence than a determination to examine the meaning of common concepts and ordinary beliefs rather than to add factual detail to our knowledge. His program is, in fact, not very different from that of modern British and U S. analytic philosophy. We may note, further, that his analyses of mental states do little more than bring out what is involved in their "intentionality" or direction to obiects But since this property is as much characteristic of outward action as of inward experience — for our actions can be shown to be oriented to things and to situations — there is much in his

analyses that could be given a behaviouristic interpretation. It has already been suggested that his best work is to be found in the *Logische Untersuchungen.*

BIBLIOGRAPHY.—The periodical *Jahrbuch für Philosophie und phänomrnologische Forschung* (1913–30) published Husserl's *Ideen,* bk. i (see text above, 1913), *Phanomenoloaie des inneren Zeitbewusstseins* (1928) and *Formale und transzendentale Logik* (1929), also, among other important contributions, Max Scbeler's *Formalismus in der Ethik* (1916) and Martin Heidegger's *Sein und Zeit (1927).* (These works were also published separately.) The periodical *Philosophy and Phenomenological Research,* ed. by M. Farber (1940–), is a continuation of the *Jahrbuch. See* further the *Husserliana,* ed. by H. L. van Breda (1950–), and works cited in the bibliography of the article HUSSERL, EDMUND, especially M. Farber, *The Foundation of Phenomenology* (1943), which contains summaries of the *Logische Untersuchungen.* (J. N. F.)

PHENOMENON (Greek *phainomenon,* from *phainesthai,* "to be shown," "to seem," "to appear"), any object, fact or occurrence perceived or observed. The Greek verb *phainesthai* can be used with or without the implication that the thing perceived is other than what it appears to be. Thus in Aristotle's ethics "the apparent good" is what seems good to a man, whether or not it really is good. In general, phenomena are the objects of the senses, sights and sounds, contrasted with the real objects apprehended by the intellect. In later Greek philosophy phenomena are the observed facts contrasted with the theories devised to explain them. A theory is said to "save the phenomena" if it is consistent with the facts.

This last use became common in the early part of the 17th century when scientists used phenomena for the observed facts that they sought to explain (*e.g.,* astronomical phenomena, the phenomena of gravitation, phenomena of magnetism), a use still current. In modern philosophy the word is sometimes used for what is immediately apprehended by the senses before any judgment takes place; but it has never become a technical term, most philosophers preferring more artificial words such as sense-datum (hence such terms as phenomenalism and phenomenology, *qq.v.*). In English versions of Kant the word is often used to translate *Erscheinung* ("appearance"), Kant's word for the immediate object of sensory intuition, the bare datum which becomes an object only when interpreted through the categories of substance and cause. Kant himself uses it for the object interpreted through the categories as opposed to the noumenon (*q.v.*), or thing-in-itself, to which the categories do not apply. (P. H. N.-S.)

PHERECRATES, Greek poet of the old Attic comedy. was a contemporary of Cratlnus, Crates and Aristophanes. At first an actor, he seems to have gained a prize for a play in 438 B.C. The only other ascertained date in his life is 420, when he produced his play *The Wild Men.* As Crates, whom he imitated, he abandoned personal satire for more general themes, although in some of the fragments of his plays one finds him attacking Alcibiades and others. He invented a metre, called after him Pherecratean, which occurs in the choruses of Greek tragedies and in Horace.

A number of fragments from his 16 (or 13) plays have been preserved in T. Kock, *Comicorum Atticorum Fragmenta,* i (1880) and A. Meineke, *Poetarum Comicorurn Graecorum Fragrnenta* (1855).

PHERECYDES OF LEROS, Greek mythographer (fl. *c.* 454 B.C.). He is probably identical with Pherecydes of Athens, although the two are distinguished by Suidas (also by I. Lipsius, *Quaestiones logographicae,* 1886). Numerous fragments of his genealogies of the gods and heroes have been preserved.

PHERECYDES OF SYROS (fl. *c.* 550 B.C.), Greek mythographer and cosmogonist, who is traditionally associated with the Seven Wise Men, especially with Thales. He was the son of Babys and is to be distinguished from the genealogist Pherecydes of Athens, who lived about a century later. The earliest known reference to Pherecydes of Syros is in the 5th-century poet Ion of Chios. The belief that he was responsible for a *heliotropion* (a means of marking the "turning-point" of the sun at the solstice) on the island of Syros made some connect him with a line in the *Odyssey* (xv, 404) and place him earlier than Homer; but tradition made him the teacher of Pythagoras. The same miracles were ascribed to both, and this may be the reason why Cicero (*Tusculan Disputations* i, 16, 38) and Augustine (*Contra Academicos* iii, 17; *Epistle* cxxxvii. 12) say that he first taught the immortality of the soul. He was also credited with the doctrine of metempsychosis.

Aristotle (*Metaphysics* 1091 b 8) characterized Pherecydes' work as a mixture of myth and philosophy. His book the *Heptamychos* (L. Preller's correction *Pentemychos* is probably unnecessary), of which only a few fragments remain. described the origin of the world and the loves and battles of the gods. Despite its mythical form, it has features reminiscent of 6th-century Ionian speculation; for instance, the god Time creates three elements, fire, air and water, which Zeus-Eros unites to form a cosmic system. Allegory is prominent, as in the names of the gods and in a fragment describing a robe embroidered by Zas (Zeus) for his bride Chthonie (Earth) with representations of earth and ocean. Its philosophical tendency and its prose form distinguish the work from most of the rich cosmogonical literature of the 7th and 6th centuries B.C. (*e.g.,* the theogonies of Hesiod and of the pseudo-Orpheus); some critics have seen the influence of Anaximander in both features.

See O. Kern, *De Orphei, Epimenidis Pherecydis theogoniis* (1888); H. Diels and W. Kranz, *Die Fragmente der Yorsokratiker,* 3 vol., 7th ed. (1954). (W. K. C. G.)

PHET BURI (PHETBURI), a province of peninsular Thailand lying between the Gulf of Thailand and southern Burma. The eastern part, especially astride the middle course of the Phet Buri river, contains areas of productive alluvial soils which produce rice, coconuts and palm sugar. Irrigation, however, is necessary. The topography of the western part is mountainous and heavily forested. Pop. (1956 est.) 225,761; area 2,454 sq.mi.

Phet Buri (pop. [1947] 53,448), the capital, is near the mouth of the Phet Buri river 93 mi. by rail southwest of Bangkok.

In ancient times before the sea route through the Straits of Malacca and around the Malay peninsula was developed, Phet Buri was the eastern terminus of an overland trade route from India and Europe to continental southeastern Asia. Ruins of ancient Brahman and Buddhist temples and caves are found in the environs; also an old palace built by King Mongkut and a modern palace built by his son King Chulalongkorn. (T. F. B.)

PHIDIAS (PHEIDIAS; active from about 475 to 430 B.C., or later), an Athenian, the son of Charmides and pupil of Hegias, may be regarded as the greatest of Greek sculptors. Among his early works, the most important were a bronze group at Delphi (perhaps *c.* 465), erected as a memorial after the battle of Marathon; a gold and ivory statue of Athena in Achaia; and the famous bronze Athena on the Athenian Acropolis, also a thank offering after Marathon, but not set up until *c.* 456 (*cf., Hesperia,* xv, pp. 106 ff.; 1946).

When Pericles rose to power (449) and initiated a great building program in Athens, Phidias was put in charge of all artistic undertakings (*see* Plutarch, *Perikles).* Phidias himself made the gold and ivory statue of Athena, about 40 ft. high including its base, that stood inside the Parthenon and was dedicated in 438.

According to Pausanias' *Description of Greece* (I, 24, 6), the goddess stood erect, wearing a tunic, aegis and helmet, a winged victory on her extended right hand, a spear in her lowered left; by her side were a shield and a serpent; base, shield and helmet were adorned with figures. From this description a number of copies have been identified. notably the Varvakeion and Lenormant statuettes in Athens, the Strangford shield in London and the reliefs found in the sea off the Piraeus.

Though Phidias himself could not have executed the sculptures of the Parthenon—the 92 metopes, the frieze about 170 yards long and the two pediments—it seems probable that he was responsible for their design. Much of the sculptural decoration has survived (now mostly in London, Athens and Paris; a few pieces in the Vatican). Since they are Greek originals, these remains show the style of Phidias better than a host of Roman copies. (*See* PARTHENON.)

Phidias' foremost work, in the estimation of the ancients, was the gold and ivory statue of Zeus, about seven times life-size. that he made for the temple at Olympia. It was considered the greatest religious statue of Greece, and Quintilian (*Institutionum*

Oratoriarum, XII, 10, 9) says that "its beauty can be said to have added something to traditional religion." All that now remain are the description by Pausanias, small reproductions on Roman coins and terra-cotta moulds used for the drapery. Zeus was shown seated on a throne, holding a Nike in his right hand and a sceptre in his left. All parts of the statue, even the sandals, were richly decorated.

After long discussion among modern archaeologists, it is now agreed that Phidias made the Athena Parthenos earlier than the Olympian Zeus; for the moulds from Olympia, which were found in a dump adjoining what was described by Pausanias as Phidias' workshop, and which had evidently been used for hammering into them the gold for the draperies of Zeus and Nike, indicate a style in the 430s rather than the 450s.

Besides his two masterpieces, ancient writers mention a number of other statues by Phidias, all now lost. The most credible identifications are: The Lemnian Athena, set up on the Acropolis and famous for its beauty, which is perhaps reproduced in a head in Bologna and a statue in Dresden; the Apollo Parnopius, also erected on the Acropolis, perhaps reproduced in the Cassel Apollo; the Anadumenus of Olympia, perhaps reproduced in the Farnese Diadumenus of the British museum; and the Amazon—made in competition with Polyclitus, Cresilas, Cydon and Phradmon (*cf.,* Pliny, N.H., xxxiv, 53)—probably reproduced in a number of copies, all headless, of which the best-preserved is that found in Hadrian's villa, near Rome.

From these works one can gain some idea of Phidias' style. Quiet stances, serene expressions and a certain majesty of conception characterize his single figures; even when movement is represented in some of his reliefs, a monumental quality is imparted. Though the construction of the human body is perfectly understood, its rendering is restrained and harmonized. In other words, Phidias may be called the initiator of the idealistic, classical style that distinguishes Greek art in the later jth and the 4th century B.C., after the experimental epoch of Myron and his associates, and before the advent of the realistic Hellenistic age. And this idealistic quality—expressed in restrained modeling and in elevation of spirit—is still considered typical of Greek art.

Phidias was also a painter, an engraver and a worker in embossed metalware. His chief pupils were Alcamenes, Agoracritus and Colotes.

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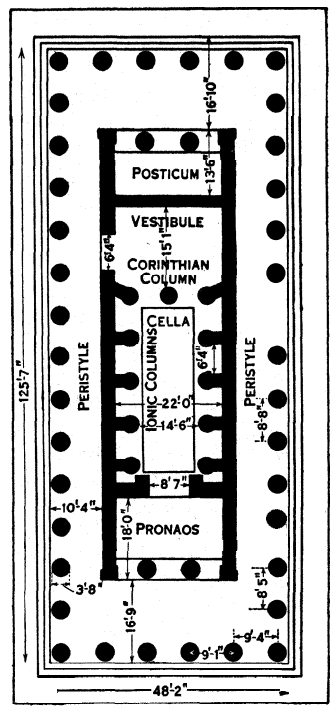
PHIGALIA or PHIGALEIA (mod. FIGALIA or PHYGALIA), an ancient Greek city on the Neda river in the southwest angle of Arcadia. among some of the highest mountains in the Peloponnesus, including Mt. Cotylium and Mt. Elasum.

In 659 B.C. Phigalia was taken by the Spartans, but soon after recovered its independence by the help of the Orasthasians. During the struggle between Achaeans and Aetolians in 221 B.C., it was held by Dorimachus, who left it on the approach of Philip V of Macedon. In common with other cities of Arcadia, it appears to have fallen into utter decay under Roman rule. Several curious cults were preserved near Phigalia, including those of the fish-tailed goddess Eurynome and the Black Demeter with a horse's head. whose image was renewed by Onatas. No autonomous coins of Phigalia are known. Nothing remains above ground of the temples of Artemis or Dionysus and the works of art which existed in the time of Pausanias. A great part of the city wall survived in modern times. 2 mi. in circuit, built of fine Hellenic masonry with a large square central fortress with a circular projecting tower.

Not at Phigalia itself, but at Bassae, 5 or 6 mi. away, on the slope of Mt. Cotylium is a well-preserved temple of Apollo Epicurius. It commemorates relief from a plague in the jth century. Pausanias (viii. 41) notes it as (next to that of Tegea) the finest in the Peloponnesus, "from the beauty of its stone and the symmetry of its proportions." It was designed by Ictinus, joint architect with Callicrates of the Parthenon at Athens. The temple was explored and measured in 1811–12 by C. R. Cockerell, the internal sculptured frieze of the cella being found in almost perfect condition. This and other fragments of sculpture are now in the British Museum.

The temple is of the Doric order, but has an internal arrangement of its cella which is unique. Probably to suit the ground, it lies north and south but the vestibule has a door to the east. It is hexastyle with 15 columns on its flanks (see figure). The internal columns of the cella are strangely placed, apparently without symmetry as regards the interior.



PLAN OF THE TEMPLE AT BASSAE

With the exception of one at the south end, which is Corinthian, the internal columns are of the Ionic order and are engaged with the cella wall, forming a series of recesses which may have been designed to contain statues. Another peculiarity of the interior is that these columns reach to the top of the cella in one order, not in two as was Doric fashion. These inner columns carried an Ionic entablature, of which the frieze formed a part. The pediments and external metopes of the peristyle appear to have contained no sculpture, but the metopes within the peristyle on the exterior of the cella had sculptured subjects. The position occupied by the great statue of Apollo is disputed. The main entrance is at the northern end through the pronaos, once defended by a door in the end of the cella and a metal screen, of which traces were found on the two columns of the pronaos. There was no door between the posticum and the cella. The general proportions of the fronts resemble those of the Theseum at Athens. except that the entablature is less massive, the columns thicker and the diminution less. In plan the temple is long in proportion to its width—measuring. on the top of the stylobate, 125 ft. 7 in. by 48 ft. 2 in., while the Theseum (built probably half a century earlier) is about 104 ft. 2 in. by 4j ft. 2 in.

The material is a fine gray limestone (once covered with painted stucco), but the roof tiles, the capitals of the cella columns, the architraves, the ceilings and the sculpture are of white marble. The roof tiles. specially noticed by Pausanias, are remarkable for their size, workmanship, and the beauty of the Parian marble. They measure 2 ft. 1 in. by 3 ft. 6 in., and are fitted together in the most careful and ingenious manner. Unlike those of the Parthenon and the temple of Aegina, the joint tiles are worked out of the same piece of marble as the flat ones, for the sake of more perfect fit.

Traces of painting on various architectural members were found by Cockerell, but they were too much faded for the colours to be distinguished. The designs are the usual Greek patterns—the fret. the honeysuckle. and the egg and dart.

The sculpture is of the greatest interest, having been designed to decorate one of the finest buildings in the Peloponnesus in the latter half of the 5th century B C.

The frieze acquired by the British Museum is complete: it is nearly 101 ft. long by 2 ft. high, carved in relief on 23 slabs of marble $4\frac{1}{2}$ to j in. thick. The subjects are the battle of the Lapithae and the Centaurs; and that between the Amazons and the Greeks, the two favourite subjects in Greek art of the best period. They are designed with wonderful fertility of invention, and lifelike realism and spirit; the composition is arranged so

as to form a series of diagonal lines or zigzags M, thus forming a pleasing contrast to the unbroken horizontal lines of the cornice and architrave. The various groups are skilfully united by some dominant line or action, so that the whole subject forms one unbroken composition.

The relief is very high, more than $3\frac{1}{2}$ in. in the most salient parts, and the whole treatment is quite opposite to that of the Parthenon frieze, which is a very superior work of art to that at Bassae. Many of the limbs are quite detached from the ground; the drill has been largely used to emphasize certain shadows, and in many places, for want of due calculation, the sculptor has had to cut into the flat background behind the figures. From this it would appear that no finished clay-model mas prepared but that the relief was sculptured with only the help of a drawing. The point of sight, more than 20 ft. below the bottom of the frieze, and the direction in which the light fell on it have evidently been carefully considered. Many parts, invisible from below, are left comparatively rough. The workmanship throughout is unequal, and the hands of several sculptors can be detected. On the whole, the execution is not equal to the beauty of the design, and the whole frieze is somewhat marred by an evident desire to produce the maximum of effect with the least possible amount of labour — very different from the almost gem-like finish of the Parthenon frieze. Even the design is inferior to the Athenian one; most of the figures are ungracefully short in their proportions, and there is a great want of refined beauty in many of the female hands and faces. It is in the fire of its varied action and its subtlety of expression that this sculpture most excels. The noble movements of the heroic Greeks form a striking contrast to the feminine weakness of the wounded Amazons, or the struggles with teeth and hoofs of the brutish Centaurs; the group of Apollo and Artemis in their chariot is full of grace and dignified power. The marble in which this frieze is sculptured is somewhat coarse and crystalline; the slabs appear not to have been built into their place but fixed afterwards, with the aid of two bronze bolts driven through the face of each.

Of the metopes, which were 2 ft. 8 in. square, only one exists nearly complete, with eleven fragments; the one almost perfect has a relief of a nude warrior, with floating drapery, overcoming a long-haired bearded man, who sinks vanquished at his feet. The relief of these is rather less than that of the frieze figures, and the work is nobler in character and superior in execution.

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PHILADELPHIA, the Greek name of the ancient Rabbath-Ammon, in Eastern Palestine, commemorating Ptolemy Philadelphus (285–246 B.C.), mod. 'Ammân. Alexander Jannaeus (102–76 B.C.) although lord of the rest of the land east of the Iordan never conquered Philadelphia. With the coming of Pompey (63 B.C.) Philadelphia was made a member of the Decapolis. When Trajan set up the *Provincia Arabia* (A.D. 106) he assigned the town to the new province and Philadelphia advanced with Bostra to greater might and prosperity. Its extensive ruins include a Byzantine basilica, baths, theatre, citadel, temple, etc. (E. Ro.)

PHILADELPHIA, the largest city of Pennsylvania, U.S., known primarily. perhaps, for its high place in U.S. history, but also one of the principal cities of the northeastern United States. In the first part of the 20th century it showed one of the most rapid rates of population growth among the major U.S. cities, its industrial growth was proportionately high and it became a leader in devising redevelopment programs to deal with the urban problems characteristic of the 20th century.

The 1950 population of the city proper was 2,071,605, a 14.6% increase over the 1940 population. Like most other large U.S. cities. Philadelphia lost population in the following decade; the 1060 census figure was 2,002,512, a decrease of 3.6%. For comparative figures for certain other years, see table in PENNSYLVANIA: *Population.* The 1960 population of the standard metropolitan statistical area. which includes Bucks. Chester, Delaware, Montgomery and Philadelphia counties in Pennsylvania and Burlington, Camden and Gloucester counties in New Jersey, was 4,348,897, an 18.5% increase over 1950. Within the metropolitan area as defined by the census bureau are the cities of Chester and Norristown (*qq.v.*) in Pennsylvania and Camden (*q.v.*) in New Jersey. The suburbs reach out far to the north and south virtually to meet those of New York city and Baltimore. for Philadelphia is a part of the almost unbroken urbanized region which has come to extend along the Atlantic coast from Maine to Virginia.

Philadelphia's eminence resulted to a large extent from its geography. Its central and oldest section lies on a peninsula between the Delaware and Schuylkill rivers. Although it is 88 nautical miles from the Atlantic ocean, the broad Delaware river and bay ensured ready access to the sea and made the city one of the leading U.S. seaports. Furthermore, Philadelphia occupies the place where the principal roads from New Tork city southward run close to the Delaware just after crossing it; an Indian trail followed this route even before the coming of the white men. Thus the city is important to inland as well as to nautical communication. The valleys of the Schuylkill and of other tributaries to the Delaware, finally, have always given Philadelphia avenues to the rich agricultural, mining and industrial areas of eastern Pennsylvania.

From the peninsula between the Delaware and the Schuylkill, where the centre of the city lies, Philadelphia stretches north and south along the Delaware to a total river frontage of 23.7 mi. Inland its extension varies from 5 mi. to 15 mi. The topography of the city is largely of a sort more characteristic of New Jersey than of the Pennsylvania hills to the west, since much of it occupies the Atlantic coastal plain. The southern extremity, the Tinicum lowland, is protected by dikes, for in places it is more than 5 ft. below high tide. The greatest part of the coastal plain rises gradually from the Delaware to a height of about 150 ft. above sea level at the fall line. There, in the western extremities of the city, communities such as Roxborough and Chestnut Hill climb hills of the Piedmont plateau, reaching an elevation of about 400 ft.

History.—Of the important Atlantic coastal cities, Philadelphia was the last to be established, in part because navigation of Delaware bay and the Delaware river presented severe problems to early mariners. The entrance to the bay was a dangerous open roadstead, which until the building of the immense Delaware breakwater in the early 19th century continued to claim hundreds of ships. The channel of the bay and river were uncommonly intricate, so that even after numerous improvements, Delaware pilots are oiten known as the most skillful on the Atlantic coast.

Giovanni da Verrazano may have seen Delaware bay in 13'24 and Henry Hudson is known to have reached its mouth in 1609. Thereafter various explorers traveled up the bay and the river until sufficient interest was stimulated lo lead to settlement attempts by the Dutch and the English in the 1630s. The first permanent white settlements in what is now Philadelphia were planted in the 1640s by the Swedes, whose interest in the region had been aroused by certain dissidents from the Dutch West India company who believed their company had not been sufficiently energetic in exploiting the Delaware country. In 163'5 New Sweden surrendered to a Dutch expedition from New Amsterdam, but from the brief Swedish colonial effort came a population of about 2,000 Swedes and Finns who inhabited the Delaware area by the 1680s, including the community in what is now South Philadelphia which was later to build Old Swedes' church.

The reign of the Dutch also proved brief. ending when New Netherland surrendered to the English in 1664. Thereafter the early history of the city of Philadelphia is inseparable from that of the state. (*See* also PENNSYLVANIA: *History.*) On March 4, 1681, William Penn received from Charles II, out of friendship with the king and the duke of York and in payment of a debt of L16.000 owed by the king to Penn's father, his charter for a colony to lie north of Maryland and west of the Delaware. As a Quaker leader. I'enn planned in his colony a "Holy Experiment," where men of his own religious sect and of other persuasions might find

freedom of the mind. Soon he sent out surveyors who were to plat a city along the river, which Penn envisioned as the capital and metropolis of his colony. He instructed the surveyors to choose a high, dry and healthy site, one where ships might well ride, and if possible one where a navigable creek flowing into the Delaware would lend further encouragement to commerce. When the surveyors reached Pennsylvania, they found such a site at the peninsula formed by the flow of the Schuylkill into the Delaware. The Lenni-Lenape Indians of the area called this place Kué-quenáku or, as the white men more commonly rendered it, Coaquannock, meaning "grove of tall pines." Penn, however, had already selected his own name, one with both classical and biblical associations and with a meaning appropriate to his purpose: Philadelphia. Passages in the Book of Revelation refer to the city of Philadelphia in Lydia in Asia Minor. That city was worthy of remembrance as the seat of one of the seven early Christian churches, and its name signified brotherly love.

Penn enjoined his surveyors and other agents so to plan Philadelphia that it should be "a greene countrie towne which will never be burnt, and always wholesome." Each house, Penn instructed, ought to be placed in the middle of its plot, with garden, orchards and fields around it. The streets were to be laid out in a straight and regular pattern, reserving spaces for markets and squares — instructions scrupulously obeyed by Thomas Holme, Penn's surveyor-general. Holme's town plan formed a perfect checkerboard, to which the streets of central Philadelphia have generally continued to adhere.

William Penn himself sailed to his colony and city late in 1682, arriving in the ship "Welcome" inside the Delaware capes on Oct. 24 and proceeding thence, probably by barge from Chester, to Philadelphia. He remained only until the political and business problems of his colony called him back to England in Aug. 1684, but during his brief stay he was able to uitness a remarkable gronth of his city and colony. His policy of religious freedom together with his astute advertising of the potential uealth of Pennsylvania began to attract a large and multinational immigration which was to make Pennsylvania the prototype of the American melting pot. Swedes and Finns were already present; Englishmen and Welshmen, especially Quakers, came in large numbers; and the interest awakened by Penn's travels in Holland and Germany brought from those areas German Pietists, religiously akin to the Quakers, who were the vanguard of the great German migration to colonial Pennsylvania. Whatever part of Pennsylvania was their destination, most immigrants landed in Philadelphia and many of them stayed there. By the time Penn departed in 1684 there were 357 houses in Philadelphia, many of them "brave brick houses." By the next year, there were said to be 600 houses, and in that year the population of the colony, centring on Philadelphia, was estimated at more than 7.000. When Penn returned to his colony in 1699, for another two-year stay, he found that population growth already had erased his "greene countrie towne." His governors had felt compelled to divide and subdivide the city lots, and many of the owners had done likewise. The rich continued to enjoy lawns and trees but the middle class was coming to live in row houses facing each other across narrow streets, while the workingmen and their families occupied still more constricted quarters, often pressed into the narrow alleys behind the principal streets. As the 18th century began, Philadelphia was becoming the crowded city of narrow red brick houses which it was to be through the revolutionary period. Remains of this period can still be seen in such places as Elfreth's alley.

The *Metropolis* of Colonial America. — By the time of Penn's second visit the economic pattern of 18th-century Philadelphia was becoming plain. Like all the cities of colonial North America, Philadelphia built its economic life upon a commerce aimed at bringing to the new world the manufactured goods of the old world. Philadelphia was well supplied with commercial resources which. as the 18th century progressed, enabled it to become the wealthiest and most populous city of British North America.

For the export trade Philadelphia could draw upon the produce of the fertile farmlands stretching from the Delaware to the Susquehanna and beyond, a region which through the early 18th century filled up with skillful and industrious German farmers and then, farther west, with Scotch-Irish settlers. Wheat, corn, hemp, flax, beef, pork and timber products reached Philadelphia from the Pennsylvania hinterland. By the second third of the 18th century iron furnaces and forges up the Schuylkill and farther west were adding another product to Philadelphia commerce. From the neighbouring provinces of New Jersey and Maryland, from the Delaware counties and in time even from the Shenandoah valley of Virginia came still more agricultural products.

Much of Philadelphia's export trade sailed to the West Indies, where foodstuffs u-ent to the plantations in exchange for sugar, molasses or rum. Directly or indirectly the sugar trade in turn gave Philadelphia merchants staples which they sold in England and there bought manufactured goods. A brisk wine trade developed with the Madeiras. In time of war with France, *i.e.*, continually through Philadelphia's colonial history, many of the West India traders were not above turning to privateering; even certain Quaker merchants seem to have formed connections with privateers. Whether righteous or not, this activity also brought swift increments of wealth. In 1696 the governor of the province reported that "Philadelphia in fourteen years is become equal to the City of New York in trade and riches." Customs receipts increased from £1,500 in 1699 to £8,000 in 1702. By the middle years of the 18th century, Philadelphia was surpassing even Boston in volume of commerce.

Often overlooked, but of equal importance with Philadelphia's \Vest India commerce and more important than her trade with Europe, was her coastwise commerce. By the 1730s Pennsylvania had become the granary for the tobacco and rice colonies of the south as well as for the West Indies. In addition and more important, Philadelphia had developed an exceedingly profitable business with New England, which produced neither wheat nor bar iron sufficient to its needs; therefore these products sailed from Philadelphia to the colonies to the north in exchange for merchandise, coins and bills of exchange. In 1752, 103 vessels cleared Philadelphia for New England. The favourable balance of this trade in the mid-18th century amounted to over £52,000 annually.

Philadelphia manufactories began to develop both as a result of the city's commercial growth and as a cause of further growth. After 1725 the Delaware valley became a shipbuilding centre; in 1726 the Delaware yards turned out only 7 ships but during the next decade and a half they built 380 vessels. The yards were soon the most extensive in the colonies. The demands of the port stimulated cooperage establishments. Flour mills appeared in the city and in 1690 the first American paper mill began to operate along the Wissahickon creek. By 1718 the cordwainers (workers in leather) were numerous enough to incorporate a craft. Fourteen rum distilleries, three steel furnaces and an anchor forge, four carriage and wagon shops, an establishment for the manufacture of fire engines and a glass works soon appeared. A distinct merchant class developed but there also emerged a growing lower class of mechanics and artisans.

With urban growth came civic improvements. In the mid-18th century Philadelphia ceased to be a wilderness outpost and became a community whose appearance rivaled that of European cities of comparable population. Public street-lighting was instituted in 1752 and in the 1760s the streets began to be paved, while 500 public pumps were set up to supply the citizens with water. Public buildings of substantial size began to appear, many of which had grace as well as size and were among the architectural achievements of colonial America. Most notable was the state house, now known as Independence Hall, the construction of which began in 1732. Attorney General Andrew Hamilton had drawn up plans for a civic centre and shared with master carpenter Edmund Woolley the designing of the building itself; in it they gave Philadelphia an imposing structure of balanced masses in the 18th-century style.

During the 18th century the population of Philadelphia spilled beyond the original northern and southern boundaries, Vine street and South street, to form the suburbs of Southwark, the Northern Liberties, Passyunk and Moyamensing. The total population of

the city and suburbs grew from 13,000 in 1740 to 22.000 in 1760 and to 40.000 by 1775. By that time Philadelphia was the largest city in the colonies (by about 15,000 persons) and in size probably ranked second only to London among empire cities.

By the 1770s Philadelphia was a centre of learning and culture as well as of trade and industry, not only by American standards but by European as well. Its growth in these directions had once been slow; in the beginning, of course, its settlers were too busy wresting a livelihood from the wilderness to bother with things of the mind, and even as late as the 1720s visitors were impressed with the way in which business swallowed up all other concerns. But a new era was coming. Historians often regard 1726 as marking the beginning of the change, for in that year Benjamin Franklin returned to the city from his first visit to England, still an obscure printer but destined to become the civic leader of Philadelphia and to guide his city into new paths of intellectual achievement. Among his contributions to the cultural life of colonial Philadelphia were his organization of certain' alert and ambitious young mechanics of the city into the mutual improvement society which became the Junto; his assistance in the development of the Library Company of Philadelphia, the first subscription library in America, out of the Junto; and his leadership in the foundation of the American Philosophical society and in the establishment and growth of the Philadelphia academy, out of which the University of Pennsylvania was to arise.

But important as he was, Franklin was merely first among equals in a general cultural awakening. The way for Franklin had been prepared (albeit by a man who did not like him) by James Logan, William Penn's secretary, the collector of a private library of more than 2,000 volumes. Among Franklin's Philadelphia contemporaries were the botanist John Bartram, correspondent of Linnaeus; the physician John Morgan, who first discovered that pus is a secretion of the blood vessels; Ebenezer Kinnersley, who rivaled Franklin as a pioneer investigator of electricity; and the astronomer David Rittenhouse. a leader in the observations of the transit of Venus across the sun in 1769 which were of great importance in determining the parallax of the sun. In the arts and letters, Benjamin West ventured his first artistic efforts in Philadelphia; Thomas Godfrey, Jr., wrote the first American tragic drama; and the literary circle which formed around Provost William Smith of the College of Philadelphia is worth mentioning if only to call attention to Smith, a man whose personal efforts did much to make Philadelphia an intellectual centre.

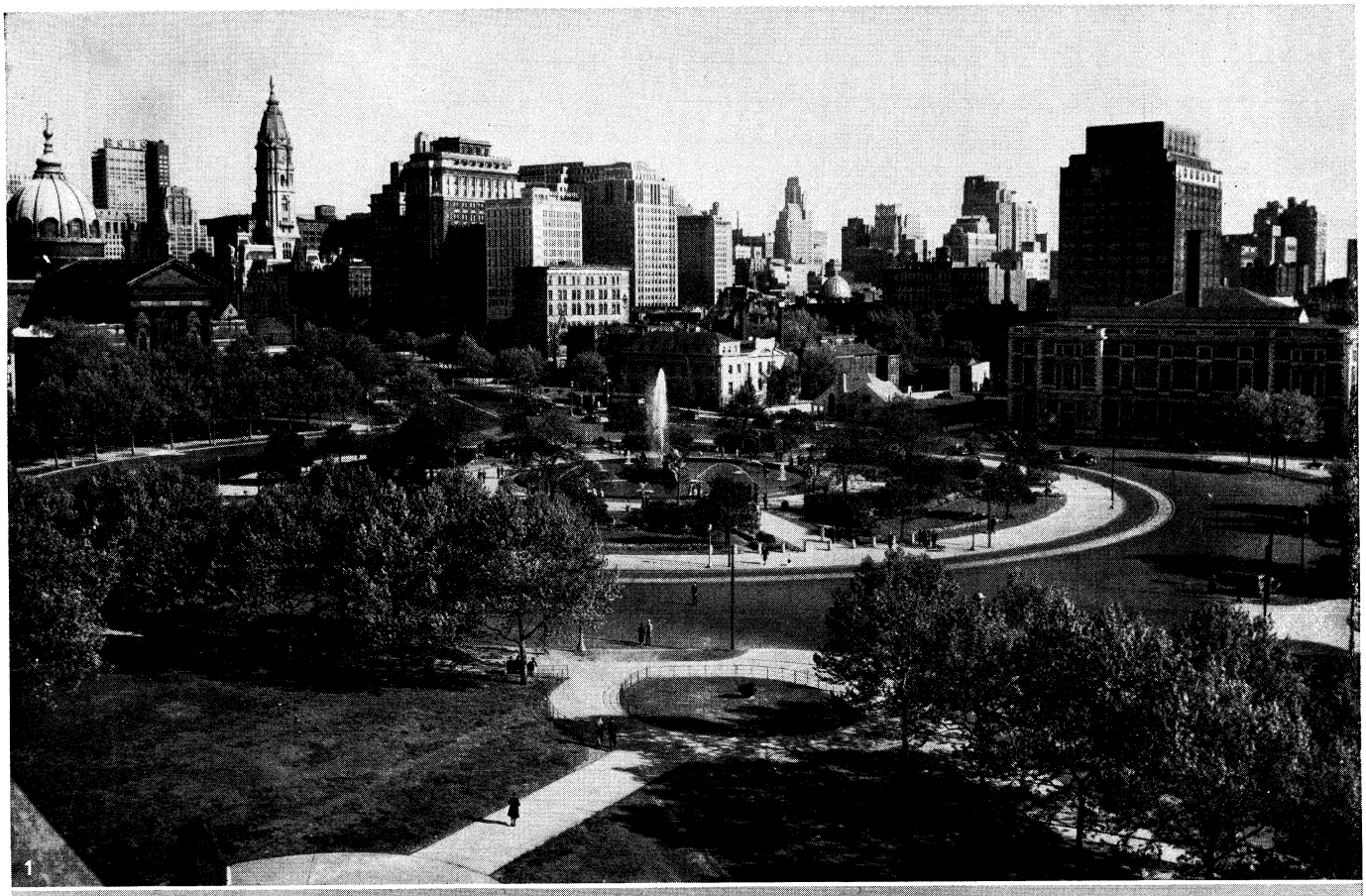
Colonial and Republican Capital. — Its general prominence. together with its central location, led to the selection of Philadelphia as the meeting place of the first continental congress in 1774 and the city embarked on its turbulent revolutionary career. The first continental congress met in Carpenters' hall, and there drew up the continental association and the Declaration of Rights and Grievances, steps which led the colonies almost directly into war against the mother country. In 1775 the second continental congress met in the state house, acknowledged the fighting around Boston by organizing the continental army under the command of George Washington and, by thus embarking on rebellion, took the course which led to the adoption of the Declaration of Independence the following year. The role of Philadelphia as the headquarters of the revolutionary government made it the objective of the British general Sir William Howe's campaign of 1777; after Howe defeated Washington's forces south of the city the congress fled and Philadelphia was occupied by the British through the winter of 1777–78. The continental army camped outside the city at Valley Forge, and fighting occasionally flared up at such places as Germantown and Barren Hill on the outskirts. In the spring of 1778, a change of generals and of war plans led the British army to evacuate the city and to return across New Jersey to New York, opening the way for the reconvening of the congress in Philadelphia.

The British occupation underlined the fact that the American Revolution made Philadelphia a city much divided within itself. Certain leading families were obviously not unhappy to welcome the British, and many Philadelphians participated gladly in the gay social season which the British officers improvised. Many Philadelphians, like many other Americans throughout the colonies, could not easily abandon the loyalty nhich as British subjects they had always felt to the crown. Mixed with their emotions of loyalty, furthermore, was the resentment which many members of the upper classes had come to feel toward a Revolution, which in Philadelphia had become peculiarly the cause of the lower classes, the mechanics and artisans. By the opening of the Revolution, Philadelphia society had become distinctly stratified. The growth of commerce had been highly profitable to some Philadelphians and had opened wide economic divisions nithin the population, so that social and economic leadership was held tightly by a comparatively small group of merchants, professional men and proprietary agents. Political leadership resided in the same hands, since the franchise was limited to men who possessed a freehold estate or personal property to the value of £50. By 1776 only about 1 in 50 of the male inhabitants could cast a ballot. The political power of the upper class further enhanced its economic power, for the city government frustrated competition from below through its regulations of markets, auctioneers and peddlers. When the Revolution broke out, the aristocrats, naturally conservative, hesitated to endorse the movement. But the mechanics, artisans and labourers took advantage of that hesitation to discredit the aristocrats as an unpatriotic class and thus to make the independence movement also a movement for increased democracy. They joined with equally discontented farmers from the back country of Pennsylvania to establish the radical Pennsylvania constitution of 1776, which allowed every adult male taxpayer to vote and hold office in the state government. It was against this background of a rising of the lower classes that much of the Philadelphia aristocracy welcomed the British occupation in 1777.

The end of the occupation brought back to Philadelphia both the continental congress and the ambitious local democratic party, but the withdrawal of the British and the eventual American victory in the Revolution did not open the way for the unmitigated triumph of either group. The continental congress was transformed into the congress of the Articles of Confederation, and during the 1780s that congress, meeting sometimes in Philadelphia but sometimes elsewhere, sank gradually into impotence. The success of the Pennsylvania and Philadelphia democrats in the state constitution of 1776 gradually gave way before a counter-revolution which culminated in the conservative state constitution of 1790. The economic power and social prestige of the Philadelphia aristocracy emerged from the war largely unimpaired, and these elements aimed at a substantial recapture of political power. In 1789 the state assembly passed an act of reincorporation of Philadelphia which was considerably more democratic than the colonial charter but nevertheless favourable to the merchant aristocracy. The vote mas restricted to freeholders, who elected 30 common councilmen for three-year terms and 15 aldermen for seven-year terms. The aldermen chose the mayor from among their own number. Significantly, the first mayor under the new government, Samuel Powel, had also been the last mayor under the colonial charter.

As for national affairs the Constitutional Convention laboured in the Philadelphia state house during the summer of 1787 with the Philadelphians Benjamin Franklin and James Wilson among its most influential members. The congress of the new government first met in New York city, but in 1790 it voted to establish the seat of the new government at Philadelphia for ten years before moving to the permanent capital on the Potomac river.

The decade 1790–1800, when Philadelphia was once again the U.S. capital, constitutes something of a golden age in Philadelphia history. Political, economic and cultural leadership of the new nation were all concentrated in Philadelphia. Congress and the US, supreme court sat in new buildings flanking the state house. Presidents Washington and John Adams maintained a republican court, centring on the president's mansion on Market street near Sixth, whence Washington proceeded through the streets in a cream-coloured French coach, ornamented with cupids and flowers. The leaders of the new nation combined with the aristocracy of the city to give Philadelphia a social life distinguished



PHOTOGRAPHS, EWING GALLOWAY

1. The skyline of Philadelphia as seen over Logan circle

2. The Philadelphia Museum of Art, with the buildings of the Philadelphia aauarium in the middle distance

for its conversation as well as for its gaiety and glitter.

The Philadelphia economy had by this time readjusted from the dislocations of the Revolution and was growing at least as rapidly as before the war. The shipyards were prospering, building vessels of such quality that even Boston, New York city and Baltimore papers advertised ships "built of the best white oak and finished off in the neatest manner on the Philadelphia plan." The US. navy yard had been established, building during the 1790s the frigate "United States," on the plan provided by the Philadelphia designer Joshua Humphreys for six sister ships, including the "Constitution." The merchant ships built in Philadelphia yards and sent out by Philadelphia merchants ventured into new quarters of the globe. Thomas Willing was instrumental in organizing the Philadelphia, Boston and New York city venture which in 1784 sent the first American trading ship to China, and thereafter until the middle of the 19th century the city uas responsible for one-third of the China trade of the United States. Philadelphia traders, at last outside the British navigation system, found new ports in Europe; coastwise trade also continued to expand. In 1793 the total value of Philadelphia exports was $6,958,736, exceeding those of all New England by $1,717,572 and of New York city by $2,934,370. Behind Philadelphia trade still stood the wealth of the hinterland, which in 1790, for example, sent 150,000 bu. of wheat to the metropolis from the upper Susquehanna country alone.

The Philadelphia golden age of the 1790s was not without a few scars. During the early years of the decade mechanics and artisans aroused by the French Revolution became increasingly noisy in their discontent with the conservative turn of C.S political events, to the point where some alarmed property owners began to fear new violence. Conservatives and democrats alike suspended political agitation. however, in the face of the great yellow fever epidemic of 1793, in which perished between 4.000 and 5,000 people, $\frac{1}{10}$ of the city's total population.

Meanwhile Philadelphia moved to leadership of the new nation in still another area, finance. Prerevolutionary America had possessed no banks in the modern sense of the term, but from the establishment of the first such institution, the Bank of North America, in 1781, the growth of an American banking system was rapid. The Bank of North America nas chartered by the Confederation congress largely at the urging of Robert Morris, its principal purpose being the financing of the Revolution. Its location in the city assured Philadelphia's position as the first financial centre of the United States. State-chartered banks quickly followed in various places and the charter of the Bank of North America was suspended briefly during the 1780s; but the priority of Philadelphia in banking plus its general economic leadership gave the city continued financial pre-eminence. For this reason as well as because Philadelphia was the national capital, the first Bank of the United States was established there in 1791 and remained even after Philadelphia ceased to be the political capital. After the charter of that bank expired in 1811, state-chartered banks reassumed first place in a financial world of which Philadelphia remained the centre. Stephen Girard of Philadelphia emerged as the principal financier of the War of 1812 and nhen congress chartered a second Bank of the United States in 1816 it was located in Philadelphia. Through the second bank and the activities of Girard, Philadelphia retained financial leadership until the 1830s. despite the fact that by that time economic supremacy in other matters had passed to New York city.

The *19th* Century.—By Andrew Jackson's presidency the golden age of Philadelphia had long since ended. The U.S. capital moved to Washington in 1800 and the capital of Pennsylvania already had departed from Philadelphia in 1799. The removal of the federal capital cast something of a shadow upon Philadelphia's cultural leadership. presently superseded by that of Boston and New York city. Philadelphia culture in the 19th century was to be distinguished by the presence of such notables as the Peales, Gilbert Stuart, Thomas Sully, Henry Inman and Thomas Eakins in painting. William Rush in sculpture, William Strickland and Thomas U, Walter in architecture, and Walt Whitman as well as lesser lights such as Bayard Taylor and S. Weir Mitchell in literature. But the relative position of the city was far below what it had been; except possibly in painting, there was no longer in Philadelphia a community of national cultural leaders, but simply a collection of various individual luminaries.

Commercial ascendancy passed from Philadelphia partly because its port could not match New York city harbour. The approach to Philadelphia by water was far more difficult. the space for berthing of ships was limited and the port was on occasion impeded by ice in winter (the Delaware is fresh water at Philadelphia). The riches of the Philadelphia hinterland as compared with the narrow Hudson valley had more than offset the deficiencies of Philadelphia harbour during the colonial and early republican periods. but in the early 19th century there was opened to New York city a hinterland far richer and vaster than Philadelphia's: the old northwest, the Great Lakes and Ohio river country. Between Philadelphia and this region rose the barrier of the Appalachian mountains; between New York city and the northwest stretched the open avenue of the Hudson and Mohawk valleys. The completion of the Erie canal in 1825 added immeasurably to the already great convenience of that avenue. Promptly after the opening of the canal. the census of 1830 revealed that for the first time the population of New York city exceeded that of Philadelphia. Even earlier, in 1820, Philadelphia's exports had been only some $6,000.000 to New York city's $12,000,000, while Philadelphia imports had stood at $9,000,000 as against $23,000,000 for New York city.

Philadelphia did not yield its population and economic leadership without a contest. The city sought an answer to the Erie canal, a route of its own into the great valley beyond the mountains. Its effort to solve the problem was extraordinary, for the city promoted and helped to finance the completion of the amazing state-owned "Pennsylvania system" west to Pittsburgh. Beginning in 1834, passengers could travel from Philadelphia to Pittsburgh in 4 days, freight in 12–14 days, over a 394-mi. route combining railroads, canals and inclined planes.

Extraordinary, even heroic, as it was, the Pennsylvania system did not serve to recapture Philadelphia's advantage over New York city; the Erie canal was a more convenient freight-handling system. But even a westward transportation system equal to New York city's could not compensate for the inferiority of the Philadelphia port. This fact emerged clearly after the Pennsylvania railroad was completed to Pittsburgh in 1854; it became one of the great railroads of the world but New York city continued increasingly to outdistance Philadelphia in population, wealth and general economic importance.

With its national pre-eminence lost. Philadelphia embarked on a less spectacular career as a regional urban centre, but the city did not cease to be a major one; it remained second in size among U.S. cities until Chicago finally surpassed it in 1890. The agricultural wealth of the immediate hinterland remained and as the 19th century proceeded this area increasingly supplied industrial wealth as well. Philadelphia looked relatively less to its harbour and more to its inland resources to sustain itself. It developed its own manufactures. The textile industry was among the first to rise in the Cnited States as in other nations in the early stages of industrialization, and in that industry Philadelphia was a leader. By 1825 there were 33 cotton and woolen factories in the city and its vicinity, 20 of them alone working 28,750 spindles. Iron foundries and glass works also secured an early prominence. After 1831 Baldwin locomotives and, still later, Stetson hats carried the name of Philadelphia through the 19th-century world. Philadelphia shoes. especially women's shoes, won note throughout the United States. The city became the principal distributing centre for the anthracite coal fields of northeastern Pennsylvania. which after about 1820 began their era of prosperity. The relative loss of emphasis upon the sea did not bring the abandonment of the shipbuilding industry; the William Cramp and Sons Ship and Engine company, founded in 1830, became the principal builders of the U.S. naval vessels during the 19th century and the builders of merchant ships, foreign and domestic, as well.

With industrial growth, the city's population increasingly spilled over the political limits, which had not changed since the first

drawing of the town plan. These limits confined the city to an area of two square miles. Beyond that area, much of Philadelphia county was as densely populated as the city itself. There political subdivisions had sprung up haphazardly until the county included 29 such units, variously organized as cities, townships or boroughs; nearly all of them lay immediately adjacent to each other, constituting for all common-sense purposes a single city but frustrating each other through their political independence. In 1854 the Pennsylvania legislature at last acted to remedy this chaos, passing the Consolidation act, which annexed 28 of the 29 subdivisions into Philadelphia.

The city shared in one way or another in most of the principal national events of the 19th century. The influx of Irish and German immigrants to the United States during the mid-19th century called forth in reaction the first major American nativist movement. In Philadelphia, nativism culminated in a series of riots extending through the spring and summer of 1844, during which two Roman Catholic churches were destroyed by fire, seven civilians and two militiamen were killed and many more persons were injured. Earlier the slavery issue had led to antiabolitionist riots, and this issue continued to divide the city during the Civil War. Philadelphia Quakers had a long history of antislavery activity, but on the other hand prewar Philadelphia was a principal banking and mercantile centre for Southern agriculturalists and had many Southern business connections. Some Philadelphians supported the Union war effort only lukewarmly even after Ft. Sumter, but for the most part the city rallied with determination to the Union cause. Philadelphians followed the leadership of Jay Cooke in contributing to war finance, and their Unionism tended to become more pronounced after the Confederate invasion of Pennsylvania in 1863. The Union league was an expression of Philadelphia's support for the Union and membership in the league soon became a mark of status in the city.

Philadelphia was the site of the 1876 Centennial exposition commemorating the adoption of the Declaration of Independence. Financed largely by Philadelphia citizens, the exposition opened 180 buildings along the Schuylkill to more than 8,000,000 visitors. The emphasis of the exposition was upon industrial and commercial technology, in which the United States already ranked as a leading nation of the world.

Journalists remarked during the exposition that the political progress of the Gnited States since independence had not matched material progress; the era was that of "Grantism." The same comment applied to Philadelphia. After the Civil War, the Republican party used its record as a war party, its program of friendship with business interests and an astute cultivation of every city precinct to win a stranglehold on Philadelphia politics. Philadelphia and Pennsylvania were in the hands of the machine led first by Sen. Matthew Stanley Quay and then by Sen. Boies Penrose. In the 20th century a local machine led by the brothers George A., Edwin H. and William S. Vare successfully challenged the statewide Penrose machine for control of Philadelphia, but with no change in the quality of city government. Lincoln Steffens not inaccurately described turn-of-the-century Philadelphia' in a phrase that has become a byword, "corrupt and contented."

The city remained contented in its corruption partly because the old problem which had led to the Consolidation act of 1854 had emerged again: population had spilled beyond the city's political boundaries. Many civic leaders moved into the suburbs and out of city politics. They worked in the city but did not live in it and they found bad government tolerable. At the same time the Philadelphia machine, like its contemporaries elsewhere. drew many of its votes from the new immigrants who came crowding into U.S. cities from southern and eastern Europe unprepared for the responsibilities of democratic citizenship. As in other U.S. cities, the new immigrants sought security by forming neighbourhoods along ethnic lines. The long history of many Philadelphia neighbourhoods as independent political entities made for an unusual degree of neighbourhood parochialism, and the forming of ethnic neighbourhoods intensified that tendency.

The 20th Century —In the 20th century, especially after World War I, the immigrants and their children gradually became leks docile voters. Other factors worked also to undermine the power of the city machine, not the least of which mas the growth in the 1930s of federal social welfare programs under the New Deal. Providing social security of various sorts in return for votes had been one of the bulwarks of all urban political machines; the federal government removed such welfare measures from local politics. For these reasons and others, by the mid-20th century traditional machine dominance had much decayed.

Furthermore, the decline of machine politics was only one of a complex of changes stirring in Philadelphia in the middle of the 20th century. By that time the phrase "corrupt and contented" was no longer so accurate; a new sense of civic responsibility had arisen. The citizens alnays had been proud of their city but that pride was becoming difficult to sustain. Rapid but unplanned industrial and population growth had created slums that were among the worst in the world. A real property survey made in 1934 disclosed that of 506,420 dwellings in the city, 19,035 were unfit for occupancy, while another 28,768 were in need of major repairs. About 19,000 houses were without bathing facilities of any kind. Many of the slum dwellings were of the distinctive "bandbox" type, three stories high but only one room wide and deep. Such were depression conditions in the 1930s, but the years during and after World War II scarcely lightened the housing problem. 4 large influx of Negroes injected racial issues into already serious difficulties and many parts of Philadelphia became overcrowded Negro ghettoes. At the same time Philadelphia suffered from the common problem of all urban centres in the automobile age, an accelerated decay of the central city as population, industry and even commerce moved into the suburbs. The only virtue in all these developments was that they made it impossible for proud citizens to remain contented; they stimulated the new sense of civic responsibility.

Civic Redevelopment. — The Philadelphia Redevelopment authority, established under a state law of 1945, was constituted under a board appointed by the mayor. Its purpose was to eliminate blighted areas and, in co-operation with both public and private enterprise, replace them with socially and economically sound projects. The authority mas to make use of federal, state and city funds. By 1955, 19 areas of the city, comprising about 11.5% of the total area and containing more than 20% of the population, had been scheduled for redevelopment. The activities of the redevelopment authority in such areas included construction of middle- and low-income housing, the rehabilitation of certain old row houses, the development of new industrial sites, the conversion of blighted areas into improved and enlarged campuses for several of the city's universities, the provision of new parks and playgrounds and projects for automobile parking and street widening. In many of its activities the redevelopment authority co-operated with the Philadelphia Housing authority, a similar agency outside the regular structure of city government, whose purpose was to clear slum areas and to build on slum and open sites safe and sanitary dwellings for low-income families. Meanwhile, private enterprise rebuilt part of downtown Philadelphia into a planned commercial area, Penn Center.

Thus Philadelphia sought to renew its blighted areas and to assure its citizens of adequate housing, and it made substantial progress toward those goals. But social problems spawned during several centuries of unplanned growth could not be remedied in a decade or tno; large blighted areas remained and new ones tended to appear as old ones were eliminated. Furthermore, new housing alone could not cope nith the fact that much of the city's housing problem was also a problem in race relations. Viewing the growth of an already large Negro minority (about 25% of the population in 1960), city leaders considered experiments which mould seek to prevent new housing developments from becoming Negro ghettoes.

Government. — Important to the progress of the various redevelopment programs of the mid-20th century was a newly reorganized city government. From its first incorporation under William Penn. Philadelphia was governed under various charters, all drawn up by the Pennsylvania legislature. After the Revolution, the charters tended to model the structure of municipal

government upon the state and federal governments, with a bicameral legislature in the city council, an executive in the major and his elected and appointed assistants and a municipal judiciary. This system brought a multiplicity of offices and a diffusion of responsibilities grossly inappropriate to city government. Under the charter of 1885, for example, the bicameral city council grew to a total membership of 145, the largest municipal legislative body in the United States, so large that it tended to strangle its own usefulness. The charter of 1919 remedied this particular problem by creating a unicameral council whose membership ranged from 20 to 22. But the charter of 1919 still failed to meet the full needs of a modern city, especially in that the mayor remained too weak an executive to assure efficient or even honest administration.

Philadelphians came to conclude that what their city required was a charter drawn up by its own inhabitants, who understood their own needs. A fight for such a charter vent on sporadically after 1922, when an amendment to the state constitution made possible municipal home rule. In 1951 the efforts of a local Committee of Fifteen combined with revelations of embezzlements by city officeholders to bring the movement for reform to a climax. In that year a special Philadelphia commission drew up a hoine rule charter, which was accepted by the voters; it went into effect early in 1952.

Under the 1952 charter, the administration is in the hands of a relatively strong mayor, elected for a four-year term. Executive responsibility is focused upon the mayor, who appoints and removes the principal administrative officers and controls expenditures. Furthermore, the mayor participates in the legislative function by recommending measures to the council, exerting his influence for their passage and exercising a power of veto which can be overridden only by a $\frac{2}{3}$ vote of the membership of council. The mayor formulates the city budget, with the council simply voting lump-sum appropriations to each agency. The council consists of 17 members, 10 of them elected from geographic districts and 7 elected at large. While the council's administrative poners are severely limited in order to assure the responsibility of the mayor, its legislative powers are broad; it can legislate on many matters vhich before 1952 required state legislative action, notably in the fields of public health and municipal salaries.

Most municipal activities are in the hands of 14 departments, which are co-ordinated by the mayor's four principal appointees: (1) the managing director, who supervises the departments of police, fire, streets, water, public health, public welfare, recreation, licenses and inspection, records and public property; (2) the director of finance, who conducts, under the mayor. budgeting, accounting and purchasing, and supervises the departments of collections and procurement; (3) the city representative, who is the city's chief public relations officer and heads the department of commerce, through it holding responsibility for wharf and airport facilities; and (4) the city solicitor, who heads the law department which gives legal advice to city agencies and represents the city in litigation. In addition, there are various independent or semi-independent boards and commissions, such as the civil service commission.

The school district is a governmental unit completely separate from the city government. In addition to the city government and the school board, five "authorities" created for special purposes outside the regular governmental structure operate within the city. These are the Philadelphia Housing authority, the Philadelphia Redevelopment authority. the Philadelphia Parking authority. the Philadelphia Airports Improvement authority and the Delaware River Port authority, the latter an interstate body.

Philadelphia courts are part of the judicial system of Pennsylvania and thus are constitutionally separate from the city government. Their structure is that which is common to all Pennsylvania judicial districts, with the exception that Philadelphia also possesses a municipal court, with limited jurisdiction over specified civil and criminal actions, and 28 magistrates' courts, which have jurisdiction in minor civil and criminal cases and hold preliminary hearings in more serious criminal cases.

An amendment to the state constitution was passed in Nov. 1951, consolidating the Philadelphia city and county governments, with all county agencies becoming city agencies. Subsequently there was a gradual integration of the former county offices into the structure of city government.

The home rule charter and the progress of city-county consolidation did much to give Philadelphia effective government. but they also left many problems unsolved. For example, the problem which the Consolidation act sought to solve in 1854 emerged again in aggravated form. In 1960 there were 625 governmental units in metropolitan Philadelphia on the Pennsylvania side of the Delaware alone. The tendency of this multiplicity of governments was to complicate such issues as police protection, water supply and urban transportation. There was an obvious need for some measure of general metropolitan area government; but there were many obstacles, both constitutional and traditional, in its path.

Industry, Commerce and Transportation. — Theleading industries are metals and metal products, textiles, food products and chemical and petroleum products. During the mid-20th century industrial expansion was especially noteworthy in the metals industry. with the establishment at Morrisville on the Delaware of a new plant of the United States Steel corporation intended for the processing of ore from Labrador-Ungava and Venezuela. In the early 1960s, there were over 1,500,000 persons employed in business establishments. Over 500.000 of them in manufacturing.

Railroads serving Philadelphia and its industries include the Pennsylvania, of which the city is the headquarters, the Reading and the Baltimore and Ohio. Truck and motorcar transportation proceeds from the city over a highway network dominated by the Pennsylvania turnpike to the west and the New Jersey turnpike to the northeast. The Philadelphia International airport brings to the city the services of transcontinental and trans-Atlantic air lines.

Although visitors are likely to remark that in no U.S. seaport is the presence of maritime activity less evident except in the immediate waterfront area. and although the harbour has long since ceased to be the major focus of Philadelphia commerce, the port continues active. The Delaware River Port authority supervises the second largest port in the United States, surpassed only by New Work city, and the largest fresh-water port in the world.

The trend in banking in Philadelphia as elsewhere in the latter part of the 20th century was toward consolidation into larger institutions. In 1950 there were 39 commercial and savings banks in the city; in 1960 there were 27.

Education. — The Quakers who founded Philadelphia were not devoted to education with the ardour of the Puritan fathers of New England. They favoured schooling in the rudiments of learning and in practical subjects but were inclined to regard higher learning as a form of worldly ostentation. Therefore they early founded elementary and some secondary schools but they did not hurry to do more. William Penn and his council hired a schoolmaster in 1683 and in 1689 leading Quakers established the Friends' Public school, now the Penn Charter school, which was intended to be open to students of poor families without fee. Not until the mid-18th century, however, was an institution approaching collegiate rank inaugurated. In 1755 various antecedents coalesced to form the College of Philadelphia. By that time the original emphasis on modesty in learning as in living had lost ground among many Philadelphia Friends and in any case the intellectual leadership of the city had passed largely to Anglicans and disciples of the Enlightenment. Once established, the college rose rapidly to prominence among kindred institutions of British America. It mas noteworthy among colonial colleges especially for the emphasis upon scientific studies and modern languages which its founders, including Provost William Smith, sought to place beside the traditional preoccupation with the classics. But it had to pass through further vicissitudes during the revolutionary era before it emerged as the University of Pennsylvania.

Meanwhile numerous private and church-related elementary schools and academies had made their appearance, with Germantown academy (1780) and Episcopal academy (1785) notable among the latter. During the late 18th century proposals for state-sponsored public education began to arise but it mas not until 1818 that Pennsylvania took a substantial step in that direction

by establishing in Philadelphia a school district where pupils might obtain education at public expense. By 1830 more than 34,000 children had received instruction. with girls between 5 and 13 and boys from 6 to 14 eligible for its free services.

The Philadelphia school district now maintains public schools through senior high school. The Roman Catholic diocese of Philadelphia maintains an extensive educational system, including elementary, special and high schools. There are in addition over 40 other private schools.

The University of Pennsylvania remains the largest educational institution in Philadelphia (see PENNSYLVANIA: *Education*), followed closely by Temple, a private university founded in 1888. Other institutions in the city include the College of Pharmacy and Science (1821); Jefferson Medical college (1825); Hahnemann Medical college (1848); Women's Medical college (1850); St. Joseph's, a Roman Catholic college for men (1851); the Protestant Episcopal Divinity school (1862); Lutheran Theological seminary (1863); La Salle, a Roman Catholic college for men (1863); St. Vincent's Roman Catholic theological seminary (1868); Drexel Institute of Technology, a private coeducational institution (1891); and Dropsie college for Hebrew and Cognate Learning (1907). In the metropolitan area are Haverford (1833), Swarthmore (1869) and Bryn Mawr (1880), colleges Quaker in affiliation or origin, and Villanova, a Roman Catholic university (1842).

Cultural Activities.— During the 18th century, Philadelphia led the British colonies in the establishment of libraries open to the public. In 1731 Benjamin Franklin and his associates founded the Library Company of Philadelphia, the first subscription library in America. Three other such libraries had been founded when the first public library in the colonies, the Loganian library, based on James Logan's collections, was opened in 1760. By 1792 the Library company had absorbed the other collections. Meanwhile the American Philosophical society had also begun a noteworthy library and the Pennsylvania hospital had established the first medical library in the United States. The 19th century witnessed the founding of the Philadelphia Bar Association Law library (1802), the Philadelphia athenaeum (1814), the German society library (1817), the Mercantile library (1821) and the Philadelphia City institute (1852). In 1891 was chartered the Free Library of Philadelphia, the present municipal library. In 1943 this institution received custody of the Library company and the Loganian library, and in the following year of the Philadelphia City institute and the Mercantile library, thus establishing a unified system. Among the approximately 280 private and special libraries in Philadelphia, that of the University of Pennsylvania is outstanding. The libraries of the Historical Society of Pennsylvania and American Philosophical society are especially rich in documents relating to American history.

Philadelphia was also something of a pioneer among U.S. cities in the establishment of museums; soon after the Revolution Charles Willson Peale, the artist, opened his famous museum in Independence Hall, a hodgepodge collection of stuffed animals, a mastodon skeleton, curious gadgets and portraits of American patriots; in assembling it Peale apparently was unable to decide whether his chief purpose was education or entertainment. Most of the portraits remain in Independence Hall.

Philadelphia has attempted to sustain the artistic tradition begun by Charles Willson Peale and. before him, Benjamin West. There are in the city about 40 art associations, schools, museums and collections. public and private. The Pennsylvania Academy of the Fine Arts, oldest art institution in the United States, dates officially from a charter of 1805, but unofficially from Peale's efforts to organize an art school beginning in 1791. Its schools remain among the most distinguished in the United States. Thomas Eakins was long an instructor, and among those he stimulated were the artists of the Henri group, or the Ash Can school (see HENRI, ROBERT). The permanent collection of the academy is rich in examples of the evolution of U.S. art.

The Philadelphia Museum of Art, a huge Greek temple standing on the leveled top of Fairmount, offers collections giving a broad view of the development of art throughout history. It has noteworthy "period" rooms, outstanding special collections such as the Arensburg collection of 20th-century painting and much U.S. and Philadelphia material. Associated with it is the Philadelphia Museum School of Art, founded in 1877–78.

In the promotion of science, the American Philosophical society continues in the path opened by Franklin and his fellow scientific leaders of 18th-century Philadelphia. The Academy of Natural Sciences (1812), the oldest such institution in the United States, has sponsored numerous explorations, including Adm. Robert E. Peary's voyage of 1892 which proved that Greenland is an island. It maintains a museum in its headquarters building. The Franklin institute (1824) emphasizes the promotion of applied science and also maintains a large public museum.

The theatre in colonial Philadelphia, as elsewhere in colonial America, had to surmount obstacles both in public attitudes and in law in order to establish itself. Itinerant performers drew crowds to the outskirts of the city as early as the 1720s, but the usual date given for the establishment of the Philadelphia theatre is 1754, when Lewis Hallam's company arrived from London. Within little more than a decade, in 1766, the Southwark theatre was erected, and the next year occurred the performance of Godfrey's The *Prince* of *Parthia,* the first American tragedy. Thereupon the Philadelphia theatre entered upon a century of imposing development. The completion of the first Chestnut Street theatre in 1793 was an architectural as well as a theatrical event. The Walnut street theatre, opened in 1809, remains as the oldest existing theatre in the United States. The Arch street theatre (1828) became the most famous of all Philadelphia theatres, associated with Joseph Jefferson and the Drews. Late in the 19th century, however, a theatrical decline set in, as the Philadelphia stage became increasingly a satellite of the New York city stage.

Music in Philadelphia began with the German immigrants; the first recorded recital was given by German mystics, the Hermits of the Wissahickon, who in 1703 played the viol, oboe, kettledrum and trumpet at an ordination service in Old Swedes' church. During the heyday of the colonial city a wider musical interest developed. An Italian music master helped encourage the art; the first public concert mas given in 1757; and Francis Hopkinson emerged as the first American composer of any importance. Organized cultivation of music was a product of the 19th century, with the organization of the Harmonic society (1802), the Haydn society (1809), the Cecelia society (1824) and. most important, the Music Fund society (1820), which built its own hall in 1824 and established a school of music there. At this hall the principal performances took place until the opening in 1857 of the Academy of Music, which with its remarkable acoustics still serves as the centre of Philadelphia musical activities. It is the home of the Philadelphia symphony orchestra.

Hospitals.— Philadelphia has been a medical-surgical centre since the 18th century. The Pennsylvania hospital (1751) was the first to be established in the British colonies and it early distinguished itself especially in the study of mental diseases. The medical school of the University of Pennsylvania (1765) is the oldest in the country. A Philadelphia medical society was organized in 1768 and the College of Physicians and Surgeons was established in 1787; by the mid-20th century the latter society had gathered a medical library of about 175,000 volumes. There are more than 40 general hospitals and more than 30 special hospitals and dispensaries within the city.

Parks and Recreation.— The Philadelphia city park system of more than 7,500 ac. includes large and small parks scattered through the city, athletic fields and play areas, maintained by the board of education, and Fairmount park, supervised by a special agency of the city government. It comprises almost 4,000 ac. and extends 10 mi. along the Schuylkill river and Wissahickon creek, including within its boundaries the beautiful Wissahickon and Cresheim valleys, the Philadelphia Zoological gardens, oldest in the United States. Robin Hood Dell for summer concerts, 15 historic mansion houses, 2 surviving buildings of the Centennial exposition, more than 50 sculptural groups and figures and many miles of driveways, avenues, footpaths and bridle paths. Throughout the park system there are varied recreational facilities, including golf; baseball, football, swimming, boating and tennis. A

special board of trustees administers Convention hall, which can be used as an indoor sports arena. Independence Hall is now a part of the Independence National Historic site, 18 ac., administered by the National Park service since 1951. The Old Custom House, a fine example of Greek revival architecture and site of the second Bank of the United States, is also a part of the national park and monument system.

See also Index references under "Philadelphia" in the Index volume.

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PHILADELPHIANS, a sect of religious mystics, founded in London in the latter part of the 17th century. In 1652 John Pordage (1607–1681), rector of Bradfield, Berkshire, gathered together a few followers of Jakob Boehme, the chief of whom was Jane Lead or Leade (1623–1704). Mrs. Leade had been from girlhood of a mystical temperament, and experienced phantasms which she recorded in a diary entitled *A Fountain of Gardens,* beginning in 1670, in which year the Philadelphian society was definitely organized. In 1693 some of Mrs. Leade's writings were translated into Dutch, and by this means and her acquaintance with Francis Lee (1661–1719), an Oxford scholar who studied medicine at Leyden and became her son-in-law, a connection was opened up with Germany and Holland. In 1703 the Philadelphians drew up their confession. but they made no further progress and soon declined, the Dutch brand withdrawing and the English government forbidding the society to meet.

PHILADELPHUS, a genus of the Saxifragaceae (*q.v.*), with about 70 species and more than 100 horticultural varieties, characteristic of North America, southern Europe and eastern Asia. They are commonly known as mock orange and are often referred to as syringa, which, however, is the proper generic designation of the lilac. The characteristic odour is the chief reason for the selection of the name mock orange to designate these plants. They are all deciduous shrubs with opposite entire or toothed leaves, the pith being solid, the lateral buds hidden in the leaf axils. The often showy flowers are solitary or arranged in terminal or lateral racemes, always 4-merous, the petals mostly white, in some varieties somewhat purplish at the base, and with numerous stamens. The fruit is a capsule with many small seeds.

These shrubs are much planted in temperate regions because of their conspicuous white flowers which are frequently very fragrant. The species can be cross fertilized readily and much hybridizing has been done. Some of the species grow unusually well in dry soils and endure the trying conditions encountered in city gardens. The mock orange is subject to few insect pests and plant diseases and is thus justly popular as an ornamental plant. The growth habit is usually upright with arching branches, most of which originate at the base of the plant.

ROCHE

PHILADELPHUS, COMMONLY KNOWN AS MOCK ORANGE

Some varieties are not more than 2 ft. high, others attain a height of 15 ft.

The size of the flower and degree of fragrance varies. Some, like *Philadelphus hirsutus,* P. *pekinensis* and *P. subcanus,* have flowers only three quarters of an inch in diameter, while the flowers of such varieties as Belle Etoile, Bicolore and Argentine attain a size of two inches or even more. Many of the species have single flowers but in some hybrids such as Glacier, Girandole and Virginal the flowers are double.

Fragrance varies considerably. some species and varieties being odourless and others, like the old-fashioned P. *coronarius,* being very fragrant.

See A. Rehder, *Manual of Cultivated Trees and Shrubs* (1940). (E. D. MI.)

PHILAE, an islet in the Nile above the first cataract, of great beauty and interest, but after the completion of the Aswan dam in 1902 submerged except for a few months yearly, when the water was allowed to run freely through the sluices of the Aswan dam. Philae marks also the end of the cataract region. Ancient graffiti abound in all this district, and on Bigeh, a larger island adjoining Philae, there was a temple as early as the reign of Tethmosis III.

About 350 B.C. Nekhtnebf, the last of the native kings of Egypt, built a temple to Isis, most of which was destroyed by floods. Ptolemy Philadelphus reconstructed some of this work and began a large temple which Ptolemy Euergetes I completed, but the decoration, carried on under later Ptolemies and Caesars, was never finished.

The little island won great favour as a religious resort, not only for the Egyptians and the Ethiopians and others who frequented the border district and the market of Aswan, but also for Greek and Roman visitors. One temple or chapel after another sprang up upon it dedicated to various gods, including the Nubian Mandulis. Ergamenes (Arkamane), king of Ethiopia, shared with the Ptolemies in the building.

Besides the temple of Isis with its birth temple in the first court, there were smaller temples or shrines of Arsenuphis, Mandulis, Imuthes, Hathor, Harendotes (a form of Horus) and Augustus (in the Roman style), besides unnamed ones. There were also monumental gateways, and the island was protected by a stone quay all around with the necessary staircases, etc., and a Nilometer. The most beautiful of all the buildings, an unfinished kiosk inscribed by Trajan, became well known under the name of "Pharaoh's Bed."

The decree of Theodosius (A.D. 378), which suppressed pagan worship in the empire, was of little effect in the extreme south. It was not until the reign of Justinian, A.D. 527–565, that the temple of Philae was finally closed, and the idols taken to Constantinople. Remains of Christian churches were disclosed by the thorough exploration carried out in 1895–96.

The tops of most of the buildings and the whole nucleus of the temple of Isis to the floor remained all the year around above the water level until the dam was raised another 26 ft.—a work begun in 1907—when the temples were entirely submerged except during July–October. But the beauty of the island and its ruins and palm trees, the joy of travelers and artists, almost vanished.

PHILANTHROPY. Philanthropy, which literally means "love of mankind," is a term now often preferred to the older and more homely word "charity." It is a comparative newcomer to the English language and does not seem to have been commonly employed before the 18th century, though Jeremy Taylor used it in one of his sermons about 1650. In modern parlance it is usually, though not always. applied to charitable enterprises on a large scale, aiming at the prevention as well as the cure of human ills.

Charity in the form of personal almsgiving began with the dawn of civilization. The closely integrated primitive tribal community had no need of it, but as soon as human societies were sufficiently differentiated to admit of rich and poor, that need arose and was met by men and women inspired by natural kindliness, by a nascent sense of social justice, or, more usually, by religious belief Practically all religions have stressed the virtues of almsgiving. "She stretcheth out her hand to the poor; yea, she reacheth forth her hands to the needy," says the Book of Proverbs of the virtuous woman; and centuries before that book was written, the Egyptian *Book of the Dead* recorded of a good man that "He gave bread to the hungry, water to the thirsty, raiment to the naked; he gave a boat to a man who had none." "Whoso giveth

to the poor lendeth to the Lord," says an ancient Christian adage; and in every age pagans, Jews, Moslems and Christians alike have been influenced by the sincere belief that he who relieves suffering in this world lays up treasure for himself in the next.

If, as was undoubtedly the case, philanthropy began with direct almsgiving, it soon spread to wider fields. Rome's greatest contribution to medicine, the hospital, developed from a refuge for sick slaves that existed in republican times on an island of the Tiber. By the 1st century A.D. private hospitals or *valetudinaria* for slaves and poor freemen had come into being and these were followed by the public hospitals of the later empire. In Christian Europe, where the care of the sick was considered a primary religious duty, hospitals, lazar houses and refuges for the aged and disabled flourished throughout the middle ages. Among the most famous hospitals of this period were St. Bartholomew's (1123) and St. Thomas's (1215) in London, and the great house built in Rhodes by the knights of St. John of Jerusalem in the early 14th century.

Mediaeval philanthropists built or endowed churches, monasteries, schools, chantries, colleges, almshouses and hostels for pilgrims and travellers. Roads and bridges were also maintained by the gifts of the charitable. In some European countries bridges were the responsibility of the Frères Pontiffes, an order founded in the 12th century, but in England their work was mainly done by lay guilds, or generous individuals like Sir Hugh Clopton who built a stone bridge at Stratford-on-Avon in the 15th century, with "a long causey made of stone, low walled on each side" leading up to it. An inquiry held in 1343 at Wool, Dorset, revealed that "the bridge . . . is and always has been maintained by alms, and nobody is bound to maintain it."

Doles for poor men and wayfarers were a common form of bequest in mediaeval wills. Bells were often endowed for the guidance of benighted travellers, and for many other purposes; in 1344, for instance, Margery Doubleday, a Nottingham washerwoman, left all her small estate to endow a morning bell to awaken her fellow laundresses, and so save them from losing money through oversleeping.

The dissolution of the monasteries and chantries in the 16th century deprived the poor of much customary aid. including those schools which the suppressed chantries and collegiate churches had formerly maintained. The widespread interest in learning so characteristic of the period inspired many rich men to found or endow free schools in their place, such as Christ's hospital (1552), Hugh Sexey's two schools at Bruton, or the small school for poor boys which John Lyon established at Harrow in 1590, little dreaming that it would eventually become one of England's most famous public schools. "There are a great number of Grammar Schools throughout this realm," wrote Harrison in 1577, "and those very liberally endowed for the relief of poor scholars." Bequests for apprenticing boys to various trades or rewarding the faithful service of maidservants were also common at this time.

By the early 18th century, however. the general attitude toward the education of the poor had changed for the worse. Many people sincerely felt that it was unnecessary, and even dangerous, for poor children to learn more than their catechism and such useful arts as knitting, lacemaking or carpentry. Of the existing free schools some had deteriorated and many were poorly attended because the growing custom of employing young children in industry and farm work made parents unwilling to send them to school when they could be earning money. As a result, countless children grew up without teaching of any sort and many more would have done so had it not been for the strenuous efforts of enlightened philanthropists and charitable organizations.

The Society for Promoting Christian Knowledge (formed 1698) founded nearly 2,000 charity schools during the first century of its existence. In 1780 Robert Raikes opened a Sunday school in Gloucester and so started a movement which spread very rapidly throughout the country. In 1789 Hannah and Martha More, shocked by the virtual savagery of children in the Mendip hills, opened schools for reading. handicrafts and religious teaching. Some millonners, like the Gregs of Styal, ran classes for their child apprentices on Sundays, the only day when work did not go on from dawn till dusk. Parish clergymen and landowners in many districts maintained schools for local children at their own cost. In the first years of the 19th century the National Society for Promoting the Education of the Poor in the Principles of the Established Church throughout England and Wales (1811) and the British and Foreign School society (1814) were founded, and upon these two voluntary organizations the main burden of English elementary education rested until the passing of the education act in 1870.

The sweeping economic and social changes of the 18th and 19th centuries brought many new problems for the charitable, not the least of nhich was the question of the destitute and homeless child. Foundling hospitals for unwanted babies existed in some European countries as early as the 17th century, usually in connection with convents and other religious houses. In 1741 a similar institution was opened in London by Capt. Thomas Coram, who had more than once been horrified to see deserted babies lying by the roadside.

The Marine society was founded by Jonas Hanway in 1758 for rescuing vagrant boys and sending them to sea in the royal navy. In 1867 Thomas Barnardo started a children's home in Stepney Causeway, London, the first of many "Barnardo Homes" which have since rescued thousands of destitute boys and girls. Similar work was, and still is, carried on by the Waifs and Strays society (now the Church of England Children's society), organized by Prebendary Rudolf in 1881, and the National Children's home founded by Stephenson in 1869. The Fairbridge society organization began in 1909 when Kingsley Fairbridge conceived the idea of settling English children overseas and training them for healthy and useful lives in farm schools specially founded in Canada and Australia.

The desire to prevent crime and raise moral standards led many philanthropists to concern themselves with prison reform and the cure of prostitution and begging. In Bavaria the U.S.-born Count Rumford established a system of workshops. or "houses of industry," to provide work for beggars between 1785 and 1795. In London Robert Dingley and Jonas Hanway founded the Magdalen hospital (1758), where penitent prostitutes could be trained for a better life in what Dingley insisted was not to be "thought a House of Correction but an happy Asylum." Hanway also attacked the worst features of the English prison system, but it was not until John Howard published The State of the Prisons in 1777 that serious reforms were attempted.

Howard recommended many drastic changes, including hard labour and solitary imprisonment, with better accommodation, food and ventilation, and more frequent jail deliveries (*i.e.*, clearances of the jails in order that prisoners might be brought to trial). Though he was sincerely concerned for the health and welfare of prisoners, his general outlook was harsh and unsympathetic and some of his suggestions were too severe even for the unimaginative government of his day.

A more humane reformer was Elizabeth Fry who, in the early 19th century, began working among the prisoners of Newgate and later induced parliament to remedy some of the worst abuses, both in the prisons themselves and in the arrangements for transporting convicts to Australia. A smaller but very valuable achievement was that of Sarah Martin, a poor seamstress of Great Yarmouth who, by personal work and propaganda, succeeded in establishing a system of paid work for women in jail and opportunities for employment after their release. Her work, and that of Elizabeth Fry, was afterward carried on by voluntary committees.

Philanthropy throughout this period mas many-sided and vigorous. inspired by religion, patriotism and the many new needs created by the Industrial Revolution. In England the Society for Bettering the Condition of the Poor was founded in 1795 by Bishop Barrington; in France the now world-wide organization for the relief of poverty knoun as the Society of St. Vincent de Paul was started by Antoine Oxanam and Jean-Sylvain Bailly in 1833. In the same year Theodor Fliedner established an order of Protestant Deaconesses in Germany, at whose school at Kaiserswerth Florence Nightingale was trained as a nurse. There were

then no English training schools to which she could go, and it was the knowledge gained at Kaiserswerth which enabled her to perform the heroic nork among the wounded in the Crimea for which she is best knoun, and subsequently to devote the rest of her life to the creation of an efficient nursing service in both civil and military hospitals.

The career of Anthony A. Cooper, 7th earl of Shaftesbury was similarly devoted to the relief of suffering. but in his case philanthropy took the form of a long struggle against the many abuses of the contemporary industrial system. He was directly responsible for a series of acts of parliament nhich improved conditions in factories, protected women and children in industry, introduced badly needed reforms in mines and lunatic asylums and forbade the employment of "climbing-boys" by chimney sweeps. In addition, he did much to improve public health and housing.

Among others nho fought against the evils resulting from bad housing were the Baroness Angela Burdett-Coutts, whose modern lodginghouses in London's east end nere begun in 1856; George Peabody, an American living in London, aho created a fund for building uorkingmen's dwellings in 1862; and Octavia Hill, whose remarkable system of house property management, now known all over the uorld, started in 1864 with the experimental purchase, restoration and personal management of three verminous and decaying houses in Marylebone, the capital for which was advanced by John Ruskin.

The first Charity Organization society in the world was formed in 1869 by a group of notable Englishmen, including Lord Shaftesbury, J. H Newman and W E Gladstone. The pioneer university settlement. Toynbee hall, was established in Whitechapel by Canon S. A. Barnett in 1884. The Working Men's college in London came into being in 1854, largely through the efforts of John Frederick Maurice. The work of Elizabeth Gilbert among the blind inspired the foundation of the Society for Promoting the General Welfare of the Blind, and other associations existed to care for the deaf and dumb, cripples and other afflicted people. Jewish philanthropists were naturally concerned to relieve their oppressed coreligionists in various countries; in this sphere the work of Sir Moses Montefiore was specially remarkable, as was that of Baron Maurice de Hirsch, who established the Jewish Colonization association, one of the great philanthropic trusts.

The existence of slavery had begun to trouble the consciences of thinking men as early as 1671, when George Fox, founder of the Society of Friends, urged all Quakers in Barbados to free their own slaves. In 1787 William Wilberforce began his long campaign for the abolition of the slave trade and the emancipation of existing slaves. As a result of his work and that of Thomas Clarkson and others the transport of slaves in British ships was forbidden in 1807 and in 1833 an act of parliament freeing all slaves in British dominions mas passed only a few days before Wilberforce's death. Great Britain's example was followed by other nations and nithin a comparatively short time after the passing of the Emancipation act. slavery had vanished from most civilized lands and their dependencies. Wilberforce thus indirectly achieved a far-reaching reform in many countries besides his own, though he only lived to see the emancipation of British-owned slaves. Another great international achievement of the 19th century mas that of Henri Dunant, the Swiss founder of the Red Cross. Horrified by the suffering which he witnessed at the battle of Solferino (1859), he put forward the hitherto unheard-of idea that there should be an international body for the care of the sick and wounded in war. His proposals, upon which the work of all Red Cross societies is based, were embodied in the famous Geneva convention, which was accepted by the representatives of 16 nations meeting at Geneva in 1864.

The first half of the 20th century saw the rise of several great philanthropic trusts, some of which were international in character. In 1902 the Rhodes trust was founded by Cecil Rhodes to provide scholarships to Oxford university for students from all parts of the British empire, the United States and Germany. In 1910 Andrew Carnegie established the Carnegie Endowment for International Peace. Three years later he founded the Carnegie United Kingdom trust to assist charitable and cultural enterprises in the country from which his family had emigrated to America. Another U.S. foundation of the same nature was the Pilgrim trust, established by E. S. Harkness in 1930, which also helps British philanthropic societies and those concerned nith the preservation of beauty spots and places of historic interest King George's Jubilee trust, which caters for the needs of youth, was formed in 1935 on the occasion of George V's silver jubilee.

The many benefactions of Lord Nuffield cover a very wide field and have been specially notable in the spheres of medicine and education. The Nuffield Trust for the Advancement of Medicine was founded in 1936, the Provincial Hospitals' trust in 1939. In 1943 the Nuffield foundation was established for the advancement of health, the improvement of social \?ell-being and the care and comfort of the aged. Other funds were created for orthopaedic work in Britain and South Africa, for the provision of iron lungs for sufferers from poliomyelitis, and for the Nuffield Institute of Medical Research at Oxford. Among the best-known of Lord Kuffield's educational benefactions are the Dominion Scholarships fund and the erection and endowment of Nuffield college in the University of Oxford.

By the middle of the 20th century the governments of Great Britain, France and several other European countries had taken over a large part of the social relief work that once depended almost wholly upon charitable individuals or organizations. Statutory social services cannot, however, cover every human need and there are many gaps which modern philanthropy is concerned to fill. That the spirit of benevolence had not withered under conditions of state responsibility was clearly shown, not only by the great trusts and benefactions mentioned above, but also by the steady public support of innumerable societies for the betterment of human conditions and the protection of animals, and the unfailingly generous response to such emergency appeals as the Save the Children campaign in 1919 and the Flood Relief appeals in 1953.

Modern philanthropy may be said to have three main aims: the elimination of evils at the source by means of education, reform and pressure for parliamentary action; the protection and assistance of the distressed, especially those for whom the statutory services make no provision, or for whom such services would be unsuitable; and the general enrichment of the quality of life in all its aspects.

Among the many associations working for these varied ends are the National Council of Social Service (1919), a representative and co-ordinating body working through rural community councils and community associations in towns; the National Society for the Prevention of Cruelty to Children (1884), with its counterpart, the Royal Society for the Prevention of Cruelty to Animals (1824); the University Federation for Animal Welfare; the Red Cross, whose peacetime activities include welfare work of all sorts; the Distressed Gentlefolks' Aid association; the Discharged Prisoners' Aid society; the National Association of Boys' Clubs and the National Council of Girls' Clubs; and a wide range of other children's and youth organizations.

Besides these, there are many societies for the care of the aged and the physically handicapped, such as the Heritage Craft schools, the National Institute for the Deaf and the National Library for the Blind, which translates books into Braille. In addition, professions and trade unions often maintain benevolent funds for their onn members, like the Musicians' Benevolent fund, the Actors' Benevolent fund and those maintained by the services.

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(C. S. HE.)

UNITED STATES

The most impressive fact about philanthropy in the United States during the first half of the 20th century was the scale at

which it continued in spite of the vast expansion of government funds for education. health, research and welfare. The right to deduct the amount of giving up to 15% of personal income made giving less expensive. but a widespread and growing interest in private financial support of human services. independent of government operations, also played an important part.

As an attitude, philanthropy may be defined as devotion to human welfare. and, as an act of good will. it is a manifestation of freedom of choice in the use of private resources for the benefit of one's fellow men. The total amount of philanthropic giving in a year in the U.S. in the 1950s was not exactly known, but some fairly dependable estimates could be made.

The purposes for which the money is given is in large part a matter of record. The traditional objects of giving are education, fine arts. health. libraries. museums, research. religion and welfare. Huge sums were raised by private persons during and after World Wars I and II to relieve distress and to improve production of goods and services. Government does not contribute directly to religion and in only limited ways to the fine arts and museums. but it became the largest contributor after World War II to broad plans for human betterment in many lands.

Giving by government on a large scale to foreign countries is in a real sense collective philanthropy. The voters approve such giving, or congress would not vote the funds. This was something new. Sporadic gifts, like the remission of the indemnity received from China for damage to persons and property during the Boxer Uprising, had occurred, but nothing on the scale of the aid programs after World War II has ever been known. The U.S. government gave outright billions of dollars to people of other sovereignties on every continent after 1945.

The services to education, health. research and welfare performed by government for its own citizens is sociologically different from the governmental contributions to foreign nations. No reliable national figures for expenditures as far back as 1930 by local, state and federal governments for this kind of services existed in the late 1950s, but the amount in dollars of that year would be a small fraction of the dollars of 1954. In May 1954, about 11.000.000 persons received $774,000,000 in social insurance and veterans' payments. and 5,200,000 persons received $219,901,000 in public assistance payments. This was almost 10% of the total population, and the amount spent was about $6.00 per capita per month for the entire population of the country.

The objects of expenditures by philanthropy and government sometimes overlap. but are usually different. Obviously religion is an exclusive domain of private giving. and in large measure the fine arts and museums depend upon voluntary contributions. Experimentation with new ways of meeting the needs of people is always open to the "venture capital" of philanthropy. and basic research in the physical. biological and social sciences continues to he a favourite use of private gifts.

Giving by Living Donors.—People continually make contributions during their lifetimes. Sometimes they endow specific projects, but most living donors give 'money to pay the costs of ongoing operations of religious institutions, the fine arts, education, research or other enterprises.

Church giving by members is in some degree obligatory. but the amount is not fixed, as it would be in taxation. The Golden Rule foundation estimated that gifts to churches and synagogues in 1952 amount to about $2,196,000,000—about one-half of all gifts by living donors. The amounts spent for charity in both the Catholic and Jewish churches is large, and the Catholic church spends large sums on education., In 1950, F. Emerson Andrews reported that the Catholic church was operating 11,497 schools, colleges and universities in the United States. Alaska and Hawaii, a part of the cost of mhich was paid by current contributions.

Private contributions are made every year to both private and public institutions of higher learning. In its report for 1953–54 the U.S. office of education reported 1,851 institutions of higher learning in the continental U.S. and outlying territories, of which 1,205 were under private control. For the year 1947–48 Andrews estimated that the amount of contributions tciinstitutions of higher learning was $91,000,000. The amount going to private institutions was $77,000,000, which was about equal to the returns on their endowments.

The annual gifts to health and welfare organizations runs to about $1,800,000,000. The Golden Rule foundation estimated the amounts for 1952 as follows: health and hospitals, not counting allocations by community chests. $151,766,650; to American Cancer Society, Inc.. Heart association, Red Cross. CARE. Community Chests and Councils of America, Inc . National Foundation for Infantile Paralysis, United Defense fund, United Jewish Appeal and a few smaller national organizations. $1,632,217.560

Community chests require separate mention. There were in 1954, 1,627 community chests in the U.S which conducted annual campaigns for funds. Most of them are small, but they blanket the country and symbolize organized philanthropic giving outside the churches by living donors. The amount of contributions in 1954 was $273,503,300. (See also COMMUNITY CHEST; FOUNDATIONS, PHILANTHROPIC.)

Philanthropic Accumulations.—The largest amounts of philanthropic funds at any one time are held by foundations, endowed institutions and trusts. Large portions of the assets of such organizations are invested and produce income. Foundations are increasingly interested in new ideas and new programs rather than in construction of buildings for which much of their money was spent. Some funds of this sort receive additions to their capital assets by new gifts by the original donor or other donors. It is the aim of some foundations, such as the Julius Rosenwald fund. to give away both capital and interest in a limited period of time. Others set no time limit for their extinction.

More than 4,000 foundations probably existed in the U.S. in the late 1950s and they had assets of about $3,000,000,000 in 1954. Only five of these—Carnegie trusts, Duke endowment. Ford foundation. Pew Memorial foundation and the Rockefeller foundation—had more than $100,000,000 each in assets, but about 350 foundations had assets of more than $1,000,000 each. The amount of their annual benefactions was unknown. One of the oldest foundations. Rockefeller. made grants of more than $12,00,000 in 1952. The relatively old Russell Sage foundation. with assets of $14,431,514, appropriated $337,374 in 1953. The Field foundation, started in 1941, had assets of $12,435,415 and made awards of $621,023 in 1951. The Ford foundation was established in 1936, and had assets of $520,232,088 in 1953. In that year Ford foundation made gifts of $60,jj5,703. Several large foundations have within the last few years been organized in the southwest and the west.

The community trusts are a distinctly U.S. invention. The first one was organized in Cleveland. O., in 1914 and is called the Cleveland foundation. There were 99 community trusts in 1954, the five largest of mhich were the Permanent Charity fund, Boston, Mass.; the California Community foundation, the Chicago Community trust, the Cleveland foundation and the New York Community trust. These five community trusts had assets of $71,030,945 in 1954, and the combined resources of all community trusts amounted to $127,395,738. Any individual or family may donate a sum of money to a community trust, however small or large. and give a name to the "fund." and it becomes a part of the community trust. Most of the awards of the trusts are made for education. health, research and welfare in their own communities. By 19j4 they were distributing more than S5,000,000 a year.

The endowments for higher education constitute a large amount of philanthropic giving. The oldest such endowment is that of Harvard university, which dates from 1636. This had grown to $271,859,993 in 1954. Chicago, Columbia and Yale universities all have large endowments. By the end of 1951 the private institutions of higher learning in the U.S. had endowments of $2,195,959,543 or $14.57 per capita for the U.S. (1950 census). Many state universities receive private donations. and some, such as California. Michigan and Texas. had large endowments. The endowment of the University of Texas in 1951 was over $131,000,000. The total endowment of state universities amounted to $482,570,573 in 1951, or a per capita amount for the U.S. of $3.20.

Total Annual **Gifts.**—Andrews gave an estimate of total individual contributions each year from 1929 to 1949 inclusive. In terms of adjusted dollars the contributions were $1,206,000,000 in

1929 and $3,961,000,000 in 1949, or about twice as much per capita in 1949 as in 1929. Income tax returns show that corporations in 1950 made contributions of $245,493,000 (adjusted dollars); much of this was given to universities and community chests.

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PHILARET [THEODORE NIKITICH ROMANOV] (?1553–1633), patriarch of Moscow, was the eldest son of the boyar Nikita Romanovich. During the reign of his cousin Theodore I (1584–98), he distinguished himself both as a soldier and a diplomatist. On the death of the childless tsar, he was the popular candidate for the vacant throne; but he acquiesced in the election of Boris Godunov, who compelled him, three years later, to take monastic vows under the name of Philaret. Philaret was confined to the Antoniev monastery, but when the pseudo-Demetrius overthrew the Godunovs he released Philaret and made him metropolitan of Rostov (1605). In 1609 Philaret fell into the hands of pseudo-Demetrius II, who named him, apparently against his will, patriarch of all Russia though, in fact, his jurisdiction was limited. In 1610 he was sent by the Muscovite boyars to King Sigismund III of Poland to negotiate for the accession of the latter's son Wladislaus to the throne of Russia. The king's intransigence caused these negotiations to break down, and Philaret was eventually arrested and sent to Poland, where he was kept in confinement (1611–19). After the election of his son Michael Romanov as tsar of Russia (1613), and a long delayed exchange of prisoners, Philaret returned to Moscow, and in June 1619 he was enthroned patriarch of all Russia. Henceforth, until Philaret's death, father and son shared as co-regents the sovereignty of the realm.

Philaret replenished the treasury by a more equable and rational system of assessing and collecting the taxes. His most important domestic measure was the chaining of the peasantry to the soil, a measure directed against the ever-increasing migration of the downtrodden serfs to the steppes, where they became freebooters instead of taxpayers. The taxation of the tsar's *sluzhylye lyudi*, or military tenants, was a first step toward the proportional taxation of the hitherto privileged classes. Philaret formed the nucleus of the subsequently famous Patriarchal library, and commanded that every archbishop should establish a seminary for the clergy, himself setting the example. He also reorganized the Muscovite army with the help of foreign officers. His death in Oct. 1633 put an end to the Russo-Polish war (1632–33), withdrawing the strongest prop from an executive feeble enough even when supported by all the weight of his authority.

See R. N. Bain, *The First Romanovs* (London, 1905); S. M. Soloviev, *History of Russia* (in Rus.), vol. viii–ix (St. Petersburg, 1895, etc.).

PHILATELY (STAMP COLLECTING) is the hobby of collecting and studying postage stamps. The first postage stamps for prepayment of letter postage were issued in England in 1840. Everything connected with them began at that date, including the vocabulary needed for the hobby of stamp collecting and even the name stamp itself. The term philately was coined in 1865 by a Frenchman, M. Herpin, who invented it from the Greek *philos* "love," a "negative," *telein* "to tax." Since the postage stamp was evidence of a letter's coming free of charge to the recipient, the postage stamp rendered it untaxed. The term caught the popular fancy much more than the word timbromania previously used, and has become the accepted word to describe stamp collecting and the study of postage stamps.

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    Grill or Grille
    Hinge
    Inverted Centres
    Miniature Sheet
    Mint
    Overprint or Surcharge
    Plate Numbers
    Postal Markings
    Precancel
    Reissues
    Remainders
    Reprints
    Se-tenant Stamps
    Tete-Beche

I. HISTORY

1. Posts.—Unlike postage stamps, the posts are as old as history. Herodotus speaks with admiration of the postal system of the Persians, and his words, "Neither snow nor rain nor heat nor gloom of night stays these couriers from the swift completion of their appointed rounds," have been carved over the doors of many post offices.

The first posts were the perquisite of the kings. but they were often permitted to carry letters and messages for members of the royal courts and friends of the courtiers, and gradually their accommodations were extended to merchants. As commerce became appreciated, so the posts became more important. Such postal privileges as had been allotted to favourites or corporations were gradually recaptured for the benefit of the state (which was often identical with the crown, of course). By the beginning of the 19th century, the theory of the post as a monopoly of the state was accepted everywhere.

The first postage stamp was not a proof of payment but the impression of a hand stamp (or what came to be known as a postmark). "A stamp is invented," wrote Henry Bishop, postmaster general of Great Britain, in a letter dated Aug. 2, 1661, "that is putt upon every letter shewing the day of the moneth that every letter comes to this office. so that no letter Carryer may dare to detayne a letter from post to post; which before mas usual." These date stamps. known as "Bishop marks," were used in Britain until 1787, after which they were enlarged and expanded until the modern common postmarks developed. A modified form was introduced into the American colonies.

The posts merely carried the letters from town to town, and to put a letter into the posts required delivery at the posting office—usually the point whence the post departed—or to receive one necessitated a visit there. In 1653, de Villayer established a service of collection and delivery of letters within Paris, and issued wrappers that were sold. each wrapper being proof of the prepayment of the charges of the local post. This was the forerunner of prepaid mail, and the wrapper was the first precursor of the postage stamp. The service ceased after a short vogue when the novelty wore off. In 1680 William Dockwra set up a penny post for London and its suburbs, which was suppressed by the government in 1682 as an infringement of its monopoly of post roads. However the entire system was incorporated into the British postal system in 1682, with Dockwra as comptroller from 1697 to 1700.

The use of embossed stamps on documents as evidence of imposts and excise taxes paid, which originated in the Netherlands, was introduced into Britain in *1694*. The famous stamp tax (or excise tax evidenced by stamps) on commodities for the American colonies of Great Britain was passed in *1765* and repealed the following year, but contributed to the unrest in America that led to the Revolution. In *1818* the kingdom of Sardinia taxed letters, certifying each with such an impressed stamp — not, however, a postage stamp.

Although originally supported by the king's private purse, the English postal system was put on a paying basis in *1635*, by fixing rates for letters on a basis of distance and by "single" and "double" letters and "per ounce." Thereafter, the rates were changed from time to time, usually upward. Each rise in charge decreased the total volume of mail, but increased net revenue. The posts were farmed out to the various postmasters general for several years. In *1812* a further increase in rates brought only a slight rise in net revenue, and actually worked a hardship on legitimate business, the rates becoming too high—4*d*. for *15* mi. or less; 5*d*. for *15* to *20* mi. and so up to 18*d*. for *700* to *800* mi., and 1*d*. for each *100* mi. additional.

2. First Postage Stamp. — In *1835* Rowland Hill (*q.v.*) began to study the tax situation in England, there having been a surplus of revenue. He noted that while reduction of tax rate sometimes brought a reduction of net revenue, the reduction of the tax on coffee by one-half had produced a net increase in revenue of one-half. Furthermore, he determined that postal revenues were falling despite increased rates, while a reduction in postal rates in France had increased the net revenue.

Further inquiry revealed that since most letters went through post unpaid, to be collected on delivery, many of these were refused and had to be returned, often to be unclaimed or refused on return, thus necessitating records at every step of the two-way trip, as well as double portage for no revenue. Most illuminating of all was the discovery that the cost of transport per letter was frequently less for a long journey — from London to Glasgow, for example — than for a short one — such as London to Kent — for the long haul went with a greater number of letters than the short local trip. Hill therefore proposed a radical change: that letters be carried any distance within Great Britain and Ireland for a fixed rate, which he suggested be a penny for each one-half ounce, and that all postage be prepaid. Wrappers and envelopes with the stamp denoting prepayment were to be sold at all post offices, and for those who wished to use their own stationery he proposed "a bit of paper just large enough to bear the stamp" (he meant the imprint of the post office hand stamp), "and covered at the back with a glutinous wash, which might, by applying a little moisture, attach to the back of the letter, so as to avoid the necessity for redirecting it."

Hill's pamphlet, Post *Office* Reform, was issued in Jan. *1837* for private circulation. Parliament investigated, and the postmaster general Lord Lichfield reported that of all the wild and visionary schemes he had ever heard or read of, it was the most extraordinary. A second edition of the book, for public circulation, had its effect. The public response was loud and strong, the treasury reduced rates to a uniform *4d*. per ½ oz. basis, and in *1839* reduced it to Hill's proposed *Id*. per ½ oz. regardless of distance, effective Jan. *10, 1840*.

Hill was asked by the treasury to work out the details. In *1839* he entrusted the design of the envelope and wrapper to William Mulready, R.A. To create the "bit of paper," he held a public competition, and more than *2,600* essays were entered. Meanwhile, Hill had heard of a new process of steel engraving, in which he became interested. When the prizes (four of £100 each) were awarded, the "label" with the glutinous wash on the back was finally produced by the new, revolutionary Perkins process for reproducing steel engravings.

Jacob Perkins, a native of Massachusetts, was an inventor of mechanical devices. In *1819*, having invented the D-roller copper-plate press, an engine lathe for engraving copper and steel plates, and the triple transfer process of reproducing steel engravings together with the machines to carry it out, he was persuaded to travel to England to interest the Bank of England in the process for producing its notes. The British minister to the United States extended the invitation, and though the Bank of England finally decided to proceed with a process then being installed, a grant, reported to be £*5,000*, was made to Perkins and his partners. Mean hile, he secured the business of many other banks, for prior to *1844* almost every British bank issued its own notes.

In brief, the essence of the process is: a soft-steel die is engraved with the original intaglio of the proposed finished engraving. This master die is then hardened and a soft-steel roller is pressed against it in a transfer press and rolled back and forth until a transfer in relief is obtained on the roller. A second, third or fourth relief or even more, likewise can be obtained on the transfer roll, each of them in relief; *i.e.*, the lines that are cut into the original die and that will retain the ink to make the print of the engraving are in relief on the transfer roll. The roll is hardened. in turn. The last stage is to impress the transfer roll against the plate from which the printing is to be done, once more in the transfer press. The relief lines become intaglio lines on the printing plate, exact reproductions of the original die, reproduced as often as wished.

To the inventor's firm of Perkins, Bacon and Petch (later Perkins, Bacon and Co.), Sir Henry Cole, on behalf of Hill, suggested in Dec. *1839* the possibility of securing the contract for the proposed labels.

For Hill's label, the background chosen was an engine-turned lathework that had been used often as a background of bank notes. To use this on the stamp, a die block was impressed with the proper amount of the geometric pattern from the transfer roll. (This same transfer roll was later used to make the background for the Cape of Good Hope triangular stamps of *1853*, the St. Vincent one-crown stamps of *1880* and the New Zealand George V series of *1915*. It is now in the possession of the Royal Philatelic society. The over-all size and the space for the portrait of the queen were carefully marked. The pattern was transferred to a roll, and the space for the queen's head and the unused portion were burnished clean. The roll was then entered on a new die block. The portrait chosen was that engraved by W. Wyon of the royal mint for the medal struck commemorating the queen's first visit to the city of London in *1837*. Henry Corbould made the drawing, and the engraving was made directly on the die by Charles and Frederick Heath. The first die was not used and a second was made. Above the head was a panel with the word "Postage," the upper corners were embellished with a cross *pattée;* below was a panel with "One Penny" or "Two Pence"; in the lower corners were initials. Hill was afraid of counterfeiting, and for this reason the initials were used.

Each plate (11 were used for the one-penny value and two for the two-pence the first year) contained *240* stamps; each horizontal row of *12* was therefore valued at as many shillings as the single stamp was worth pence. There were *20* rows, edch full sheet being worth in pounds what each stamp was valued in pence. The lower right-hand corner of the stamps was lettered "A" for the first vertical row, "B" for the second and so up to "L" for the 12th; the lower left corner was similarly lettered "A" for the first horizontal row, "B" for the second and so to "T" for the 20th. It was thought that any counterfeiter would use only one or two combinations, and any very frequent recurrence of these would apprise the postal clerks of the attempt.

Neither the envelopes and wrappers nor the stamps were ready in January. Hand stamps were used to mark the letters "paid" until May *6, 1840*. On May *1*, both stamps and envelopes, including wrappers, were ready — the one-penny black, the two-pence blue — and nere put on sale. They were not valid for postage until May 6. It was Hill's thought that the envelopes and wrappers would be in demand, and adhesive stamps would be merely for the exceptional user. But in fact, it was the stamps that were in demand, and the printers worked night and day to keep the offices supplied, while the original supply of the envelopes and wrappers was never exhausted in the year they were available for postage.

In the latter part of *1885* James Chalmers, whose father had been a printer in Dundee, advanced the proposition that Hill had

stolen the idea for the adhesive postage stamp from the elder Chalmers. Both the principals were dead, but an unpleasant controversy arose that was scotched by Chalmers' own evidence, which gave the date of his father's suggestion as after Hill's (quoted above) had been read into evidence before a parliamentary comtnittee. However, from time to time, copies of Chalmers' vitriolic pamphlets come into the hands of newcomers to philately and provide another tempest in a teapot.

Although Hill's estimate of the loss of revenue was greatly surpassed by the facts, there was never any serious question of reverting to the old system. Prepaid postage, and with it the adhesive label that later became the postage stamp, had become accepted.

3. Usage Spreads. — In 1843 the empire of Brazil issued three values of postage stamps, becoming the second government to use them. These stamps did not contain the portrait of the emperor, but large figures of value on a background of engine-turning, and are popularly known as bull's-eyes. In the same year two Swiss cantons, Zurich and Geneva, issued stamps. That of Geneva was a double stamp: a half paid the postage within one commune, the whole paid it within the canton.

The first adhesive stamp in the United States was issued in 1842 by the semiofficial City Despatch Post of New York city for local carrier delivery. In 1845 several postmasters in the United States issued stamps to facilitate prepayment of letters—New York city issued a 5-cent value; St. Louis issued 5- and 10-cent stamps (later adding 20-cent); and the postmaster at New Haven, Conn., issued a 5-cent envelope.

In the succeeding two years, more postmasters issued similar local labels all with the tacit consent of the postmaster general, since the postmasters were charged with each letter they forwarded "paid" and the issuing of the stamps was merely their own method of bookkeeping.

In 1847 the United States issued stamps of 5- and 10-cent value and the "postmaster's provisionals" were abandoned. Prepayment became obligatory in 1856.

In 1845 the Swiss canton of Basle issued a stamp. In 1847 the British colony of Mauritius issued two values made locally that have become two of the philatelist's most sought-after rarities. In 1848 the Bermuda postmaster issued a provisional similar in purpose to those issued by the U.S. offices between 1845 and 1847. France and Belgium issued their first stamps in 1849, as did Bavaria. In 1850 Austria, Hanover, Prussia, Saxony and Schleswig-Holstein in central Europe, Spain and the three British colonies of New South Wales, Victoria and British Guiana all issued stamps. So did the Swiss federation, replacing the cantonal issue of previous years, for these stamps were valid in all cantons.

The first British stamps bore no country name, being intended only for internal use. Subsequent issues of Great Britain have likewise been content to bear the legend "Postage" without any designation of the country of issue. The first Brazilian issue was also without a name. The Swiss stamps, seeking to avoid giving offense to German-, French- or Italian-speaking Swiss, were likewise without a country name; subsequent' issues avoided argument by carrying the Latin name "Helvetia," or later "Confoederatio Helvetica."

After 1850 the remaining countries of the world began to issue stamps, more being added each year. Some countries began with local issues for the larger cities. Others plunged into national production. Following World Wars I and II numerous new countries and subdivisions issued stamps, while others ceased to exist as stamp-issuing entities. *See* also POSTAL SERVICES.

II. STAMP MANUFACTURE

Although the first stamps, those of Great Britain, were made by intaglio printing, not all stamps are so made. Five basic processes of printing are used in making stamps: (1) the engraved or intaglio process, in which the lines to be reproduced are incised into the surface of the plate and inked, while the surface is wiped clean; (2) typographed or letterpress, in which the lines to be printed are raised above the surface and inked; (3) lithographed or offset, in which the line to be reproduced is drawn on stone (or, more modern, on a metal plate with a surface simulating that of stone) mith an oily ink which attracts the oily ink used to reproduce it, which in turn is repelled by water on the rest of the stone; (4) embossed, in which the paper is raised by an incised die struck against a soft platen or "force"; and (5) photogravure (rotogravure), in nhich lines are photographed through a screen on a sensitive film covering the plate and then etched into it as in engraving. *See* also GRAVURE; LITHOGRAPHY; PHOTO-ENGRAVING; PRINTING.

1. Production. — The first stamps were made by private contractors under governmental supervision. Great Britain still contracts with private companies for supplies of stamps. The United States began by contracting for both postage and revenue stamps but, after the Civil War, the treasury department began printing its own tax stamps at the bureau of printing and engraving. In 1885 this bureau bid on the postage stamps, but lost to a private concern, the American Bank Note company. In 1894, however, the bureau was low bidder; thereafter it produced the postage stamps as well as the revenue stamps, banknotes, currency and bonds.

France also began with a private contractor, but after 28 years transferred the production of stamps to the national mint. Many countries have followed the lead of Great Britain and entrusted their stamps to private concerns — Perkins. Bacon and Co.. which produced the first British stamps, also produced the original issues for many other countries. For Chile, for example, the company printed the first issue in sheets of the same dimension and layout as the first British issue, which made bookkeeping rather difficult for the Chileans, who use a decimal currency. Most countries with decimal coinage use sheets of 100.

2. Paper and Watermarks. — Philatelists are deeply conscious of the kind of paper used for stamps. Chief item in papermaking for stamps is the watermark (*q.v.*), a sign or symbol made in the paper as it is manufactured. On paper to be used in printing stamps, watermarks may be spaced so as to fall on each particular stamp, or to run through the sheet in a recurring pattern or to fall with one quarter on each stamp, a block making a full pattern. Typical watermarks are the small crown that appears on each of the 1840 stamps of Great Britain or the "crown and C **A**" on many colonial stamps; the "USPS" used by the United States between 1895 and 1915, a letter or part of one letter falling on each stamp; or the wavy lines used by Bavaria for early issues, which fell on each stamp and in the margins as well.

Basically, paper (*q.v.*) is wove or laid. Wove paper is made on a moven screen, and either presents no appearance other than general opacity when held to the light, or it dimly resembles a tiny network, as a moven screen greatly reduced. If the screen is strengthened with heavier wires evenly spaced in one direction, it becomes a laid paper, with these lay-lines showing. If these are exceptionally heavy, it is called batonné paper, and if the heavy batons are placed perpendicular to lay-lines it is laid batonné. A thin onion-skin paper sometimes used for stamps is called *pelure* paper.

Paper in which coloured fibres are used, presenting a gray or mottled appearance, is termed granite paper. Silk paper has tiny threads of coloured silk worked into it, and silk-thread paper has one or two very noticeable silk threads laid lengthwise or across it, falling on each stamp.

3. Gum. — The glue applied to the back of the stamp, which is moistened and thereby made to adhere to the envelope, wrapper, etc., is referred to as gum. Different kinds of gum may be distinguished by colour, opacity, streaks, etc. Stamps may be ungummed. Usually gum is applied to the sheet of stamps before the perforation process is performed.

4. Perforation. — The first stamps were printed on a sheet of paper with no provision for separation one from the other. This required use of a knife or scissors to secure individual stamps. Such stamps are known to collectors as imperforate. In 1847 an Irish engineer, Henry Archer, offered a machine to provide stamps with separations. A toothed wheel cut a series of scallops between the stamps, permitting easy tearing of the sheet. Experiments were made by the British post office, and in 1848 the ma-

chine was put in service. However, the wheel used to cut the scallops soon became blunted; it also aamaged the work table. A new set of wheels with lancet-shaped knives fared little better. In 1849 Archer introduced a machine that punched tiny holes between the rows of stamps. Such sheets as were not ruined in experimenting were sold in the regular course of business by the post offices. In 1854 the machine was so far perfected that thereafter all British stamps were perforated.

Philatelists differentiate between these various methods of separating stamps. The first method, which cuts the paper between the stamps but does not remove any of it, is called rouletting; it is further differentiated by the pattern of the cutting: serpentine. scalloped (or en arc), saw-toothed (or en scie), straight-line (or en ligne), etc. When small portions of the paper are removed, it is termed perforated. These, with imperforate, make up the three main classes of separation of stamps.

Philatelists further differentiate stamps by their perforations. To many, though not all collectors a difference in the number of perforations creates a separate, collectible variety. To obviate differences caused by slight variations in the dimensions of stamps, philatelists measure the number of perforations in 20 mm. Thus, "perf. 12" means that there are 12 holes counted in 20 mm., and so on. Roulettes are similarly counted.

III. STAMP COLLECTING

No one can say with certainty when stamp collecting began, but clearly it was subsequent to May 1, 1840, when the first postage stamps were put on sale. The earliest reference to it is in an advertisement in the Times of London in 1841:

A young lady, being desirous of covering her dressing-room with cancelled postage stamps, has been so far encouraged in her wish by private friends as to have succeeded in collecting 16,000. These, however, being insufficient, she will be greatly obliged if any good-natured person who may have these (otherwise useless) little articles at their disposal, would assist her in her whimsical project. Address to E. D., Mr. Butt's, Glover, Leadenhall Street; or Mr. Marshall's, Jeweller, Hackney.

That this mania for accumulating, if not collecting, was rather widespread within the year is evidenced by this paragraph in Punch, 1842:

A new mania has bitten the industriously idle ladies of England. To enable a wager to be gained, they have been indefatigable in their endeavours to collect penny stamps; in fact they betray more anxiety to treasure Queen's heads than Harry the Eighth did to get rid of them!

Accumulation led to collecting, in all probability, though there is no evidence of just how or where it started. From the practically simultaneous outbreak of evidence in 1862, it seems clear that collecting was spontaneous and not confined to any one region. Great Britain. France, Germany, Belgium and the United States apparently had collectors prior to that year.

1. Catalogues. — In the British magazine Notes and Queries of June 23, 1860, appears a letter from a schoolmaster recounting that one of his pupils had a collection of 300 or 400 different stamps, and that "Sir Rowland Hill had told him at that time there might be 500 varieties on the whole." He suggests that a list of stamps would be useful and asks if there is any shop in London where stamps are sold and that has a list available. The identical idea must have been surging in other lands. In 1861 Oscar Berger-Levrault, in Strasbourg, issued his list of stamps, Timbres-Poste, by lithography from manuscript. In Paris, Alfred Potiquet published a *Catalogue* des Timbres-Poste *Crées dans* les Divers Etats *du* Globe. The acceptance of the lists must have been immediate, for Berger-Levrault issued a second edition later in the year. In Jan. 1862, J. B. Moens of Brussels, Belg., issued his *Manuel du Collectionneur*. In England, Frederick Booty, J. E. Gray and Mount Brown all issued catalogues in 1862. A pirated edition of the last, listing 1,200 varieties, was issued by A. C. Kline in Philadelphia. Brown issued two more editions of his catalogue, the third (1866) listing 2,400 varieties, inclusive of what is now termed postal stationery or envelopes, wrappers and letter sheets, as well as many local issues.

The standard modern catalogues exclude this latter material, and yet the total number of listings, including minor varieties, reaches more than 200,000.

E. Stanley Gibbons issued in 1863 a catalogue that continues to be one of the major catalogues of Great Britain. The standard in France is by Yvert and Tellier; in Germany it is Michel's catalogue, in Switzerland Zumstein's. The Scott catalogue (originating in 1863) and the Minkus catalogue (begun in 1954) are standard works for the United States. Each of the above catalogues stresses information about the country in which it is issued, either as part of the main volume or in a separate specialized edition nhich may include postal stationery. Also, because of the sheer bulk of printed matter needed to catalogue over 200,000 philatelic items, the major catalogues tend to be published in two or three volumes; shortened versions for beginners and general collectors are produced by both Gibbons and Scott.

Many stamps are issued for postal charges other than letter carrying (see below), and some of the major catalogues list these also. Revenue and telegraph stamps also are collectible and may be listed in modern catalogues.

2. Albums. — The first stamp albums were issued in 1862. Justin Lallier originated both the French and the English editions, in Paris. He rapidly increased his albums, to accommodate new stamps as they were issued. and for several years held first place among collectors for the completeness and arrangement of his books. In the latter part of the decade (1867) he began to add information about stamp collecting and bibliographies.

3. Special **Stamps.**—Airmail stamps are issued especially for letters to be carried by air. Italy issued the first of these for an experimental flight in 1917; the first regular issue was that of the United States the following year. Almost every country has issued them since. with the exception of Great Britain and its colonies, though in these countries certain values of the regular postal issues are of denominations primarily for airmail use. Special delivery, registry, insured and acknowledgment-of-receipt stamps are for payment of the special fees levied for these services. Late fee stamps are sometimes issued to pay the extra postage for letters mailed after the closing of special mails.

Official stamps are issued for the use of governmental departments. Formerly widely used, they are now largely supplanted by printed franks.

Semipostal stamps are sold at a premium over their letter-carrying value, the overage going to some officially recognized charity. Postage due stamps indicate the amount a letter lacks of full payment of the charges. which is collected on delivery. Newspaper and parcel post stamps are for the special duties indicated.

Commemorative stamps are regular postage stamps issued to honour some event, activity or person of national importance. They are a species of governmental propaganda. The first stamps of this kind were issued by New South Wales in 1888, on the 100th anniversary of the founding of the colony. Argentina (1892) and the United States (1893) issued stamps commemorating the 400th anniversary of the discovery of America. In 1897 Great Britain and Canada signalized the diamond jubilee of Queen Victoria's coronation. Thereafter, the practice became common.

4. **Specialization.**—When Mount Brown's catalogue listed 2,400 stamps (1866), a modest collection of 2,000 varieties would contain more than 80% of all stamps. A similar proportion in the early 1960s would necessitate 150,000 varieties. Because of the sheer bulk of such a general collection, most collectors turn to more or less limited fields. For example. they may collect only the stamps of one country, or of one continent or of one period. Others specialize in collections of certain kinds of stamps; some collect only one issue and study it thoroughly, others may collect only revenue stamps or postal stationery. Those interested purely in stamp designs may collect art or religion on stamps, or flowers, fish, bridges, etc.; this sort of collecting is called topical or thematic.

The collection of postal markings, both on stamped and prestamp covers, is a form of specialization; collecting of precanceled stamps is another. Meters (machines that print a postal frank on the envelope) have given rise to yet another specialized form. Telegraph stamps, issued to prepay telegrams in certain countries, are also collected by specialists.

Plating. — The collecting of one issue or even of one stamp

of an early issue, may necessitate some of the deepest philatelic study. The early stamps, especially the engraved ones, were often retouched after transfer, so that each stamp on each plate has minute identifiable characteristics. For instance, it is possible to identify each of the 2.640 specimens of the Great Britain one-penny of 1840, and this is easy, compared with other issues, because the plate position is located by the check letters in the corners. It is also possible to identify most of the 2,600 varieties of the 3-cent U.S. stamps of 1851. This has led to "plating" or reconstruction of the original sheet, which in turn has led to many interesting discoveries of the ways in which sheets were laid out and manufactured.

Christmas Seals.—Christmas seals were invented by a Danish postal clerk, Einar Holbøll, in 1903, as a source of revenue for an antituberculosis society. They were used on packets and letters sent at Christmas, and sold for a small sum, the money going to the society. The use spread to many other countries, where they are issued each year. While they have no franking power, they are widely used and often collected.

Government Philatelic Agencies.—Specialization in 20th-century stamps has been helped by establishment of governmental philatelic agencies to sell fine-quality stamps to collectors. The United States opened the first of these in 1921, and the success was soon so apparent that similar agencies were established by many European countries. The U.S.S.R. made traffic in stamps a government monopoly and Germany followed suit when the nazi party came into power. In 1942 the U.S. placed revenue stamps on sale at a special agency for collectors.

The forms of specialization are limitless, and the ingenuity of collectors leads to the constant discovery of new and individual methods.

5. Famous Collections.--Many famous collections of the past have been dispersed and absorbed by others. One of the most famous of all times was the collection of Philippe la Renotiere von Ferrari, an Austrian subject resident in Paris. During World War I he fled to Switzerland, where he died in 1917. His property was seized by the French government, and his collection, which he had formed during 40 years, was sold at auction, realizing more than 26,000,000 fr. (£400,000 or $2,000,000 at the rates of exchange of the day).

Arthur Hind's collection, which included the Duveen collection of Mauritius and the Griebert collection of Spain and which was sold in 1933–34 after his death. brought a gross return of nearly $1,000,000. In addition, the unique 1-cent British Guiana magenta of 1856 was sold by private negotiation for a price reputed to be more than $45,000, the highest price ever recorded for a single stamp.

The outstanding collection in Europe in the early 1960s was the private collection of Queen Elizabeth II. Principally formed by King George V, who was a famed philatelist, it is especially rich in British and colonial issues.

Of the several famous collections in the United States, one of the most bizarre was formed by Col. E. H. R. Green; it stressed unusual materials, such as quantities of the "blue paper" issues of the U.S., the only position blocks of the 24-cent airmail with inverted centre (U.S., 1918) and a number of sheets of the imperforate 5-cent carmine error (U.S., 1915). Other noted collections were those of Sol Newbury (Chicago), Alfred Lichtenstein and Theodore Steinway (New York). Alfred H. Caspary's stamps were sold in the late 1950s in New York city for $2,895,146, the largest sum realized by any stamp collection to that time.

The Thomas K. Tapling collection, bequeathed to the British museum, may well be the finest in public hands. The Smithsonian institution collection at Washington, D.C., stresses U.S. stamps. The postal museums of many European capitals have outstanding collections; such as those at Berlin, at The Hague and at Stockholm; the last received the Hans Lagerlof (New York) collection.

IV. PHILATELIC SCHOLARSHIP

1. Societies.—Clubs or societies of collectors are to be found in most cities of the world. with national and international societies tending to bind them together. The American Philatelic society, founded in 1886, had about 13,000 members in the early 1960s; the Society of Philatelic Americans (1894) had about 6,000. The Royal Philatelic society of London was founded in 1869 and became "royal" in 1906. The Junior Philatelic society of London was founded in 1899. The Collectors club of New York stands pre-eminently for philatelic research, as does the Royal Philatelic society. Many countries have national philatelic organizations with research groups.

Because of the quantity of philatelic material, added to each year by the issuance of about 3,000 new stamps, with the resultant tendency to specialization, specialist societies have sprung up, notably since 1945. Many of these issue bulletins. Particularly noteworthy are the specialty clubs dealing with the philately of France and colonies, Germany, Italy and colonies, Korea, Lithuania, Luxembourg, Japan, Switzerland, airmails, postal history, postal stationery, U.S. bureau issues, and others too numerous to list.

2. Congresses.—The Philatelic congress of Great Britain celebrated its 50th anniversary in 1959 and the American Philatelic congress celebrated its 25th the same year. The "congress" idea fosters philatelic research by the publication of articles annually in book form, with annual conventions at which these articles are discussed and the material upon which they are based is studied. The first (Congress Internationale des Timbrophiles) congress was held in Paris, June 26, 1878. After 1945, there was an increase in the number of congresses held in various countries.

3. Exhibitions.—One of the most important activities of stamp clubs is the holding of exhibitions from time to time. The national societies hold annual exhibitions, offering valuable awards in competition. International exhibitions are held in the United States at approximately ten-year intervals. Other countries arrange to honour philatelic or national events at the appropriate date with similar world-wide celebrations.

4. Literature.—Perhaps no hobby has been so prolific of literature as philately. The standard catalogues (see above) issued annually are generally minor encyclopaedias of the hobby, but there are and usually have been journals in every language.

It is difficult to list accurately monthly or weekly publications, since many are short-lived. The first one of record that was specifically devoted to philately was the British Monthly Intelligence; appearing first in Oct. 1862, it lasted only three issues. In Dec. 1862 appeared the British Monthly Advertiser, which appeared in Jan. 1863 as the Stamp Collector's Review; it lasted nearly two years. Moen's (Brussels) published the Timbre-Paste for many years, starting in 1863, in which year the German *Magazin* fur Briefmarken-Sammler began. In 1874 John K. Tiffany published The Philatelical Library, a catalogue of philatelic literature in his extensive private library in St. Louis, Mo. This collection of books he afterward sold to the earl of Crawford, who combined it with his own extensive holdings and bequeathed all to the British museum.

Among the journals founded in the 19th century and still extant are *Mekeel's* Weekly Stamp News (founded 1892) and the *American* Philatelist (published by the American Philatelic society, founded 1887, but with two lapses since), in the U.S.; the London Philatelist (published by the Royal Philatelic society); and Echoes de la Timbrologie, in France.

There have been many books on stamp collecting, especially in specialized fields. Since these appeal to a limited public, they are issued in small editions and few remain long in print.

5. Libraries.—In the United States the library of the Collectors club of New York is outstanding. The Philatelic library of Los Angeles, the Eugene Klein collection in the Philadelphia Free library and that of the Philatelic Research society (Oakland, Calif.) also are noteworthy. Many public libraries have growing sections devoted to philately and are usually expected to have at least the standard catalogues. In England the library of the Royal Philatelic society has been kept up-to-date consistently, and in other European countries where there are postal museums, libraries are apt to be an important adjunct. Probably the best philatelic library in private hands is that of George T. Turner of New York.

6. Some Philatelic Terms.—Philatelists, as other hobbyists,

use words with special meanings pertinent to their collecting. Some have been coined, others are words from current usage twisted to specific connotations. Many words in the philatelic vocabulary have been internationalized from the French.

Bisect.—These are stamps that have been cut in half or into smaller bits to serve as postage; *e.g.*, the 3-cent of the 1869 U.S. issue was bisected (trisected would be a better term, but philatelists continue to use bisect) to permit the mailing of a number of forms that called for only two cents' postage. Such bisects are usually collected only when on the original envelope or mailing piece, and then with a cancellation identifying them with the letter. Some bisects also have been overprinted with the new fractional value; in such case they bear their own proof of bona fide and do not need the supporting evidence of the letter.

Block.—A block consists of four or more stamps with the horizontal and vertical separations untouched. Thus, a block of four stamps can only be arranged two wide by two deep.

Booklets.—These are blocks of stamps, sometimes all of the same denomination, sometimes of different denominations, arranged between covers, usually with interleaving to prevent sticking. Size and value of booklets is determined by the country of issue.

Coil Stamps.—These are stamps issued in long strips—(usually 500) for use in mailing or vending machines. Some countries, notably Sweden, prefer coils for post office sale in place of sheets as they are easier to store. The stamps are usually imperforate on top and bottom (or the two sides) and perforate between the stamps. If imperforate top and bottom, they come from horizontal coils; if imperforate on the two sides, from vertical coils.

Cover.—A cover is the outer wrapping of a piece of mail: the envelope or outer side of a folded sealed letter or the wrapper of a packet. A stamp is "tied to cover" when the cancellation or other postal marking falls partly on the stamp and partly on the cover.

Double Impression.—This occurs where the sheet of paper was put through the press twice, the second imprint shifting slightly from the first one.

Double Transfer.—In engraved stamps this occurs where the impression on the printing plate, either through shifting in the transfer press or an attempt to re-enter and deepen the impression has caused portions of the entry to have double lines.

Grill or Grille.—This is the impression of a knurled roller on a stamp to break the fibres of the paper so the canceling ink will soak in and prevent washing to reuse.

Hinge.—In arranging a collection, stamps are not pasted directly on the album page but secured there by hinges. small rectangles of paper gummed on one side and folded. The gum is a special kind that allows the hinge to be peeled off with minimum damage to the stamp and its original gum. One gummed section is fastened to the stamp, the fold at the top of the stamp; the other is fastened to the page. Thus the stamp may be lifted at will for study of the back.

Inverted Centres.—These occur only when two or more plates are used to make a stamp. Occasionally a sheet will be reversed when passing through the second press, and the centre will be inverted in relation to the frame; actually the centre may have been printed first, in which case, strictly speaking, it is an inverted frame.

Miniature Sheet.—This term has two meanings. (1) A form of collecting in which stamps from the corners, sides, top, bottom and at least one from the centre are put together to show every possible variety the sheet possesses—nine stamps from a U.S. sheet of 100 would give this effect. (2) More commonly the term is applied to little sheets of 25, 10 or fewer stamps issued as souvenirs of an occasion or a national event. These are also known as souvenir sheets.

Mint.—This is the condition of a stamp as it comes from the post office, with its original gum undamaged and without blemish on its face. A stamp that has lost its gum but is otherwise unblemished is spoken of as unused—no gum, save in rare instances when there was originally no gum, in which case it is still mint.

Overprint or Surcharge.—Either of these terms is used to refer to a stamp that has been printed over, to change one or several of the original qualifications. The trend is to use the word overprint, to avoid connotations that have become attached to the word surcharge. Stamps are often overprinted to change the value, usually because there is a shortage of a needed denomination and a surplus of another. Stamps are also overprinted to change the country, as stamps of one nation used in the territory of another in war or after cession. Another overprint is applied to change the use of stamps; a revenue stamp, for example, may be overprinted for postal duty. Stamps that have been withdrawn have been overprinted to make them valid again.

Plate Numbers.—These are often put on the margins of plates, and thus are printed on the sheets, to identify the plate. Sometimes, as with many issues of Great Britain, they are worked into the design and appear on every stamp.

Postal Markings.—These are the cancellations, postmarks and other hand or machine stampings applied by the post office to the letter or piece of mail.

Precancel.—Precanceled stamps are a particular form of overprint, a cancellation applied before sale to the user. Only those with special permits are allowed to use precanceled stamps, and these must be employed according to strict regulations. They are intended to save unnecessary labour by the post office clerks, and are usually used for large mailings of identical pieces or for newspapers or periodicals.

Reissues.—These, not to be confused with reprints, are made by governments. hence are often called government reprints; frequently they are rarer and more valuable than the original issues.

Remainders.—Remainders are stamps left in the hands of governments after they have been demonetized. Sometimes these remainders are sold in bulk and accordingly depress the value of unused stamps.

Reprints.—These are stamps printed from the original plates after the stamps are no longer valid for postage. The only reason for doing this is to sell the stamps to collectors, and reprinted stamps are accordingly generally deprecated by philatelists. A few governments have been guilty of this practice, and some of them have been persuaded to turn the plates over to private parties. The most notable cases mere those of certain Central and South .American governments which, in the last decade of the 19th century, entered contracts with the Hamilton Bank Note company, of New York, by which the company furnished a complete series of stamps each year, and after the stamps had been demonetized. was permitted to sell the remainders and such other stamps as it wished to make from the plates. These issues, called Seebecks after the president of the company, have suffered accordingly. Certain African countries made similar contracts more recently.

Se-tenant *Stamps.*—These are two or more stamps unsevered from each other in which one or more of the stamps differ from the other. Sometimes two denominations of stamps are printed in one sheet; a pair of stamps of the different denominations would be described as a se-tenant pair.

Tete-Beche.—Occasionally plates have been made with one stamp entered upside down. Such a stamp is said to be tete-beche, and can only be identified when se-tenant with one or more of the normal stamps.

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(M. HA ; H. K. Z.)

PHILEMON (c. 363–*c.* 264 B.C.), poet of the Athenian New Comedy, an elder contemporary and successful rival of Menander, whom posterity preferred to him. Born probably in Syracuse, by

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig.. 9

Fig. 10

Fig. 11

Fig. 12

BY COURTESY OF (1) FINBAR KENNY OF J. & H. STOLOW, NEW YORK CITY, (5, 9, 10) H. R. HARMER, INC., NEW YORK CITY, (11) CHARLESS HAHN AND H. R. HARMER. INC.: OWNERS, (2) BURRUS, (4) LEEMAN, (7) RAYMOND H. WEILL CO., NEW ORLEANS, (8) BRITISH MUSEUM; PHOTOGRAPHS, (2, 3, 4, 6, 7, 8, 12) LIFE, © TIME, INC., (5, 9, 10, 11) ADRIAN BOUTRELLE

SOME FAMOUS STAMPS OF THE WORLD

1. **British Guiana, "One-Penny** Magenta." The most valuable stamp In the world, **issued** in 1856. One **hundred** years later **it** was valued at about $100,000
2. Hawaii, two-cent **"Missionary."** First issue of **Hawaii,** 1851
3. Mauritius, "Post **Office."** An Issue of **1847** where the words "post office" rather than **"post paid"** were **used** by the **local** designer of this limited **issue**
4. Switzerland (canton of Basle), the **Basle "Dove"** tricoloured **stamp** of 1845, a favourite of **collectors**
5. **Cape** of Good Hope. "Triangle." The **first series** of stamps to be **issued** in nonrectanguiar shapes **(1853–64)**
6. Mauritius, 1848. The word "pence" was **misspelled "pence"** by the engraver
7. St. Louis, Mo, "Bear." An example of a postmaster's provisional, issued privately by the postmaster in 1845 before the **U.S.** had a general issue
8. New South Wales, "Sydney View." The first pictorial stamp, **issued** in **1850**
9. Japan, 1871. the first issue of Japan. An example of oriental **design** and a stamp without Roman lettering, **which** is relatively uncommon
10. Confederate States of America, five-cent, **1861.** The first general **issue** of the Confederacy
11. United **States, "$1.00** Trans-Mississippi," an early **commemorative stamp** (1898) regarded as exceptionally beautiful by **collectors**
12. Newfoundland, **"Hawker."** The first stamp issued for an **Atlantic ocean flight,** April 1919. It was made by overprinting a regularly **issued stamp**

PHILATELY

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

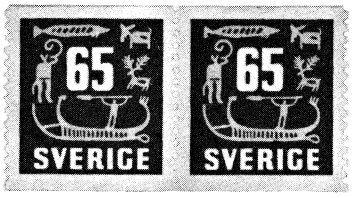

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Fig. 11

Fig. 12

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Fig. 14

Fig. 15

Fig. 16

Fig. 17

BY COURTESY OF (1, 3, 5, 6, 8, 10–12, 14–17) HELEN CONWAY ZIRKLE, (2, 4, 7, 13) CHARLESS HAHN AND H. R. HARMER, INC., N.Y., (9) CHARLESS HAHN: PHOTOGRAPHS, (2, 4, 7, 13) ADRIAN BOUTRELLE

U.S. AND FOREIGN STAMPS

1. Lebanon, airmail, 1951, showing Crusader castle, Sidon harbour. 2. Brazil, "Bull's-Eye," 1843, the first stamp issued in the western hemisphere. 3. Italy, special delivery, 1948. 4. United States, 5-cent and 10-cent, 1847, the first general-issue stamps of the country. 5. Egypt, commemorative. 1956, honouring Museum week. 6. Sweden. pair of vertically perforated coil stamps, 1954. 7. United States, airmail, 1918; only one sheet of 100 stamps with the centre inverted (plane upside down) reached the public. 8. Netherlands, postage due stamp, 1947–53. 9. Great Britain, "Penny Black," 1840, the first adhesive postage stamp. 10. India, official or service stamp. 1950, for use on government mail. 11. Mexico, postal tax stamp, 1939, obligatory on ail mail, the revenue to be used to combat malaria. 12. Bulgaria, parcel post, 1931–32. 13. Canada, the "Bluenose," 1929, considered exceptionally beautiful by philatelists. 14. Germany, newspaper stamp, 1939. 15. Korea, airmail, 1954, showing east gate of Seoul. 16. Japan, airmail, 1953, showing Buddha of Kamakura and Mt. Fuji. 17. Finland. semipostal stamp, 1938, surtax for benefit of soldiers of the Union of the Finnish Front

328 he was producing plays in Athens, where he eventually became a citizen; he also worked in Alexandria for a time. Some 60 titles from his 9; comedies are known; they survive in Greek fragments (perhaps including quotations from his son, Philemon the Younger). and in Latin adaptations by Plautus *(Mercator, Mostellaria, Trinummus* and possibly other plays). His characteristics include neatly contrived plots, vivid description and frequent moralizing in a style which lacks Menander's grace.

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PHILEMON, EPISTLE TO, a New Testament book. A short personal note by the apostle Paul has been preserved. which owes its origin to a romantic episode in the life of a slave, called Onesimus. For some reason he had run away from his master Philemon, a prosperous Christian citizen; it may be inferred that he had also been guilty of pilfering (ver. 18). For either offence he was liable by law to be crucified. In some unexplained way he had come across Paul and been converted to Christianity. This opened a difficult situation. The apostle boldly solved the problem by sending Onesimus back along with Tychicus, who was going to Colossae with Paul's letter to the local church; "I send him with Onesimus, that faithful and beloved brother. who is one of yourselves" (Col. iv, 9). But, not content with this certificate in favour of the converted and penitent slave, Paul sends also a note to his master, bespeaking his Christian interest in Onesimus. It is a brief letter, tactful and charming, in which the apostle, after greeting Philemon and his wife and the local church that met in his house, rejoices over Philemon's character. which, he says, emboldens him to enter a plea for poor Onesimus, now returning to his duty, a very different man from what he was when he ran away. Paul delicately suggests that he would like to have kept the slave beside him, and offers to be responsible for any debts incurred by Onesimus. He hints that this generous action on the part of Philemon will be a personal kindness to himself as well as to the slave. "You count me a partner? Then receive him as you would receive me, and if he has cheated you of any money or owes you any sum, put that down to my account. This is in my own handwriting. 'I Paul promise to refund it'—not to mention that you owe me, over and above, your very soul. Come, brother, let me have some return from you in the Lord. Refresh my heart in Christ."

Where the letter was written. we do not know. Rome was a natural place of refuge for runaway slaves, who could lose themselves in the huge population easily; if Colossians was written from Rome, so was this note. Where Philemon stayed is also uncertain; he may have been resident at Laodicea or at Ephesus, for though Onesimus accompanied the letter to the Colossian church, it does not follow that Colossae was the seat of his master; indeed, as Philemon was converted by Paul, that cannot have taken place at Colossae, which Paul had never visited. Still, Philemon may have shifted his quarters to Colossae.

The letter appears in two 2nd-century canons: that of Marcion and the Muratorian, though its lack of dogmatic importance as well as its brevity threw it afterward into some disfavour.

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PHILEMON AND BAUCIS, in Ovid's *Metamorphoses,* are a pious Phrygian couple who hospitably received Zeus and Hermes when their richer neighbours turned the gods away, they being disguised as wayfarers. As a reward, they were saved from a flood that drowned the rest of the country; their cottage was turned into a temple, and at their own request they became priest and priestess of it, and long after ended their lives at the same moment, being turned into trees.

The story lingers in the New Testament account (Acts xiv) of Paul's healing of the lame man at Lystra, nhose inhabitants identified Paul and his companion Barnabas with Zeus and Hermes, "come down to us in the likeness of men." Similar stories are given in the *Märchen* (fairy tales) of the Grimm brothers.

PHILES, MANUEL (*c.* 1275–134j), of Ephesus, Byzantine poet At an early age he removed to Constantinople, where he was the pupil of Georgius Pachymeres. in whose honour he composed a memorial poem. Having offended one of the emperors by indiscreet remarks published in a chronography, he was thrown into prison and only released after an abject apology. Philes' character. as shown in his poems. is that of a begging poet, always pleading poverty, and ready to descend to the grossest flattery.

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PHILETAS OF Cos (c 330–*c.* 275 B.C.), Greek poet and grammarian, is rightly regarded as the founder of the Alexandrian school of poetry He was tutor to Ptolemy II and taught Zenodotus. Hermesianax and Theocritus. The titles of five of his poems or collections of poems have survived, the most Important being apparently the *Demeter,* an elegy narrating Demeter s wanderings. Though he wrote at least one poem in hexameters Philetas chief fame was as an elegist. His lady love was Bittis (or Battis) and Hermesianax states that the Coans put up a statue of him singing her charms. Among the Romans Propertius and Ovid mention him as their model. Philetas also compiled a lexicon of *Miscellaneous Glosses* (*Miscellanea*) comprising a collection of rare words from Homer, the Greek dialects and other sources.

See A. A. Day, *The Origins of Latin Love-Elegy,* pp. 14–19 (1938). (E. A. B.)

PHILIDOR, FRANÇOIS ANDRE DANICAN (1726–1795), French composer and chess player, was born at Dreux, on Sept. 7, 1726. He was widely regarded as the strongest chess player of the 18th century. After producing several musical works of minor importance, he brought out at Paris, in 1759, his successful light opera, *Blaise le Savetier,* which was followed by a number of others He died in London on Aug. 31. 1795.

PHILIP, one of the 12 apostles. *See* APOSTLE.

PHILIP, "the evangelist," is mentioned in Acts vi, 5, as one of "the seven" chosen to superintend certain secular business of the Jerusalem Church, in consequence of dissension between the Aramaic-speaking and Greek-speaking disciples. Luke by mentioning the common meals wishes his readers to connect these officials with the later diaconate, but they seem to have been originally parallel among the Hellenistic Jews to the Twelve among the Hebraists. Philip's was a ministry of the word. He went to Samaria and preached with much success, Simon Magus being one of his converts. He afterwards instructed and baptized the Ethiopian eunuch on the road from Jerusalem to Gaza. His missionary journey ended at Caesarea (Acts viii). Here he entertained Paul and his companions on their last journey to Jerusalem (xxi. 8). (W. K. L. C.)

PHILIP I (1052–1108), king of France, eldest son of Henry I of France and Anne, daughter of Jaroslav I (d. 1054), grand duke of Kiev, came to the throne, when a child of eight, by the death of his father on Aug. 4, 1060. He had been crowned at Reims. May 23. 1059. His minority came to an end in 1066. In the long reign that followed he showed no great ability or energy, and a looseness of morals which embroiled him with the church. Before he was fifty years of age he became "fond of nothing but good cheer and sleep." But he increased the lands of his house around Paris, maintained order in them, and held his own against William I and William II of England, whose power in France far exceeded his own. This he accomplished for the most part by taking advantage of the quarrels among his vassals. During the years 1070–74 he greatly strengthened his position in Flanders by these means. In the struggle between Fulk Rechin and his brother Geoffrey the Bearded for the inheritance of their uncle, Geoffrey Martel (d. 1060), count of Anjou, Philip received

from Fulk in 1069, as the price of his neutrality, Château Landon and the Gatinais. This acquisition linked the county of Sens, acquired in 1055, with the rest of the domain round Paris, Melun and Orleans. War with William I and William Rufus was chronic but intermittent. In his last years Philip left the duty of repelling the attacks of his Norman and other enemies to his son Louis, associating him with himself, as "king-designate," some time between May 24,1098, and Sept. 25, 1100.

It was his second marriage which was the cause of Philip's greatest difficulties. On May 15, 1092, he carried off Bertrada, daughter of Simon, baron de Montfort, wife of Fulk Rechin, and prepared to marry her, though his wife Bertha was still living. The bishops, headed by Ivo, bishop of Chartres, refused to attend the ceremony of marriage, but one was found to perform it. Philip's open simony had long been a cause of friction with the papacy. When he added bigamy and adultery, Urban II excommunicated him. Philip was reconciled with the Church in 1104, and took an oath not to have any converse or society with Bertrada except in the presence of "nonsuspect" persons. But they seem to have gone on living together, and even visited Fulk Rechin (Bertrada's husband) in company on Oct. 15, 1106. Philip died at the end of July 1108.

His reign is chiefly remarkable for the steady growth of the royal domain. By his first queen he had four children: Louis VI, who succeeded him; Henry, who died young; Charles; and Constance, who married Hugh I, count of Champagne, and later Bohemund I, prince of Antioch. By Bertrada de Montfort he had three children: Philip, count of Montes; Fleury or Florus, who married the heiress of Nangis; and Cecilia, who married, first Tancred, prince of Galilee and Antioch, and secondly Pons de Saint Gilles, count of Tripoli.

PHILIP II (1165–1223), known as PHILIP AUGUSTUS, king of France, son of Louis VII and Alice (or Adela), daughter of Theobald II, count of Champagne, was born on Aug. 21, 1165. On Nov. 1, 1179, he was associated with his father as king by being crowned at Reims; and at once his father's illness threw the responsibility of government on him, the death of Louis on Sept. 19, 1180, leaving him sole king. His long strip of royal domain was hemmed in by the Angevin empire on the west and by the kingdom of Arles on the southeast. Henry II of England was feudal lord of the greater part of France, practically all west of a line which began at Dieppe and ended at the foot of the Pyrenees more than halfway across to the Mediterranean, while at one point it nearly touched the Rhone. Philip's predecessors had consolidated the Capetian power within these narrow limits, but he himself was overshadowed by the power of his uncles, William, archbishop of Reims, Henry I, count of Champagne and Theobald V, count of Blois and Chartres. He secured an ally against them, and an addition to the royal domain, by marrying, on April 28, 1180, Isabella or Elizabeth, daughter of Baldwin V, count of Hainaut, and of Margaret, sister of Philip of Alsace, the reigning count of Flanders, who ceded, as Isabella's dowry, the district afterwards called Artois. On June 28, 1180, Philip made a treaty with Henry II at Gisors; but from 1181 to 1185 he had to struggle against the feudal league of his Champagnard uncles and other great barons, whose most active member was Stephen I, count of Sancerre (1152–91). Having secured his position at home, the king turned against Henry II and, by the truce of Châteauroux in June 1187, gained Issoudun and the seigniory of Fréteval in the Vendômois. Though the truce was for two years, Philip assembled an army in 1188 to invade Normandy, demanding Gisors and the conclusion of the marriage which had been arranged between his sister Alice and Richard I of England, who had meanwhile deserted his father. But Richard took the cross, and Philip seized the county of Berry. Further reconciliations and conferences followed, and Henry II, two days before his death, did homage and surrendered the territories of Graçay and Issoudun (capitulation of Azay). Pledges of mutual good faith and fellowship were exchanged between Philip and Richard of England on Dec. 30, 1189, and they both prepared to go on the crusade.

The Crusade.—Before setting out Philip arranged for the government of France during his absence by the testament of 1190, by which he proposed to rule France as far as possible from Palestine. On the way to Palestine the two kings quarrelled. At the siege of Acre Philip fell ill; and he returned to Paris at Christmas 1191, having concluded on his way an alliance with the emperor Henry VI against Richard, despite his pledges not to molest his lands. Philip did his utmost by offers of money to prolong Richard's captivity and, allied with the English king's brother John, attacked Richard's domains. But upon Richard's return the Normans rallied to him, and Philip was defeated at Fréteval on July 5, 1194. He continued the war, generally with ill success, for the next five years. Again a formidable coalition was formed against him, including Baldwin IX, count of Flanders (also count of Hainaut), Reynald, count of Dammartm and Boulogne. Louis, count of Blois, and Raymund VI, count of Toulouse. In Germany, Otto of Brunswick, afterward the emperor Otto IV, allied himself with Richard, while Philip was supported by Otto's rival. Philip of Swabia. Richard's death in April 1199 removed Philip's archenemy, and Richard's successor, John, concluded the treaty of Le Goulet with him on May 22, 1200, ceding to him the county of Evreux, Graçay and Issoudun and the suzerainty of Berry and Auvergne. John also renounced his suzerainty over Brittany and the guardianship of his nephew, Arthur; pledged not to aid the count of Flanders or Otto IV without Philip's consent; paid him a relief of 20,000 marks; and recognized himself as Philip's vassal for his continental fiefs.

Conquest of Normandy.—But in 1202 the war was renewed. At an interview at Le Goulet on March 25, Philip demanded the cession of Anjou, Poitou and Normandy to his ward, Arthur. John refused; he was summoned to Paris before the royal judges and, failing to appear, was sentenced at the end of April 1202 to lose all his fiefs. Brittany, Aquitaine and Anjou were conferred on Arthur. Philip invaded Normandy, took Lyons-la-Forkt and Eu and, establishing himself in Gournay, besieged Arques. But John, joined by William des Roches and other lords of Maine and Poitou, jealous at the increase of Philip's power, defeated and captured Arthur at Mirebeau. Philip abandoned the siege of Arques in a fit of fury, marched to the Loire, burning everywhere, and then returned to Paris. But John soon alienated the Poitevin barons, and William des Roches signed a treaty with Philip on March 22, 1203. Then Philip continued his great task, the conquest of Normandy, capturing the towns around the fortress of Château Gaillard which Richard had built to command the valley of the Seine. Pope Innocent III tried to bring about peace, but Philip was obdurate; and after murdering Arthur of Brittany, John took refuge in England in Dec. 1203. The fall of Château Gaillard, after a siege which lasted from Sept. 1203 to April 1204, decided the fate of Normandy. Rouen, bound by ties of trade to England, resisted for 40 days but surrendered on June 24, 1204. The conquest of Maine, Touraine, Anjou and Poitou in 1204 and 1205 was little more than a military promenade, though the castles of Loches and Chinon held out for a year. Philip secured his conquest by lavishing privileges on the convents and towns. He left the great lords, such as William des Roches, in full possession of their feudal power. In 1206 he marched through Brittany and divided it among his adherents. A truce for two years was made on Oct. 26, 1206, by which John renounced all claims in Normandy, Maine, Brittany, Touraine and Anjou; but it did not last six months. Then Poitou was thoroughly subdued, and another truce was made in 1208, little more than southern Saintonge and Gascony being left in the hands of John. Philip had reduced to a mere remnant the formidable continental empire of the Angevins, which had threatened the existence of the Capetian monarchy.

Philip then undertook to invade England. He had collected 1,500 vessels and summoned all his barons when John, frightened, made his profession of allegiance to the cardinal-legate Pandulph.

Disappointed of his hopes of England, Philip turned his arms against Ferdinand, count of Flanders. He invaded Flanders and took the chief towns within a week; but he had part of his fleet burned by the English at Damme and had to burn the rest to save it from falling into their hands. He returned to Paris; and Ferdinand retook most of the towns which had been taken by the king. A war of fire and pillage began, in which Philip and his son Louis

burned their way through Flanders, and Ferdinand did the same through Artois.

The Victory of **Bouvines.**—In 1214 came the great crisis of Philip's life. A league including his rebel vassals. Reynald of Dammartin and Boulogne and Ferdinand of Flanders, with the emperor Otto IV and a number of German princes of the Rhine region, had been formed in the northeast, while John of England made one more attempt to recover his heritage at the head of an army of mercenaries, aided by the fickle baronage of Poitou. John landed at La Rochelle on Feb. 10, 1214, and was at first successful. On June 19 he laid siege to La Roche-aux-Moines, the fortress which defended Angers and commanded the Loire valley; but on the approach of a royal army under Prince Louis on July 2 his army was panic-stricken, and he fled hastily to La Rochelle. The Angevin empire in France was lost. Meanwhile Philip himself won his greatest victory at the bridge of Bouvines (*q.v.*), among the morasses of Flanders. At first taken by surprise, he turned the abortive attack into a complete rout. Reynald and Ferdinand were taken prisoner, and Otto IV fled from the battlefield. The army of the allies was utterly destroyed (July 27, 1214). The battle of Bouvines, a decisive battle for the history of Germany as well as for France and England, sealed the work of Philip Augustus. The expedition of his son Louis to conquer England can hardly be considered as an incident of his reign, though he was careful to safeguard the rights of the French crown. More important was the Albigensian crusade, in which he allowed Louis to take part, though he himself, preoccupied with the king of England, had refused time after time to do anything. He treated Simon IV de Montfort as if he were a royal *bailli;* but it was not in virtue of any deep-laid scheme of his that in the end Amaury de Montfort, Simon's son, resigned himself to leave his lands to the crown of France and gave the crown a power such as it had never before possessed in Languedoc.

Organization of France.—Philip II surrounded himself with clerks and legists of more or less humble origin, who gave him counsel and acted as his agents. His *baillis,* who at first rather resembled the itinerant justices of Henry II of England, were sent into the royal domain to supervise the conduct of the *prévôts* and to be responsible for all that concerned order, justice and taxes; while in the south local feudal magnates were given similar powers with the title of *sénéchal (see* BAILIFF AND BAILIE). Feudal service was more and more compounded-for by a money payment, and additional taxes were raised. The extension of the system of *sauvegarde,* by which abbeys, towns or lay vassals put themselves under the special protection of the king, and that of *pariage,* by which the possessor surrendered half the interest in his estate to the king in return for protection or some further grant, increased the royal power. The gentry was completely reduced to bondage. The nobles were ceaselessly watched (their widows could not remarry without the king's consent). The king, moreover, held himself to be supreme suzerain and also sovereign over the whole feudal system.

It has been said with some justice that Philip II was the first king of France to take the bourgeoisie into partnership. He favoured the great merchants, granting them trade privileges and monopolies. The Jews he protected and plundered by turns, after the fashion of mediaeval kings. Among the subject towns administered by *prévôts* a great extension of the "custom of Lorris" took place during his reign. Philip was the ally and protector of the communes. Before him they were resisted and often crushed; after him they were exploited, oppressed and finally destroyed. In the case of Senlis he extended the jurisdiction of the commune to all crimes committed in the district. It is true that he suppressed some communes in the newly conquered fiefs, such as Normandy, where John had been prodigal of privileges, but he erected new communes in his own private domain, quite corftrary to the custom of other kings. He seems to have regarded them as a kind of garrison against feudal unruliness, while the rents that they furnished increased his financial resources. He created no new types of commune, however, except Péronne, which received a maximum of political independence.

Philip's policy of building up a strong monarchy was pursued with a steadiness of aim which excluded both enthusiasm and scruple. He shrank from no trickery in carrying out his ends and had no room for pity. He could not even trust his own son with any power and was brutal in his relations with his queen, Ingeborg. As the result of his steadiness of aim and patient sagacity, at the end of his reign the crown was victorious over the feudal nobility and the royal domain extended to the frontiers along with royal authority. Artois, the Amiénois, Valois, Vermandois, the greater part of the Beauvaisis, Normandy, Maine, Anjou. Touraine and an important part of Poitou and Saintonge, were added to the domain during his reign. The number of *prévôtes* was increased from 38 to 94; and the royal revenue increased from 19,000 livres a month to 1,200 livres a day.

Philip Augustus died on July 14, 1223. He was married three times. His first wife, Isabella, by whom he had one son, Louis, died in 1189 or 1190. After her death he married Ingibjörg or Ingeborg (*q.v.*), daughter of Valdemar I oi Denmark, whom he soon repudiated. In 1196, in defiance of the pope, he married Agnes, daughter of Bertold IV, duke of Meran. This led to his excommunication and brought the interdict upon France, and did more to weaken him than any other act of his. In 1200 he was forced to put away Agnes and to recognize Ingeborg as his lawful wife, but he kept her in prison until 1213. By Agnes (d. 1201) he had a son Philip, called "Hurepel," count of Clermont, and a daughter Mary, who married Philip, count of Namur (d. 1213), and then Henry II, duke of Brabant. Ingeborg lived until 1237 or 1238.

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PHILIP III (1245–1285), surnamed THE BOLD *(le Hardi),* king of France, son of Louis IX and Margaret, daughter of Raymund-Berengar IV, count of Provence, was born on April 3, 1245. His funeral monument at St. Denis depicts a man with beardless. square-cut features, but lacking character and animation. The authenticity of this effigy is fairly well borne out by what is known of him from other sources. He had many of the virtues of his father, St. Louis, but neither decision of character nor devotion to duty. He was pious, charitable, of unimpeachable morality, quick-tempered but placable, no great scholar and only energetic as a hunter. The absence in him of the qualities that fit a man to rule made his court the arena of intriguing factions, which in reality ruled France during his reign of 15 years (1270–85). Matthew of Vendôme, abbot of St. Denis, an old servant of Louis IX, acted as Philip's counsellor, so the chroniclers state, throughout the reign; but it was probably with administration, not with policy, that Matthew was chiefly concerned. Philip began his reign in 1270 by falling entirely under the influence of Pierre de la Brosse. formerly surgeon and valet-de-chambre to his father, and made him lord (sieur) of Langeais. Châtillon-sur-Indre and Damville. His influence lasted until Philip's second marriage in 1274 with Mary, daughter of Henry III, duke of Brabant. She supplied a centre for the enemies of the favourite, who, in 1278, was charged with various crimes, including that of poisoning the king's eldest son, and hanged at Montfaucon. His death left the parties of Mary, the queen, and Margaret, the queen-mother, to struggle for the mastery.

Nevertheless, under the reign of this feeble and disparaged king, the royal domain was considerably enlarged, particularly in the years during which Philip followed the advice of his father's old counsellors. As early as 1271, he took hold of the huge inheritance of his uncle Alphonse of Poitiers, that is of almost the whole of the Languedocian south. But after Henry III of England had demanded the settlement of the claims allowed to him by the treaty of Paris (1259), the right of his son Edward I to such territories as Guienne, Agenais and southern Saintonge was recognized by the treaty of Amiens (1279). In May 1284, Philip had married his second son Philip to Joan of Artois, the sole heiress of Navarre and Champagne, thus preparing the annexation of the latter province

to France. However, being more and more under the thumb of his second wife Mary of Brabant and of his uncle Charles of Anjou, Philip was carried away to undertake more and more perilous and costly expeditions. An expedition against Castile in aid of the children of his sister, Blanche, proved abortive. Regardless of this warning. he was induced in 1284 to take up the quarrel of his uncle Charles I of Anjou in Sicily, after the Sicilian Vespers (see VESPERS, SICILIAN) in 1282. TWO assemblies of barons and prelates were held at Bourges in Nov. 1283 and Feb. 1284 to deliberate on the question. This was a mere matter of form. Mary of Brabant and her party had decided the matter beforehand, and the crown of Aragon, which the French pope Martin IV had declared forfeited by Peter III, was accepted for Charles of Valois, Philip's third son. The project was strongly opposed by Matthew of Vendôme, who was in correspondence with the king of England on the subject. It was the first warlike expedition undertaken by the house of Capet outside France and proved a disastrous failure. Philip died during the retreat at Perpignan on Oct. 5, 1285.

Philip was twice married. On May 28, 1262, he married Isabella, daughter of James I, king of Aragon, who died in 1271. By her he had four children: Louis, who died in 1276; Philip, born in 1268; Charles of Valois, born on March 12, 1270; and Robert, who died young. By his second wife, Mary (d. 1322), daughter of Henry III of Brabant, whom he married in 1274, he had three children: Louis, count of Evreux; Margaret, who married in 1299 Edward I, king of England; and Blanche, who married Rudolph 111, duke of Austria.

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PHILIP IV (1268–1314), called THE FAIR (le *Bel),* king of France, was the son of Philip III and his wife, Isabella of Aragon. His reign, which began in Oct. 1285, is one of the most momentous in the history of mediaeval Europe, yet it belongs rather to the history of France and to that of the papacy than to the biography of the king (see FRANCE: *History).*

No king has ever been so variously judged as Philip the Fair: some saw a great king in him; others deemed him only a feeble character, not of outstanding merit, interested but little in politics and letting his ministers act as they thought fit. Yet, it must be observed that his counsellors, whom he drew from the legal class (that is, from people willing to see the rights of the monarch and of the state increased), never fell into disgrace: such men as Guillaume de Nogaret, Enguerrand de Marigny (*q.v.*) and Pierre Flote had Philip's support in all circumstances; and this suggests that he was perhaps himself the promoter of the whole policy, or at least that he understood it and approved of it. Tall and handsome, with irreproachable manners, well-read, brave, cold and silent, his ambition was to be the sole master of his kingdom, above any other secular or ecclesiastical power and without any limitation of this authority to the royal domain proper.

In the first place, Philip tried to use peaceful methods and succeeded in establishing his judges' orders and the right of appeal to his courts as applicable to Burgundy and Brittany, provinces which did not belong to the domain. His procedure was the same in financial matters. But in Aquitaine, where he had to encounter the king of England, and in Flanders he was unsuccessful and, resorting to violent means, was not always favoured by fortune. In 1294 he attacked Edward I of England, then busied with the Scottish War, and seized Guienne. Edward won to his side the counts of Bar and of Flanders. but they were defeated. A truce was made in 1297 and renewed until the peace of 1303. Meanwhile the Flemings had utterly defeated the French army at Courtrai in 1302. The reign closed with the French position unimproved in Flanders, except for the transfer to Philip of Douai and Béthune and their dependencies by Count Robert of Lille. However, it was in his reign that the royal administration was definitely constituted, the king's rights as sovereign enabling him to interfere everywhere, against the feudal lords and against the clerics. This expensive policy and his interest in the wealth of the monarchy as a means of augmenting his power caused Philip to be permanently occupied with financial affairs; and it was this preoccupation that brought him into conflict with the papacy and led him to suppress the Templars.

The greatest event of the reign was the struggle with Pope Boniface VIII (*q.v.*). The pope went so far in 1296 as to forbid any lay authority to demand taxes from the clergy without his consent. When Philip retaliated by a decree forbidding the exportation of any coin from France, Boniface gave way to save the papal dues, and the bulls issued by him in 1297 were a decided victory for the French king. There was a truce until 1301. After the arrest, by Philip's orders, of Bernard Saisset (*q.v.*), bishop of Pamiers, in that year, the quarrel flamed up again. To ensure the support of his people the king had called an assembly of the three estates of his kingdom at Paris in April 1302; in the following year Guillaume de Nogaret seized the person of the pope at Anagni. Boniface escaped from his captors only to die (Oct. 11); and the short pontificate of his saintly successor, Benedict XI, was occupied in a vain effort to restore harmony to the church. The issue of the conclave that met at Perugia on his death was ultimately determined by the diplomacy and gold of Philip's agents, and the new pope, Clement V, was the weak-willed creature of the French king. When in 1309 the pope installed himself at Avignon, the new relation of the papacy and the French monarchy was patent. It was the beginning of the "Babylonish captivity" of the popes. The most notable of its first-fruits was the hideous persecution of the Templars (*q.v.*), which began with the sudden arrest of the members of the order in France in 1307 and ended with the suppression of the order by Pope Clement at the council of Vienne in 1312. Philip died on Nov. 29, 1314. In 1284, he had married Joan, queen of Navarre (d. 1305), through whom Navarre passed under the king's rule and who brought Champagne to the royal domain. Three of Philip's sons, Louis X, Philip V and Charles IV, succeeded in turn to the throne of France; his daughter, Isabella, married Edward II of England.

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PHILIP V (1294–1322), king of France, called THE TALL, second son of Philip IV and Joan of Navarre, received the county of Poitiers as an apanage. While Philip was watching the conclave in Lyons, on June S, 1316, his elder brother Louis X died, leaving a four-year-old daughter, Joan, by his first (adulterous) wife and a widow with child. Philip returned at once to Paris, where his uncle, Charles of Valois, had occupied the royal palace and the Louvre. Supported by the high officers and the Paris burgesses, Philip succeeded on July 12 in taking hold of the palace; on July 16 an assembly of noblemen gave him an oath of allegiance and decided that he should be regent of France and Navarre till the majority of the unborn king. Charles of Valois and his supporters accepted him. On Nov. 15, Queen Clemence gave birth to a son, John I, who lived only five days. Philip had already prepared for the elimination of his niece Joan, by treating with her uncle, the duke of Burgundy, to whom he gave his daughter in marriage. He proclaimed himself king on Nov. 19, received oaths from his brothers and uncles and on Jan. 9, 1317, was crowned in Reims despite the protest of Agnes of Burgundy, Joan's grandmother. Most of the great barons did not attend the coronation, and there was some armed resistance from the nobility in Champagne, Artois and Burgundy.

Because of this dubious legitimacy, Philip tried to keep in touch with public opinion and summoned a number of assemblies to get their support. In Feb. 1317 he received approbation for his conduct from an assembly of noblemen, bishops, Paris burgesses and university masters, which proclaimed that women could not succeed to the crown. In March of the same year two assemblies were held, one in Paris for delegates from the northern towns, the second in Bourges for the south. A fourth meeting took place in Paris in the following April. During the four succeeding years

new assemblies were held, gathering barons, bishops and townsmen either from a single province or from several. They took no political character, dealing only with coinage and weights (the king tried vainly to achieve uniformity by suppression of the feudal coins) and with money demands from the government. They were poorly attended, and their failure illustrates the general obedience and the power of the monarchy. which came undamaged out of the succession crisis.

Philip did much to restore royal power, which had been weakened by the feudal reaction under his brother: he reorganized the police forces by developing the towns' militias, whose captains were under his authority; he ordered large inquests to redress grievances. In an attempt to settle the Flemish question, he made concessions to the Flemish count by the treaty of Paris (Sept. 1, 1316). But the quarrel about the indemnity due from Flanders by virtue of the treaty of Athis-sur-Orges went on, despite papal arbitration in 1318, and Philip had to send armies to Flanders in 1318 and 1319. Then Robert of Béthune, threatened by internal opposition, accepted the papal arbitration and did homage in Paris (April 1320). After difficult and protracted negotiations and the seizure of the county of Ponthieu, Philip got homage from Edward II (at Amiens on June 20, 1320). Philip died on Jan. 9, 1322, leaving a daughter and a pregnant wife.

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PHILIP VI (1293–1350), king of France, was the son of Charles of Valois, third son of Philip III the Bold, and of Margaret of Sicily, and was thus the nephew of Philip IV the Fair, whose sons, Louis X, Philip V and Charles IV, died successively without leaving male heirs (except the posthumous and short-lived John I). He succeeded to the throne on the death of his cousin, Charles IV, in 1328. Before his accession Philip had enjoyed considerable influence, for he was count of Valois, Anjou, Maine, Chartres and Alençon. He had married in, 1313 Joan (d. 1348), daughter of Robert II of Burgundy, a determined woman who was long known as the real ruler of France.

When Charles IV died, in Feb. 1328, his wife was pregnant, and it became necessary to appoint a regency until the birth of the child, who would, if a son, succeed to the throne. At the assembly of barons called to choose a regent, Edward III of England, the nephew and nearest male relation of Charles IV, put in a claim. Edward III, however, descended from the royal house of France by his mother Isabella; and the barons, probably actuated by an objection to the regency of an English king, decided that neither a woman, "nor by consequence her son, could succeed to the kingdom of France." Philip of Valois, then, in spite of his belonging to a junior branch of the family, was elected regent. On the birth of a girl to the queen widow the regency naturally led to the throne of France, and Philip was crowned at Reims on May 29, 1328. Navarre had not accepted the regency, that kingdom being claimed by Philip count of Evreux (who was, like Philip of Valois, a grandson of Philip III of France), for his wife Joan, eldest daughter of Louis X. The new king of France secured the friendship of the count by allouing Joan's claim to Navarre, in return for a renunciation of any right to Champagne. Edward III of England, after more than one citation, reluctantly fulfilled (1329–31) the formalities of homage for part of Guienne. Meanwhile Philip VI had won a victory, which he turned into a massacre, at Cassel (Aug. 23, 1328) over Bruges and the other towns of west Flanders, which under the leadership of Jakob van Artevelde had thrown off the authority of their count, Louis of Nevers. The count of Flanders was reinstated and maintained his authority by a reign of terror.

Philip VI enjoyed powerful alliances. In Italy he was allied with his uncle, Robert of Anjou, king of Sicily, and with his former enemy, Galeazzo Visconti; in the north with the duke of Brabant and the princes of the Netherlands; on the east with the reigning princes of Lorraine and Savoy; with the king of Bohemia and with Pope John XXII at Avignon and his successor Benedict XII. In 1336 it seemed that the crusade, for which Philip VI had been preparing since 1330 would at last start; but the relations with Edward III of England, always strained, became worse, and within a year France was embarked on the struggle of the Hundred Years' War. The causes which led to war, the conflict for commercial supremacy in Flanders, disputed rights in Guienne, the help given by France to the Scots and the unnatural situation of an English king who was also a vassal of the French crown are dealt with elsewhere (see HUNDRED YEARS' WAR, THE). The immediate rupture in Flanders was due chiefly to the tyranny of the count of Flanders, Louis of Nevers, whom Philip had reinstated. Edward III had won over most of Philip's German and Flemish allies, and the English naval victory at Sluys (June 24, 1340), in which the French fleet was annihilated, effectually restored English preponderance in Flanders. A truce followed, but this was disturbed after a short duration by the disputed succession to the duchy of Brittany (*q.v.*).

A truce made at Malestroit in 1343, at the invitation of the pope, was rudely broken by Philip's violence. Olivier de Clisson, who with 14 other Breton gentlemen was suspected of intrigue with Edward III, was invited to a great tournament in Paris. On their arrival they were seized on Philip's orders and, without form of trial, beheaded. Then followed Edward III's invasion of Normandy and the campaign of Créçy (*q.v.*). Philip's army was destroyed; he himself was wounded and fled from the field. He sought in vain to divert Edward from the siege of Calais by supporting the Scots in their invasion of England; but eventually a truce was arranged, which lasted until 1351. Philip died at Nogent-le-Roi on Aug. 12, 1350. Philip VI met his necessities by the imposition of the hated *gabelle* or salt tax and by debasing the coinage; and he obtained heavy subsidies from the various provinces. In 1349 he bought Montpellier from James III of Majorca and the province of Dauphiné (for his grandson Charles) from Humbert II, count of Vienne. Philip married a second wife, Blanche of Navarre. By his first wife he left two sons—his successor, John II, and Philip of Orléans, count of Valois.

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PHILIP (c. 1177–1208), German king and duke of Swabia, the rival of the emperor Otto IV, was the fifth and youngest son of the emperor Frederick I and Beatrix, daughter of Renaud III, count of Upper Burgundy. and brother of the emperor Henry VI. He entered the church, was made provost of Aix-la-Chapelle, and in 1190 or 1191 was chosen bishop of Würzburg. Philip forsook his ecclesiastical calling and was made duke of Tuscany in 1195 receiving an extensive grant of lands. In 1196 he became duke of Swabia, on the death of his brother Conrad; and in May 1197 he married Irene, daughter of the eastern emperor, Isaac Angelus, and widow of Roger II, king of Sicily. Philip appears to have been designated as guardian of the young Frederick, afterwards the emperor Frederick II, in case of his father's early death. In 1197 he had set out to fetch Frederick from Sicily for his coronation when he heard of the emperor's death and returned at once to Germany. He found growing hostility to the kingship of a child, and the absence of the two Welf claimants, Otto and Henry, the sons of Henry the Lion, made possible Philip's own election as German king at Miihlhausen on March 8, 1198. He was crowned at Mainz on Sept. 8.

Meanwhile a number of princes hostile to Philip, under the leadership of Adolph, the archbishop of Cologne, had elected an antiking in the person of Otto, second son of Henry the Lion, duke of Saxony. War followed, in which Philip drew his principal support from south Germany. In 1199 he received further accessions to his party and carried the war into his opponent's territory. In March 1201 Innocent III placed Philip and his associates

under the ban, and began to work for Otto. Otto, aided by Ottakar I., king of Bohemia, and Hermann I., landgrave of Thuringia, drove him from north Germany, and compelled him to seek, in vain, reconciliation with Innocent. The submission of Hermann of Thuringia in 1204 marks the turning-point of Philip's fortunes, and he was soon joined by Adolph of Cologne and Henry I, duke of Brabant. On Jan. 6, 1205, he was crowned again by Adolph at Aix-la-Chapelle, though it was not till 1207 that his entry into Cologne practically brought the war to a close. Philip was then loosed from the papal ban. He was preparing to crush the last flicker of the rebellion in Brunswick when he was murdered at Bamberg, on June 21, 1208, by Otto of Wittelsbach, count palatine in Bavaria, to whom he had refused the hand of one of his daughters. He left four daughters, one of whom, Beatrix, afterwards married his rival, the emperor Otto IV. Philip was a brave and handsome man, and contemporary writers, among whom was Walther von der Vogelweide, praise his mildness and generosity.

See O. Abel, *Konig Philipp der Hohenstaufen* (1852); *E.* Winkelmann, *Philipp von Schwaben und Otto ZV. von Braunschweig* (Leipzig, 1873–78); ***Regesta imperii.*** *V.*, ed. J. Ficker (Innsbruck, 1881); R. Schwrmer, *Innocenz ZZZ. und die deutsche Kirche wahrend des Thronstreites von 1198–1208* (Strasbourg, 1882).

PHILIP I., king of Macedonia, a semi-legendary prince, son of Argaeus, was, according to Herodotus (viii. 137–139) and Thucydides (ii. 100), the third of the Macedonian kings. There is, however, no real evidence for his existence.

PHILIP II. (382–336 B.C.), king of Macedonia, the son of Amyntas II. and the Lyncestian Eurydice, reigned 359–336. At his birth the Macedonian kingdom, including the turbulent peoples of the hill country behind, was very imperfectly consolidated. In 370 Amyntas died, and the troubled reign of Philip's eldest brother, Alexander II., was cut short in 368 by his assassination. His murderer, Ptolemy of Alorus, ruled as regent for the young Perdiccas, Amyntas's second son. In 367 Philip was delivered as a hostage to the Thebans, then the leading power of Greece, where he got to know Epameinondas, whom he greatly admired and whose influence may be traced in Philip's military reforms. When he returned to Macedonia (364) Perdiccas had succeeded in getting rid of Ptolemy; but he fell in 360–359 before an onslaught of the hill tribes instigated by the queen-mother Eurydice, leaving only an infant son. Pretenders sprang up and the kingdom fell into confusion. Philip seized the throne and drove back his rivals. He now began the great task of his life—the creation of the Macedonian national army. Cavalry, the famous "companions," he already had; his work was to produce an efficient force of infantry. This new force of his making consisted of the *hupaspistai* who may have been peltasts on Iphicrates's model, and the phalanx, which in its use for shock tactics on the wing in conjunction with the cavalry shows the influence of Epameinondas, but was less densely packed, and was armed, unlike Greek troops, with a long pike. The first experiment he made with this new organism was brilliantly successful. The hill tribes were broken by a single battle in 358, and Philip established his authority inland as far as Lake Ochrida. In the autumn of the same year he took the Athenian colony Amphipolis, which commanded the gold-mines of Mt. Pangaeus. Their possession was all-important for Philip, and he set there a new city, Philippi. Athens was temporarily pacified by assurances that Amphipolis would be handed over to her later on.

He avoided as yet a forward policy, and having taken Pydna and Potidaea soon after Amphipolis, he made them over to the Olynthian confederation (*see* OLYNTHUS). His marriage with the fierce witch-woman, Olympias, daughter of the Epirote king, falls in this period, and in 356 she bore him his greater son, Alexander. In 353 Philip was ready for strong action. He first attacked Abdera and Maroneia, on the Thracian sea-board, and then took Methone, which belonged to Athens. An overt breach with Athens was now inevitable. In the same summer he invaded Thessaly, where the Aleuadae of Larissa ranged themselves on his side against the *tagos* Lycophron, "tyrant" of Pherae. Pherae called in the help of the Phocian mercenaries, who had profaned Delphi, and Philip was twice heavily defeated. But next year the Macedonian army won a complete victory over the Pheraeans and Phocians. This battle made Philip tagos of Thessaly, and he annexed Magnesia, which included Pagasae. But on advancing further he found the Athenian expedition which had failed to secure Pagasae holding Thermopylae, and withdrew. From 352 to 346 Philip did not again come south. He was active in completing the subjugation of the Balkan hill-country to the west and north, and in reducing the Greek cities of the coast as far as the Hebrus (Maritza). Then, in 349, he opened war upon Olynthus. Athens sent no adequate forces, in spite of the upbraidings of Demosthenes (see his Olynthiacs), and in the spring of 347 Olynthus fell. Macedonia and the regions adjoining it having now been securely consolidated, Philip celebrated his "Olympian" games at Dium. In 347 Philip advanced to the conquest of the eastern districts about the Hebrus, and compelled the submission of the Thracian prince Cersobleptes. Meanwhile Athens had made overtures for peace (see the De falsa *legatione* of Demosthenes), and when Philip, in 346, again moved south, peace was sworn in Thessaly.

The Phocians, who still dominated Delphi and held Thermopylae, now furnished a pretext to Philip as the champion of Pan-Hellenism and Apollo. The Phocian mercenaries at Thermopylae were bought off and Philip crossed into central Greece. There he made Thebes his ally and visited the Phocians with crushing vengeance. The Pythian games of 346 were celebrated at the delivered Delphi under Philip's presidency. Pan-Hellenic enthusiasts already saw Philip as the destined captain-general of a national crusade against Persia (Isocrates, *Philippus*, about 345). And such a position Philip had determined to secure; the Macedonian agents continued to work throughout the Greek states and in the Peloponnesus Sparta soon found herself isolated. Euboea, too, submitted to Macedonian influence.

But more work had to be done in the Balkan highlands. In 344, or one of the following years, the Macedonian arms were carried across Epirus to the Adriatic and Thessaly was completely reorganized. In 342 Philip led a great expedition north "comparable to nothing in antiquity since Darius' famous march to Scythia." Meanwhile he continued to foster diplomatic relations with various Greek states, and, by conciliatory measures, to support the efforts of the pro-Macedonian party in Athens. But Demosthenes eventually carried the day, and Philip came more or less openly to blows with Athens over Diopeithes's behaviour in the Chersonese. Athens then supported the revolt of Philip's allies in Propontis, and struck a heavy blow at his prestige when his sieges of Perinthus and Byzantium failed in 339. But before marching south he led another expedition across the Balkans into the country now called Bulgaria, and returned to Pella with much spoil but severely wounded in the thigh.

In 338 he once more crossed into central Greece. The pretext was the contumacy shown by the Locrian town Amphissa to the rulings of the Amphictyonic council. Philip's fortification of Elateia filled Athens with alarm. Thebes was induced to join Athens; so were some of the minor Peloponnesian states, and the allies took the field against Philip. This opposition was crushed by the epoch-making battle of Chaeroneia, which left Greece at Philip's feet. Thebes was occupied by a Macedonian garrison; Athens, which had expected a fight to the death, was treated generously. In the following year (337) Philip was in the Peloponnesus and held a congress of the Greek states at the isthmus (from which, however, Sparta held sullenly aloof). The states attending were organized into an Hellenic league, with a constituent council and a supreme judicial court (the Amphictyonic council), acknowledging the military command of Philip and sending contingents for the expedition against Persia that was next in his plans. Philip returned to Macedonia to complete his preparations; an advance force was sent into Asia in the spring of 336. Philip was murdered that year during the marriage festival of his daughter at Aegae, the old capital of Macedonia. He left, however, in the Macedonian army a splendid instrument which enabled his son within ten years to change the face of the world.

See the authorities under **GREECE**: *History. A* vivid and masterly sketch of Philip's personality and work is given in D. *G.* Hogarth's

Philip and Alexander (1897). For economic policy, A. B. West in *Numism. Chron.* (1923) 169.

PHILIP III (ARRHIDAEUS), king of Macedonia, was the feeble-minded son of Philip II of Macedonia by a Thessalian wife. He was chosen by the Macedonian army at Babylon in 323 to be nominal king conjointly with the infant Alexander, and was killed in Macedonia by order of Olympias (317 B.C.). *(See* MACEDONIAN EMPIRE.)

PHILIP IV, king of Macedonia, was the son of Cassander, king of Macedonia; he reigned only one year (297–296 B.C.).

PHILIP V, king of Macedonia, son of Demetrius II and Chryseïs, was an infant at his father's death in 230–229 B.C. His cousin, Antigonus Doson, administered the kingdom as regent till his death in 221–220 B.C., when Philip was 18 years old. Philip now ascended the throne and reigned till 179 B.C. His reign was occupied in the vain struggle to maintain the old Xfacedonian supremacy in the Balkan peninsula, which became hopeless after the intervention of Rome and the decisive battle of Cynoscephalae (197 B.C.). *See* ROME: *Ancient History.* (E. R. B.)

PHILIP I, the Handsome (1478–1506), king of Spain, son of the emperor Maximilian I, was born at Bruges on July 22, 1478. In 1482 he succeeded to the Burgundian possessions of his mother Mary, daughter of Charles the Bold. In 1496 he married Joanna, daughter of Ferdinand and Isabella. He died suddenly at Burgos on Sept. 25, 1506.

PHILIP II (1527–1598), king of Spain, son of the emperor Charles V and Isabella of Portugal, was born at Valladolid on May 21, 1527. Philip was educated in Spain. The emperor, as he moved from one part of his wide dominions to another and in the camps of his armies, watched his heir's education from afar. The trend of his letters was to impress on the boy a profound sense of the high destinies to which he was born, the wisdom of distrusting counsellors, and the necessity for keeping his nobles apart from all share in the conduct of the internal government of his kingdom. Philip grew up grave, self-possessed and distrustful. He was beloved by his Spanish subjects, but utterly without the power of attracting men of other countries. Though accused of extreme licentiousness, Philip was probably less immoral than most kings of his time, and he was rigidly abstemious. His power of work was unbounded, and he had an absolute love of reading, annotating, and drafting dispatches. Unhappily for Spain, Charles decided to transmit the Netherlands to his son. In 1543 Philip had been married to his cousin Mary of Portugal, who bore him a son, the unhappy Don Carlos, and who died in 1545. In 1554 Charles summoned Philip to Flanders and arranged the marriage with Mary, Queen of England, in order to form a union of Spain, the Netherlands and England against France. The marriage proved barren. The abdication of his father (Jan. 16, 1556) constituted Philip sovereign of Spain with its American possessions, of the Aragonese inheritance in Italy, Naples and Sicily, of the Burgundian inheritance—the Netherlands and Franche Comté—and of the duchy of Milan. It was a legacy of immense responsibilities and perils, for France was bound to endeavour to ruin a power which threatened its independence. France was beaten at St. Quentin and Gravelines, and forced to make the peace of Cateau Cambrésis (April 2, 1559). But the death of Mary of England (Nov. 17, 1558) and the establishment of Elizabeth I on the English throne, put on the flank of Philip's scattered dominions another power, forced no less than France by political necessities to be his enemy. His marriage with Elizabeth of Valois (June 22, 1559), and the approach of the wars of religion, gave him a temporary security from France. Kevertheless. when Philip went back to Spain, in Aug. 1559, he was committed to a life-long struggle, in which he could not prove victorious except by the conquest of France and England.

External and internal influences alike drove Philip into conflict with the Netherlands, France and England. The conflict became one between Protestantism and Roman Catholicism, in which Philip appeared as the champion of the Church. It was a part he rejoiced to play. His persecutions hardened the obstinacy of the Dutch, exasperated the English and provoked a revolt of the Moriscoes. No experience of the failure of his policy could shake his belief in its essential excellence. Philip had a high ideal of his duty as a king, and had no natural preferences for violent courses. His strong measures in Aragon in 1591 were provoked by extreme misconduct on the part of a faction. When he enforced his claim to the crown of Portugal (1579–1581) he preferred to placate his new subjects by guarding their privileges. He even made dangerous political concessions to win over the gentry. In private life he was orderly and affectionate to his family and servants. He was slow to withdraw the confidence he had once given. In the painful episode of the imprisonment and death of Don Carlos, Philip behaved honourably. He died at the Escorial on Sept. 13, 1598.

As an administrator Philip had all the vices of his type, that of the laborious, self-righteous man, who thinks he can supervise everything, is capable of endless toil, and jealous of his authority. He set the example of the unending discussions in committee and boundless minute writing which choked the administration.

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PHILIP III (1578–1621), king of Spain, son of Philip II, and Anne, daughter of Maximilian II, was born at Madrid, April 14, 1578. He inherited the beliefs of his father, but no share of his industry. He left the direction of government entirely to his favourite, the duke of Lerma, and, after the latter's overthrow in 1618, to the new favourite, the duke of Uceda, Lerma's son. Philip's own life mas passed amid court festivities, on which enormous sums of money were wasted, or in the practice of childish piety. It was said that he was so virtuous as hardly to have committed a venial sin. He died at Madrid. March 31. 1621.

See R. Watson and W. Thompson, *History of Philip III,* 2 vol. (1876, 1808).

PHILIP IV (1605–1665), king of Spain, eldest son of Philip III and Margaret, sister of the emperor Ferdinand II, was born at Valladolid April 8, 1605. His reign, after a few years of barren successes, was a long story of political and military decay and disaster. A fine horseman, a keen hunter and a patron of art and letters, he indulged in these pastimes, leaving the government to his favourite Gaspare Olivares. When, in 1643, the disasters falling on the monarchy led to the dismissal of Olivares, Philip had lost the power to devote himself to hard work. After a brief attempt at directing the administration of the most extensive and the worst organized monarchy in Europe, he returned to his pleasures and was governed by other favourites. His political opinions were those he had inherited from his father and grandfather. He thought it his duty to support the German Habsburgs and the cause of the Roman Catholic Church against the Protestants. to assert his sovereignty over the Ketherlands. and to extend the dominions of his house. The utter exhaustion of his people in a hopeless struggle with the Netherlands. France and England was seen by him with sympathy, but he considered it unavoidable. His court was grossly vicious. Philip IV died on Sept. 17, 1665.

See A. Cánovas del Castilo, *Estudios del reinado de Felipe IV* (Madrid, 1889), and the introduction by F. Silvela to the *Cartas de Sor Maria de Agreda y del rey Felipe IV* (Madrid, 1885–86).

PHILIP V (1683–1746), king of Spain, founder of the Present Bourbon dynasty, was the son of the dauphin Louis and Maria Anna, daughter of Ferdinand Maria, elector of Bavaria. Born at Versailles, Dec. 19, 1683, he was named heir by the will of Charles II. Carefully educated as duke of Anjou by F. Fénelon, he was all his life strongly adverse to the moral laxity of most of the princes of his time, and greatly under the influence of his two wives, Maria Louisa of Savoy (d. Feb. 1714), whom he married in 1702, and Elizabeth Farnese of Parma, whom he married in Dec. 1714. His strongest passion was to secure his succession to the throne of France, and in this pursuit he indulged in many intrigues against the house of Orleans. even abdicating in 1724. But when his son Louis died a few months later, he resumed the throne.

See Coxe, *Memoirs of the Kings of Spain of the House of Bourbon* (London, 1815).

PHILIP, LANDGRAVE OF HESSE (1504–1567), son of the landgrave William II., was born at Marburg on Nov. *13,* 1504. He became landgrave on his father's death in 1509, and having been declared of age in 1518, was married in 1523 to Christina, daughter of George, duke of Saxony. In *1522* and also in 1523 he assisted to quell the rising of Franz von Sickingen (*q.v.*), who had raided Hesse five years previously, and in 1525 he took a leading part in crushing the rebellion of the peasants in north Germany, being mainly responsible for their defeat at Frankenhausen. About this time Philip adopted the reformed faith. His plans to protect the reformers rested upon two main principles—unity among the Protestants at home and military aid from abroad. The schemes he put forward as one of the heads of the league of Schmalkalden, aimed primarily at overthrowing the house of Habsburg. Envoys were sent to seek aid from France, England and Denmark; Turkey and Venice were looked to for assistance; the jealousy felt towards the Habsburgs by the Bavarian Wittelsbachs was skilfully fomented. Before the formation of the league of Schmalkalden Philip was intimate with Zwingli. In *1526* he had aided John the Constant, elector of Saxony, to form an alliance of reforming princes; and in 1529 he called together the abortive conference at Marburg, hoping thus to close the breach between Lutherans and Zwinglians Deceived by the forgeries of Otto von Pack (*q* o.), he believed in the existence of a conspiracy to crush the reformers, and was only restrained from attacking his enemies, in 1528, by the influence of John of Saxony and Luther. In *1529* Philip signed the "protest" presented to the diet at Spires, being thus one of the original "Protestants"; in 1530 he subscribed the Augsburg confession, and helped to form the league of Schmalkalden.

He next restored Ulrich, duke of Wurttemberg (*q.v.*) to his duchy. Württemberg had passed into the possession of the Habsburgs, and after Philip's brief and victorious campaign in *1534* it was said that the landgrave had done more for Protestantism by this enterprise than a thousand of Luther's books would do. The Concord of Wittenberg, made in *1536,* was preparatory to a general attack on the Habsburgs, but war was prevented by the illness of the landgrave and other circumstances. At this point he took a fatal step His union with Christina was unhappy, and, having fallen in love with Margaret von der Saal (d. 1566), he obtained an opinion from Protestant theologians that bigamy was not forbidden by Holy Writ. Luther and Melancthon at length consented to the marriage, but stipulated that it should be kept secret, and it was celebrated in March 1540. The marriage became known, and Philip's friends deserted him. He objected to Luther's counsel to deny the existence of a second marriage. But the general hostility compelled him to come to terms, in *1541,* with Charles V. at Regensburg; he undertook to break off relations with France and England and loyally to support the emperor.

From *1526* onwards Philip had been forwarding the progress of the Reformation in Hesse. Catholic worship was suppressed, and the secularized church revenues supplied an endowment of the new university of Marburg. Peace between the emperor and the landgrave was soon broken In 1542 Philip persuaded the league of Schmalkalden to attack Henry II., duke of Brunswick-Wolfenbuttel, ostensibly in the interests of the Protestant towns of Brunswick and Goslar. The duchy was quickly overrun, and Hcnry—a Catholic prince—driven out; but the good understanding between the emperor and the landgrave was destroyed, and the relations between Protestants and Catholics became worse than before. Nor was the fissure in the Protestant ranks closed, and Charles took advantage of this disunion to conquer Gelderland and to matcre his preparations for overthrowing the league of Schmalkalden. Unlike John Frederick of Saxony, Philip divined, or partly divined, the emperor's intentions, and urged repeatedly that the forces of the league should be put in order. This advice passed unheeded, and when Charles suddenly showed his hand, and in July 1546 issued the imperial ban against the landgrave and the elector, it was seen that the two princes were almost isolated. Fighting began along the upper Danube, and when indecision and want of funds had ruined the league's chances of success, Philip returned to Hesse and sought help from foreign powers; while in April 1547 John Frederick was captured at Miihlberg. After this defeat the landgrave was induced to surrender to Charles in June by his son-in-law, Maurice, now elector of Saxony, and Joachim II., elector of Brandenburg, who promised Philip that he should be pardoned, and were greatly incensed when the emperor refused to assent to this condition. Philip was sentenced to detention for 15 years, but he was released in 1552, and after the Peace of Passau in this year he returned to Hesse. The landgrave continued the work of reforming and organizing the Church in Hesse. In *1562* he aided the Huguenots with troops, and he was frequently in communication with the insurgents in the Netherlands; but his efforts to form a union of the Protestants were fruitless. Philip, who is sometimes called the *Magnanimous,* died at Cassel on March *31, 1567.*

See *Briefwechsel Landgraf Philipps mit Bucer,* ed. M. Lenz (Leipzig, 1881–90); *Politisches Archiv des Landgrafen Philipp,* ed. F. Küch (Leipzig, 1904); W. W. Rockwell, *Die Doppelehe des Landgrafen Philipp von Hessen* (Marburg, 1904); K. Varrentrapp, *Landgraf Philipp von Hessen und die Universität Marburg* (Cassel, 1904), and *Phzlzpp der Grossmütige, Beiträge zur Geschichte seines Lebens und seiner Zeit,* published by the *Historischer Verezn fur das Grossherzogtum Hessen* (Marburg, 1904).

PHILIP, KING (*c.* 1639–1676), chief sachem of the Wampanoag Indians in America, and the son of Massasoit (d. *1662).* To Massasoit's two sons, Wamsutta and Metacoinet, the English gave the names respectively of Alexander and Philip. Alexander succeeded his father as sachem, and in the same year, while in Marshfield, whither he had gone to explain certain alleged unfriendly acts toward the English, was taken ill; he died on his way home Philip, who succeeded Alexander, suspected the English of poisoning his brother. The English had grown stronger and more numerous, and had begun to meddle in the internal affairs of the Indians. In *1671* the Plymouth authorities demanded that the Wampanoags should surrender their arms; Philip consented, but his followers failed to comply, and measures were taken to enforce the promise. Philip thereupon went before the general court, agreed to pay an annual tribute, and not to sell lands or engage in war with other Indians without the consent of the Plymouth government. In *1674,* when three Wampanoags were executed at Plymouth for the alleged murder of Sassamon, an Indian convert who had played the part of informer to the English, Philip could no longer hold his followers in check. There were outbreaks in the middle of June *1675,* and on June *24,* the massacre of whites began.

The colony of Connecticut took quick measures of defence, guarded its frontier, maintained its alliance with the Mohegans, and suffered little injury. Massachusetts and Plymouth were slower in acting and suffered great loss. Rhode Island raised no troops, and suffered severely. Early in the autumn Philip went nearly as far west as Albany in an unsuccessful attempt to get aid from the French and the Mohawks and supplies from the Dutch traders. At Deerfield on Sept. *18,* about *60* English were killed and the settlement was abandoned. In the spring of 1676 it became evident that the Indian power was waning. The warriors had been unable to plant their crops; they were weaker numerically and more poorly armed than the English, and the latter had also made an alliance with the friendly Naticks and the Niantics. On Aug *1,* 1676 Philip's wife and nine-year old son were captured, and on Aug. 11, an Indian traitor guided the English to the sachem's hiding place in a swamp at the foot of Mount Hope (in what is now the township of Bristol, R.I) where early the next morning he was surprised, and while trying to escape was killed by an Indian The head of Philip was sent to Plymouth and set on a pole in a public place, where it remained for a quarter of a century. The struggle was now over in southern New England, but it continued along the north-eastern frontier till the spring of 1678.

See George *M.* Bodges, *Soldiers in King Philip's War* (Leominster, Mass., 1896); John Gorham Palfrey, *History of New England,* vol. iii. (Boston, 1864); and especially George W. Ellis and John E. Morris, *King Philip's War* (1906). *See* also *Entertaining Passages Relating to King Philip's War* (Boston, 1716; new ed. with notes by H. M. Dexter, Boston, 1865), the account by Col. Benjamin Church (1639–1718).

PHILIP, JOHN (1775–1851), British missionary in South Africa, was born on April *14, 1775,* at Kirkcaldy, Fife. In *1818*

he joined John Campbell in his second journey to South Africa to inspect the stations of the London Missionary Society, and in 1822 the Society appointed him superintendent of their South African stations. His anger was aroused by the barbarities inflicted upon the Hottentots and Kaffirs (by a minority of the colonists), and he set himself to remedy their grievances. His influence was seen in the ordinance of 1828 granting all free coloured persons at the Cape every right to which any other British subjects were entitled. During 1826–1828 he was in England, and in 1828 he published *Researches in South Africa.*

One of Philip's ideals was the curbing of colonial "aggression" by the creation of a belt of native states around Cape Colony. In Sir Benjamin D'Urban, Philip found a governor anxious to promote the interests of the natives. When, however, at the close of the Kaffir War of 1834–35, D'Urban annexed the country up to the Kei River, Philip's hostility was aroused. He came to England in 1836, and agitated against the Cape government. D'Urban was dismissed, and Philip returned to the Cape as unofficial adviser on native matters. He died on Aug. 27, 1851. *See* SOUTH AFRICA, UNION OF: *History.*

PHILIPON, CHARLES (1806–1862), French journalist, caricaturist and lithographer who raised caricature from the level of a print-seller's venture to that of a regular feature in journalism. Born at Lyons, April 19, 1806, he settled in Paris in 1823, took to lithography and began to draw caricatures for a living. He was an excellent draftsman with a fertile and irrepressible sense of satire. Moreover, he had vigorous political opinions, an enterprising spirit and boundless energy. Among the projects that overflowed from his active mind was an ambition to found a paper. This was realized in 1830 when he published a journal of political satire, *La Caricature.* Its career was brief and turbulent; after an avalanche of legal actions, it was suppressed in 1834. Meanwhile, in 1832, Philipon had produced a daily paper (with a new drawing every day) called *Le Charivari* which, ten years later, was to become godfather to *Punch* or *The London Charivari.* In 1838 *La Caricature* made a cautious reappearance under the title of *La Caricature Provisoire* but its success was such that, before long, the adjective *Provisoire* was discarded. His next publication of importance, *Le Journal pour Rire* (later *Le Journal Amusant*) appeared in 1849 in the form of large newspaper sheets filled with woodcuts. Besides these journals, Philipon issued many occasional publications, such as *Le Musée Philipon, Le Robert Macaire, Les Physiologies* and numerous political brochures.

As an artist, his best-known invention was a drawing which depicted the gradual transformation of Louis Philippe into the shape of a pear. *La Poire* became the common symbol of the king and all Philipon's artists used it in their caricatures. They were a notable group: he was able to attract and inspire the best talents in France. Honor6 Daumier and Gustave Doré were the most famous but, there were also Paul Gavarni, Grandville (J. I. I. Gérard), Henri Monnier, Auguste Raffet and Charles Joseph Traviés.

For one man, his achievement was considerable; his effect on caricature in France and other countries mas decisive, as was his influence on the development of lithography as an artistic and commercial medium.

Philipon died in Paris, Jan. 25, 1862.

See Champfleury (Jules Fleury), *Histoire de la Caricature Moderne* (1865); Edwin de Turck Bechtel, *Freedom of the Press and L'Association Mensuelle: Philipon Versus Louis Philippe* (1952). (F. W. W.-S.)

PHILIPPA OF HAINAUT (c. 1314–1369), queen of the English king Edward III, was the daughter of William the Good, count of Holland and Hainaut, and his wife Jeanne de Valois, granddaughter of Philip III of France. By a special dispensation of the pope, Philippa was married to her cousin Edward III by proxy at Valenciennes in October 1327, and landed in England in December. She joined Edward at York, where she was remarried on Jan. 30, 1328. Her marriage dower had been seized by the queen dowager Isabella to pay a body of Hainauters, with whose help she had compassed her husband's deposition. The alliance ensured for Edward in his French wars the support of Philippa's influential kindred; and before starting on his French campaign he secured troops from William the Good, as well as from the count of Gelderland, the count of Julich and the emperor Louis the Bavarian.

Before 1335 Philippa had established a small colony of Flemish weavers at Norwich, and she showed an active interest in the weaving trade by repeated visits to the town. She also encouraged coal-mining on her estates in Tynedale. Her eldest son, Edward the Black Prince, was born in 1330, and she subsequently bore six sons and five daughters. In November 1342 she became guardian of John of Gaunt and her younger children, with their lands. The anecdotes of her piety and generosity prove her popularity. On a famous occasion her prayers saved the citizens of Calais from Edward's vengeance. There is a generally accepted story, based on the chronicles of Jehan le Bel and Froissart, that she summoned the English forces to meet the Scottish invasion of 1346, and harangued the troops before the battle of Neville's Cross.

Philippa was the patron and friend of Froissart, who was her secretary from 1361 to 1366. Queen's College, Oxford, was not, as is stated in Skelton's version of her epitaph, founded by her, but by her chaplain. Robert of Eglesfield. His chief benefactions were made to the hospital of St. Katharine's by the Tower, London. She died on Aug. 15, 1369.

See Agnes Strickland, *Lives of the Queens of England,* vol. i. In addition to the account given in his *Chroniques,* Froissart wrote a formal eulogy of her, which has been lost.

PHILIPPEVILLE, a seaport of Algeria, chief town of an *arrondissement* in the *département* of Constantine, and 54 mi. N. by E. of that city, on the Bay of Stora. Pop. (1954) 48,773. Philippeville is important as the port of Constantine. Philippeville occupies the site of successive Phoenician and Roman cities. By the Romans it was named Rusicada. Some parts of the Roman theatre remain. The modern town was founded by marshal Valée in 1838.

PHILIPPI (Turk. FILIBEJIK), a city of ancient Macedonia, on a steep hill near the river Gangites (mod. Angista), overlooking an extensive coastal plain on the highway between Neapolis (Kavalla) and Thessalonica. Originally called Crenides (Fountains), it was fortified by Philip II of Macedon, to command the neighbouring gold mines. In 42 B.C., after the defeat of Brutus and Cassius there by Octavius and Antony, it became a Roman colony, *Colonia Julia Philippensis,* probably increased after the battle of Actium *(Col. Aug. Julia Phil.),* with the Jus Italicum, and the rank of a "first city." It was twice visited by St. Paul, whose Epistle to the Philippians was addressed to converts here. The site, now uninhabited, is marked by ruins of an amphitheatre and a great temple with inscriptions. To the east is the huge monument of C. Vibius, known to the Turks as Dikelitashlar and to the Greeks as the Manger of Bucephalus.

PHILIPPIANS, EPISTLE TO THE, a book of the New Testament. Though Philippi was the first place in Europe where St. Paul preached the gospel, the letter to the local church was one of the last he wrote. Ever since he founded the church, he kept in touch with it (iv, 15f); indeed he had accepted a gift of money from it. But the present letter is an answer to one written by the Philippian Christians, who had enquired anxiously about his health and prospects, assuring him of their prayers, and wondering nhen he would be able to revisit them (i, 25f). Epaphroditus, who had brought the money, had fallen ill, and the apostle apparently sends him back reluctantly, perhaps with the present letter. It is a friendly missive, which falls into two parts. The first begins by relieving their anxiety about himself, assures them that he hopes to return before very long, and warns them, in the meantime, to preserve their unity (i–ii). At this point there is a sudden change in tone. The letter swerves into a passionate denunciation of some errorists or agitators (iii, 1f), after which the writer resumes (iv, 1–7) his counsels to the community. The closing appeal (iv, 8f) is for harmony.

Modern criticism of the epistle is no longer concerned with supposed traces of gnosticism in ii, 6f. The two engrossing questions are *(a)* the place from which the letter was written, and (b) whether or not it is a literary unity.

The former problem is raised by those who point out that the

Greek term "praetorium" ("palace" in the English version of i, 13) does not necessarily mean the Roman barracks of the praetorian guard at Rome, but might conceivably, for example, refer to the palace of Herod at Caesarea (Acts xxiii, 35) or to judicial authorities at a centre like Ephesus, where we know Timotheus mas living (Acts xix, 22), and where the apostle was once imprisoned. The data indicating Rome as the place of composition cannot be hastily set aside, *i.e.*, the considerations which involve the latter part of the two years confinement at Rome (Acts xxviii, 30) as the period when the letter was written.

The second problem starts from the abrupt change in iii, 2. It is thought by some (*e.g.*, by B. W. Bacon. *The Story of St. Paul*, pp. 367f) that iii, 2f represents an earlier letter, written in reply to the gift of money, and subsequently added to the later i, i–iii, 1, as 2 Corinthians x–xiii has been added to an epistle which chronologically it preceded. The partition theories, of which this is the simplest form, imply that two letters have been mutilated and transposed; otherwise, the hiatus at iii, 2 is inexplicable. But the writer may have been interrupted at iii, 1, or something may have occurred which moved him to turn aside sharply. In iv, 4 he echoes the note sounded in iii, 1, and the intervening outburst may be psychologically explained without recourse to any theory of transposition.

He associates Timotheus with him in the address (i, 1), owing to his local ties with Philippi (ii, 22 and Acts xvi, 3f), but the apostle nrites in the first person throughout, even in iv, 21; indeed he speaks of his companions as distinct from himself, and iii, 17 is no real exception to this. The letter is an affectionate personal message from St. Paul in the evening of his life to a church with which his relations had been exceptionally friendly. Their troubles were not connected with doctrine; the great passage in ii, 5f is introduced as a motive to humility, not as specific instruction on the person of Christ. These Macedonian Christians had a naturally affectionate temperament, which affected their religion; the apostle's chief prayer for them is that their emotional warmth may ripen into insight and understanding (i, 9f), and his concern for them is solely for their Christian principles of conduct.

The earliest definite traces of the letter in 2nd-century literature occur in Polycarp, who had some close interest in the church of Philippi. It passed at once into the early canons of Scripture, and soon was quoted by church fathers such as Irenaeus, Clement of Alexandria and Tertullian.

BIBLIOGRAPHY.—In English the older commentaries by Ellicott (5th ed., 1888) and Lightfoot (6th ed., 1891) may be supplemented by H. A. A. Kennedy's in the *Expositor's Greek Testament* (1903), M. R. Vincent's in *The International Critical Commentary* (1897) and a commentary on the English text by M. Jones, *Westminster Commentaries* (1918). German editions are by Lohmeyer (Gottingen, 1928), P. Ewald in Zahn's *Commentar* (1923) and M. Dibelius in Lietzmann's *Handbuch* (1913), and A. Klopper's (1893), Soden's (1903) and R. A. Lipsius' *Handcommentar* (1892) are by no means superseded. General studies of the epistle will be found in R. R. Smith's *The Epistle of St. Paul's First Trial* (1899), in Sir W. M. Ramsay's *St. Paul the Traveller* (ch. x and xv) and in Weizsacker's *Apostolic Age* (vol. i, pp. 218f, 279f). Weizsacker dealt the deathblow to the older view that the epistle was non-Pauline, the last traces of which are to be found in van Manen's article in the *Encyclopaedia Biblica* (3703f).

(J. MOF.)

PHILIPPICUS, east Roman emperor (711–713), became distinguished as a soldier under Justinian II. His proper name, which indicates his Armenian origin, was Bardanes. He made some pretensions to the throne on the outbreak of the first rebellion against Justinian; these led to his banishment, by order of Justinian, to Cherson. There Bardanes successfully incited the inhabitants to revolt, and on the assassination of Justinian assumed the purple. Among his first acts was the summoning of a *conciliabulum* of eastern bishops, which momentarily restored monotheletism. His domains were attacked at once by Terbelis, king of the Bulgarians in Europe, and the Saracens in Asia. The reign of Philippicus was ended by a military conspiracy.

See Gibbon, *Decline and Fall of the Roman Empire*, ed. by J. B. Bury, vol. v, pp. 195–196 (1911).

PHILIPPINES, REPUBLIC OF THE (REPÚBLICA DE FILIPINAS, REPUBLIKA ÑG PILIPINAS), an archipelago named after Philip II of Spain, of approximately 7,100 islands, about 500 mi. off the southeast coast of Asia, lying between lat. 4° 23' and 21° 25' N. and long. 116° and 126° 30' E. It is bounded on the west and north by the stormy China sea, on the east by the Pacific ocean and on the south by the Sea of Celebes and the coastal waters of Borneo. The islands extend north and south about 1,152 mi. and east and west about 688 mi., their shape, if bounded by straight lines, being about that of an isosceles triangle and their area 115,707 sq.mi. The northernmost island, Y'Ami, is 65 mi. S.E. of Formosa, while the southernmost, Saluag, is 30 mi. E. of Borneo. Only 462 of the islands have an area of 1 sq.mi. or more. Eleven have areas of more than 1.000 sq.mi.—Luzon, the most northerly of the large islands, 40,420 sq.mi.; Mindanao, the most southerly, 36,537 sq.mi.; Samar, 5,050 sq.mi.; Negros, 4,905 sq.mi.; Palawan, 4,550 sq.mi.; Panay, 4,446 sq.mi.; Mindoro, 3.759 sq.mi.; Leyte, 2,785 sq.mi.; Cebu, 1,703 sq.mi.; Bohol, 1,575 sq.mi.; and Masbate, 1,262 sq.mi.

In addition to the large islands and those with distinct names are various groups, among which may be noted the Babuyanes and Batanes, north of Luzon; the Visayas (or Bisayas), between Luzon and Mindanao; the Cagayan and the Calamian groups, respectively east and north of Palauan; and the Sulu archipelago of 448 islands, the chief of which is Jolo.

Additional information on the Philippines can be found in the articles on the individual islands, provinces and major cities.

This article is divided into the following sections:

I. Physical Geography
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  2. Geology
  3. Volcanoes
  4. Climate
  5. Vegetation
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II. The People
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  A. The Philippines Under Spain
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VI. The Economy
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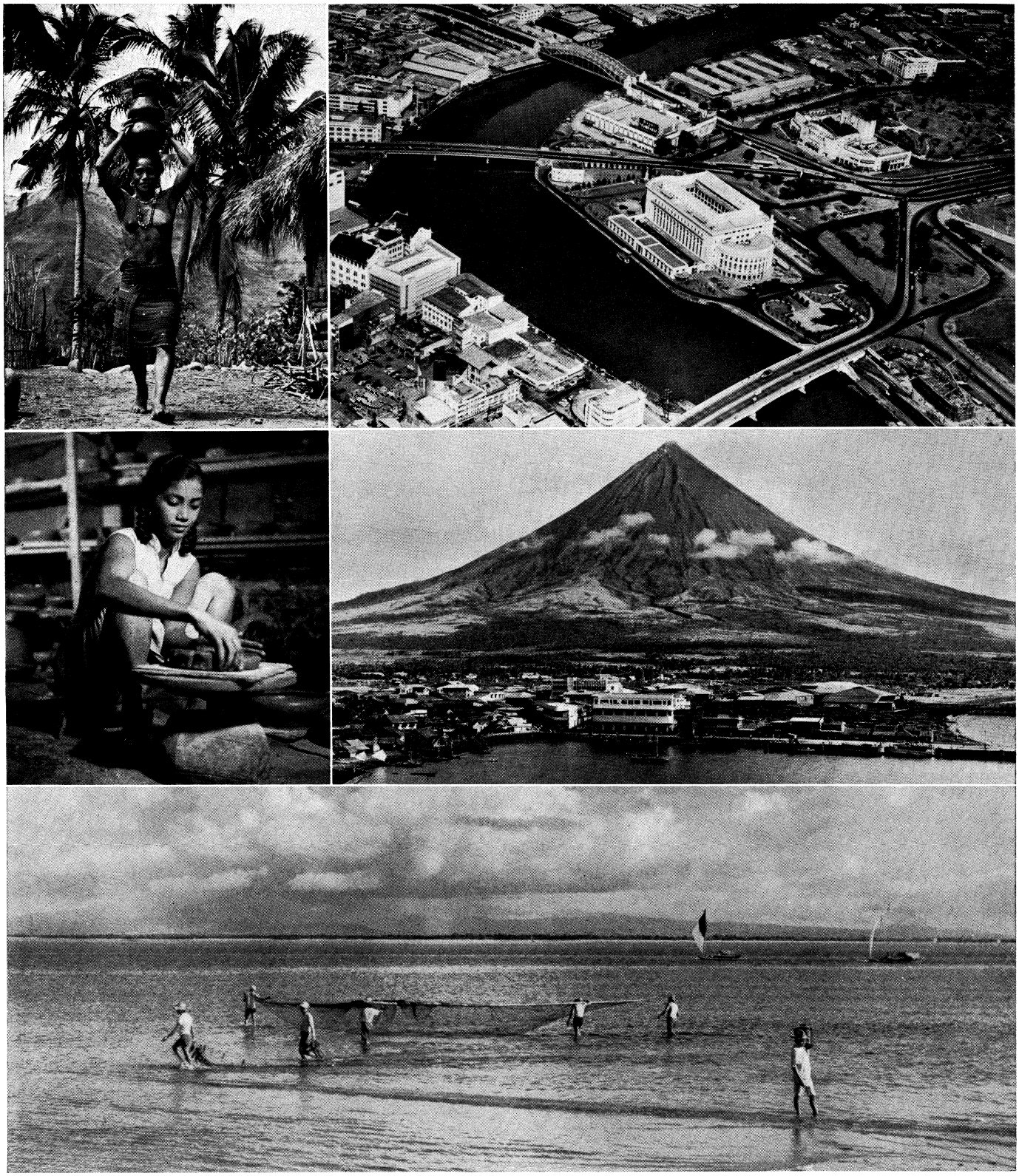
I. PHYSICAL GEOGRAPHY

1. Physical Features.— The irregular configuration of the archipelago, the coast line of more than 14,400 mi., the great extent of mountainous country with the mountains lying close to the sea in many places, the narrow and interrupted coastal plains, the generally northward trend of the river systems and the lakes comprise the salient physical features of the Philippines. The islands have volcanic. coral and all principal rock formations. The mountain ranges for the most part run in the general direction of the main axes of the islands. The Cordillera Central of Luzon, running north to the Pacific ocean from the northern boundary of the central plain, is the most prominent chain. It consists of two, and in places three, parallel ranges, each of which averages 5,900 ft. in height. The narrow Ilocos or Malaya range, lying close along the narrow west coast, rises in places to more than

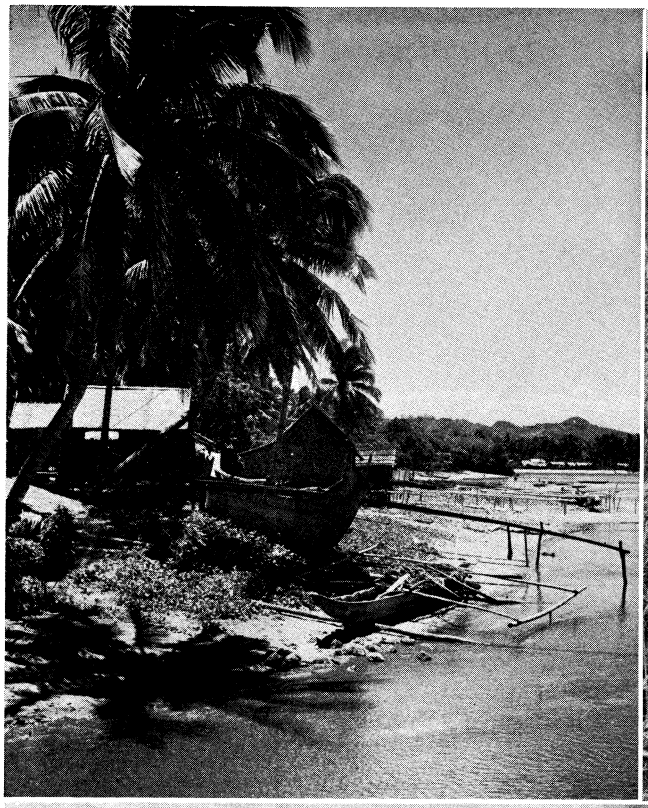


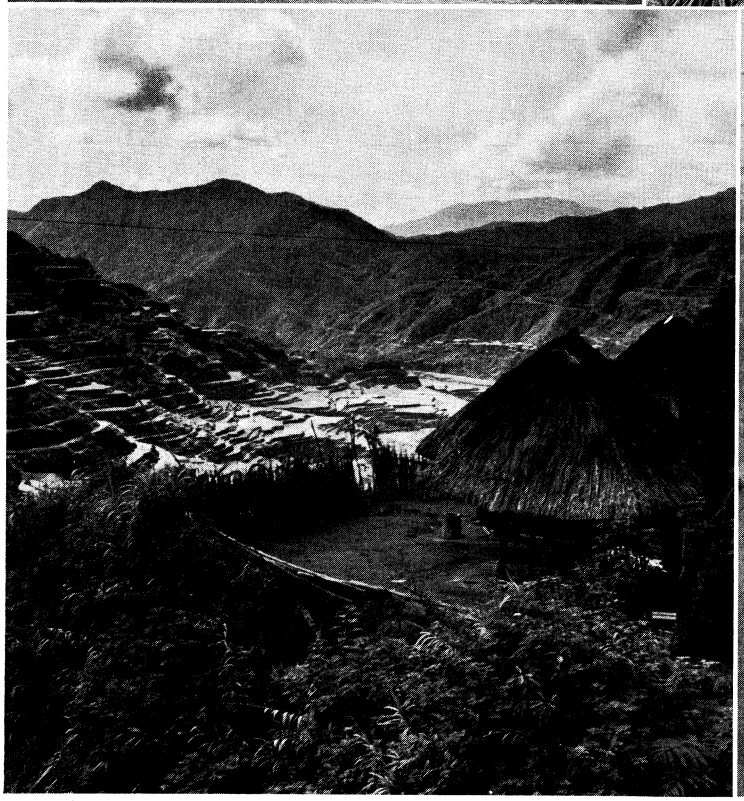
BY COURTESY OF (TOP LEFT) SHELL PHOTO. (TOP RIGHT) CHARLES MILLER FROM PHILIPPINE ASSOCIATION. (CENTRE LEFT) UNITED NATIONS. (CENTRE RIGHT) PAN AMERICAN WORLD AIRWAYS FROM PHILIPPINE ASSOCIATION: PHCTOGRAPH (BOTTOM) EWING GALLOWAY

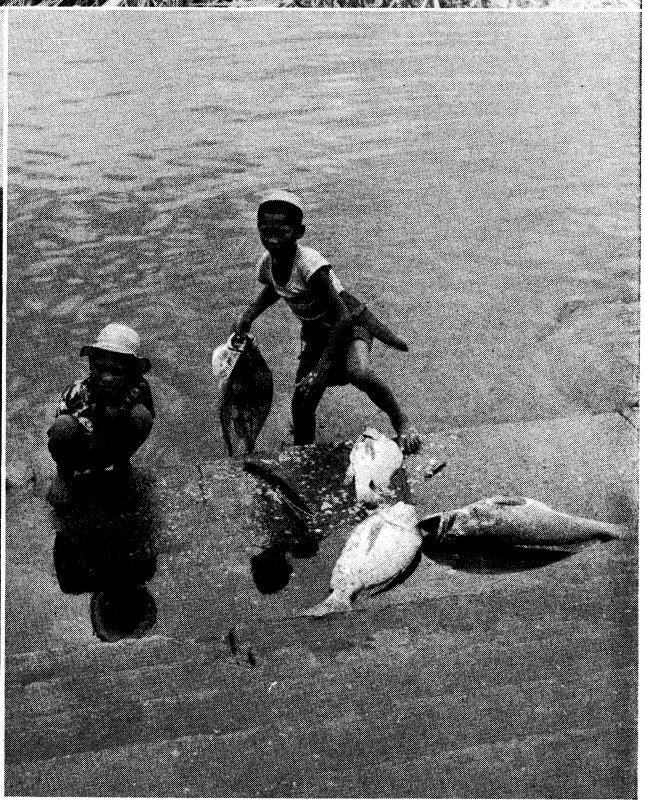
VIEWS OF THE PHILIPPINES AND ITS PEOPLE

Top left: Kalinga woman in a mountain province of Luzon
Top dght: Downtown Manila and the Pasig river. The building in the centre is the post office
Centre left: A young Philippine girl working at a potter's wheel
Centre right: Mayon volcano, near Legaspi, 7,943 ft. high, one of the *most* perfectly shaped volcanoes in the world
Bottom: Mindanao fishermen pulling in their nets

PHILIPPINES







BY COURTESY OF (TOP LEFT, BOTTOM LEFT, BOTTOM RIGHT) SHELL PHOTOS, (TOP RIGHT) CALTEX

RURAL PHILIPPINE ISLANDS

Top left: Scene along the coast of Mindanao Island near Baliangao
Top right: Women harvesting a rice crop on an upland farm
Bottom left: Ifugao houses and terraced rice fields, Luzon
Bottom right: Children and their catch on Mindanao Island

5,000 ft. The Sierra Madre, fringing the northeast coast, rises to more than 5,000 ft. and is seldom less than 3,500 ft. high; it is largely volcanic. This range and the Cordillera Central coalesce in Nueva Vizcaya forming the Caraballo mountains. North of the latter and between the two ranges is the fertile Cagayan valley, about 50 mi. wide. In the southwestern part of northern Luzon are the rugged Zambales mountains, which consist of more or less isolated old volcanic stocks.

The central plain of northern Luzon is about 150 by 50 mi. and only about 100 ft. above sea level .except near its centre. The greater part of southern Luzon is occupied by isolated volcanoes and irregular masses of hills and mountains. The highest peak is Mayon (7,949 ft.) near Legaspi in Albay province.

Through Palawan (about 15 mi. wide) extends a range with an average height of 4,000 to 5,000 ft. Each of the Visayan islands, except Samar and Bohol, is traversed longitudinally by a single range with occasional spurs. Several peaks in Panay reach an altitude of 6,000 ft. or more. In Negros is Mt. Canlaon, a volcano of 8.087 ft., and other peaks reach an altitude of more than 6,000 ft.

There are several important ranges in Mindanao, the Diuata range along the eastern coast being the most prominent. West of this lies the fertile Agusan valley. 40 or 50 mi. wide. Farther west and southwest is the valley of the Rio Grande de Mindanao, the largest river system in the island, and between the lower course of this river system and the southern coast lies a range trending northwest and southeast. On the southern border of the basin of Rio Grande de Mindanao river is Mt. Apo (9,610 ft.), the highest peak in the Philippines. Around Lake Lanao are a number of volcanic peaks. A low cordillera extends into Zamboanga province.

Many of the mountains are covered with dense forests in which are many valuable hardwood timbers. In northern Luzon the principal mountain tree is the pine. In many places where the forests have been burned away their place has been taken by cogon or other coarse grasses. The plains lying amid the mountains—*e.g.,* the central plain of Luzon, the Bikol plain of southeastern Luzon, the Cagayan plain of northern Luzon, the central plain of Panay and the Agusan and Cotabato valleys in Mindanao—have the densest populations of the islands except in Cebu, where the people live mostly on the coastal plain, as the interior is high and rugged. The most important rivers are the Cagayan, Agno, Pampanga, Pasig and Bikol in Luzon and the Rio Grande de Mindanao and Agusan in Mindanao. The Cagayan, flowing northward through northern Luzon and draining about one-fourth of the island, is the largest river. This river and the Rio Grande de Mindanao and the Agusan are each more than 200 mi. long. The Pasig, flowing through Manila, is commercially important. The largest lake in the archipelago is Laguna de Bay, located south of Manila.

2. Geology.—Mountain building is still in progress, and evidence of the recent vertical movement of various portions of mountain mass can be measured. The archipelago is the crumpled edge of the Asian continental platform. The structure is a complex one, however, for in addition to faulting and folding, volcanic actions of diverse kinds have taken place. Prior to the Tertiary period there seems to have been a period of intense deformation, when some of the schists were formed. Toward the end of the Miocene period, the Vigo and Batan formations were generally folded, in some places being intensively crumpled and faulted. Another less pronounced period of folding occurred in the Pliocene or early Pleistocene period. The islands were subjected to a great uplift during the Pliocene, Pleistocene and Recent periods. A striking similarity exists between the formation in the Philippines and the western coast of America. Practically all rock types are found in the islands, as well as areas of coral limestone.

3. Volcanoes.—The volcanoes are the most conspicuous feature of the landscape, but there is relatively little volcanic activity. All gradations of volcanoes can be seen, from the almost perfect cone of Mayon to old, worn-down volcanic stocks whose present form gives little indication of their origin. The several distinct volcanic areas are that of southwestern Luzon (the provinces of Rizal, Cavite, Laguna, Batangas and a portion of northwestern Quezon); that of southeastern Luzon; the mountain region in Camarines Norte; Negros; Mindanao; Jolo; and a few others. Seismic disturbances are common.

4. Climate.—The archipelago has a decided variety of climate. The general direction of winds is from north to east, October to January; east to southeast, February to April; and southwest, the rest of the year. Typhoons often strike the islands from the east to the southeast, then curve to the north, sometimes crossing the land to the China sea, sometimes only touching the eastern shores. Eighty-five per cent of them affect the islands from Samar to the north while only 15% are felt south of Samar. Often the greatest loss of life and destruction of property are caused not by high-velocity winds but by the concomitant or subsequent torrential rains, which cause floods.

Temperature differences are slight on the lowlands but altitudinal variations are marked. Rainfall variations are important in dividing the archipelago into climatic regions, and many local rainfall patterns exist. The most common raicfall pattern is that having two pronounced seasons, dry in winter and spring, rainy in summer and autumn, with local variation in the length of the dry season and in the total rainfall. This is found in western Luzon and the western Visayas. A second kind of pattern has a marked winter maximum of rain and irregular but short dry seasons during the summer and aututnn, with local variations. This is found in eastern Luzon, the eastern Visayas and northern and eastern Mindanao. Southern and western Mindanao have no pronounced seasonal maximum of rain but do have short irregular dry seasons, with local variations.

5. Vegetation.—About 10,000 species of flowering plants and ferns have been found. The flora is essentially Malaysian, but continental (Himalayan) elements occur in the mountains of northern Luzon, while a few Australian types are found at various altitudes. There is a small percentage of native genera and a high percentage of native species (about 60%). The dominant forest species are usually native. Among the grasses of the grasslands are lalang (cogon) and other coarse grasses. The vegetation of the coastal regions (including the mangrove swamps) is practically identical with that of similar areas throughout the Malay archipelago. Considerably more than half the land area of the islands is covered with forest. Members of the *Lauan* family, known as Philippine mahogany, often comprise a high percentage of the forest. There are many other valuable hardwoods as well as many softwoods. About 1,000 different woods have a commercial value, among which may be noted apitong, camagon, ipil, lauan, *mayapis,* molave, narra, tangile, tindalo and yacal. Some timber trees attain a huge size which makes them especially adaptable for tables and other large pieces of furniture. There are many useful kinds of palms, including the coconut palm, from which is obtained food, clothing, fibre for export, coconut oil, copra, building material and other products. Useful bamboos and rattans abound. About 900 species of orchids occur, some of them very rare. Several hundred fibres are known, among them the abacá, from which Manila rope is made. The forests also yield gums (including rubber), various fruits, nuts, spices and drugs, oils and other useful substances.

6. Animal Life.—Mammals are scarce, with the exception of shrews, rats, mice and bats. The edentates are represented by the pangolin (*Manis javanica*). Red or brown deer (Rusa) are found in Basilan, Mindanao, Leyte, Samar and the Calamian Islands. The mouse deer or chevrotain (*Tragulus nigricans*) is found in Balabac and Palawan. The timarau (Bubalus mindorensis), a small buffalo. is peculiar to Mindoro. Carnivores are represented by mongooses (*Mungos palawanus* and *M.* parvus), the binturong (*Arctictis* binturong), an otter (Aonyx cinerea), civet cats (Viverra and Paradoxurzts) and a small wildcat (Felix *minuta*) which is also found in Java. At least 56 species of bats are known, many being peculiar to the Philippines. The flying lemur (*Cynocephalus volans*) and tarsier (Tarsius) range from Basilan to southern Luzon. Large fruit bats live in colonies and are sometimes hunted for their flesh and fur. Only one genus of monkey (Pithecus) has been found, but it is represented by five species. Five new genera of small mammals (Celaenomys, Chrotomys, *Rhynchomys,* Batomys and *Carpomys*) representing 15 species

have been discovered on a small plateau on the top of Mt. Data in northern Luzon, at an altitude of more than 8,000 ft. There are about 760 species of birds which show rather strong relationship to those of Borneo. Reptiles and batrachians also abound.

The marine fauna is one of the most abundant known, more than 1,000 species having been found, at least three-fourths of which are used as food. Sharks and rays are caught for their fins. The fresh-water fish fauna is relatively unimportant. Terrestrial and marine molluscs are abundant, the Philippines having the richest molluscan fauna of any equal area in the world, and many of the shells are of great beauty. Many of the molluscs are edible and of considerable local importance. Pearl oysters abound and the pearls of the Sulu archipelago have an international reputation. The shells of *Placuna* placenta have been used as a substitute for window glass. Land molluscs are found in great variety and are remarkable for their beauty. The best sponges of the southern islands are equal to those of the Mediterranean. Coral beds are numerous. (R. E. HE.)

II. THE PEOPLE

The population of the Philippines is composed of a considerable number of cultural and linguistic groups, the result of varied historical relationships and of local specialization. Ancestors of the present-day population came from southeast Asia, either by way of the island chains to the south or directly across the China sea. Chinese from the coastal cities of south China came to trade and remained in Luzon and the Bisayas; Arab and Indian traders added their blood to the Moslem population in the southern islands; later came rulers from Spain and the U.S. At the time of Magellan (1521) the estimated population of the Philippines was about 500.000; since then it has increased over fortyfold. During this period there has been a blending of diverse racial strains, though linguistic differentiation continued until well into the 20th century. Increased mobility and the long period of Spanish and U.S. control, however, brought about considerable cultural uniformity except in the Moslem and pagan areas.

1. Racial Types.—The peoples of the Philippines belong to the Malay race which is a subdivision of the great Mongoloid stock of eastern Asia (see RACES OF MANKIND). They were preceded in the archipelago by the Negritos (*q.v.*), small Negroes related to those of the Andaman Islands and Malaya, who entered via land bridges at the height of the last glaciation, and survive today in the Bataan peninsula and other marginal areas. Discovery in 1958 of extinct fauna in apparent association with hand axes in the Cagayan valley make it probable that earlier types of man related to the Java series may have inhabited the area.

The Malay race is sometimes divided into an earlier Indonesian or proto-Malay element, with a more Caucasoid appearance, and a later, more Mongoloid Malay type characteristic of the coastal regions; but these distinctions are not clear-cut in the Philippines. The composition of the "Filipino blend", as it was called by archaeologist H. Otley Beyer, shows a number of earlier migrations, but the origins of the bulk of the population are to be sought in southeast Asia and Indonesia, where there are obvious resemblances in physical type.

2. Languages.—All of the Philippine populations, including the Negritos, speak languages belonging to the widespread Malayo-Polynesian stock which includes most of the peoples of Oceania. Language offers an important clue to the history of Philippine groups, and according to Paul Benedict, the region of Hainan island is the probable "jumping-off" place for Malayo-Polynesian peoples for their journeys into Oceania.

About 75 linguistic groups are found in the Philippines, and today language is an important identifying feature of Filipino ethnic groups. Three or four of these groups are major languages which are gradually absorbing their smaller neighbours. Tagalog (*q.v.*), the most important of these linguistic groups, is second in size, but its strategic position in central Luzon led to its adoption in 1946 as the basis for the national language. Bisayan or Visayan, the largest major language group, occupies the central islands but is split into three subdivisions. In northern Luzon, Ilokano has become the dominant language.

Spanish was never widely used among the masses and declined sharply after World War II. English was the most widely used language at mid-20th century, being spoken by about 40% of the population, but Tagalog was also being taught in the schools and was increasing at a faster rate.

3. Religion.—The great bulk of the Philippine population is Roman Catholic, reflecting the long period of Spanish control. Islam was introduced prior to the Spanish conquest by Moslem traders from the south, but its spread was checked by the advent of the Spaniards until its resurgence in the 20th century. The aboriginal pagan religions are still to be found in the Mountain Province and Mindanao, though many of these groups have come under Christian or Moslem influence.

During the revolt against Spain the Philippine Independent church split off from Roman Catholicism under the leadership of Gregorio Aglipay. The Aglipayans, less than 10% of the population, have kept many aspects of Roman Catholic ritual but have modified doctrine, introduced the vernacular, and added national heroes to the roster of saints. The Aglipayans later divided into two groups, one of which affiliated with the Episcopal Church.

Protestantism entered the Philippines with the U.S. occupation. In 1925 there were about 22 independent national churches, and by the second half of the 20th century the number had more than doubled. With 2% to 3% of the population as members, most of these Protestant denominations are affiliated uith the Philippine Federation of Christian Churches. An independent group, the Iglesia ni Kristo, grew rapidly in the post-World War II period.

4. Customs and Culture.—Filipino culture has roots far back in the past of the Malayan world, and has been profoundly influenced by Spanish culture and by U.S. training for independence. The major ethno-linguistic regional groups show a general cultural uniformity. Outside of the cities rice (or corn) agriculture and fishing furnish the basic subsistence; the family and the "kinship circle" are the centre of social life, and the annual cycle of ceremonies and fiestas of folk catholicism give colour and meaning to daily life.

In the Moslem areas in the south, there is a stronger development of political authority and territorial units, and the religious customs follow the Islamic pattern, but the other bases of life are similar to those in the Christian areas. Aboriginal cultures surviving in marginal regions show greater variability and retain some aspects of the pre-Spanish period. (F. R. E.)

III. HISTORY

The Philippine archipelago first became known to Europeans on March 16, 1521, through Ferdinand Magellan (*q.v.*). But there are authentic Chinese accounts of trading voyages as early as the 10th and 13th centuries, and the contact probably went back much further. A Hindu influence undoubtedly came by way of the Malay peninsula, Java and other islands nearby, and probably reached back to the early centuries of the Christian era. The Hindus influenced the life of the people intimately. Many Sanskrit words in the languages and dialects of the people of the Philippines and the forms of the letters used at the time of their discovery by the Spanish indicate this.

A. THE PHILIPPINES UNDER SPAIN

The second, third and fourth Spanish expeditions were those of Garcia Jofre de Loaisa, Alvaro de Saavedra and Ruy Lopez de Villalobos. The next expedition, that of Miguel López de Legazpi (1564–72), was dispatched, like its predecessor, from New Spain, but it was far more carefully planned. Leaving Puerto de Navidad in New Spain on Nov. 20, 1564, Legazpi reached Cebu in April 1565, where the first permanent settlement was made early in May. But Legazpi, with inadequate forces and resources, meeting prolonged hostility from the Portuguese who also were present in the region, at last (1569) moved his main forces to the island of Panay, hoping thereby to have better protection. In 1571 Legazpi made Manila the administrative centre. Thereafter the conquest of Luzon proceeded rapidly, at first principally under Juan de Salcedo, the precocious young grandson of Legazpi. All the archi-

pelago except the Moro islands of Mindanao, the Sulu archipelago and Palawan were in fairly peaceful possession of the Spaniards before 1600. In June 1572 the city of Manila was formally established. In 1574 Manila was attacked by the Chinese Limahong, but he was forced to retire from the island and from the entire group. Several of the provisional governors were churchmen who played into the hands of the ecclesiastics or catered to their own order.

1. Conquest. — The Spaniards were accepted easily, even hospitably in many cases, and the native populations coming into closest contact with them began almost immediately to take on a veneer of European culture. The conquest was especially easy along the coast and in the low interiors where the Spaniards first went. The principal opposition at Manila in 1570 came from Moslems, but that faith was not yet strongly entrenched in Luzon. The situation was quite different in Mindanao and at various other points in the south. The Spaniards were instinctive enemies of Islam, and it was they who gave the Philippine Moslems the name Moro (*q.v.*) by which they are still known. In 1574 the Moros of the Rio Grande de Mindanao offered submission. In 1578–79 Francisco de Sande (governor, 1575–80) conducted a fairly successful expedition against the Moros, but the Spaniards were unable to gain any lasting advantage. Until 1837 piratical raids were almost continuous. The Moros ravaged the coasts far and wide, even threatening Manila itself. They often joined the Dutch after the latter began to be interested in oriental waters. In 1848 on Balanguingui Island, Gov. Narciso Claveria y Zaldua won the most decisive victory ever gained over the Moros. In 1850 Gov. Antonio de Urbiztondo y Eguia destroyed the strongholds on Tonkil Island and the next year stormed and captured the town of Jolo. This ended the real power of the Moros.

During the interim between Magellan's discovery and the settlement of Manila, the Portuguese actively contested Spanish right to the archipelago. Their hostility ceased only with the union of Spain and Portugal (1580–1640). In 1577 Sir Francis Drake started on the voyage which brought him to the Philippines at Mindanao. Again, in 1587, Thomas Cavendish sailed to the Moluccas and thence back to California to intercept the rich galleon "Santa Ana." He then went to the Philippines, where he tried in vain to capture the shipyard at Iloilo.

The Dutch came next. Their primary object was trade rather than colonies. In 1596–97 Adm. Cornelius Houtman opened trade with the Netherlands, and during the years 1598–1600 the expedition under J. C. van Neck and W. van Warwijck traded in the Moluccas. In 1600 Oliver van Noordt reached Philippine waters, where he committed various depredations. Dutch vessels now traded for spices and other oriental wares in the Moluccas, harried the coasts and waters of the Philippines and attacked Portuguese, Spanish, Japanese and Chinese shipping. In 1610 Gov. Juan de Silva defeated and killed the Dutch admiral Francis de Wittert at Playa Hondo, near Manila, and captured part of his fleet. In 1640 the Dutch captured Malacca and in 1662 they permanently occupied the Moluccas. Their attacks in the Philippines gradually ceased.

On Sept. 22, 1762, a British expedition reached Manila, found the Spanish but ill prepared and on Oct. 5 captured the city. By the treaty of Paris in 1763 Manila was restored to Spain.

With Legazpi had come five Augustinians; in 1577 came the Franciscans, in 1580 the Jesuits, in 1587 the Dominicans and in 1605 the Augustinian Recollects. It was the intention of Spain to replace the friars by secular parish priests whenever any mission assumed the character of a parish. But the friars, desirous of retaining their holdings and power, fought secularization and it was never carried out in its entirety. The friars became the storm centre of the gradually increasing Filipino demand for change; the insurrection of 1896 was directed principally against them, and during the later insurrection against the United States they suffered many indignities.

The last Manila galleon left the Philippines in 1811 and returned in 1815. Thereupon the trade was taken over by private persons, exports to the value of 750,000 pesos were allowed and three other ports besides Acapulco were opened to it, namely San Blas, Guayaquil and Callao. In 1766, however, the crown had allowed direct trade between Spain and Manila by one national vessel annually. In 1785 the Royal Company of the Philippines began to trade between Manila and Cádiz; the company ceased to exist in 1830.

In 1809 an English commercial house was permitted to establish itself in Manila, and in 1814 a like privilege was extended to all foreigners. As a rule, however, Spaniards were still jealous of foreigners, and reactionary decrees in 1828 and 1840 forbade them to sell goods at retail or to do any business in the provinces. The vacillating Spanish policy is seen again in the opening of seven ports to foreign trade in 1830 and their closing the next year. In 1837 Manila was reopened to foreign trade, and Iloilo and Cebu were reopened in 1855 and 1863. In 1842 there were 39 Spanish shipping and commercial concerns in Manila and about a dozen foreign houses. Various governments maintained consuls, among them Great Britain and the United States.

2. Philippine Nationalism. — During the first half of the 19th century, there were only from 2,000 to 5.000 Spaniards in the archipelago. Spanish was spoken by some of the natives, principally in Manila and a few other important centres, but the friars had made comparatively little effort to inculcate a knowledge of Castilian. There was no homogeneity among the several native peoples, very largely because of the different languages. Partly because of these conditions, insular representation in the Spanish *Cortes* carried little meaning or a mistaken one to the mass of the population. After the building of the Suez canal, in 1869, ambitious Filipino youths went to Spain and other countries for study. The first daily newspaper was *La Esperanza* (1847). *La Solidaridad* was founded in 1888 in Barcelona by Graciano López Jaena in the interest of Filipino propaganda, and throughout its course it urged reforms in both religion and government. One of its foremost contributors was the precocious Chinese mestizo, José Rizal y Mercado. The Filipinos had ample grounds for complaint, especially after 1872. That year about 200 native soldiers at the Cavite arsenal revolted, killed their officers and shouted for independence. Plans for a similar demonstration in Manila failed. The insurrection was quickly suppressed. and led to wholesale arrests, life imprisonment and the execution, among others, of three Filipino secular priests, whose connection with the uprising was not satisfactorily explained.

Meanwhile the gradually expanding idea of Filipino nationality began to manifest itself. The campaign of Rizal, Marcelo del Pilar, López Jaena and Apolinario Mabini, leaders in the Young Filipino party, was a protest against both the domination of the friars and economic and administrative caciquism. These aspirations met a sympathetic reception from several governors, but other Spaniards, especially the friars, were diametrically opposed; and much of the old easy and cordial intercourse between the two peoples was changed. Rizal threw himself into the propaganda with eagerness. In 1891 he founded at Hong Kong an organization called the Liga Filipina, and in 1892 formed a branch at Manila. He was arrested in 1896 at Barcelona, returned to the Philippines, given a farcical trial and executed on Dec. 30, 1896. At about the time of Rizal's establishment of the Liga Filipina there was also founded an organization called the Supreme Worshipful Association of the Sons of the People, which is generally called the Katipunan. The organization was altogether Tagalog and is said to have numbered anywhere from 100,000 to 400,000 members. On Aug. 26, 1896, the actual insurrection broke out. "The cry of Balintawak" is the name given to the first hostilities by the Filipinos. The centre of the revolt was in Cavite province, where Emilio Aguinaldo first came into prominence. Spain sent over reinforcements until there was an army of 28,000 besides a few loyal regiments of native soldiers. A stiff campaign of 52 days brought the defeat of the insurgents, but upon the execution of Rizal the insurrection broke out again and spread to the provinces of Pangasinan, Zambales and Ilocos. Fernando Primo de Rivera opened negotiations with Xguinaldo and concluded with the insurgents the pact of Biac-na-Bató. Accordingly, Aguinaldo left for Hong Kong on Dec. 27, 1897. With the blowing up of the "Maine" on Feb. 15, 1898, actual hostilities broke out between

Spain and the United States. (See SPANISH-AMERICAN WAR OF 1898.) Aguinaldo returned to the Philippines May 19. 1898, and announced renewal of the struggle with Spain. The Filipinos, who declared their independence of Spain on June 12, 1898, proclaimed a provisional republic with Aguinaldo as president, and on Sept. 9, 1898, moved their capital to Malolos, with Apolinario Mabini, the "mouthpiece of the revolution," as Aguinaldo's chief adviser. A revolutionary assembly met on Sept. 15 and on Sept. 29 ratified Filipino independence. In November and December revolutionary tribunals were organized in the Visayas. The Philippines were ceded by Spain to the U.S. along with Puerto Rico and Guam by the Treaty of Paris, Dec. 10, 1898.

B. THE PHILIPPINES UNDER THE UNITED STATES

1. The Insurrection. — Relations between the Americans and the Filipinos were unfriendly and grew steadily worse. On Jan. 23, 1899, the Malolos constitution, by virtue of which the Philippines were declared a republic and which had been approved by the assembly on Nov. 29 and by Aguinaldo on Dec. 23, was proclaimed. Aguinaldo, who had been president of the provisional government, was elected president.

On the night of Feb. 4 the inevitable conflict between the Americans and Filipinos surrounding Manila was precipitated. Morning found the Filipinos, who had fought bravely, even recklessly, defeated at all points. While the fighting was in progress, Aguinaldo issued a proclamation of war against the United States. On Feb. 6 the U.S. senate ratified the treaty with Spain, and reinforcements were immediately sent to the Philippines. Antonio Luna, the best-trained military man among the Filipinos, was given charge of military operations, but seems to have been greatly hampered by the jealousy and distrust of Aguinaldo. which he fully returned. Luna was murdered, and on March 31, 1899, Malolos was captured by the U.S. forces. The Filipino government fled northward. In Nov. 1899 the Filipinos resorted to guerrilla warfare, with all its devastating features. The capture of Aguinaldo by Gen. Frederick Funston in March 1901 virtually ended the real insurrection, although the last surrender was that of Gen. Miguel Malvar in Samar on April 16, 1902. The major operations of the insurrection were conducted in Luzon, and throughout the army was assisted materially by the Makabebe scouts, who remained loyal to the U.S. Meanwhile, on April 7, 1900. Pres. William McKinley instructed the second (Taft) commission to "bear in mind that the government which they are establishing is designed not for our satisfaction nor for the expression of our theoretical views, but for the happiness, peace and prosperity of the people of the Philippine Islands." Nothing was said about independence, although the instructions were later often cited in support thereof.

2. Taft.—Gov. William Howard Taft initiated negotiations with Pope Leo XIII for the purchase of friar lands (about 400,000 ac.) which were finally bought Dec 23, 1903, at a price of approximately $7,250,000. Taft pledged the credit of the Philippine government for the amount, and bonds were issued therefor. A considerable portion of the lands, of high agricultural quality, were later sold to Filipinos. The pope also replaced the Spanish archbishop and bishops with U.S. prelates.

In 1904 Taft was called home to become secretary of war, but he continued to govern the Philippines from Washington, D.C. In 1905 he took a party of senators and representatives to the islands, at the expense of the Philippine governinent, and on Oct. 16, 1907, on the eve of his presidential campaign, he opened the first Philippine legislature at Manila, although there was still fighting in the Visayas and the act of 1902 required a state of "complete peace" before convening the legislature. Among other acts, that body voted to continue both Spanish and English as official languages until 1913, when Spanish was to be dropped. That, however, was never accomplished, and it was not until 1940 that Tagalog was added as another official language. On hug. 6, 1909, congress passed the Payne bill, granting important trade concessions to the Philippines, and in 1913 the Underwood act provided for complete free trade between the islands and the United States. This concession continued until Jan. 1, 1941.

3. The Governors **General.**—Taft mas succeeded as governor by Luke E. Wright of Tennessee, who had been a member of the Philippine commission and became the first American to bear the title of governor general. Serving from 1904 to 1906, he was very popular with Americans; but his firm and conservative policy failed to suit the more radical Filipinos and he was transferred to Tokyo as minister. Henry C. Ide of Vermont was the next incumbent of the office. He too was a member of the Philippine commission and had seen service in Samoa during the partition of that group. He was a wise and able administrator but was permitted to remain as governor general for a few months only. He was succeeded by James F. Smith of California, who had come to the islands as a colonel of volunteers and later served on the supreme court and the Philippine commission. It was understood that he was much opposed to accepting the governorship but that Taft insisted on having a Catholic for the office. Smith served from 1906 until 1909. On Nov. 11 of that year, W. C. Forbes of Massachusetts was inaugurated as governor general, serving until Aug. 1913, when he was removed. Some of his acts occasioned bitter controversy (such as his deportation, without trial, of a large and prosperous group of Chinese merchants who had been long established in Manila). and his administration was a stormy one. Francis B. Harrison of New York succeeded and served from 1913 to 1921, the longest term of any U.S. governor general.

The Wood-Forbes mission, sent by Pres. Warren G. Harding in the first year of his administration, reported that the grant of immediate independence would be premature and urged that the U.S. government not be left in a position of responsibility without authority. Leonard Wood, a major general in the regular army and the former military governor of Cuba and later of the Philippine Moro province, seemed unusually well equipped for the governor generalship to which President Harding appointed him, effective Oct. 6, 1921. But by that time the Filipino leaders, having had a taste of power under Wood's predecessor, were in no mood to submit to authority if actually exercised. He administered the government through undersecretaries until 1927, when he died in Boston, Mass. Meanwhile, Pres. Calvin Coolidge had sent Carmi Thompson of Ohio "to investigate and report" on the Philippines. He made the trip with considerable publicity and likewise reported against the grant of independence, but recommended certain reforms.

Henry L. Stimson of New York was the next governor general. As secretary of war in the Taft administration he had acquired considerable familiarity with Philippine affairs, and he had just returned from a successful mission to untangle a difficult situation in a middle American state. Proceeding with tact and caution, he gradually won over the Filipino leaders, obtained some reforms and was about to secure others, when he was called home in 1929 by Pres.-Elect Herbert Hoover to become secretary of state.

In May 1930, Dwight F. Davis of Missouri, who had also been secretary of war, was appointed. His administration was uneventful, as was that of Theodore Roosevelt, Jr., who succeeded him in 1932. Pres. Franklin D. Roosevelt appointed Frank Murphy of Michigan. a strong advocate of independence, who took office as governor general June 15, 1933, and served until Nov. 15, 1935, when he became the first high commissioner in the Philippines. Leaving that post in 1936, Murphy was succeeded by Paul V. McNutt of Indiana, who served until 1939. He realized the value of the islands as a source of supply for tropical products and for their mineral wealth, and evidently felt that the grant of independence was a mistake for both countries. But it was now too late to effect any change in the general policy. Francis B. Sayre of Massachusetts, who was appointed to succeed him, arrived in Manila Oct. 21, 1939. He had been on the faculty of Harvard university and later an assistant secretary of state. His prescribed task was to prepare for independence.

4. Campaign for Independence. — As early as 1929, the campaign of the Filipinos for that goal had been gaining momentum, with new allies, in the United States, among producers of sugar. tobacco, fats and other products and the labour unions which feared the competition of Filipino immigrants. A bill supported by these interests and providing for independence finally passed

both houses of congress, was vetoed by President Hoover, passed again over the veto in Jan. 1933, but failed of ratification by the Philippine legislature because of opposition by Manuel Quezon, who, his opponents declared, wished to divert credit from those who had secured passage of the bill in his absence from Washington. This would have been an opportune time to re-examine the whole question, for the Filipinos had been given their long-sought chance and had rejected it. But the U.S. interests were determined to push the measure through. Quezon hurried to the United States to win President Roosevelt's support for a new bill, differing but little from its predecessor, but omitting the important provision reserving absolutely. as in Cuba, sites for naval bases, etc. (These were later to be the subject of "negotiation" and promised to be a fruitful source of trouble.)

The new bill, known as the Tydings-McDuffie act—public law 127—passed both houses of congress, received presidential approval March 24, 1934, and was ratified by the Philippine legislature on May 1. It established a Philippine commonwealth, provided for independence in 1946 and for a graduated tax on Philippine exports to the United States (to be collected by said government for a sinking fund for bonded indebtedness) of 5% of the corresponding U.S. duty for the first year, beginning Jan. 1, 1941, and increasing by 5% each subsequent year. This mas amended by the act of 1939 (public law 200), exempting cigars, scrap and filler tobacco, coconut oil and pearl or shell buttons, which were all subjected to free quotas, reducible by 5% each year. Hemp and copra were already on the free list. The U.S. immigration laws were applied, and the annual Filipino quota was limited to 50.

Pursuant to the act, a constitutional convention assembled in Manila July 30, 1934, and remained in session until Feb. 8, 1935, when a draft constitution was approved. It was certified by President Roosevelt on March 23 and ratified on May 14 of the same year by popular vote. It was on the whole a creditable document; but two of its unique features—a single six-year term for the presidency and a unicameral legislature—were eliminated by amendments adopted in 1939 and approved by President Roosevelt Dec. 2, 1940. Quezon. elected first president of the commonwealth in Sept. 1935, was re-elected for a four-year term Nov. 4, 1941. but with the understanding—not legally enforceable—that he would give way to Vice-Pres. Sergio Osmeiia after two years. The Philippine army, which had been trained under the supervision of Douglas MacArthur, son of the last American military governor, was called into the U.S. service on July 26, 1941, in time to help meet the Japanese invasion, Dec. 8 (Philippine time). (See WORLD WAR II.)

With the Japanese invasion, Quezon, Osmefia and the commonwealth cabinet left the Philippines to conduct a government in exile in Washington. Osmefia became president upon the death of Quezon in Aug. 1944 and returned to the Philippines when U.S. forces made their first Philippine landings on Leyte Island Oct. 20, 1944. General MacArthur proclaimed the liberation of the Philippines in July 1945 In general elections held in April 1946, Osmefia was defeated by Manuel Roxas y Acuna, who served as the last president of the commonmealth and within a few months became first president of the Republic of the Philippines.

C. The Philippines After Independence

On July 4, 1946, the commonwealth ended and the Republic of the Philippines came into existence as a sovereign independent state. In contrast with the transition which had been envisaged at the time of the Tydings-McDuffie act of 1934, the Philippines had suffered invasion, a three-year Japanese occupation and the added war damage of liberation. An estimated 1,000,000 lives had been lost as a result of the war. The damage to major industries was estimated as follows: shipping 85%, transportation 70%, mining 80%, sugar production 65% and coconut oil production 95%. Losses in production of rice, hemp, lumber and tobacco and in the fishing industry were estimated at $117,000,000. Damage to dwellings, port facilities and communications was extensive. Manila mas one of the world's most devastated capitals. In addition to a shattered economy, the Roxas government was confronted with political controversy and an incipient Communist-led rebellion.

Immediately prior to independence the United States had acted to assist the Philippine government in restoring the economy. On April 30, 1946, Pres. Harry S. Truman signed the Philippine Rehabilitation (mar damage) act and the Philippine Trade act of 1946. The Rehabilitation act authorized the appropriation of $620,000,000 to meet war damage claims and for Philippine government reconstruction programs and authorized 12 United States government agencies to engage in rehabilitation programs in the Philippines The Trade act extended the period of duty-free trade until 1954 with an increase of 5% of the full tariff rate to be applied thereafter. The act provided that no change would be made in U.S. import quotas of Philippine sugar and cordage for a period of 28 years. A military assistance pact authorizing the establishment of U.S. bases was signed March 14, 1947. This was followed by a mutual defense treaty signed Aug. 30, 1951.

Pres. Elpidio Quirino became chief executive upon the death of Roxas on April 15, 1948. Within one year the deficit in the general fund was reduced from 153,000,000 pesos to less than 1.000.000 pesos.

During the Quirino administration the Hukbalahap movement became a threat to the republic. This movement had developed during the Japanese occupation as a guerrilla army to fight Japan. After the defeat of Japan the Huks. as they were called, turned against landowners and. in the interest of gaining reforms, committed acts of violence and terror principally in central Luzon and in Panay. At the end of 1949 the Huks renounced reform by constitutional means, became identified with the Communist party and advocated the forceful overthrow of the government. In 1951 Secretary of Defense Ramón Magsaysay began a program of combined military pressure and granting of homesteads on the island of Mindanao to surrendered Huks. By Dec. 1955 the Huk rebellion had died out.

Magsaysay was elected president of the republic as candidate of the Nationalist party in the elections of Nov. 1953. He was elected on a platform promising real reform in government. During Magsaysay's first year in office, he succeeded in dominating the professional politicians of his Nationalist party. Early in May 1954 the president relinquished the post of minister of defense, feeling that the problems of internal security were under control. The chief Hukbalahap leader, Louis Taruc, surrendered to the government during that month. Major progress in opening new land settlements outside crowded Luzon had taken the edge off agrarian unrest, though the basic issues of land reform had not yet been carried out in Luzon itself. President Magsaysay had at least temporarily stopped trends of opportunism among his political opponents by committing the Philippines to participation in the free world's collective security programs against Communism, and to the maintenance of the strong traditional ties to the United States.

The main problem facing the Magsaysay administration in the mid-1950s was unemployment, a result in part of stagnation in the Philippine economy. Magsaysay, who died in a plane crash in March 1957, was succeeded by Vice-Pres. Carlos P. Garcia. Garcia. a member of the Nacionalista party, was then elected president on Nov. 12. 1957; his vice-president was Diosdado Macapayal of the Liberal party. For the most part Garcia continued the policies of the previous administration.

Following independence the United States and the Philippines joined in treaty arrangements for the defense of the islands. Under the terms of a military bases agreement concluded in March 1947. the use of designated military, naval and air bases was granted to the United States for a period of 99 years. In Aug. 1951 a mutual defense treaty was signed between the two countries. In Sept 1954, at a conference in Manila, the Philippines joined with seven other nations (Pakistan, Thailand, Australia, New Zealand, France, the United Kingdom and the United States) in signing the southeast Asia collective defense treaty, which committed the members to act against aggression, colonialism and internal subversion in the treaty area.

On May 15, 1958. a new U.S.-Philippine defense agreement was announced which established a mutual defense board and resolved the question of U.S. military bases. A memorandum signed

Oct. 12, 1959, shortened the 99-year lease originally signed in 1947, to 25 years.

IV. POPULATION

The population of the Philippines in 1948 was 19,234,182, an increase of more than 3,000.000 since 1939 (16,000,303), or an average annual increase rate of 2%. The 1960 census indicated a total population of 27,455,799.

Of the total population in 1948, only 14% lived in towns and cities with populations over 5.000, and more than half these were concentrated in Manila and its suburbs (1,405,000). Manila alone had a population of 983.906 ([1960] 1.145.723). Two other port cities, Cebu (167,503 [259,194]) and Iloilo (110,122 [150,976]), also had considerable population concentrations. Although the populations in these urban centres increased approximately 46% between 1939 and 1948, the larger percentage of the Philippine population continued to live in rural villages of fewer than 1,000 persons. Thus the Philippines can be characterized as a predominantly rural country. The average density of population in 1961 was 239.1 per square mile. The areas of greatest density were the provinces of Rizal (1,850), Laguna (1,016) and Cavite (763), while Palawan (29) and Mindoro Occidental (41) were the most sparsely populated.

Area and Population by Province

Province (with capital city)	Area (in sq.mi.)	Pop. (1960 census, prelim.)	Density per sq.mi.
Abra (Bangued)	1,471	116,700	79.3
Agusan (Butuan)	4,120	271,973	66.0
Aklan (Kalibo)	738	226,516	306.9
Albay (Legaspi)	996	515,961	518.0
,Antique (San Jose)	1,035	239,164	231.1
Bataan (Balanga)	517	145,922	282.2
Batanes (Basco)	76	10,335	136.0
Batangas (Batangas)	1,191	682,855	573.3
Bohol (Tagbilaran)	1,575	602,497	382.5
Bukidnon (Malaybalay)	3,104	195,630	63.0
Bulacan (Malolos)	1,021	557,691	546.2
Cagayan (Tuguegarao)	3,470	445,697	128.4
Camarines Norte (Daet)	829	188,569	227.5
Camarines Sur (Naga)	2,060	826,640	401.3
Capiz (Roxas)	965	314,834	326.3
Catanduanes (Virac)	552	156,640	283.8
Cavite (Cavite)	498	379,904	762.9
Cebu (Cebu City)	1,880	1,340,439	713.0
Cotabato (Cotabato)	8,868	1,152,474	130.0
Davao (Davao)	7,529	903,224	120.0
Ilocos Norte (Laoag)	1,308	287,029	219.4
Ilocos Sur (Vigan)	1,037	338,579	326.5
Iloilo (Iloilo)	2,048	966,145	471.8
Isabela (Ilagan)	4,069	442,821	108.8
Laguna (Santa Cruz)	465	472,215	1,015.5
Lanao del Norte (Iligan)	1,313	280,461	213.6
Lanao del Sur (Marawi)	1,261	531,269	421.3
La Union (San Fernando)	530	295,164	556.9
Leyte (Tacloban)	3,084	1,177,407	381.8
Marinduque (Boac)	355	114,892	323.6
Masbate (Masbate)	1,571	336,709	214.3
Mindoro Occidental (Mamburao)	2,075	84,321	40.6
hlindoro Oriental (Calapan)	1,816	227,119	125.1
Misamis Occidental (Oroquieta)	802	251,104	313.1
Misamis Oriental (Cagayan de Oro)	1,512	387,839	256.5
Mountain Province (Bontoc)	5,458	436,204	79.9
Negros Occidental (Bacolod)	2,989	1,332,017	445.6
Negros Oriental (Dumaguete)	2,053	598,783	291.7
Nueva Ecija (Cabanatuan)	2,120	608,736	287.1
Nueva Vizcaya (Bayombong)	2,627	137,996	52.5
Palawan (Puerto Princesa)	5,693	162,918	28.6
Pampanga (San Fernando)	827	615,823	744.6
Pangasinan (Lingayen)	2,021	1,124,842	556.6
Quezon (Lucena)	4,616	656,892	142.3
Rizal (Pasig)	791	1,463,530	1,850.2
Romblon (Romblon)	512	132,012	257.8
Samar (Catbalogan)	5,309	871,857	164.2
Sorsogon (Sorsogon)	793	348,708	439.7
Sulu (Jolo)	1,087	327,050	300.9
Surigao (Surigao)	3,079	360,143	117.0
Tarlac (Tarlac)	1,175	427,348	363.7
Zambales (Iba)	1,408	213,618	151.7
Zamboanga del Norte (Dipolog)	2,285	280,391	122.7
Zamboanga del Sur (Pagadian)	4,232	744,469	175.9
Manila, city of	14	1,145,723	81,837.4
Total	114,830*	27,455,799	239.1

*Land area.

Nationalities of the population in 1948 were as follows: Filipino, 19,100,620; American, 6,955; Chinese. 121,702; Spanish 1.886; British, 555; Indian, 677; Swiss, 68; French, 86; Swedish, 82; Norwegian, 65; Italian, 70; Dutch, 410; other, 1,006.

V. ADMINISTRATION AND SOCIAL CONDITIONS

1. Government and Administration. — Duringthe period of United States control, from 1898 until the Philippine republic attained sovereignty on July 4, 1946, the Philippine citizens increasingly mere granted and assumed the responsibilities of self-government. With the end of military government on July 4. 1901, a civil government was established under a governor (later called governor general). On July 1. 1902, the U.S. congress passed an enabling act providing for a popularly elected assembly which would constitute the lower house of a Philippine legislature. The Philippine commission, which consisted of seven members appointed by the president of the United States, would serve as the upper house An election of members of the assembly mas held on July 30, 1907. Under the provisions of the enabling act two resident commissioners were appointed to the United States with power to speak on legislation affecting the Philippines but with no vote. In 1909 the Philippine commission was expanded to include four Filipinos.

The Jones act of Aug. 29, 1916. provided for the replacement of the Philippine commission by an elected senate of 24 members and for a house of representatives of 91 (later 92) members. The act proclaimed a bill of rights.

The Philippine Commonwealth and Independence act (Tydings-McDuffie act) abolished the office of governor general and placed remaining United States authority in a high commissioner. The commonwealth government was established in Nov. 1935 with Manuel Quezon as its first president.

While the islands were under Japanese occupation during World War II, the commonwealth government continued to operate in exile in the United States.

When the Republic of the Philippines became a sovereign and independent state. no substantial changes mere made in the structure of government provided in the constitution of 1935 (as amended in 1940 and 1946). By the amendment of 1940, executive power was lodged in a president and vice-president, elected for terms of four years uith eligibility for re-election.

The legislative power was vested in the congress of the Philippines, composed of the senate and the house of representatives. It was provided that the 24 members of the senate be elected at large by direct popular vote for six-year terms and the members of the house of representatives, representing 102 congressional districts, be elected for terms of four years.

Judicial power was vested in the justices of the supreme court (the highest tribunal), the court of appeals, courts of first instance, municipal courts of chartered cities and justices of the peace. All justices and judges were appointed by the president.

Each of the 53 provinces of the Philippines in 1958 (later increased to 55 provinces) was governed by a provincial board composed of the governor and two other board members, all elected. The 1,078 municipalities were administered by elected mayors and had municipal councils.

The governing body of each of the 30 chartered cities in 1958 was a municipal board composed of a mayor, vice-mayor and councilors. The members might be either appointed by the president or elected as provided by the charter Quezon City, east of Manila, was designated as the national capital and in the late 1950s construction of several government buildings was under way, but most of the functions of national government remained in Manila The 55 provinces, their areas and capital cities are shown in the population table.

2. Education. — The educational system of the Philippines is the most extensively developed in the orient. During most of the Spanish period. elementary education was undertaken only by the pastors and curates of parishes and was designed primarily to inculcate Christian values. A decree in 1863 established a compulsory educational system under civil control. Although this decree was never fully implemented. educational facilities and opportunities were expanded. A program of mass education was begun in 1901 under United States civil government; soldiers had acted as teachers for about two years prior to that time. The program sought to develop free political institutions through universal education. In 1901, 1.000 U.S. teachers were brought en masse to the Philippines. English was established as the medium of instruction and remained so. A system of scholarships was set up to train Filipinos in U.S. colleges and universities. The educational sys-

tem thereafter continued to expand rapidly. The Philippine people eagerly adopted the U.S. concept of education. Education is highly valued as a factor in individual advancement and national development. The republic is perhaps unique in that the majority of the rural elementary schools have been built directly by the people through private initiative and planning. The educational system is highly centralized. with administrative control in Manila. Public education embraces all levels: elementary school, four years; intermediate school, three years; secondary school, four years: college and university. There are public schools for arts and trades, commerce, agriculture and fishing. Tuition is paid from the secondary level on, but many scholarships are available. The private educational system is vitally important, particularly at secondary. normal. collegiate and university levels. All private schools are supervised and accredited by the government.

Education is the second largest item in the national budget, amounting each year to nearly 20% of the total. The literacy rate of those persons 10 years old and over in the late 1950s stood at about 65%, the highest in southeast Asia.

3. Defense. — There is a program of mutual defense and cooperation with the U.S. and SEATO (see HISTORY above). The Philippine constabulary and local police maintain public order. The former is part of the armed forces whose chief of staff has over-all command of the land, sea and air forces.

VI. THE ECONOMY

A. FINANCE AND TRADE

1. National Finance. — The Philippines entered the period after World War II under financial difficulties. Large reconstruction costs were only partly compensated by U.S. financial aid and war damage compensation. and government deficits, as well as trade deficits. were normal: owing in good part to large-scale development programs.

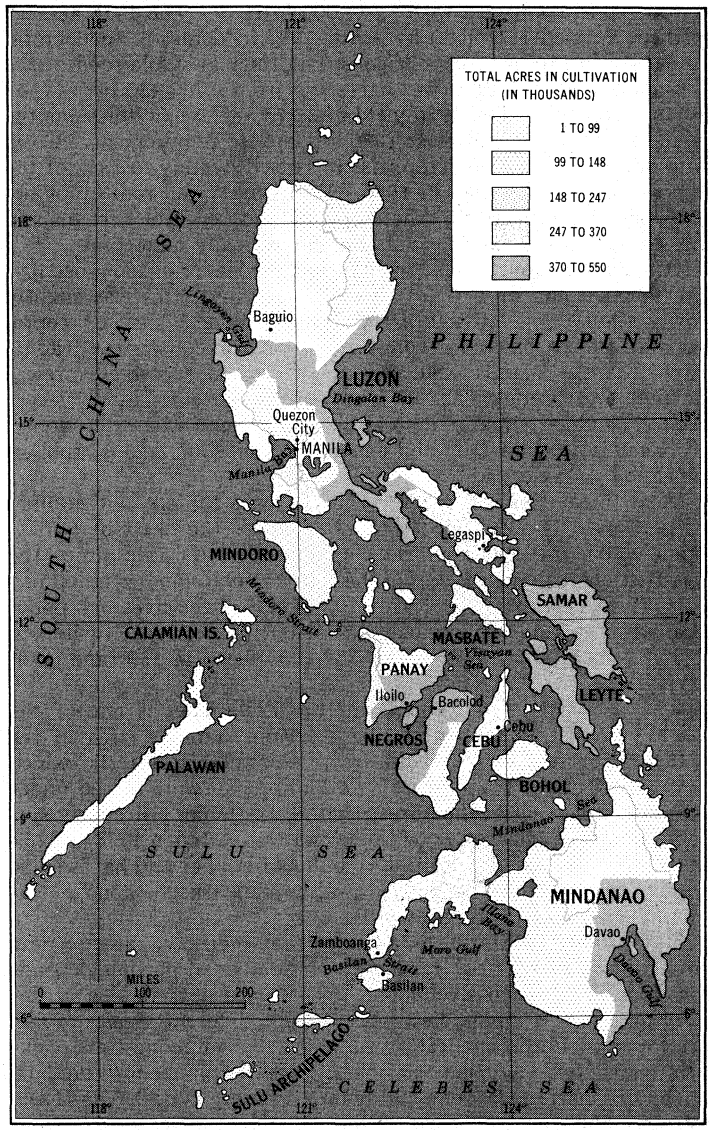
The Philippine Central bank's foreign exchange reserves fell from 800.000.000 pesos at the end of 1948 to 450.000.000 pesos on Dec. 9, 1949. On that date controls were imposed, placing all foreign exchange under licencing. The economic and fiscal position of the Philippines continued to decline, and the Bell mission recommended in 1950 that, among other measures, taxes be increased and reforms be made in tax collection procedure. During 1951 tax machinery was improved and new taxes were imposed. including a tax of 17% on the sale of foreign exchange.

During 1949 and 1950 import controls had been established as a measure to stimulate Philippine production and to conserve foreign exchange. This resulted in a decline in the yield of some internal taxes but it improved the general financial position. A partial relaxation of import controls in 1951 contributed to a government surplus in 1952. The degree of import control varied after 1952. Throughout the 1950s national government expenditures slightly exceeded revenue for each fiscal year.

The international reserve had reached a high point of 782,500,000 pesos on April 30. 1951, after the low level in 1949, but it declined slowly after that.

In addition to the Central bank, there are more than 15 commercial banks with more than 100 branches and agencies, a few savings and mortgage banks, and numerous rural banks. Banking operations are also conducted by the Postal Savings bank, the Agricultural Credit and Cooperative Financing administration, the Rehabilitation Finance corporation, building and loan associations and pawnshops.

2. Trade. — During the period the Philippines were under Spanish rule, external commerce for the most part was limited to trade with Spain and Mexico. Under Cnited States sovereignty, foreign trade expanded. With the passage of the Paine Tariff act of 1909 and later the Underwood act of 1913, providing for unrestricted free trade between the two countries, the Philippines became largely dependent on the U.S. market. In pre-World War II years more than 65% of Philippine trade was with the United States. During the years after independence trade with the United States declined from 86% of the total trade of the Philippines in 1945 to about 54% in 1959.



MAP OF THE REPUBLIC OF THE PHILIPPINES. SHOWING DISTRIBUTION OF ACREAGE UNDER CULTIVATION

Although the Philippine prewar exports were sufficient to offset imports the wartime scarcity of consumer and hard goods resulted in an unfavourable balance of trade in the postwar period. In 1958 total trade (exports dnd imports) nas valued at more than 2,000,000,000 pesos with an uniavourable trade balance of about 145.000.000 pesos. The leading postwar exports mere copra, sugar, abaci. abaci manufactures, coconut oil. base metals, lumber, canned pineapple, dried coconut and embroideries. Among the principal imports were textiles. grains and preparations, petroleum, automobiles, iron and steel and manufactures, tobacco, dairy products. paper manufactures and machinery.

B. PRODUCTION

1. Agriculture. — The fertile soil and tropical climate of the Philippines are well adapted to the raising of agricultural products, and farming engages about two-thirds of the employed population.

The total land area of the Philippines is 29,741,290 ha. (1 ha. = 2.471 ac.). Of this total, in 1956, about 11,415.000 ha. were commercial forest; 4,459.900 ha noncommercial forest; and 612,700 ha. in mangrove and swamp. About 5,726,580 ha. uere in cultivation and 2,453,810 ha, were classed as potential cropland. In 1940, 5,172,700 ha. had been planted, with 3,527,900 ha. (68%) in food crops: 1.644.800 ha. (32%) in export crops.

The index of agricultural production for 1955 reached 124% of the 1940 productivity, and the number of farms was approximately

1,720,000 as compared with 1,634,000 in 1939. The 1956 acreage planted totaled 5,726,580 ha., with 75% in domestic food crops. and 25% in export crops. Rice is the principal staple food of the Filipinos, and in 1936 it was harvested from 2,742,480 ha. (47%) of the cropland. The 1956 yield of 3,273,332 metric tons was the highest on record and close to the domestic requirement. Corn, another important food crop, also increased steadily to 28% of the cropland, 1,647.840 ha., in 1956. Fruits, nuts and root crops occupy significant shares of the cropland, and vegetables, beans and peas, coffee, cacao and peanuts are domestically important.

Among the export crops, coconut was the leader in 1956, occupying 992,000 ha., or 17% of the total cropland; this was slightly lower than the 1940 figure. Coconut products such as copra, coconut oil, desiccated coconut and copra cake form the leading export of the islands. Sugar cane revived to exceed its prewar acreage and production, but is no longer the chief money crop. Abacá declined slightly in relative importance in the economy. Tobacco is a minor crop and export, as are ramie, kapok, rubber, pineapple and derris.

Next to farming, livestock raising engages the greatest number of persons. The carabao (water buffalo) is the beast of burden upon which the Philippine farmer depends. As a result of the destruction of livestock during the war the total number remaining in 1949 was estimated at 1,972,859. By 1958 the livestock population was as follows: carabao, 3,596,400; cattle, 896,200; horses. 221,100; hogs, 6,083,600; goats, 537,100; sheep 17,150; and poultry. 52,468,700.

2. Forestry. — The Republic of the Philippines is one of the world's largest lumber-producing countries, ranking fifth in the ratio of forests to total land area. Commercial forests, which cover 34% of the total area of the Philippines, were placed under the administration of the bureau of forestry under a licencing system. The stand of hardwood timber was estimated in 1958 at 525,000,000,000 bd.ft. In addition to building lumber and hardwoods. forest products include dyewoods, rattan, tanbarks, bamboo, guttapercha, gum copal and fibres.

3. Fisheries. — Fishing is an important industry, ranking next to farming and livestock raising in the number of persons depending upon it for their livelihood. Fish comes next to rice in importance in the Filipino diet. About 1,900 different species of fish are found in Philippine waters, of which the commonest are milkfish, mackerel. snappers, sea bass. porgies, pompanos, mullets, anchovies, barracuda, tuna and bonito. Before World War II the average annual commercial inshore catch amounted to about 21.000 tons in addition to 25.000 tons produced in fish ponds. Total fish production in 1956 was 390.600 metric tons. Canned tuna is the principal fish exported. Other marine products include coral. pearls. shells and sponges. Among the shells and shell products are mother-of-pearl, trochus, tortoise, green snail shells and shells used for windows.

4. Mining. — The mineral wealth of the Philippines includes deposits of gold. silver, iron, copper. chrome, manganese and lead. In addition to the base metals, such nonmetallic minerals as asbestos, asphalt, marble, coal, gypsum, limestone, clay, petroleum and building stone are found.

Gold deposits are in Baguio on Masbate; and in Surigao, Davao and Zamboanga on Mindanao. Iron deposits are found in Camarines Norte and Bulacan on Luzon and in Surigao. Chromite and copper are mined in Zambales on Luzon. Manganese is found in Ilocos Norte and Zambales on Luzon; on Palawan and Siquijor.

Gold and iron mining are old industries, with records of gold mining by crude methods prior to the arrival of Magellan. Coal mining dates from the early Spanish period Petroleum formations are known to exist, and prior to World War II there were a few producing wells; in 1939. however, all petroleum lands were withdrawn from entry for five years pending the development of exploitation plans. During the Japanese occupation the mining industry suffered from lack of maintenance and the looting of equipment. After independence, the mining industry was the last of the major prewar industries to be rehabilitated.

While gold production had been 1,033,037 oz. in 1939, representing a 64% increase over production in 1929, in 1956 production was only 408,390 oz. Silver production in 1956 was 524,955 oz. as compared with the production of 1,175,192 oz. in 1938. The production of other minerals in 1956 (in metric tons) was: zinc, 420; lead, 2,261; copper, 21.482; iron ore. 1,372,529; coal, 146,306; chromite ore (refractory) 625,980 and (metallurgical) 125,037; and manganese ore, 4,470. Total value of mineral production in 1956 was 186,275.522 pesos.

5. Industry. — Industrial development. speeded during the period of the commonwealth, was devoted primarily to the manufacture and processing of agricultural products. Among these were: sugar, rope, cigar and cigarette. cordage, wood and rattan furniture factories; sugar, rice and lumber mills; pineapple and fish canneries; beer distilleries; and spinning mills. During the years immediately preceding the war, modern factories were established for producing shoes. hats, leather products. perfume and pearl buttons. Household industry produced embroideries, candies and fibre hats.

After independence in 1946, new industries were developed as a result of government-imposed import controls, government loans and legislation exempting new industries from taxation for a period of four years. These included an oil refinery and factories producing chemical products, fibre products, aluminum and enamelware, medical supplies, radios and musical instruments, wood and pulp products, knitted goods of rayon and cotton, plastics, rubber and steel products.

The National Development company, established during the commonwealth period and reorganized following independence, engaged in enterprises deemed in the interest of a systematic development of Philippine resources. Its subsidiary corporations included the National Food Products corporation, National Rice and Corn corporation, Peoples Homesite corporation, National Footwear corporation, Insular Sugar Refining corporation, National Tobacco corporation, Manila Railroad company and others.

The National Development company participated directly in the construction of hydroelectric plants, a steel mill, shipyards, steel-products plants, pulp mills, heavy-machinery shops and spinning mills. The Rehabilitation Finance corporation granted loans to private investors for approved industrial enterprises.

C. Transport and Communications

During World War II transportation and communication facilities were badly damaged, but after the war they were substantially rehabilitated. In 1959 there were 22,202 mi. of roads in the Philippines. Bridges numbered 11,090. The railways are of the narrow-gauge type. The Manila Railroad company, owned by the Philippine government, operates a system of 310 mi. in Luzon extending from San Fernando, La Union, in the north to Legaspi, Albay, in the south. The Philippine Railway company has 78 mi. of railways in the islands of Panay and Cebu.

Because of the republic's insular nature interisland shipping between the more than 200 local ports is an important factor in domestic trade and communications, and more than 3,000 vessels are engaged in this local trade. Foreign shipping, which more than doubled after World War II, is handled through the ports of entry. Manila being the largest and most important of these. Other ports of entry include Cebu, Iloilo, Zamboanga, Davao, Tabaco, Tacloban, Jolo, Jose Pañganiban, San Fernando and Aparri.

Philippine Air Lines services more than 40 stations within the islands and maintains international connections with Hong Kong. Several international airlines also stop at the Philippines.

In 1956 there were about 1.200 post offices and 500 telegraph offices. Of the more than 80,000 telephones in use throughout the republic in 1959, more than half were in Manila. (R. E. He.)

See also Index references under "Philippines, Republic of The" in the Index vclume.

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PHILIPPINE SEA, the name applied since 1944 to that part of the western North Pacific ocean lying east and north of the Philippines. The floor of the Pacific in this area is formed into a natural basin by a series of geologic folds and faults in the form of arcs. These arcs protrude above the surface in many places, forming a series of bordering islands. The Philippine Islands of Luzon, Samar and Mindanao are on the southwest; Palau, Yap and Ulithi of the Caroline Islands are on the southeast; the Marianas, including Guam. Tinian. Saipan and others, are on the east; the Bonin and Volcano Islands. including Iwo Jima, Kita Iwo and others lie to the northeast; the Japanese islands of Honshu. Shikoku and Kyushu lie to the north: the Ryukyu Islands, including Okinana, are to the northwest: Formosa marks the extreme western edge of the sea. Maximum measurements for the Philippine sea are 1.800 mi. from north to south and 1.500 mi east to nest Ocean trenches, or deeps, mark the eastern sides of the various folded arcs Within the Philippine sea are located the Ryukyu trench and the Philippine or Mindanao trench (htindanao deep) The latter reaches the second lowest depths known in any section of the ocean floors. Maximum depth is achieved about 120 mi. northeast of the town of Surigao on northeastern Mindanao. The depth here is 34 583 ft., recorded in 1951 by the Danish oceanographic ship "Galathea." correcting a 1945 reading of 34.440 ft. recorded by the U.S S. "Cape Johnson" and a 1927 reading of 35.400 ft recorded by the German cruiser "Emden." The warm North Equatorial current flons westward across the southern part of the sea Upon meeting the Philippine Islands the current divides; part swings north as the warm Kuroshio or Japan current and part swings toward the equator as the Counter Equatorial current.

During A'orld War II the U.Snavy achieved two significant victories over the Japanese fleet in the southern Philippine sea. The first nas fought by carrier planes alone on June 19–20, 1944 The second, sometimes called the battle of Leyte Gulf. involved the major units of both fleets and was a decisive American victory *See* WORLD WAR II: *The War at Sea.* (R. E. HE)

PHILIPPOPOLIS (Bulg. PLOVDIV), the second town of Bulgaria, capital of the district of the same name. is situated on the right bank of the Maritsa, 96 mi. E.S E. of Sofia. Pop. (1956) 162.518. The city lies on and between seven granite rocks which rise out of the flat and fertile plain of the Maritsa; the southern Balkans are distant about 25 mi., the northern Rhodopes about 12 mi It is a wealthy commercial city, centre of the trade in tobacco. wheat, silk and attar of roses of south Bulgaria. There is also a growing industry in flour-mills, tobacco factories, beer, soap, leather. ink. furniture and sugar.

History.—Eumolpia, a Thracian town, was captured by Philip of Macedon and made one of his frontier posts; hence its name of Philippopolis. Under the Romans, Philippopolis, or Trimontium. was the capital of Thracia. It is said that 100.000 persons were slain when it was captured by the Goths. In 762 it was in ruins when the Emperor Constantine Copronymus settled large colonies of Armenian Paulicians in and around it as frontier guards. It recovered its prosperity under the later Roman Empire. and excited the admiration of the crusaders. Frederick Barbarossa made it his headquarters (1189); in 1205 it was granted to Renier of Trit The next year the Greeks declared for the Byzantine emperor. nhereupon the Armenians betrayed the city to the Bulgarian tsar, Kaloyan, who massacred its Greek inhabitants. and razed the city. It recovered again, and became of extreme importance as the centre from which the Bogomils (*q.v.*) derived their doctrines through Armenian teachers. It was retaken by the Greeks in 1262, by the Turks in 1363. It was occupied by Russian troops in 1878, and under the treaty of Berlin was made capital of the autonomous province of Eastern Roumelia, being united nith Bulgaria in 1885 *(see* BULGARIA: *History).*

PHILIPPUS, MARCUS JULIUS, Roman emperor AD. 244 to 249. often called "Philip the Arab." was a native of Bostra in Arabia Trachonitis. Having entered the Roman army, he rose to be praetorian praefect in the Persian campaign of Gordian III. and. inspiring the soldiers to slay the young emperor, was raised by them to the purple (244). Of his reign little is known except that he celebrated the secular games with great pomp in 248, when Rome nas supposed to have reached the thousandth year of her existence. A rebellion broke out among the legions of Moesia, and Decius. who was sent to quell it, was forced by the troops to put himself at their head and march upon Italy. Philip was defeated and slain in a battle near Verona. According to Christian writers. he was a convert to Christianity.

PHILIPS, AMBROSE (1674–1749), English poet whose contemporary reputation rested chiefly on his *Pastorals,* was born at Shrensbury, Oct. 9, 1674. He was educated at Shrewsbury school and St. John's college, Cambridge, where he became a fellow~in 1699. In 1700 he published *The Life of John Williams,* an abridgment of J. Hacket's *Scrinia Reserta,* A *Memorial to Archbishop Williams* (1693). After traveling in Holland, he obtained a commission and served in Spain. In 1709 his *Pastovals* appeared in J. Tonson's *Miscellany* and won praise from Addison, Steele and Pope. They were later parodied by John Gay in *The Shepherd's Week* (1714). Philips became secretary to Daniel Pulteney. the British envoy at Copenhagen, in 1709 and there composed a widely admired verse epistle to the earl of Dorset, *A Winter Piece* (1709). After tutoring in Italy he returned to London, where *The Distrest Mother* (1712). his adaptation of Racine's *Andromaque,* was a success. His other plays are *The Bviton* (1722) and *Humfrey, duke of Gloucester* (1723). His quarrel with Pope, described by Dr. Johnson as a "perpetual reciprocation of malevolence," resulted from an article in *The Guardian* (No. 32 of 1713) in which Philips, and not Pope, whose *Pastorals* had also appeared in Tonson's *Miscellany,* was hailed as the successor of Theocritus, Virgil and Spenser.

Gradually Philips lost his literary friends. In 1714 he was made paymaster to the lottery. and justice of the peace for Westminster; but in 1724 he became secretary to Dr. Boulter, archbishop of Xrmagh, whom Snift detested, and found himself the butt of literary Dublin. His poems on the children of Lord Carteret and Daniel Pulteney, scoffed at by Swift as "little flams," were parodied, and he was nicknamed "Namby Pamby." He sat in the Irish parliament and held legal positions before returning to London in 1748. He died there. June 1 or 2, 1749. His *Poems* were edited with an introduction by M. E. Segar in 1937.

PHILIPS, JOHN (1676–1708/09), English poet and man of letters. son of Dr. Stephen Philips, archdeacon of Shropshire, was born at Bampton, Oxfordshire, on Dec. 30, 1676. He was educated at Winchester and Christ Church. Oxford. His poem, *The Splendid Shilling,* was called by Addison in *The Tatler* "the finest burlesque poem in the British language." Harley and St. John commissioned him to write a Tory counterblast (*Blenheim*) to Joseph Addison's *Campaign. Cyder* (1708), one of the earliest of the great didactic poems of the 18th century, is modeled on the *Georgics* of Virgil. *Cerealia, an Imitation of Milton* (1706), although printed without his name, may safely be ascribed to him. In all his poems except *Blenheim* he inserted a eulogy of tobacco. Phiips died at Hereford on Feb. 15, 1708/09.

See *The Whole Works of . . . John Philips . . . To which is prefixed his life, by* [G.] Sewell (3rd ed., 1720); ***The Poems*** *of John*

Philips (1927), ed. *M.* **G.** Lloyd Thomas; and Johnson's *Lives* of *the Poets.*

PHILIPS, KATHARINE (1631–1664), English poet known to her contemporaries as the "Matchless Orinda," was born in London on Jan. 1. 1631. She married James Philips, a Welsh Puritan and parliamentary leader, in 1648. Her home in Cardigan became the centre of a "society of friendship," the members of which were known by romantic pseudonyms, Mrs. Philips being Orinda; her friend Mrs. Anne Owen, Lucasia; her husband, Antenor; and Sir Charles Cotterell, Poliarchus. Henry Vaughan exchanged poetical compliments with her and Jeremy Taylor addressed to her *A Discourse of the Nature, Offices and Measures* of *Friendship* (1657). The atmosphere of the circle is preserved in *The Letters of Orinda to Poliarchus* (1705). Her *Pompey* (1663). a translation from Corneille, was successfully acted and her poems appeared in a pirated edition (1664). An authentic edition by Sir C. Cotterell appeared in 1667. She died of smallpox in London on June 22, 1664.

Orinda's poems represent a transition from the old courtly poetry to the Augustan manner of the Restoration. One of her lyrics was praised by Keats and she wrote the heroic couplet with skill and dignity. *The Letters to Poliarchus* are lively and spirited.

The poems were edited by G. Saintsbury in his *Minor Poets of the Caroline Period,* vol. *1* (1905). *See* also **P.** *W.* Souers, *The Matchless Orinda* (1931) (V. DE S P.)

PHILIP THE BOLD (1342–1404), duke of Burgundy, fourth son of John II. of France and Bonne of Luxemburg, was born on Jan. 15, 1342. He earned his surname by his bravery on the field of Poitiers He accompanied King John into captivity in England. In 1360 he received the title of duke of Touraine, and in June 1363 was entrusted with the government of Burgundy, which John had united to the crown at the death of the last duke of the Capetian family, Philip of Rouvre, in 1361. In September 1363 John made Philip duke of Burgundy, and first peer of France. The donation was ratified at the accession of Charles V. of France; he took possession of the duchy at the end of 1364. Charles appointed him (in 1366) his lieutenant in Champagne and married him in 1369 to Margaret, daughter and heiress of Louis of Mâle. count of Flanders, and widow of Philip of Rouvre.

Philip proved a faithful ally to Charles. He took part in the almost bloodless campaign against the duke of Lancaster, who had landed at Calais; in 1377 he took several towns in French Flanders from the English; and in 1379 relieved Troyes, which had been besieged by the English. On Charles's death Philip found himself, with his brothers, the dukes of Anjou and Berry, in charge of the government of France in the name of Charles VI., who was a minor; and in the absence of the duke of Anjou, who left France in 1382 to conquer the kingdom of Naples, Philip occupied the most powerful position in the realm. He persuaded the young king to intervene in Flanders, where the citizens of Ghent, whose rebellious spirit had necessitated Philip's intervention in 1379, had again revolted under Philip van Artevelde and had expelled Louis of Mâle. On Nov. 27, 1382, the Franco-Burgundian chivalry crushed the rebels at Rosebecke, and on his return the duke of Burgundy took part in repressing the popular movements which had broken out in Paris and other French towns. In 1383 an insurrection in Flanders supported by England gave rise to another French expedition; but in January 1384 the death of Louis of Mâle made Philip master of the countships of Flanders, Artois, Rethel and Nevers; and in the following year the citizens of Ghent decided to submit. At this period Philip sought to ingratiate himself with the emperor by giving two of his daughters in marriage to two princes of the house of Bavaria; he also took an important part in bringing about the marriage of a princess of the same family, Isabel, to King Charles VI.

Hostilities, however, were renewed between France and England. A formidable expedition was prepared under the direction of the duke of Burgundy, and a fleet of 1,400 sail assembled at Sluys; but the enterprise failed owing to the dilatoriness of the duke of Berry. The fatiguing and inglorious expedition in the Netherlands weakened Philip's credit with his nephew, who on his return declared himself of age and confided the government to the ancient councillors of his father, the "Marmousets." The king's madness (1392) restored his uncles to power, and particularly Philip, who after assuring peace by treating with the duke of Brittany and by concluding a truce of twenty-eight years with England, made strenuous efforts to put an end to the Great Schism, visiting Pope Benedict XIII. at Avignon in 1395 in the hope of obtaining a voluntary resignation from him. For the discords in the king's council *see* CHARLES VI. For a brief period Philip was dispossessed of authority, but he regained it in 1402 and kept it till his death (April 27, 1404). The cathedral of St. Bénigne at Dijon contains his remains, and his tomb (formerly in the Chartreuse of Dijon) is in the Hôtel-de-ville. Philip appears to have governed his territories with sagacity and a certain moderation. He granted numerous privileges to the inhabitants of Dijon and created in 1386 two *chambres des comptes,* one at Dijon and the other at Lille. (R. P.; X.)

PHILIP THE GOOD (1396–1467), duke of Burgundy, son of John the Fearless, duke of Burgundy, and Margaret of Bavaria, was born at Dijon on June 13, 1396, and succeeded his father on Sept. 10, 1419. The assassination of John the Fearless (*q.v.*) drove his successor to the English side. In 1419 Philip signed with Henry V. of England the treaty of Arras, by which he recognized Henry as regent and future heir of the kingdom of France, and in 1420 gave his adherence to the treaty of Troyes. Early in December 1420 Philip entered Paris with the king of England, and subsequently took part in the defeat of the French at Monsen-Vimeu. By a treaty concluded by Philip at Amiens in April 1423 with the dukes of Brittany and Bedford, John, duke of Bedford, married Philip's sister Anne, and Arthur of Brittany, earl of Richmond, became the husband of Philip's sister Margaret. A few years later discord arose among the allies. When the duke of Bedford besieged Orleans the inhabitants offered to surrender, but to the duke of Burgundy; whereupon Bedford retorted that "he did not beat the bushes for others to take the birds." When this speech reached Philip's ears he withdrew his troops in dudgeon, and concluded a truce with France (1429). Bedford succeeded in conciliating him and in 1430 Philip took part in the campaign against Compiègne.

But another conflict arose between the duke of Burgundy and the English. Jacqueline, countess of Hainaut *(see* JACOBA) the divorced wife of the duke of Brabant and the heiress of Holland and Zeeland, had married the duke of Gloucester, who attempted to take forcible possession of his wife's territories. Philip claimed Brabant as a bequest from his cousin Philip, the late duke, with the result that the Burgundians repulsed the troops of the duke of Gloucester, and Jacqueline was forced to recognize the duke of Burgundy as her lieutenant and heir. Moreover, the duchess of Bedford had died in 1433. Charles VII., who in spite of the efforts of the cardinal of Ste-Croix had hitherto refused to return to France, finally decided to take part in the conferences which were opened at St. Vaast d'Arras on Aug. 6, 1435. Philip agreed to recognize the king of France as his legitimate sovereign on condition that he should not be required to pay him homage during his lifetime. Charles solemnly craved pardon for the murder of John the Fearless and handed over to the duke the counties of Mâcon, Auxerre, Bar-sur-Seine and Ponthieu, and the towns on and near the Somme (Roye, Montdidier, Péronne), reserving the option of redeeming the Somme towns for 400,000 gold crowns. Philip faithfully served the king, aiding him in re-entering Paris and preparing an expedition against Calais, which, however, failed through the ill-will of his Flemish subjects (1436). In 1440 he paid the ransom of Charles of Orleans and married him to Mary of Cleves. In 1442 Philip conspired to give the duke of Orleans a larger share in the affairs of the kingdom.

Philip was frequently disturbed by the insubordination of the Flemish communes. He had to quell seditions at Liége (1430), Ghent (1432 and 1448), Antwerp (1435) and Bruges (1438). Shortly after the final defeat of the citizens of Ghent at Gavre (1453) Philip vowed that he would lead a crusade against the Turks, who had seized Constantinople. The expedition, however, did not take place, and was but a pretext for levying subsidies. In 1459 Philip sent an embassy under the duke of Cleves into Italy to

take part in the conferences preparatory to a fresh expedition against the Turks, but this enterprise likewise fell to the ground. In 1456 the duke of Burgundy had given an asylum to the Dauphin Louis (afterwards Louis XI.), who had quarrelled with his father and had been forced to leave France. Louis repaid his protector by attempting to sow discord in the ducal family of Burgundy, and then retired to the castle of Genappe in Brabant. At Charles VII.'s death, however, Philip was one of the first to recognize the new king, and accompanied him to Paris. During the journey Louis won over the seigneurs of Croy, the principal counsellors of the duke of Burgundy, and persuaded Philip to allow him to redeem the Somme towns for the sum stipulated in the treaty of Arras. This proceeding infuriated Philip's son Charles, count of Charolais, who prevailed upon his father to break his pledge and declare war on the king of France On April 12, 1465, Philip handed over to his son the entire administration of his estates. The old duke died at Bruges on June 15, 1467.

Philip was a great lover of pomp and luxury and a friend of letters, being the patron of Georges Chastelain, Olivier de la Marche and Antoine de la Salle, and the founder of the collection of mss. known as the "Bibliothèque de Bourgogne" (now at Brussels), and also of the university of Dôle (1421). He administered his estates wisely; promoted commerce and industry, particularly in Flanders; and left his son a well-lined treasury. He was thrice married: in 1409 to Michelle (d 1422), daughter of Charles VI. of France; in 1424 to Bonne of Artois (d. 1425); and in 1429 to Isabel (d. 1472), daughter of John I., king of Portugal, when he founded the order of the Golden Fleece He was succeeded by Charles, afterwards known as Charles the Bold, his only surviving son by Isabel. (R. P.; X.)

PHILISTINES. "Philistine" was the general name for the people of Philistia (Assyr *Palaštu, Pilištu;* Egypt *p-r-s-t*), a district embracing the rich lowlands on the Mediterranean coast from the neighbourhood of Jaffa (Joppa) to the Egyptian desert south of Gaza On the subsequent extension of the name in its Greek form. Palaestina. *see* PALESTINE.

According to biblical tradition the Philistines are the remnant of Caphtor (Jer. xlvii. 4, Amos ix. 7), and the Caphtōrīm drove out the aboriginal Avvim from Gaza and district, as the Horites and Rephaim were displaced by Edom and Ammon (Deut. ii. 23). These Caphtōrīm, as well as Ludim (Lydians) and other petty peoples, apparently of the Delta, are once reckoned to Egypt (Gen. x. 14). By Caphtor the Septuagint has sometimes understood Cappadocia, which indeed may be valid for its age, but the name is to be identified with the Egyptian K(a)ptar, which in later Ptolemaic times seems to mean Phoenicia, although the earlier *Keftiu* connoted Crete, and possibly "the south Anatolisn coast as far as Cilicia" (Hall). The Cherethites, associated with the Philistine district (1 Sam. xxx 14, 16, Ezek. xxv. 16, Zeph ii. 5 *seq*), are sometimes recognized by the Septuagint as Cretans, and, with the Pclethites, they form part of the royal bodqguard of Judaean kings (2 Sam. viii. 18, xv. 18, xx. 7, 1 Ki. i. 38, 44; in 2 Sam xx. 23 the Hebrew text has Carites).

The earliest occurrence of the name "Philistines" outside the Old Testament is in Egypt, where the Purasati (Pulesati) are one of a great confederation from north Syria, Asia Minor and the Levant, which threatened Egypt in the 20th dynasty. They are not among the hordes enumerated earlier by Rameses II or Merneptah but in the eighth year of Rameses III (c. 1194 B.C.); the Purasati (Pulesati) take part in a widespread movement on land and sea. The Syrian States were orerahelmed and the advance upon Egypt seemed irresistible. Rameses, however, collected a large feet and an army of native troops and mercenaries and claimed decisive victories The Egqptian monuments depict the flight of the enemy. The sequel of the events is not known, though about a century later the Zakaray are found at Dor, and treat with scant respect the suzerainty of Egypt.

The Egyptian monuments represent the I'urasati with a very distinctive feather head-dress resembling that of the Lycians and Mycenaeans. Their general physiognomy is hardly Cilician or Hittite, but European, especially Greek. They fought with a broad-sword and carried a round shield. On archaeological grounds the Purasati were not Mycenaeans from Crete, despite tradition, but rather from Asia Minor (Lycia, Caria), though they may have passed some time in Crete.

Palestine and the West.—The Philistines appear in the Old Testament as a Semitic or at least a Semitized people. Both the language and the religion were Semitic. The male god Dagon has his partner Astarte (*q.v.*), and Baal-zebub, a famous oracle of Ekron (2 Ki. i.) resembles the local "baals" of Palestine. Philistia seems to be completely Hellenized after the Persian age; but it is not certain that Greek culture pervaded all classes; foreign influence probably always made itself felt upon the coast-towns The use of the term ἀλλόφυλοι in Maccabaean and later writings (cf. the contemptuous hatred of Ben Sira, Ecclesiasticus 1. 26, and the author of Jubilees xxiv. 30 *sqq*) expresses the conditions of the Greek age and the Maccabaean wars. The Mediterranean coast-land was always exposed to incursions of aliens; Carians appear as royal and temple guards at Jerusalem (2 Ki. xi. 4), and old Greek traditions tell of a Carian sea-power and relations between Philistia and Greek lands. Even the presence of Carians and Ionians in the time of Psammetichus I may be assumed. and as these are planted at Defneh it is noteworthy that this place is also closely associated uith a Jewish colony (viz, Tahpanhcs, Jer. xliii, *seq*). In fact, Palestinian intercourse with the West is fairly continuous; and excavation at Beth-shan. Gezer, and other sites, has shown many important indications of Western influence, so that some authorities even recognize a "Philistine" pottery.

History.—The Philistines form a confederation of five cities (Ashdod. Ascalon [Ashkelon], Ekron, Gath and Gaza), which remained unconquered by the Israelites (Josh. xiii. 2 *seq*, Judges iii. 3; contrast Josh. xv. 45–47, xix 43). The institution of the Hebrew monarchy (*c.* 1025 B.C.) follows upon periods of Philistine oppression (Judges iii. 31, x. 7, 11, xiii. 1, 5; *see* SAMSON; ELI; SAMUEL; SAUL; DAVID). Their subjugation is ascribed to Samuel (1 Sam. vii 13), Saul (xiv. 47), and David (2 Sam. viii. 1). They evidently recovered their independence, and twice within a short time the northern Israelites laid siege to the border fortress of Gibbethon (1 Ki. xv. 27, xvi. 1;). The interrelations of the south Palestinian peoples follows from the unchangeable geographical conditions, and Judah always depended upon its relations with the Philistines on the west and with the Edomites and Arabian tribes on the south-east. "Philistia," with Edom and Beth-Omri (*i.e.,* the Israelite kingdom), paid tribute to the Assyrian king, Adad-Nirari III. (c. 802 B.C.). The omission of Judah is noteworthy. In the later Assyrian period Philistia was mixed up in pro- and anti-Assyrian intrigues, and suffered from Tiglath-pileser (734), Sargon (720) and Sennacherib (700). In the 7th century Gaza, Ascalon, Ashdod and Ekron were Assyrian vassals, together with Judah, Rloab and Edom—in all, 22 kings of the "Hittites" Herodotus mentions the Scythian invasion and sack of the temple of Aphrodite Urania (Astarte) at Ascalon. also the prolonged siege of Ashdod by Psammetichus, and the occupation of Kadytis (? Gaza) by Necho Rut the Babylonian empire followed upon traditional lines and thrust back Egypt, and Nabonidus (553 B.C.) claims his vassals as far as Gaza. The Persians took over the realm of their predecessors, and Gaza grew in importance as a seat of international commerce. Nehemiah speaks not of Philistines, but of Ashdodites (iv. 7), speaking an "Ashdodite" dialect (xiii 24); just as Strabo regards the Jews, the Idumaeans, the Gazans and the Ashdodites as four cognate peoples having the common characteristic of combining agriculture with commerce. In southern Philistia, at least, Arabian immigration became more pronounced In the time of Cambyses Arabs were settled at Jenysos south of Gaza (Herod iii 5), and when Alexander marched upon Egypt. Gaza with its army of Arabs and Persians offered a strenuous resistance On the history of the district *see* further GAZA; JEWS; MACCABEES; PALESTINE.

Traditions of the Philistines.—The Philistines were prominent. in popular tradition, and the story of Isaac and the Philistine Abimelech (Gen. xxvi., *cf* xxi 32) is of great interest for its unbiased picture of enmity, alliance and covenant. But a parallel story (xx.) is without this *Philistine* background. Similarly,

one account of the Israelite invasion conceived a conquest of earlier giant inhabitants (Anakim), who survived in Gaza, Gath and Xshdod (Josh. xi, 21 *seq.*, contrast xiii, 3), but were driven out from Hebron by Caleb (Josh. xv, 14, *cf.* Num. xiii, 22, 28). The Philistines themselves are called the remnant of the Anakim (Jer. xlvii. 5, so the Septuagint), or as Caphtorim replace the earlier Avvim (Deut. ii. 23, *see* Josh. xiii, 3). Samuel's great defeat of the Philistines leads to "peace between Israel and the *Amorites*" (1 Sam. vii, 14); and the migration of the Danites is placed after Samson's conflicts with the *Philistines* (Judges xviii, seq.), or is due to the pressure of *Amorites* (i, 34). Even in David's fights with the Philistines in Judah, Jerusalem is Jebusite, neighbouring non-Israelite cities are Hivite or Amorite (Josh. ix, 7, 2 Sam. xxi, 2). and his strange adversaries find a close parallel in the semimythical sons of Anak (2 Sam. xxi, 16, 18, 20, 22). In another tradition, however, David is on intimate relations with a Philistine king, Achish (or Abimelech, Ps. xxxiv). Traditions agree that the Israelites had to fight for their freedom, but antagonism between Philistines and Israelites was not persistent.

(S. A. C.)

PHILISTUS, Greek historian of Sicily, was born at Syracuse about the beginning of the Peloponnesian War (432 B.C.). He was a faithful supporter of the elder Dionysius, and commander of the citadel. In 386 he was banished for secretly marrying the tyrant's niece. He commanded the fleet against Dion, but was defeated and put to death (356). He settled at Thurii, but afterward moved to Adria, where he remained until the death of Dionysius (366). He was then recalled by the younger Dionysius, whom he persuaded to dismiss Plato and Dion. At Adria, Philistus occupied himself with the composition of his history of Sicily in 11 books, down to 363, from which point the work was carried on by Athanas. Cicero calls him "the miniature Thucydides."

PHILLIMORE, SIR ROBERT JOSEPH (1810–1885); English judge, was born at Whitehall on Nov. 5. 1810. Educated at Westminster and Christ Church. Oxford, he was admitted as an advocate at Doctors' Commons in 1839 and called to the bar at the Middle Temple in 1841. He was soon engaged as counsel in many cases of importance before the admiralty, probate or divorce courts. He was appointed judge of the Cinque Ports in 1855, queen's counsel in 1858, advocate-general in admiralty in 1862, and judge of the court of arches five years later. Noted for his care and patience, combined with unusual lucidity of expression, he was the last judge of the old court of the lord high admiral; after the Judicature act he continued to sit as judge for the new admiralty, probate and divorce division until 1883.

PHILLIMORE, WALTER GEORGE FRANK PHILLIMORE, 1st BARON (1845–1929), British judge, was born in London on Nov. 21, 1845, the eldest son of Sir Robert Joseph Phillimore (*q.v.*). He was educated at Westminster and Christ Church, Oxford, and was called to the bar in 1868. He was made a judge in 1913, and promoted to the court of appeal in 1913. He retired from the bench in 1916, and in 1918 was raised to the peerage. He was English representative on the commission which sat at The Hague in 1920 to prepare the scheme of a permanent court of international justice. He died on March 13, 1929.

PHILLIPPS DE LISLE, AMBROSE LISLE MARCH (1809–1878), a leading figure in the 19th-century Roman Catholic revival in England, was born at Garendon Park, Leicestershire, on March 17, 1809, the elder son of Charles March Phillipps; he took the name De Lisle in 1862 from his paternal grandmother's family, then without heir. Converted to Roman Catholicism from evangelical Anglicanism at the age of 16, he founded in 1835 the first post-Reformation English Trappist monastery, called Mount St. Bernard, presenting an estate in Charnwood forest, Leicestershire, to a group of monks from Ireland.

He wrote a number of religious works and was the benefactor of other religious communities, the supporter of the Gothic revivalism of A. W. N. Pugin (*q.v.*), a friend of leading figures of the Oxford movement, and an overoptimistic worker for the corporate reunion of the churches. He died at Garendon on March 5, 1878.

See E. S. Purcell, *Life and Letters of Ambrose Phillipps De Lisle,* 2 vol. *(1900).* (M. DK.)

PHILLIPS, EDWARD (1630–?1696), English writer and biographer of Milton. who was his uncle, was born in London Xug. 1630. His father, who died in 1631, was Edward Phillips of the crown office in chancery, and his mother was Milton's only sister: Anne. Edward and his younger brother John were educated by Milton, in whose house they boarded and studied the classics, mathematics and music. Edward entered Magdalen hall, Oxford, in Nov. 1650, but left in 1651 to be a bookseller's clerk in London. He was tutor to John Evelyn's son (1663–65). and, later. in the families of Lord Herbert and the earl of Arlington. His interesting memoir of Milton (1694) is prefixed to his translation of Milton's *Letters of State.* John Aubrey states in his *Minutes* of *Lives* that all the poet's papers came into his nephew's hands. His other works include A *New World in Words, or a General Dictionary* (1658). which ran through many editions; an edition (1660–62) of Sir Richard Baker's *Chronicle* of *the Kings of England,* with the section on 1650–58 showing a strong royalist slant; and *Theatrum Poetarum* (1675), a list of great poets. principally English ones, with critical notes and a prefatory *Discourse of the Poets and Poetry* which may have been written by Milton. He also added a supplement (1676'1 to John Speed's *Theatre of Great Britain,* and wrote *Enchiridion linguae latinae* (1684), said to be based on Milton's notes. The date of his death is unknown. but his last book is dated 1696.

His brother JOHX PHILLIPS (1631–1706) has been proved to be the author of a biography of Milton which was long thought anonymous. He appears to have acted as Milton's secretary, and in 1652 published a Latin reply to the anonymous attack on the poet entitled *Pro Rege et populo anglicano.* In 1655 he wrote a bitter attack on Presbyterianism, *A Satyr Against Hypocrites,* much in line with Milton's disapproval of the sect. In 1656 he was summoned before the privy council for his share in a book of licentious poems. *Sportive Wit* (1656). which was suppressed, but only to be replaced by another. *Wit and Drollery* (1656). John Phillips was a voluminous writer, often obscene, but entertaining.

See W. Godwin, *Lives of Edward and John Phillips* (1815); H. Darbishire, The *Early Lives* of *Milton (1932).*

PHILLIPS, STEPHEN (1868–1915), British poet and dramatist. was born on July 28, 1868, at Somertown near Oxford. He was educated at Stratford and Peterborough grammar schools. and entered Queen's college. Cambridge; but during his first term at Cambridge. when F. R. Benson's dramatic company visited the town, he joined it, and for six years played various small parts. In 1890 a slender volume of verse was published at Oxford with the title *Primavera,* which contained contributions by him and by his cousin, Laurence Binyon, and others. In 1894 he published *Eremus,* a long poem of loose structure in blank verse of a philosophical complexion. *Poems* (1897) brought him many readers. George Alexander commissioned Phillips to write him a play. the result being *Paolo and Francesca* (1900). produced at the St. James's theatre in 1901. Other dramas in blank verse followed: *Herod: a Tragedy* (1900), *Ulysses* (1902), *The Sin of David* (1904), and *Nero* (1906). In these plays, three of which mere produced by Beerbohm Tree, the poet's avowed aim was to revitalize the method of the Greek drama. *Paolo and Francesca* was the most successful.

Phillips died at Deal, Kent. on Dec. 9, 1915.

PHILLIPS, WENDELL (1811–1884). U.S. orator and reformer, was born in Boston on Nov. 29. 1811. His father, John Phillips (1770–1823), became the first mayor of Boston. Wendell entered Harvard college before he was 16 and graduated in 1831. He graduated at the Harvard law school in 1834. and was admitted to the bar in Boston. He soon came under the influence of the antislavery movement. witnessing in 1835 the mobbing, in Boston. of William Lloyd Garrison.

A meeting was held on Dec. 8. 1837. at Faneuil hall, Boston, to express the sentiments of the people on the murder of Elijah P. Lovejoy, at Alton (Ill.) for defending his press from a proslavery mob. In the course of the meeting a speech was made in opposition to its general current by James T. Austin, attorney general of the state. who said that Lovejoy had died "as the fool dieth." and compared his murderers with the men who threw the tea into Bos-

ton harbour just before the War of Independence The speech seemed likely to divide the audience. when Wendell Phillips took the platform. "When I heard," he said. "the gentleman lay down principles which placed the murderers of Alton side by side with Otis and Hancock, with Quincy and Adams, I thought these pictured lips (pointing to their portraits) would have broken into voice to rebuke the recreant American. the slanderer of the dead" That successful appeal determined the sentiment of the meeting and gave Phillips his first fame and determined his career.

Accepting unhesitatingly the leadership of Garrison, and becoming like him a disunionist, he thereafter lived essentially a platform life, interested in a variety of subjects. but first and chiefly an abolitionist. After the Civil War, however, he broke with Garrison over the question of discontinuing the Anti-Slavery society; and from 186j until the society was diibanded in 1870, he. instead of Garrison. was its president. Phillips' style of eloquence was direct and brilliant, but eminently self-controlled. He may be said to have introduced the direct and colloquial manner upon the C.S. public platform. His logic, while never obtruded, was rarely at fault. but he loved the flash of the rapier, and was never happier than when he had to face a mob and utterly foil it by sheer superiority in fencing. The two volumes of his speeches, as edited by James Redpath, nere fortunately made from verbatim reports, and they wisely enclose in parentheses those indications of favour or dissent from the audience which transformed so many of his speeches into exhibitions of gladiatorial skill. After slavery had fallen Phillips associated himself freely with reformers occupied in other paths. He contended in later years for prohibition, woman suffrage and various penal and administrative reforms. He died in Boston on Feb. 2, 1884.

PHILLIPSITE, a mineral of the zeolite group, is a hydrated potassium, calcium and aluminum silicate. Like other natural and synthetic zeolites its unique crystalline make-up and structural porosity make it possible for the mineral to lose and regain water reversibly with little or no change in fundamental structure. Like other zeolites it has the property of exchanging electrically charged atoms (ions) with other substances. (For discussion of these properties *see* ZEOLITE.) Phillipsite is a mineral of secondary origin and occurs with other zeolites in cavities in basic volcanic rocks (basalts and phonolites); in red clay and deep sea deposits; and is formed from some hot spring waters. It has been found near Rome, Italy, in France, Germany and Australia, near Melbourne, and at the Giant's Causeway, County Antrim, N.Ire. The composition of phillipsite approximates $(K_2,Ca)Al_2(SiO_3)_4.4H_2O$. It varies somewhat in composition, the variety pseudophillipsite having the formula $(K_2,Ca)_2Al_4Si_5O_{18}.9H_2O$. Crystals are monoclinic, but only complex cruciform twins are known. Spherical groups with a radially fibrous structure and bristled with crystals on the surface are not uncommon. The hardness is 4.5, and the specific gravity 2.2.

The species was named in 182j after the English mineralogist William Phillips (1775–1828); it also has been called christianite after Christian VIII of Denmark.

PHILLPOTTS, EDEN (1862–1960), English novelist. poet arid dramatist, was born at Mount Abu, Rajputana. India. Nov. 4, 1862, and educated at Plymouth. A clerk for ten years in an insurance office, he then studied for the stage, but became a writer, producing over 100 novels, many of them with a Devonshire setting. Among his more important works are the novels *Children of the Mist* (1898); *Sons of the Morning* (1900); *Widecombe Fair* (1913); studies of boyhood and adolescence, *The Human Boy* (1899); *The Waters of Walla* (1950); plays, *The Farmer's Wife* (1917); *Yellow Sands* (with his daughter Adelaide, 1926); poems, *The Iscariot* (1912); *Brother Beast* (1928); *The Enchanted Wood* (1948); and *One Thing and Another* (poems and essays, 1954). He died at Broad Clyst, near Exeter, Dec. 29, 1960.

PHILLPOTTS, HENRY (1778–1869), English bishop, was horn at Bridgnater on May 6, 1778, and was educated at Gloucester College school and Corpus Christi college, Oxford. He was consecrated bishop of Exeter in 1831, holding with the see a residentiary canonry at Durham. In 1819 he had defended the existing poor law and the action of the government in the Peterloo (*q.v.*) massacre. In 182j he vehemently opposed Catholic emancipation, engaging in a fierce polemic on the subject with Charles Butler (1j50–1832). "Henry of Exeter" continued to support the Tory party, even when it passed the Roman Catholic Emancipation act of 1829. He died on Sept. 18, 1869. The famous Gorham judgment was the outcome of his refusal to institute to the living of Brampford Speke a clergyman George Cornelius Gorham (1787–1857), who had openly disavowed his belief in baptismal regeneration; he denounced the equally famous tract 90 in his episcopal charge of 1843.

PHILO, often called PHILO JUDAEUS (c. 30 B.C.–*c.* A.D. 40), Jewish philosopher, is the most important representative of Hellenistic Judaism, and his writings give us the clearest view of this development of Judaism in the Diaspora. He was probably a native of Alexandria, where he appears to have spent his whole life apart from his journey to Rome. His brother Alexander was alabarch or arabarch (*i.e.,* probably, chief farmer of taxes on the Arabic side of the Nile), from which it may be concluded that the family was influential and wealthy (Josephus, *Antiquities,* xviii, 8, 1). The only event of his life which can be actually dated belongs to A.D. 40, when Philo, then nearing the end of his years, went to Rome to persuade the emperor Gaius to abstain from claiming divine honour from the Jews. Of this embassy Philo has left a full account (*De legatione ad Gaium*).

The Hellenistic Jew.—Philo appears to have been the greatest of all the Jewish philosophers of the Alexandrian school and has been called "the first theologian." On one side he is quite a Greek, on the other quite a Jew. His language is formed on the best classical models, especially Plato. He knows and often cites the great Greek poets, but his chief studies had been in Greek philosophy. His system was eclectic, but the borrowed elements are combined into a new unity with so much originality that he may fairly be regarded as representing a philosophy of his own, which has for its characteristic feature the constant prominence of a fundamental religious idea.

Philo's closest affinities are with Plato, with the later Pythagoreans and with the Stoics. Yet with all this Philo remained a Jew, and a great part of his writings is expressly directed to recommend Judaism to the respect and, if possible, to the acceptance of the Greeks. He was not a stranger to the specifically Jewish culture that prevailed in Palestine; in Hebrew he was not proficient, but he had evidently made some study of that language. His method of exegesis is similar in form to that of the Palestinian rabbinic scholars, and there are coincidences in matter. Philo recognized the Mosaic Scriptures of the Pentateuch as of absolute divine authority and as containing all truth. The other Jewish Scriptures he also recognized as prophetic (*i.e.,* as the writings of inspired men) but he did not place them on the same lines with the Law: everything that is right and good in the doctrines of the Greek philosophers had already been quite as well, or even better, taught by Moses. Thus, since Philo had been deeply influenced by the teachings of Greek philosophy, he found in the Pentateuch everything which he had learned from the Greeks. From these premises he assumed as requiring no proof that the Greek philosophers must in some way have drawn from Moses, a view which had already been expressed by Aristobulus. These presuppositions were maintained by an allegorical interpretation of Scripture. With its aid he discovered indications of the profoundest doctrines of philosophy in the simplest stories of the Pentateuch. This method of allegory is borrowed from the Stoics.

Theology.—Philo's doctrine of God starts from the idea that God is a being absolutely bare of quality (ἄποιος), excluding any composition of body and soul, or of the four elements, or of substance and accidental quality, or of matter and form. No limitation can be predicated of God. who is eternal, unchangeable, simple substance, free, self-sufficient, better than the good and the beautiful. To predicate any quality of God would be to reduce Him to the sphere of finite existence. Of Him we can say only *that* He is, not *what* He is; and such purely negative predications as to His being appear to Philo, as to the later Pythagoreans and to the Neoplatonists, to constitute the only way of securing His absolute elevation above the world.

A consistent application of Philo's abstract conception of God would exclude the possibility of any active relation of God to the world, for a being absolutely without quality and movement cannot be conceived as actively concerned with the multiplicity of individual things. And so in fact Philo does teach that the absolute perfection, purity and loftiness of God would be violated by direct contact with imperfect, impure and finite things. But the possibility of a connection between God and the world is reached through a distinction which forms the most important point in his theology and cosmology; the proper being of God is distinguished from the infinite multiplicity of divine ideas or forces: God himself is without quality, but He disposes of an infinite variety of divine forces, through whose mediation an active relation of God to the world is brought about.

Mediating Forces.—Philo's conception of the nature of these mediating forces was self-contradictory. On the one hand they are nothing else than ideas of individual things conceived in the mind of God and, as such, ought to have no other reality than that of immanent existence in God; and so Philo says expressly that the totality of ideas, the *κόσμος νοητός*, is simply the Reason of God as Creator (*θεοῦ λόγος ἤδη κοσμοποιοῦντος*). Yet, on the other hand, they are represented as daemons or angels, hypostases distinct from God, individual entities existing independently and apart from Him. This vacillation, however, as E. Zeller and others have justly remarked, is necessarily involved in Philo's premises, for, on the one hand, it is God who works in the world through His ideas, and therefore they must be identical with God; but, on the other hand, God is not to come into direct contact with the world, and therefore the forces through which He works must be distinct from Him. The same inevitable amphiboly dominates in what is taught as to the supreme Idea or Logos. Philo regards all individual ideas as comprehended in one highest and most general idea or force—the unity of the individual ideas—which he calls the Logos or Reason of God and which is again regarded as operative Reason. The Logos, therefore, is the highest mediator between God and the world, the firstborn son of God, the archangel who is the vehicle of all revelation and the high priest who stands before God on behalf of the world. Through him the world was created, and so he is identified with the creative Word of God in Genesis (the Greek *λόγος* meaning both "reason" and "word"). Here again, we see, the philosopher is unable to escape from the difficulty that the Logos is at once the immanent Reason of God, and yet also an hypostasis standing between God and the world. The whole doctrine of this mediatorial hypostasis is a strange intertwining of very dissimilar threads; on one side the way was prepared for it by the older Jewish distinction between the Wisdom of God and God Himself, of which we find the beginnings in Job (xxviii, 12 seq.) and in Proverbs (viii, ix) and the fuller development in Ecclesiasticus and in the Book of Wisdom, the last of which comes very near to Philo's ideas if we substitute for the term "wisdom" that of (divine) "reason." The Stoic teacher Posidonius had already identified the Platonic ideas with the Stoic Logos. Philo goes a step further by placing the ideas in the Mind of God; but he makes it clear that they represent only God's relation to the world, not his essence.

The world and creation, in Philo's doctrine, rest on the presupposition of an absolute metaphysical contrast between God and the world. The world can be ascribed to God only in so far as it is a cosmos or orderly world; its material substratum is not even indirectly referable to God. Matter (*ὕλη*, or, as the Stoics said, *οὐσία*) is a second principle, but in itself an empty one, its essence being a mere negation of all true being. It is a lifeless, unmoved, shapeless mass, out of which God formed the actual world by means of the Logos and divine forces. Strictly, the world is only formed, not created, since matter did not originate with God.

Ethical Teaching.—Philo's doctrine of man is also strictly dualistic and is mainly derived from Plato. Man is a twofold being, with a higher and a lower origin. Of the pure souls which fill airy space, those nearest the earth are attracted by the sensible and descend into sensible bodies; these souls are the Godward side of man. But on his other side man is a creature of sense, and so has in him a fountain of sin and all evil. The body, therefore, is a prison, a coffin, or a grave for the soul which seeks to rise again to God. The highest maxim of Philo's ethics is therefore deliverance from the world of sense and the mortification of all the impulses of sense. In carrying out this thought, Philo differs from the Stoics. The Stoics cast man upon his own resources; Philo points him to the assistance of God, without whom man, a captive to sense, could never rise to true wisdom and virtue. Even in this life the truly wise and virtuous is lifted above his sensible existence and enjoys in ecstasy the vision of God, his own consciousness sinking and disappearing in the divine light. Beyond this ecstasy there lies but one further step, viz., entire liberation from the body of sense and the return of the soul to its original condition; it came from God and must rise to Him again. But natural death brings this consummation only to those who, while they lived on earth, kept themselves free from attachment to the things of sense; all others must at death pass into another body; transmigration of souls is in fact the necessary consequence of Philo's premises.

Works.—The titles of the numerous extant writings of Philo present at first sight a most confusing multiplicity. More than three-fourths of them, however, are really mere sections of a small number of larger works. Three such great works on the Pentateuch can be distinguished.

1. The smallest of these is the *Ζητήματα καὶ λύσεις* (Quaestiones *et solutiones*), a short exposition of Genesis and Exodus, in the form of question and answer. The work is cited under the Greek title by Eusebius and by later writers, but the Greek text is almost wholly lost, and only about one-half preserved in an Armenian translation. Genesis seems to have occupied six books. Eusebius tells us that Exodus filled five books. In the Armenian translation, edited by the learned Mechitarist. J. B. Aucher (Venice, 1826). are preserved four books on Genesis and two on Exodus, but with lacunae. A Latin fragment, about half the fourth book on Genesis (*Philonis* Judaei *CII* quaestiones et *totidem responsiones* morales *super Genesim*), was first printed at Paris in 1520. Of the Greek are numerous but short fragments in various *florilegia*. The interpretations in this work are partly literal and partly allegorical.

2. Philo's most important work is the *Νόμων ἱερῶν ἀλληγορίαι*, a vast and copious allegorical commentary on Genesis, dealing with chapters ii, iii and iv, verse by verse and with select passages in the later chapters. The readers in view are mainly Jews, for the form is modelled on the rabbinic Midrash. The main idea is that the characters which appear in Genesis are properly allegories of states of the soul (*τρόποι τῆς ψυχῆς*). All persons and actions being interpreted in this sense, the work as a whole is a very extensive body of psychology and ethics.

3. A work of a very different kind is the group of writings expounding the "Mosaic Law for Gentiles." These, in spite of their diverse contents, present on nearer examination indubitable marks of close connection. In them Philo seeks to give an orderly view of the chief points of the Mosaic legislation in the Pentateuch and to recommend it as valuable to Gentile readers. The method of exposition is somewhat more popular here than in the allegorical commentaries, for, though that method of interpretation is not wholly excluded, the main object is to give such a view of the legislation as Philo accepted as historical. This work has three main divisions: (a) the interpretation of the first two chapters of Genesis, *Περὶ Μωύσεως κοσμοποιίας* (De *opificio mundi*), as Moses put his account of the Creation at the beginning of the Pentateuch in order to show that his legislation was conformed to the will of nature and that therefore those who followed it were true cosmopolitans; (b) the *βίοι σοφῶν*, biographies of the three righteous men, Abraham, Isaac and Joseph—being, so to speak, the living unwritten laws which, unlike written laws, present the general types of moral conduct; (c) legislation proper, in two subdivisions (i) the ten principal chapters of the law and (ii) the special laws belonging to each of these ten. An appendix adds a view of such laws as could not be brought under the rubrics of the decalogue.

4. Of the miscellaneous writings attributed to Philo, some appear to have survived in their entirety, some are extant only in translation or in fragments and some have been held to be spurious.

The Greek texts of the three books Περὶ βίου Μωύσεως (*Vita Mosis*) and of the treatise Περὶ εὐγενείας (*De nobilitate*) have been preserved. Two of five books on the affairs of the Alexandrian Jews also survive in Greek: namely Εἰς Φλάκκον (*In Flaccum*), in which Philo relates how the governor Flaccus, early in Caligula's reign, allowed the mob to persecute the Jews in Alexandria; and Περὶ ἀρετῶν καὶ πρεσβείας προς Γάϊον (*De legatione ad Gaium*), in which he describes the persecution following Caligula's demand for divine honours and recounts his embassy to Rome to seek relief for the Jews of Alexandria. Of the two books Περὶ προνοίας (*De providentia*), the title of which is twice mentioned by Eusebius, we now possess only an Armenian version edited with Latin translation by J. B. Aucher (Venice, 1822); book i appears moreover to be in a Christian recension. Also in Armenian, except for two small fragments preserved in the *Florilegium* of Leontius and Johannes, is the surviving text of Philo's Ἀλέξανδρος ἢ περὶ τοῦ λόγον ἔχειν τὰ ἄλογα ζῶα (*De Alexandro et quod propriam rationem muta animalia habeant*), mentioned both by Eusebius and by Jerome. Eusebius (*Praeparatio Evangelica,* viii, 6, 7, 11) preserves fragments of the Ὑποθετικά and of Ἡ ὑπὲρ Ἰουδαίων ἀπολογία the latter being presumably identical with the Περὶ Ἰουδαίων that he mentions elsewhere.

The authenticity of the treatise Περὶ τοῦ πάντα σπουδαῖον εἶναι ἐλεύθερον (*Quod omnis probus liber sit*) was disputed by Z. Frankel and by R. Ansfeld but was defended by Paul Wendland, who believed it to be an early work of Philo's. The Philonic origin of the document on the Therapeutae, Περὶ βίου θεωρητικοῦ (*De vita contemplativa; see* THERAPEUTAE) was also disputed, notably by P. E. Lucius in *Die Therapeuten* (Strassburg, 1879), but was ably defended by L. Massebieau in the *Revue de l'histoire des religions,* xvi (Paris, 1887), by F. C. Conybeare in *Philo about the Contemplative Life* (Oxford, 1895) and by Wendland in *Die Therapeuten* (Leipzig, 1896). Against J. Bernays and others who denied Philo's authorship of the treatise Περὶ ἀφθαρσίας κόσμου (*De incorruptibilitate mundi*)—apparently one of the sources from which the supposititious Περὶ κόσμου (*De mundo*) was compiled —F. C. Cumont's vindication, *Philo de aeternitate mundi* (Paris, 1891) may be consulted. Two discourses extant only in Armenian, one on Samson, the other on Jonah, are inauthentic.

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For studies of Philo *see* R. Marcus, "Recent Literature on Philo (1924–1934)," *Jewish Studies in Memory of G. A. Kohut* (New York, 1935); E. R. Goodenough, bibliography in *The Politics of Philo Judaeus* (New Haven, 1938). The following deserve special mention: C. Siegfried, *Philo von Alexandria* (Jena, 1875); B. Ritter, *Philo und die Halacha* (Leipzig, 1879); J. Drummond, *Philo Judaeus,* 2 vol. (London, 1888); H. Guyot, *Les Réminiscences de Philon le Juif chez Plotin* (Paris, 1906); N. Bentwich, *Philo-Judaeus of Alexandria* (Philadelphia, 1910); H. A. A. Kennedy, *Philo's Contribution to Religion* (London, 1919); T. H. Billings, *The Platonism of Philo Judaeus* (Chicago, 1919); E. Bréhier, *Les Idées philosophiques et religieuses de Philon d'Alexandrie,* 2nd ed. (Paris, 1925); I. Heinemann, *Philons griechische und jüdische Bildung* (Breslau, 1932); E. R. Goodenough, *By Light, Light: the Mystic Gospel of Hellenistic Judaism* (New Haven, 1935) and *An Introduction to Philo Judaeus (ibid.,* 1940); H. H. Wolfson, *Philo: Foundations of Religious Philosophy in Judaism, Christianity and Islam,* 2 vol. (Cambridge, Mass., 1947); and S. Sandmel, "Philo's Place in Judaism: a Study of Conceptions of Abraham in Jewish Literature," *Hebrew Union College Annual,* xxv, xxvi (Cincinnati, O., 1954–55). (E. Sc.; C. Bi.; A. An.)

PHILOCTETES, son of Poeas king of the Malians of Mt. Oeta, a celebrated hero of the Trojan War. Homer merely states that he was distinguished for his prowess with the bow; that he was bitten by a snake on the journey to Troy and left behind in the island of Lemnos; and that he subsequently returned home in safety. In the post-Homeric accounts, Philoctetes or his father were given the bow and arrows of Heracles (*see* HERCULES) as a reward for kindling the fire on Mt. Oeta, on which the hero immolated himself. Philoctetes remained at Lemnos till the tenth year of the war. An oracle having declared that Troy could not be taken without the arrows of Heracles, Odysseus and Diomedes (or Neoptolemus) were sent to fetch Philoctetes. On his arrival before Troy he was healed of his wound by Machaon, and slew Paris; shortly afterward the city was taken. On his return to his own country, finding that a revolt had broken out against him, he again took ship and sailed for Italy, where he founded Petilia and Cremissa. He fell fighting on the side of a band of Rhodian colonists against some later immigrants from Pallene in Achaea. His tomb and sanctuary were shown at Macalla, on the coast of Bruttium.

See Homer, *Iliad,* ii, 718, *Odyssey,* iii, 190, viii, 219; Sophocles, *Philoctetes,* and Jebb's *Introduction;* Diod. Sic. iv, 38; Dio Chrysostom, 52, 59; Philostratus, *Heroica,* 6; Strabo vi, 254; Hyginus, *Fab.* 36, 102.

PHILODEMUS (*c.* 110–40 B.C.), Greek poet and Epicurean philosopher who did much to spread Epicurean doctrine among Roman men of letters, was born at Gadara in Coele-Syria. After studying at Athens under the Epicurean Zeno of Sidon, he became the mentor of a Roman of high rank, L. Calpurnius Piso, with whom he lived in the vicinity of Naples. Horace is thought to have been much influenced by him. Cicero implicates Philodemus in a personal attack on Piso in his speech *In Pisonem,* but knew his writings well and used them as a source for Epicurean doctrine. Of his poems, 34 epigrams are extant; these consist of light verse, not linked with his philosophy. Treatises by Philodemus predominate among the books of the great Epicurean library discovered at Herculaneum (*q.v.*); the library itself may have belonged to him, the house to Piso or to his heirs. But restoration of the severely damaged rolls is difficult. Much of what Philodemus says evidently comes from Zeno of Sidon; but he gives glimpses of controversies between the later Epicureans and their opponents, and among themselves. (D. J. A.)

PHILODENDRON, a genus comprising about 200 species belonging to the Araceae family which are chiefly tree climbers, rarely erect plants, of the American tropics. The stems are mostly woody, branching, internodes often elongated, leaves thick, entire or pinnately cut, the petioles sheathing, and unisexual flowers borne on erect spadices that are slightly shorter than the white, yellow or red fleshy spathes. Philodendrons are widely grown as foliage plants in greenhouses and homes or out-of-doors in frostless regions. They require supports on which to climb and abundant moisture. (J. M. Bl.)

PHILOLAUS (*fl.* in second half of 5th century B.C.), Greek philosopher of the Pythagorean school, was born at Tarentum or at Crotona (so Diogenes Laërtius viii, 84) in southern Italy. After the death of Pythagoras great dissensions prevailed in the Italian cities. According to some accounts, Philolaus fled, taking refuge first in Lucania and then at Thebes, where he had Simmias and Cebes as pupils, who subsequently, being still young men, were present at the death of Socrates. Before this Philolaus had returned to Italy, where, it is said, he taught Archytas. He entered deeply into the Pythagorean number theory, particularly dwelling on the properties inherent in the decad—the sum of the first four numbers, consequently the fourth triangular number, the *tetractys* (*see* PYTHAGORAS AND PYTHAGOREANISM). It is from a book of his that Plato's successor Speusippus is reported to have reproduced the doctrine. Pythagoras probably knew the construction of three of the regular solids, and Empedocles is stated to have been the first who maintained that there are four elements. Philolaus, connecting these ideas, held that the elementary nature of bodies depends on their form and assigned the tetrahedron to fire, the octahedron to air, the icosahedron to water and the cube to earth; the dodecahedron he assigned to a fifth element, ether or the pure air surrounding the universe. The elements themselves seem to have been the product of number, and they existed in a harmony produced by the normal Pythagorean principles of Limit and the Unlimited. Similarly, in an animate body health consisted in a balance of the two further opposites, heat and cold. Philolaus regarded the soul as a "mixture and harmony" of the bodily parts; he also assumed a substantial soul, whose existence in the body is an exile because of sin, showing the religious outlook that Plato attributes to him in the *Phaedo* (61 D *ff.*). For the important astronomical theory sometimes attributed to him, *see* PYTHAGORAS AND PYTHAGOREANISM.

If these contributions were indeed made by Philolaus, it would seem that he was the first systematizer of Pythagoreanism. But it has to be stated that the evidence for his having made them is a matter of dispute. Both the astronomy and the physics which are credited to him have been held to be inadmissible before Plato's *Timaeus.* Certainly

the discovery of how to construct the octahedron and the icosahedron is put after Philolaus' time on far better evidence. (And the only quotation about the five elements, it should be noticed, does not name the regular solids at all.) The man himself has even been considered a fanciiul invention of Plato; and Erich Frank argued that his works were forged by Speusippus. Ii his genuineness is accepted, it is certainly necessary to be discriminating about the quotations which have survived and still more so about the descriptions of his doctrine made by ancient writers.

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PHILOLOGY, a comprehensive name for the study of language and literature: too wide to be exact and therefore tending to fall into disuse in favour of a clear distinction between literary and linguistic scholarship. A human society is apt to be bound together by a single language, in which its entire cultural tradition, written and unwritten, is composed. As time goes by the universe of tradition is seen to contain diverse subject matter, which for convenience of handling is classified broadly to correspond to the activities of the particular society, its law, religion, history, philosophy, for example. That part of tradition. the content of which is dominantly imaginative and the form artistic, excites its own interest and criticism and even devotion, for the sake of its better preservation and understanding: this is philology.

Sheer bulk of material and the essential differences of theory and method which separate the study of literature from the study of language, have led to distinct disciplines and, except in well-defined fields such as the classics. Slavonic, far eastern, Celtic (to give more familiar examples) where students are still expected to study both language and literature, it is rare to find the finished expert who is at home in both. The best scholars are; but usually the one or the other pursuit has become his chief preoccupation and linguistics and language (*qq.v.*) form an exacting study that claims full attention, with the result that students of literature tend more and more to leave it to specialists. In the middle ages and for long after the Renaissance there was no such separation, but in the western world beginning about 1800 A.D., it has steadily become more intense. Native scholars of far eastern languages and literatures, of Ugro-Finnish, Indic. or Semitic, still are likely not to recognize it. On the other hand there may be no written Literature, as among the Polynesians, American Indians or central African tribes even though there is much folklore and religious poetry, so language necessarily looms large.

In French, Italian, German and most European languages, the term corresponding to English philology: therefore. means the study of literature. In English it is sometimes used instead of comparative philology, which means linguistics, especially comparative and historical rather than descriptive linguistics.

Even the study of literature has given rise to its own specialities —palaeography and textual criticism (*qq.v.*) among others.

All the main languages of the world have articles of their own, *e.g.,* AMERICAN ABORIGINAL LANGUAGES; ARABIC LANGUAGE; CHINESE LANGUAGE; ENGLISH LANGUAGE; FRENCH LANGUAGE; GERMAN LANGUAGE; GREEK LAXGUAGE; HEBREW LANGUAGE; ITALIAN LANGUAGE; JAPANESE LANGUAGE: LATIN LANGUAGE; MANCHU LANGUAGE; MONGOLIAS LANGUAGE; POLYNESIAN LANGUAGE; RUSSIAN LANGUAGE; SERBO-CROATIAN LANGUAGE; SPANISH LAXGUAGE; TURKISH LANGUAGE. This is by no means an exhaustive list as many little-known languages are included, *e.g.,* BUSHMAN LANGUAGES. In the event of a language not receiving discussion under its own name it may be discovered under the name of the family to which it belongs, *e.g.,* INDO-EUROPEANS: *Language Classification;* CELTIC LANGUAGES! etc.

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PHILO OF LARISSA (*c.* 159/158–86/85 B.C.), Greek philosopher, succeeded his teacher Cleitomachus as head of the academy, whose scepticism he, in advanced age, considerably toned down (*see* ACADEMY, GREEK), particularly in ethics (he in detail compared the tasks of the philosopher and the physician). He conceded, it seems, to the Stoics the existence of true, objectively certain sense-presentations but still denied that they were subjectively discernible from false ones. When in Rome (88 B.C.) he strongly influenced Cicero, thus contributing to the transplanting of Greek philosophy to the Latin world. None of his writings is extant. (PP. M.)

PHILOPOEMEN (253–184 B.C.), Greek general, was born at Megalopolis, and educated by the academic philosophers Ecdemus and Demophanes or Megalophanes. In 233–2 Philopoemen skilfully evacuated Megalopolis before the attack of Cleomenes III, and distinguished himself at Sellasia (222). The next 11 years he spent as a condottiere in Crete. Elected commander of the league's cavalry on his return, he reorganized that force and defeated the Aetolians on the Elean frontier (210). Appointed to the chief command two years later, he introduced heavy armour and close formation for the infantry, and with a well-trained army beat Machanidas of Sparta, near Mantinea. The new "liberator" was now so famous that Philip V of Macedon attempted to poison him. In 202–1 Philopoemen drove Nabis, the Spartan tyrant, from Messene and routed him off Tegea. After another long sojourn in Crete he again received the command against Nabis. Though unsuccessful at sea, he almost annihilated Nabis's land force near Gythium, but was prevented by the Roman Flamininus from taking Sparta.

In 190 Philopoemen protected Sparta, which meanwhile had joined the League and thereupon seceded, but punished a renewed defection so cruelly as to draw the censure of Rome. At Messene he likewise checked a revolt (189), but when that city again rebelled, in 184, he was captured in a skirmish and promptly executed. Philopoemen's great merit lies in his having restored that military efficiency without which the Achaean league (*q.v.*) could never stand.

Polybius' *Histories* (x–xxiii) are the chief authority. These and a special treatise on Philopoemen (lost) were used by Plutarch (*Philopoemen*), Pausanias (viii, 49–51), Livy (xxxi–xxxviii) and, indirectly, Justin (xxx–xxxiv).

PHILOPONUS, JOHN (5th–6th century A.D.), was a prolific writer of the philosophical school of Alexandria. As an expositor and critic of Aristotle he exercised a deep influence on later generations. The name John marks him as a Christian, and there is no good ground for supposing him to have been a convert. Since his earliest studies were in language and literature, he styled himself "Grammaticus," and he was also known by the surname Philoponus ("industrious"). which seems to have been the class-name of a group of active Christian laymen.

In philosophy John was a pupil of Ammonius Hermiae (*q.v.*). Among his works are several commentaries on treatises of Aristotle, which seem to be partly based on Ammonius' oral instruction. He frequently adopts, on religious grounds, a critical attitude toward Aristotle, which distinguishes him from other commentators of the age. His *De aeternitate nzundi,* written in 529, which has survived almost complete, is a refutation of Proclus, who, with other Neoplatonists, supposed the heavens to be divine and imperishable; a philosophical defense is given of the view that the world was created by God from nothing and will be destroyed. The work, written when Christianity was in the ascendant at Alexandria, may have been designed to shield the Alexandrian school of philosophy. Resides this, John wrote a treatise! the general outline of which is known to us from the bitter retort made by Simplicius (*q.v.*), against certain principles of Aristotle's physical science. John's theological writings, in which he supported

the Monophysites (*Opuscula* Monophysitica, edited by A. Sanda, Beirut, 1930), were condemned as heretical in 680. (D. J. A.)

PHILOSOPHY (ARTICLES ON). The article PHILOSOPHY AND PHILOSOPHICAL STUDIES provides a general introduction to the subject matter of philosophical inquiry. For an outline of the course that this inquiry has pursued in the western world *see* PHILOSOPHY: HISTORY OF. Parallel to the latter from the final period of antiquity are ARABIC PHILOSOPHY and JEWISH PHILOSOPHY. CHINESE PHILOSOPHY and INDIAN PHILOSOPHY are independent.

METAPHYSICS briefly indicates the type of inquiry traditionally included under this heading. For particular aspects *see,* for instance. ABSOLUTE; ANALOGY; BODY AND MIND; CAUSALITY; COSMOLOGY; DETERMINISM; DURATION AND TIME; FORM; FREE WILL; INFINITY AND THE INFINITE; LOGOS; PLURALISM AND MONISM; PRE-ESTABLISHED HARMONY; QUALITIES; SUBSTANCE; and UNIVERSAL.

KNOWLEDGE. THEORY OF, a key article, is supplemented by the following: BELIEF; EMPIRICISM; IDEA; INNATE IDEAS; INTUITION; PHENOMENALISM; RATIONALISM; SKEPTICISM; and TRUTH. A distinct group is formed by SCIENCE and SCIENTIFIC METHOD, together with INDUCTION and PROBABILITY, and the shorter HYPOTHESIS.

LOGIC and LOGIC, HISTORY OF, with SEMANTICS IN LOGIC, are supplemented by numerous articles including ABSTRACT AND ABSTRACTION; CATEGORY; CLASSIFICATION; CONVERSION: *Logic* and *Mathematics;* DEFINITION; EXPLANATION; FALLACY; MATHEMATICS, FOUNDATIONS OF; MEANING; NAME (IN LOGIC); PROPOSITION; SYLLOGISM; and THOCGHT, LAWS OF.

ETHICS and ETHICS, HISTORY OF, are supplemented by EGOISM; HEDONISM; and UTILITARIANISM. *See* also POLITICAL PHILOSOPHY. The subject of AESTHETICS stands by itself.

For schools and individual systems of philosophy the following articles, in roughly chronological order, may be consulted: PYTHAGORAS AND PYTHAGOREANISM; ELEATIC SCHOOL; SOPHISTS; ACADEMY. GREEK; PERIPATETICS; CYRENAICS; CYNICS; STOICS; NEOPLATONISM; SCHOLASTICISM; CARTESIANS; CAMBRIDGE PLATONISTS; IDEALISM; TRANSCENDENTALISM: NEO-KANTIANISM; NEO-HEGELIANISM; POSITIVISM; PRAGMATISM; PHENOMENOLOGY; LOGICAL POSITIVISM; and EXISTENTIALISM.

Of the many philosophers on whom there are separate biographical articles the following, also in chronological order, may be regarded as outstanding: LAO-TZU; CONFUCIUS; THALES; PARMENIDES; ZENO (of Elea); DEMOCRITUS; SOCRATES; PLATO; ARISTOTLE; MENCIUS; EPICURUS: LUCRETIUS; CICERO; PLOTINUS; AUGUSTINE, SAINT (Aurelius Augustinus); BOETHIUS. ANICIUS MANLIUS SEVERINUS; ERIGENA. JOHANNES SCOTUS; ABELARD. PETER; AVERROES; MAIMONIDES; AQUINAS, SAINT THOMAS; BACON, ROGER; DUNS SCOTUS. JOHN: OCCAM. WILLIAM OF; MACHIAVELLI, NICCOLO; BACON, FRANCIS; DESCARTES, RENÉ; PASCAL. BLAISE; HOBBES, THOMAS; SPINOZA. BENEDICTUS DE; LOCKE, JOHN; LEIBKITZ, GOTTFRIED WILHELM; BERKELEY, GEORGE; HUME. DAVID: CONDILLAC. ETIENNE BONNOT DE; CONDORCET, MARIE JEAN ANTOINE NICOLAS DE CARITAT, Marquis de; KANT. IMMANUEL; FICHTE. JOHANN GÖTTLIEB; HEGEL, GEORG WILHELM FRIEDRICH; SCHLEIERMACHER. FRIEDRICH DANIEL ERNST; SCHELLING, FRIEDRICH WILHELM JOSEPH VON; KIERKEGAARD. SOREN AABYE; COMTE. AUGUSTE; SCHOPENHAUER, ARTHUR; MARX, KARL HEINRICH; NIETZSCHE. FRIEDRICH; HUSSERL, EDMUND; BERGSON, HENRI: WITTGENSTEIN, LUDWIG; and RUSSELL, BERTRAND ARTHUR WILLIAM RUSSELL, 3rd Earl.

See also RELIGION AND THEOLOGY, ARTICLES ON.

PHILOSOPHY, HISTORY OF. The separate histories of the numerous philosophical schools, surveys also of the development of separate disciplines such as logic and ethics. accounts of the central problems such as scepticism and, finally, studies of individual philosophers are given under the appropriate headings throughout this encyclopaedia. Here, however. we shall attempt to give a more comprehensive view of the history of western philosophy from ancient Greece onward and to show the succession of the various schools of thought and their reaction in response to criticism from one another.

ANCIENT PHILOSOPHY

The name "philosophy" is itself Greek, and ancient philosophy will, in the survey which follows. be understood to be limited to the philosophy of the Greeks, with its continuation during the Roman period down to the reign of Justinian. Such a restriction sounds at first arbitrary but is perhaps justified by these considerations. The contact of the Greeks with foreign religion and ideas was only spasmodic. The mythologies of Babylonia and of Egypt, within which the germ of science was included. were not without influence upon the earliest Greek thought. Later, the Platonic academy (4th century B.C.) showed knowledge of and interest in the dualistic religion of Persia. Some scholars think that there are traces of oriental influence in the system of Plotinus, though others again assert its wholly Greek character. Alexandria, in any case. was a centre in which Jewish and Greek ideas came together. Yet these influences are not close or continuous or certain enough to make it worth while to compare Greek and oriental philosophy in one survey. and it seems to have been always the Greek genius which converted mythology into science or philosophy as we should today understand them. The mediaeval thinkers, Arabic and Jewish as well as Latin. derived their view of the scope and problems and methods of philosophy from the Greeks.

In the development of ancient philosophy, four phases may conveniently be distinguished.

1. Those who belong to the first phase, commonly termed pre-Socratic, try to give a rational account of the origin and existing state of the world and the powers operative within it. Parmenides and the Eleatics, who directed their attention not to the physical world but to being in general, nevertheless come within this first phase; it was their historical function to show the complexity and difficulty of the concepts of change and movement; and by doing this they deflected for some time the course of physical inquiry, though they did not arrest it. The science of mathematics probably emerged during this first period.

2. A new phase opens when, in the jth century B.C., moral and practical problems are brought to the front by Socrates and the Sophists. Socrates, however. did not urge men to desist from scientific inquiry (that is a false, though ancient, view of the part that he played) but, as will be explained. gave a new impulse to science itself. During this period. likewise under the impulse of Socrates, the question within what limits scientific knowledge is possible begins to be recognized as one of the problems of philosophy; and both logic and the theory of knowledge date from this time. Otherwise. the confident endeavour to gain the widest possible knowledge of nature, because of its intrinsic interest. goes forward. Aristotle and his immediate successors may in this way be considered the latest representatives of a movement having its centre at Athens and initiated by Socrates and the Sophists.

3. 4 third phase extends from the early 3rd century B.C. to the 1st century A.D. With the decline of the self-governing city-state, social conditions were transformed and at the same time the speculative spirit was beginning to grow weary. There now appeared rival systems of "philosophy." which agreed in offering such a world picture as might bring peace of mind to the individual, however little favoured by circumstances. Happiness was no longer associated with political exertion. The disinterested pursuit of knowledge mas no longer recognized as essential to philosophy, and ethics (in a practical sense) became its vital part. It is true, however. that the sciences were at this time beginning to flourish independently of philosophy.

4. Finally, from the 1st century A.D. onward: there is a revival of speculative confidence, accompanied by an intelligent and respectful interest in the classics of earlier philosophy.

Pre-Socratic Philosophy.— In the *Theogony* of Hesiod we have a description in epic style of the formation of the world from chaos, the emergence of several generations of gods and the successive ages of man. These, with frank pessimism, are depicted as a decline from the golden toward the iron age. This is already not far from philosophy. and the borderline will be crossed when the narrative form and the reference to personal agents are abandoned, when prose is employed instead of poetry and when a system resting on rational deduction and to some extent on observation is put

forward. In the 6th century B.C. these conditions are fulfilled in men who flourished at Miletus and elsewhere on the Greek fringe of Asia Minor. These thinkers all deal with the development of a varied world out of one basic substance (not yet called by that name). This is not supposed to be lifeless. but rather endowed with some intrinsic power of development. As for the law by which development is governed. Anaximander holds that there is a "justice" in the cosmos whereby each particular substance, having exceeded its bounds for a time, must pay recompense to others. It appears also that. in accordance with this law, the cosmos will at fixed intervals be dissolved to allow chaos to resume its rights. Anaximenes, somewhat later. introduces the influential idea that it is by a process of contraction and expansion that the one substance appears as many.

The use of systematic observation by these thinkers is at best occasional. they assume no necessary sequence of cause and effect. and their thought has many archaic features. They regard the world as "divine" and do not seem to see themselves as antagonists of the traditicnal religion. They come to fulfil. rather than to destroy. In Xenophanes of Colophon, however. we find a hard-hitting critic of the theology handed down from Homer and Hesiod. He seems to have asserted the unity and omnipresence of God; and he is ranked by Plato and Xristotle as a precursor of Parmenides.

In such cosmogonies as those of Hesiod and Anaximander. one basic entity is supposed to grow into many and to become possessed of diverse qualities. Parmenides, by an analysis of the idea of "being" itself. arrives at the view that this change is impossible. He returns to the poetical form of exposition and gives two alternative and, in his opinion. discontinuous accounts of the world. The first is an account of reality. which. as it is based on reason alone. is true. The second is a description of appearance and takes the form of a cosmogony not unlike those which previous thinker:: had offered. Only at this level are qualitative change and movement admitted. "Being" itself must be perfectly homogeneous, immune from change and timeless; *i.e.,* beyond any distinction of past, present and future. Being cannot have an origin. for this would have to be "not-being." which is unnamable and inconceivable. The being of Parnienides is not personified: and though a theology could be founded on his deduction, his own use of it is purely logical.

At this point some mention must be made of Heraclitus and of Pythagoras and his early followers. whose systems have always been supposed to precede Parmenides' but are only to be understood. according to the more probable view of Karl Reinhardt. as a later response to his thought. Heraclitus replies that the tension between opposites. governed by a rational principle which holds them in balance. is the key to an understanding of the world. (It seems to have been the self-styled Heracliteans of a later day who developed this into a belief in universal change. involving the consequence that all judgment is relative and science impossible. From such a conclusion Heraclitus was held back by his insistence that "measure" and "logos" [=reason] remain firm in a changing world.) As for Pythagoreanism. it seems to have been, in its first form, a system whereby the series of numbers was made to evolve from more abstract principles and the sensible world was in turn derived from number.

Whatever may be the relation between Parmenides and these two movements, the effect of his argument upon subsequent philosophy, for a long time to come. was decisive. No one was able to question this reasoning. which seemed to show the need for a persistent substance; but no one could resign himself to the belief that a moving. physical world is forever beyond the range of rational explanation. Systems therefore now arose in which, in deference to Parmenides, qualitative change was abandoned. hut plurality and local movement were retained. This is the procedure of Empedocles, of Anaxagoras and of the first atomists. Leucippus and Democritus. There are important differences between these systems. The Parmenidean attack on "not-being" involved the denial of empty space or void. and in this hoth Anaxagoras and Empedocles concurred. professing to be able to explain movement without such an assumption. The atomists, being persuaded that the void was really essential to the possibility of movement. sought to establish its existence hoth experimentally and by reasoning. Again. Anaxagoras in contrast with the atomists boldly accepted the view that matter is infinitely subdivisible. precisely as abstract extension is. Moreover. Anaxagoras and Empedocles raised two new questions and gave contrasted answers to them: how does movement first originate? and what is the cause of structures and processes which seem to be purposive in character, especially in the plant and animal world? Greek philosophy was now passing beyond the belief that the power of movement might be assumed as a datum in the original substance.

Apart from such indirect influence. Parmenides also had followers of his own. Zeno of Elea. Melissus and the rhetorician Gorgias. Zeno of Elea is responsible for a modification of the Eleatic thesis, inasmuch as he starts not. as Parmenides did, from "being" but from "the one." For Parmenides, unity was rather the first attribute of being. Zeno shows that plurality in any form, including the abstract units demanded by the arithmetician, is monstrous and inconceivable. His famous paradoxes about movement, reported by Aristotle in the *Physics*, have a similar purpose. In Zeno and Gorgias, the dialectical technique which Parmenides had adopted with a metaphysical purpose in view has obviously become an end in itself; the latter should probably be regarded as a critic, not as a follower, of Parmenides. (*See* also articles ELEATIC SCHOOL; and IONIAN SCHOOL OF PHILOSOPHY.)

From **Socrates** to **Aristotle.**—There is a change of atmosphere during the second half of the 5th century B.C., and the principal scene of events during this and the following century is not Ionia or Italy but Athens. To this change there were two sides. On the one hand, there was a general tendency to turn from natural science and speculative cosmology toward human affairs and practical problems. Socrates (c. 470–399 B.C.) certainly pointed out this road (see Plato, *Phaedrus,* 229e–230d); and in this he was assisted or preceded by the older Sophists. such as Protagoras, who made it their business to provide an intellectual training for the man of action in the democratically governed Greek states. On the other hand. there was the aspect in which Socrates alone was the innovator: it was his mission to propound basic questions hitherto overlooked. both in the sphere of physics and in that of ethics. and thereby to bring to light latent dogmatism and to make his contemporaries aware, for the first time, of problems concerning philosophical and scientific method; and here the Sophists were no longer the allies of Socrates but his opponents. His classic debate with them. recorded in several of Plato's earlier dialogues, turns on the questions whether moral virtue can be taught and whether there is one form of moral goodness or several: and the Sophist professes to *know* the answer to these questions. while Socrates does not. Hence the difficulty of deciding whether to range the Sophists together with Socrates or in the earlier period.

The former aspect of Socrates' work is well enough expressed in the aphorisms which Cicero derived from his Greek teachers; namely, that he brought philosophy down from heaven to earth, introduced it into the cities and houses and made it inquire into manners and morals. Yet if this were all, he would have been only one moralist among others, and full justice is not done to his achievement unless he is viewed as an innovator in the sphere of method. who opened up new possibilities to physical science itself and posed new problems to the philosophers. He was no despiser of physical science and did not wish to make other men desist from it as fruitless or impossible. He himself had soon abandoned it, but only in order to raise problems which were not without a bearing on its future progress. The earlier physicists had emphasized matter at the expense of form. and the Sophistic contemporaries who shared his interest in practical questions were more concerned with describing the moral qualities than with defining them. He inferred. apparently from the example of the practical arts. that the great test of knowledge is the ability to state what a thing is, what is the unvarying essence which a word. if rightly used, denotes. His persistence in posing this question and subjecting others to cross-examination led, in due course. to the discipline which came to be known as logic: and another offshoot of the same demand for a definition of moral ideals was the Platonic doc-

trine of transcendent ideas or forms (see FORM).

This view, whereby Socrates is an important figure within the progress of science, is stressed by Plato, in the Phaedo, and by Aristotle, in the *Metaphysics*, both of whom would claim to be following in the Socratic tradition. (See further the articles ETHICS, HISTORY OF; LOGIC, HISTORY OF; SOCRATES; SOPHISTS. The first two of these are relevant also for all that follows.)

Plato was only one of several writers who commemorated Socrates, and various schools were commonly supposed to be affiliated to him. Antisthenes seems to have held up for admiration the physical sturdiness of Socrates, his self-control and his contempt for worldly goods; he declared himself an enemy to pleasure, and he opposed the Platonic doctrine of ideas (presumably in what he thought to be the true spirit of Socrates). From him, through Diogenes of Sinope, descend the Cynics, preachers and moralists contemptuous of all conventions, who reappear in one guise or another on several occasions in the Hellenistic and Roman periods. On the other hand. the Cyrenaics, who considered that pleasure in itself is good and pain evil, were affiliated to Socrates through Aristippus; such a thesis is, in fact, maintained by Socrates in Plato's dialogue *Protagoras*. Another member of the Socratic circle founded a school which lasted for several generations; this was Euclid of Megara (see also MEGARIAN SCHOOL OF PHILOSOPHY). He upheld the Socratic procedure of teaching by dialogue and, like Socrates, had a moral and practical purpose. In other respects his doctrine owed something to the Eleatics. Later there was some hostility between his followers and Plato's, and the Megarian school became a nursery of dialecticians.

Whereas the sources for all the doctrines mentioned above are fragmentary, the entire writings of Plato (c. 428–*c.* 348 B.C.) are extant and there is even, from Aristotle and Theophrastus, some indication of his unwritten teaching. Plato remains throughout faithful to the dialogue form, and. until a late stage in his career as a writer, uses Socrates as the principal interrogator; but Socrates then subsides into a listener's role. other speakers come to the front and Plato begins to define his position with reference to the older systems—to Parmenides, to Heraclitus, to Pythagoras and their surviving representatives. The subjects treated are: the nature of the soul and of causation; the presence of design in the physical world; "being" and its various senses; human knowledge and the relation between thought and sense perception and language. It is convenient here to concentrate upon the first two of these. The doctrine of the Phaedo is that the soul is akin to the permanent and invisible, the body to the changing and perceptible. The nature of this affinity was not, at that time, further explored (the soul is never declared to be a "form"); but, together with other arguments, Socrates says that it is enough to give us confidence that the soul will survive the body. The soul is not, at this stage, regarded as a source of change, but rather as a perfectly unchanging being. In the Theaetetus, Plato demonstrates that the senses alone can present only a series of changing impressions. They cannot even relate these to one another, still less convey knowledge of forms which have no sensible counterpart. In the *Phaedrus* and in the Laws, he develops a new doctrine of the soul which is also a theology (since God is a perfect soul). The soul is by its essence a self-motion, the source of every movement which bodies display. Bodies, once they have received movement from soul, can impart it to one another; but there is no movement not initiated by soul. This does not mean that the soul is in space, for the primary movement with which soul stirs itself is that of reflection or foresight, and the physical movement is secondary.

There are, however, random and irregular movements in the cosmos; and it is only soul with mind or reason (*nous*) inherent in it which can impart regular movement. The word *nous* has a complex previous history. Plato tells us repeatedly that *nous* cannot exist alone, that it must inhere in a soul (*Sophistes*, Philebus and Timaeus). The doctrines of forms and reminiscence do not seem to have been abandoned by Plato at the time when he was working out this later system; and presumably a soul with *nous*, or rational soul, mould be one which is guided by steady intuition of the forms. Making the best use of the science available at the time, Plato undertakes to show, or rather says it can be shown, that the principal movements in the cosmos, including that of the sun and planets, are in fact perfectly regular. Given the principles that he has just stated, it follows that the world is controlled by divine beings, perfect souls to whom we are akin. He presents this teaching (Laws, books x and xii) as the exact reverse of what many persons, under the influence of the Sophists, were coming to believe. In the Timaeus there is an account of the origin of the world in which the following factors are involved: (1) the forms; (2) the "artificer," a personal agent who is guided by intuition of the forms and from whom regular movements in the physical world, as well as all adaptation of things to a purpose, are derived; (3) the world-soul, which is formed by the artificer and serves, as it were, as his representative; (4) the "receptacle," within which qualities or powers exist in shuffling disorder, until the artificer regulates them by measure and number. This last factor is identified with space, but also has some of the functions which in Aristotle's terminology belong to "matter." In view of later developments in theology, it is to be noticed that Plato's "artificer" is not the source of all reality and is not the creator, in the full sense, of either form or matter. Another important metaphysical distinction made in the later dialogues is that between "limit" and "the unlimited," two factors which combine to form a "mixture"; the mixture must have a "cause" and, where this cause is "reason," will be harmonious and durable. Here there is an even closer approach to the Aristotelian distinction of form and matter (*Philebus*, 23–26).

According to Aristotle (384–322 B.C.) there are four factors in every process of causation, whether natural or artificial: form and matter, which never exist apart from one another, being correlative; the motive cause, from which the change immediately proceeds; and the end "for the sake of which" the process occurs. This analysis is meant to be applied not only to physical change but also to such processes as teaching a science or imparting moral discipline to a child. The "matter" upon which form is imposed will in that case be the untrained capacities or emotions, and it is plain from this that the Aristotelian "matter" is quite different from what is so termed in modern physics. Another point to be noticed is that Aristotle is here distinguishing factors in causation rather than causes in the modern sense and that his "causes" may be contemporary with, or even subsequent to, the processes caused; *e.g.*, if a man walks for the sake of health, health is a "final cause."

Aristotle applied his analysis to the criticism of his predecessors, including Plato. For a long time, matter had been the only one of the causes to be recognized; subsequent thinkers had had a glimpse of the efficient and formal causes, but no one had yet succeeded in naming all four. No addition to the analysis was conceivable, and in this respect it was the completion of all previous thought, the goal to which others had struggled without clearly perceiving it. Plato is complimented by Aristotle for his clear recognition of the formal cause (and here Aristotle shows the genesis of his doctrine from Socrates and the Pythagoreans); moreover, in his physical doctrine and in his unwritten teaching, he recognizes the need for a material or nonformal factor; but he has failed to give any consistent account of efficient causation (Plato's derivation of movement from the soul is, apparently, viewed in this criticism not as a part of his regular doctrine, but as a tentative suggestion).

Aristotle's positive views grow naturally out of this criticism. By "movement" is meant a transition from a "potential" state to one of "actuality," and such transition will take place only under the influence of a subject which is itself actual and can bring out the potentiality in another ("movement" here has a wider sense than in modern usage and applies to all qualitative change, whether physical or not). Once the thing has reached maturity (a state for which Aristotle coins the term "entelechy"), it will from time to time, but not continuously. display its powers in action. This display of powers ("activity," or "energy") is not exactly "movement" in the sense above defined, for it is not the realization of something incomplete. An illustration may be drawn from the acquisition and use of scientific knonledge: a boy's power of learning is developed under the influence of a teacher, this

transition corresponding to "movement"; but once he has acquired the scientific knowledge. it will be latent in him nhenever it is not in actual use. Hence a new contrast between possession and use is. as it were, superimposed on that between the potential and the actual. We ourselves and the beings who surround us are complex and have to inhibit one activity in order to engage in another. Growth and change in the physical world are to be explained in analogous fashion.

This conceptual analysis is then applied by Aristotle in the following way. God alone is fully actual—a form nithout matter, who does not have to be raised from the potential to the actual state. His activity is the uncaused cause of all change; but he is its "final cause" or goal and he does not, as in the Platonic system. design the world. The efficient cause of change is "nature"; *i.e.*, an inherent impulse in things. both living and lifeless, leading them to develop their capacities and to make use of them when developed. The Platonic definition of soul as a self-moving agency is rejected on the ground that soul cannot participate, even incidentally. in movement; and instead. soul is regarded as the "form" proper to an organic body. Such a definition does not apply to God. who is incorporeal (and. perhaps, not to the human soul *qua* rational). God is therefore viewed not as a soul but as a mind engaged in unbroken reflective activity: and Plato's axiom that "mind" must always inhere in "soul" is also silently discarded.

This survey. concentrating on the theory of causation. will perhaps have shown why Xristotle is the parent of biological science and Plato rather of mathematical physics. (For other aspects of their thought. *see* the articles ARISTOTLE; ETHICS, HISTORY OF; LOGIC. HISTORY OF: PLATO.)

From Aristotle to the 1st Century A.D.—The years from approximately 310 B.C. to the 1st century A.D. form another distinct epoch. Philosophy was now regarded primarily as a way of life. Scientific knowledge was no longer pursued with enthusiasm by the philosopher as such; he valued it only in so far as it made clear the position of man in the world. This was an era of increasing specialization in scientific. historical arid philological studies. Because of the changed circumstances. the philosophical idea of the good life was no longer bound up with the city-state. Slavery persisted, but the division between Greek and barbarian began to break down. and men recognized one another as brothers. with one God for their parent. whether this view was developed by the Stoics or, as Sir W. W. Tarn maintained, by Alexander the Great himself.

After the first generation. the schools of Plato and Xristotle themselves began to succumb to these dominant influences *(see* ACADEMY, GREEK; and PERIPATETICS). Among newer systems, that of Epicurus (341–270 B.C.) may be considered first. Epicurus held that the physical world came into being from the spontaneous downward movement of atoms in an infinite void and that nothing further is needed to explain its existing state. It is. however, destined to be destroyed; *i.e.*, not annihilated, but dissolved into its component atoms. which will then enter into fresh combinations. Similar worlds doubtless exist else\\-here and have existed in the past. The soul is material and is enclosed in the body, from which it will escape and be dispersed at death. The gods live at peace in the spaces between the worlds. which they did not organize and for which they assume no responsibility. For the demonstration of these truths physical science is essential: beyond this it becomes supertluous. The one criterion of truth. which cannot possibly be disputed, is sense perception. The wise man will live in prudent enjoyment of physical pleasures, free from all anxiety about the future life, unconcerned with fame and other dubious goods. He will, however. for this very purpose need to acquire justice and the other commonly recognized virtues. Epicurus showed, as no one before him had done, the happiness of an inner life which is available to all; and no doubt this was why he was hailed by his followers as a "saviour." Rut his theory of knowledge is weak (the "ultimates" in his system. the atoms and the void, lie beyond perception. which he says is the criterion of truth'), and he frankly discouraged all innovation which would disturb the basis of the system.

Stoicism on the other hand was a more flexible system which could and did develop in response to circumstances or to effective criticism from without. For a general view of this system. *see* STOICS. The doctrine was first laid down by Zeno of Citium (born 335 B.C.) and re-established with far greater precision by Chrysippus (*c.* 280–206 B.C.). The Stoic ethical system at this time was strange and uncompromising, oriental rather than Hellenic in character. In the 2nd century B.C. appeared Panaetius of Rhodes (horn c. 185), who reinterpreted the psychology and ethics of the Stoa in such a way as to stress its close affinity with Platonism and the common descent of both doctrines from Socrates. Soon after this. Poseidonius (*c.* 13j–c. 50 B.C.) gave a new form to the physical and theological doctrine inherited from the older Stoics. As a result of the work of these powerful thinkers, Stoicism secured a new lease of life and awakened great and enduring interest in Roman circles. But throughout the last two centuries B.C. the Stoics. as the most prominent dogmatic school, came under fire from sceptics of more than one variety. The scepticism of Pyrrho of Elis. though founded on epistemological arguments which he collected from earlier writers. was really a moral doctrine; he made "indifference" in face of all external circumstances into a cardinal principle of ethics *(see* SKEPTICISM). The scepticism of the New Academy. associated mainly with the name of Carneades. was of a more intellectual character and arose rather within the main Greek philosophical tradition.

The history of the years from 200 to *c.* 50 B.C. is roughly, therefore, as follows. Epicureanism. always attractive, but not participating in any development. stood in the background. The leading dogmatic system (and the only one which. in the sphere of morals, could put forward ideas acceptable either to the Roman rulers or to their subjects) was Stoicism. And while the Stoics had appropriated the moral teaching of Plato (and probably some part of the system of Xristotle), the Academy, which had surrendered those doctrines. had become the focus of scepticism. In the 1st century B.C. there was. however, the attempt of Antiochus of Ascalon to revive the atmosphere of the "Old Academy" and to pretend that Zeno. in spite of the appearance of novelty which his terminology creates. contributed nothing new to the Platonic doctrine. The debates arising from this situation are reflected in the philosophical writings of Cicero (106–43 B.C.). Historians sometimes write of a specific phase of Eclecticism. which pieces together a system from previous systems. But if there ever was such a movement. Cicero at least ought not to be assigned to it. He is a consistent representative of the New Academy, wielding a method, but hostile to the very idea of system.

When Zeno and Epicurus first established their systems, they seem to have been less conscious of opposition toward one another than of the need for joining forces in the attack on the two reigning schools. the Xcademy and the Peripatos. Aristotle, being judged mainly from his dialogues, was still ranked as an idealist; Zeno and Epicurus had in common a thoroughgoing materialism. The Platonic theory of knowledge, in which the mystical belief in reminiscence always played a part, was disparaging to the senses, whereas the new schools refused to accept any foundation except the unshakable certainty of perception. Both Platonists and Aristotelians held that a wide culture in the sciences was necessary to the philosopher; Zeno and Epicurus made physics subordinate to ethics and gave it a form which even the late learner (who to Plato and Theophrastus is a comic figure) could grasp. The Platonists maintained. and both the Stoics and the Epicureans denied, the eternity of the physical world. Even in ethical doctrine the two latter schools were linked by the wish to offer some means of attaining independence of mind. When, however, their joint attack had been crowned with success. the equally important contrasts between them could not for long be disguised: one was a system of duty. the other one of hedonism. The Stoics were believers in divine providence and regarded the world as a single divine being permeated by *logos* (reason). which attains to self-consciousness in man. In the Epicurean "theology." the gods are not allowed to design the worlds but placed in the interspaces where they cannot do harm or have harm done to them. Thus after an interval Panaetius was able to bring round the Stoic school into alliance with the Xcademy in the manner above described.

Later Greek Philosophy. — Stoicism itself after the 1st century A.D. has little history as an organized school, though it produced writers whose names are still famous, such as Epictetus and Marcus Aurelius Antoninus. It had, honever, far-reaching influence as a fertilizer in many different fields. The Stoic ethics remained prevalent. both among philosophers and among the public, as the best that pagan antiquity had to offer; the important conception of a law of nature. which all men as rational beings ought to recognize in their dealings with one another, rests on a Stoic foundation. From the Stoic armoury, Christian theologians were able to borrow many arguments concerning design in the physical world. As a coherent system Stoicism did not survive. Not only had its dogmatic pretensions been fatally injured by criticism from the Academy; but also. from the Augustan age onward, men sought more and more a religious view of the world such as no materialistic creed could provide.

Those thinkers who did not lapse into scepticism, which was revived by Aenesidemus, turned naturally toward some version of Platonism or to Neopythagoreanism, which is by this time not easy to distinguish from Neoplatonism. The works of Plato were edited in the 1st century A.D. by Thrasyllus, and the treatises of Aristotle, after centuries of obscurity,. had been brought to light and edited in the previous century by Andronicus of Rhodes. These are the editions from uhich modern texts descend. Both Plato and Aristotle were now classics in the philosophical schools and became the subject of learned expositions still preserved, in which much valuable information is embedded.

The revival of interest in Plato took various forms. As has been mentioned above. Antiochus (1st century B C.) went back to the ethical doctrine of the early Academy and cast doubt on the originality of the Stoics. Far more thinkers were inspired by the cosmology of Plato and by his theory of the soul: for example, a treatise by Albinus, of uncertain date. consists of a systematic exposition of Platonism, free use of Aristotelian terminology being made in it; in Philo is found another such exposition, this time from the point of view of a Jew of Alexandria: and in Plutarch of Chaeronea interest in the religion of Plato is especially prominent. Plutarch's attack in some of his treatises upon Stoic and Epicurean doctrines. from a Platonic point of view. seems to show that these still had some vitality.

The system of Plotinus (c. A.D. 205–270) resembles these in its general intention but is much bolder and rests on a broader historical basis. He and his follo ers were profound students of Aristotle as well as of Plato and were deeply interested in the pre-Socratic philosophy. Giving a relatively unimportant place to the doctrine of forms. Plotinus develops Plato's doctrine that soul is the motive principle from which bodies (if they can be said to exist at all) derive their power of action; and by this means he corrects the materialism of the Stoics and others influenced by them. He proceeds to draw, much more firmly than Plato. the general picture of a graduated immaterial world. For the soul, though it is the principle of physical change, occupies only a middle position in the entire scale of reality. Above particular human souls is the world-soul, above this again the mind (Plato's "artificer") which fabricates the world-soul and in which the highest knowledge is located. Beyond mind, knowledge and existence lies the One, which no human language can suffice to describe The heavenly bodies are divine beings (and in defense of this view the Neoplatonists make use of arguments dating back to Plato and Aristotle); the part of the visible world in nhich we live is admittedly imperfect by absolute standards. but has its proper place in the graduated scale and ought not to be regarded as the nork of a malicious spirit working against the Good. Astrology is condemned, as presupposing a false view of the mode of action of the celestial deities.

Plotinus entered into no controversies resulting from his work, but Porphyry (c. 233–*c.* 304) took the offensive in a criticism of Christian doctrine and the Athenian Keoplatonists Proclus (410–485) and Simplicius (6th century) assembled all the resources of Greek philosophy in the attempt to present a religious view that could be set up in rivalry to Christianity. Christian thinkers naturally protested against the belief in the divinity of the stars and in the eternity of the physical world and against the associated belief in precisely similar cycles of human history. On their side, the Neoplatonists thought it impiety to deny the divinity and intelligence of the stars. regarded the Incarnation as unthinkable and held fast to their arguments which seemed to show the eternity of the world. (See NEOPLATONISM.)

From the point of vièw of a later age, this controversy seems to tend toward an issue of which none of the disputing groups was at the time aware. The created world of the theologians is a possible object of science (and. indeed, as proceeding from the inscrutable will of God, of humble experimental science). whereas the besouled cosmos of the Neoplatonists. to which man feels himself akin. is not such an object. This is a defect which neither the genius of Plotinus nor the learning of his various successors could outweigh, though it did not become obvious for many centuries. Although Greek philosophy failed in its last contest, it had provided many of the arms by which it was defeated.

(D. J. **A.**)

PATRISTIC AND MEDIAEVAL PHILOSOPHY

Early Christian thinkers could not be indifferent to philosophical doctrines aiming at human happiness and dealing with the questions which religion also was intended to answer. For similar reasons some Jews, for example Philo, had interpreted Scripture in terms of philosophy and vice versa. Philosophy (particularly Platonism and Stoicism), when it was not rejected as impious, was in turn accepted as supporting revelation and used for apologetic purposes, being considered as foreshadowing, or sharing in, Christian doctrines, or as likely to add something. in certain fields, to the incompletely revealed truth. or again as ready to be combined, in a semimythological form, with elements derived from religious texts and traditions. In the first five centuries A.D. there were no Christian philosophers in a strict sense, but the influence of Greek and Roman philosophy was widespread and deep; some doctrines were developed with originality, and the new problems of the relation between reason and faith. of the possibility of rationalizing dogmas and of fitting new historical facts or interpretations and psychological experiences into the usual categories of thought, were faced in ways which were important for the future of philosophy.

Philosophical speculation from the 6th century to the 16th was mainly concerned with the issues already debated. in Greek and in Latin, by pagan and Christian thinkers and was based on their doctrines. Interest spread to new provinces, east. west and north. Philosophical language was created on the Greek pattern in Armenian, in Georgian and in Persian, in Syriac, in Arabic and in Hebrew; it developed enormously in Latin and, mainly from Latin. was inserted into the European vernaculars. French. Spanish. Catalan. Italian, English, German and Irish; it thus became part and parcel of modern speech both technical and ordinary.

The continued interest in philosophical studies was ensured above all by the late Greek schools of Constantinople, Athens, Alexandria, etc Teaching in Greek was never completely extinct until 1453. Foreign students transplanted in their countries some of the Greek doctrines and methods from the jth century onward; thus the Armenian. Georgian and Syriac schools came to life, and Latin thought was being enriched until early in the 6th century. Refugees from Athens in the 6th century and from Alexandria in the 7th carried the philosophical tradition into Persia and strengthened the Syriac schools. From these and through new contacts with Constantinople, there arose in the 9th century the cosmopolitan philosophical tradition in Arabic: and later this tradition appears in Hebrew. The Greek inheritance passed again (and much more extensively) into Latin in the 12th–I jth centuries. both from Constantinople and from the Arabic west. On the other hand. Latin philosophy influenced the Greek. Hebrew and Armenian cultures in the 14th and 15th centuries. The works which contributed most to speculation were Aristotle's treatises on logic, psychology. metaphysics, physics. ethics and politics, several Peripatetic and Neoplatonic commentaries on the same texts and a few independent Neoplatonic works, principally Proclus' Elements of *Theology*. Plato was directly known almost only

through his cosmology (*Timaeus*) and, among the Arabs, through the *Republic* and the *Laws* The logical principles of philosophical method, the dualities of matter and form, substance and accidents, potency and act the four causes, the notions and classifications of virtues, the idea of man as a "political animal" and the doctrine of experience as the basic of knowledge were taken over from Aristotle and became instruments of thought through these ten centuries. Among the permanent Neoplatonic contribution5 to mediaeval speculation were the doctrines of a hierarchical organization of the norld. subject to the law of efficient causality and to the one First Cause: of spiritual beings ("Intellects." etc) as intermediaries between man and God; and of the tendency of everything to return to its origin.

The purely philosophical tradition was often supplemented, sometimes almost superseded, in those ten centuries by the philosophico-theological tradition of the Fathers of the church and of some heretics; Christian, Moslem and Jewish philosophers had to face all or some of the problems which they had faced. The Fathers provided. directly or indirectly. inspiration. materials for discussion and solutions. They also added to the purely philosophical legacy by passing on Platonic and Stoic doctrines and original theories of their own. Above all. St. Augustine was ever present as an authority and a model for those who read Latin; and Dionysius Areopagiticus powerfully affected philosophy and theology among Greeks and Latins. Armenians and Syrians.

Starting from these premisses and often accepting the older doctrines. mediaeval philosophers (especially those of the Latin and Xrahic tradition. to a smaller extent those of the Byzantine, and Jewish) pushed farther and deeper the study of the workings of the mind; attempted new or more convincing answers to old questions (*e.g.*, those of the existence of God and of the immortality of the soul): examined with refined techniques the claims of *a priori* and *a posteriori* knowledge; considerably advanced the inquiry into the functions and pitfalls of language: debated and clarified the concepts of knowledge, certainty. belief, faith and probability; tried to organize all human knoll-ledge systematically: often asserted the supreme value of intelligence in a humanistic sense: reasserted the importance of sense experience and induction; enlarged and made more concrete the scope of social and political philosophy: and opened the way to the mathematical interpretation of physical phenomena.

Patristic Philosophy. — St, Paul's words "the invisible things of God from the creation of the world are clearly seen. being understood by the things that are made" (Rom. i. 20) suggested to Christian thinkers how to combine philosophy and religion: and the obviously philosophical use of *logos* at the beginning of St. John's Gospel would give a doctrinal basis to such a combination. The apologists of the 2nd century took a definite stand with regard to philosophy: Justin Martyr and Athenagoras confirmed Christian doctrines by showing that they agreed either with Plato's or with the Stoics' views and borron-ed Philo's idea that the Greelr philosophers derived their best opinions from Moses; Tatian. on the contrary. claimed that philosophy is misleading and God unknowable to human reason. At the same time, new half-philosophical doctrines were propounded which took into account the basic worry to which religion was to be a remedy: the problem of evil. The best among the gnostics, Valentinus and Marcion (see also GNOSTICISM). opposed the view of evil as a positive being to the optimism of most Greek philosophy. The history of the world is one long or ever-renewed strife between Good and Evil; Evil will disappear with the destruction. not with our perfect knowledge. of this world (see also MANICHAEISM). In Clement of Alexandria (c. 1 jo–c. 215) philosophy appears partly as the best instrument for moulding Christian theology, partly as a forerunner of revelation; this view was to reappear in Abélard nine centuries later. Origen (c. 18;–c. 254) answered Celsus' objections to Christian doctrines with philosophical arguments: the Christian God is still the "eternal immutable activity" of the philosophers, because before creating our world He may have created others and because the Incarnation meant a change in the mind of men, not in the nature of God.

St. Augustine (354–430) transformed some aspects of Platonism and Stoicism, the two doctrines which most inspired him after he abandoned Manichaeism. According to him knowledge is. above all. the result of illumination coming from God and manifesting itself within and through our own mind. whether it is concerned mith dispelling the ultimate doubts about our existence or with the highest notions. Matter was not created as a barren receptacle of forms. but enlivened by mtiones *seminales*, principles of development. Thence forms will supervene, each as a mark or imitation of the "exemplar" which is in the perfection of God's nature: each thing may have many forms. but every created thing, however spiritual (souls. angels). will have its own matter; this distinguishes creatures from Creator. The idea of mankind's forming the *civitas terrena* in its passing on earth looked backward to the cosmopolitanism of the Stoics and forward to the *humana civilitas* of Dante and to the more modern doctrines of a universal polity.

The so-called Dionysius Areopagiticus (late jth century) interpreted much of the Neoplatonic metaphysics of Proclus in terms of Christian theology. His analysis of the "names of God" suggested discussions on the philosophy of language, not only of theology; his *Caelestis Hierarchia* and *Ecclesiastica* Hierarchiu gave the blessing of a supposed friend of St. Paul's to the theory of the degrees of being which. also from a work of Proclus summarized in the Dr *Causis*, implanted itself in most philosophical systems of the 13th century; while his negative theology often set the rules for the doctrines on the limits between rational and revealed knowledge.

Byzantine Philosophy. — After the closing of the Athenian schools (529), philosophical activities continued for more than a century in Alexandria and other centres: the Theodosian university of Constantinople probably kept them alive through the 6th, 7th and 8th centuries. while St. Maximus interpreted and expanded Dionysius Areopagiticus' doctrines and St. John of Damascus presented philosophy as a discipline introductory to theology. Photius and Michael Psellus, respectively in the 9th and in the 11th century, upheld the primacy of rational inquiry over mythological fiction and over mysteries and magic. the former supporting Aristotelianism and positive research, the latter preferring Platonism and intellectual intuition. The revival of Aristotelian studies in the 11th and following centuries (John the Italian, Michael of Ephesus. Eustratius. Theodorus Metochites) spread from Constantinople into the Latin west. In the 1 jth century the philosophical optimism of the Platonist Gemistus Pletho. according to which all men may agree on the same "philosophical religion." and the view of Cardinal Bessarion on the fundamental agreement between Platonism and Aristotelianism directly influenced philosophers in Italy. To Italy was transferred. after the fall of Constantinople (1453), what remained of the Byzantine philosophical tradition.

Arabic Philosophy. — After the early Mutazilites (8th century), who confined themselves to philosophical apologetic of Islam, mainly discussing the unicity of God. free will. evil and creation, a more definite philosophical tradition in the Arabic language arose in Baghdad and spread to Persia and to Spain. The attempts of Al-Kindi (*see* KINDI), an Arab. in the 9th century to combine n-ith Islam Aristotelian and Neoplatonic theories, particularly concerning the noneternity of the world, the independence of the soul and prophetic knowledge, were succeeded by more constructive thinking. The Persian Rhazes (*i.e.*, Razi: d. *c.* 930), a rationalist for whom science and philosophy stand higher than religion and a man of great medical doctrine and experience, expounded a system based on five eternal principles: the Creator, the soul of the world. matter, time and space. Al-Farabi (see FARABI; *c.* 870–950), a Turk, again asserted the superiority of philosophy as the highest of human achievements. accessible to all men and the best instrument for establishing a sound political organization.

Avicenna (979–1037), another Persian. a more systematic and universal thinker (his *Shifa* is the first great philosophical encyclopaedia, mainly organized on the model of the traditional order of Aristotle's works), examined and elaborated most problems discussed and solutions given by authors known to him. Religion

and philosophy have. according to him. an equal status. or religion is superior: this attitude is reflected in his doctrine of prophecy (*i.e.,* that it is one of the highest intellectual faculties) and in his interpretations of Aristotle's theory of the soul and of active and passive intellect. A strong reaction against philosophy came from Algazel (*see* GHAZALI; 1058–1111), who "demolished" philosophy by exposing its inner contradictions and established the primacy of sacred texts and rationalized dogmas. But he was soon powerfully contradicted by the greatest Spanish Arab. Xverroes (1126–98) of Córdova.

According to Averroes. philosophy alone leads to complete, pure. final truth, while sacred texts contain at best a simplified and childish account for less-gifted people. and rational theology is muddled. pretentious and misleading (the theory oi "double truth" which often goes under his name was completely alien to his doctrine). His penetrating, extensive analysis of Aristotle's works was a model and a mine of ideas and information for philosophers of the Latin tradition from the 13th century onward. His commentaries and his views on philosophical truth led. probably more than anything else, to the establishment of a "free" philosophy in the west; while Avicenna's systematic order and his psychological and gnosiological analyses were of continuous inspiration in the 13th century, particularly to Duns Scotus. (*See* ARABIC PHILOSOPHY.)

Jewish Philosophy.— If we except the syncretism of Philo and the philosophical elements in the Kabbalah, Jewish philosophy is closely connected with the Arabic tradition and often, indeed. written in Arabic. Jewish attempts at adapting Platonism and Aristotelianism so as to avoid contradictions with the Bible anticipated and sometimes influenced the views of Christian thinkers. Saadia hen Joseph (*q.v.*) proved against Aristotle that the world has a beginning and that the soul is a substance: against the Platonists. that every soul is created for its body: against the Neoplatonists. that the world resulted from creation, not from emanation. The doctrines of the plurality of forms and of the presence of matter in spiritual creatures were expounded by Avencebrol (*see* IBN GABIROL; c. 1021–C.1058) in more definite and clearer terms than by St. Augustine and thus were taken up by the most representative Latin thinkers of the 13th century. Judah ben Samuel Halevi (*c.* 1085–c. 1140).a Jewish Algazel. opposed philosophy; but Maimonides (1135–1204), a man from Córdova as was Averroes. maintained that theology and philosophy necessarily agree in spite of their different methods (this view mas later held by St. Thomas Aquinas, who knew Maimonides' work). His theory that immortality consists in participation in knowledge (*i.e.,* in the eternal "active intellect") is comparable with that of Spinoza, one of his later admirers. Hillel hen Samuel, Levi hen Gerson (Gersonides). Hasdai ben Abraham Crescas and others in the 13th and 14th centuries did not produce any important or independent doctrine. The only prominent thinker of the 14th–I jth centuries. Judah ben Isaac (Leo Hehraeus), already belongs to the Platonism of the Italian Renaissance. (See JEWISH PHILOSOPHY.)

Western Philosophy.—Boethius (*c.* 480–524) did not carry out his plan of harmonizing Plato and Aristotle; hut his translations and unoriginal elahorations of Aristotelian. late Peripatetic. Stoic and Porphyrian logic provided the basis for much of the philosophical revival of the 9th and following centuries and for most logical studies until recent time. His application of philosophical methods and categories to theological problems was followed and carried farther in the 12th and 13th centuries. His exaltation of philosophy as the greatest of human possessions was influential in less professional philosophical circles. Three centuries later an Irishman. Johannes Scotus. or Erigena (*c.* 815–*c.* 877), favoured by the Frankish kings' cultural policy and influenced by Greek and Latin Fathers, especially by Dionysius Xreopagiticus. produced the first great synthesis of the Latin middle ages, the almost pantheistic *De Divisione naturae.* This. however, was to be less important than the frequent theological debates on substance and accidents and the scholastic training on Porphyry's *Isagoge* and on Aristotle's *Categories* and *De Interpretationc.* On the basis of these texts much thought was given to the relations between words and things and to the different functions of words. In particular, the question whether universal words ("man," "animal." "white." "humanity." etc.) correspond or not to definite things provided the opportunity for shaping and expounding various metaphysical and epistemological views; for example, the "nominalism" of Roscellinus (*c.* 10jo–c. 1122). the "realism" of Anselm (1033–1109), etc. On the other hand. logic was often but an instrument of apologetics; even Xnselm's famous proof that God exists because we have in our mind an idea of Him harnesses some rules of logical consistency in order to make explicit a religious intuition. (*See* also ONTOLOGY.)

In the 12th century dialectic is still in the forefront. For Peter Abélard (*i.e.,* Ahaelardus. 1079–1142) philosophy meant the dialectical elaboration of religious and moral problems. supported by views from ancient philosophers. His interest was often more genuinely philosophical: systematic doubt and inquiry into the meanings of words and into the propriety of their usage were his rules in the Sic *et non;* and the true value of words, their functions in clauses and the psychological processes connecting things and words were the subject matter of the best sections in his commentaries. At this time, the pre-eminence of philosophy of language is also manifest in the study of sophisms (a new and henceforward permanent feature of philosophical studies) and in other new chapters of logic (*suppositiones, relationes,* etc.). A more metaphysical interest was shown by Gilbert de la Porrée (c. 107j–1154), who thought it possible to separate universals, such as "humanity" or "divinity." from particulars. such as "men" or "God"; while cosmological doctrines, partly inspired by Plato's *Timaeus,* were prominent in the school of Chartres.

The bulk of the Greek and Arabic legacy was then discovered. Scholars of the western world collected and translated books of science. philosophy. theology: Aristotle's physical, psychological, ethical and metaphysical treatises. something of Plato, texts from Proclus. some sections of Avicenna's encyclopaedia, something of Al-Kindi and of Al-Farabi. Xvencebrol. Euclid. Ptolemy, Archimedes. Galen and Hippocrirtes, John Chrysostom and 'John of Damascus.

Some logical works of Aristotle in Boethius' translation were also rediscovered. The first signs of the assimilation of some of these works are found in Spain (with Dominicus Gundisalvij and possibly in the pantheistic doctrine of Amalric of Bena and in the materialistic monism of David of Dinant.

Complete assimilation was the work of the 13th century. The church's cautious attitude toward unknown doctrines slightly delayed it: but in Oxford and soon in Paris (where a few works were excluded from the schools for some time) the process of analyzing and commenting upon many of these writings led to the newly discovered doctrines' being used in debates and for new constructions. Averroes became available in Latin in the 1230s, and other Aristotelian works, including the Politics, followed. Doctrines already popular in Latin had to be revised and refined. The theory of light as an element in the world and a means of knowledge was Augustinian in origin but was advanced by Robert Grosseteste (c. 1175–1253) in a new, more scientific spirit. Franciscan philosophers. such as St. Bonaventura (1221–74), would still accept the theories of the multiplicity of forms. of exemplarism. of matter in spiritual creatures, of knowledge by illumination, of *rationes seminales,* hut they tempered them under the impact of the new texts; they faced the new doctrines or tried to find in them some support for their views. Philosophy asserted itself as something valuable in its own right; according to Roger Bacon (c. 1220–*c.* 1292) it can be a means of domination and well-being for mankind. The new urge to discover truth. either in the writings of philosophers, or by deduction, experience and experiment. led to the encyclopaedic works of Xlbertus Magnus (c. 1206–80) and Bacon.

Competition between theology and philosophy, between faith and reason, became a burning issue. Although criticisin was alert on all sides and Aristotle was more often than not simply *an* authority and hardly ever *the* authority. nevertheless some views that were either his or ascribed to him, as well as certain views of other "pagans" (Proclus, Avicenna, Averroes), were such as might

carry too much conviction and endanger more "orthodox" doctrines (*e.g.*, the doctrine of creation or that of individual immortality). Enthusiasts and reasoning thinkers (such as Albertus) would alike proceed with their philosophical inquiries, fearless of possible conflicts. but add from time to time the rider that "this is what philosophers teach." implying or stating that in case of disagreement they themselves would be on the side of orthodoxy. Thus philosophy would be pursued for its own sake, and its value as a giver of truth would be impaired only slightly. This was notably the case with the "Averroists" like Siger de Brabant (*c.* 1235–*c.* 1284), who would adhere as much as possible to Aristotle and try to develop a more coherent Aristotelian system than Xristotle had ever produced. They avoided speaking of double truth, but came near to it: their ideal was a satisfactory account of reality independent of theological interferences.

An attempt at producing a comprehensive philosophical doctrine based on the conviction that faith and reason — philosophy on the one hand and Scripture and Fathers of the church on the other — are in agreement was made by St. Thomas Aquinas (*c.* 1225–74): a magnificent compromise between orthodoxy and Aristotelian philosophy. Some provinces of knowledge are the preserve of faith: but sense experience. aided by the "first principles" (which are present in the "active intellect" of every man) and by logic, reveals the structure of the universe and allows men to approach the less accessible realities, including the existence of God. Thomas took Aristotle as his model for most basic doctrines (matter and form. efficient and final causes. categories of being, movements and elements) but often "adapted" him and sometimes abandoned him. Thus the matter of each thing, not form, bears the marks of individuality: the highest level of reality (being) characteristic of each thing is its *one* form ("rationality" in man supersedes "animality" and other forms, it is not added to them); human soul is the form of the body. but, being individually created, is separable from it; the world is created, although "created *ab aeterno*." The Aristotelian theory of knowledge is systematized, the emphasis being put on sense experience. In this lies the philosophical importance of Thomas' criticism of the a priori (ontological) proof of the existence of God and its replacement by the hardly original "five ways": all of these start from sense experience. It is mainly due to Thomas that Aristotle's ***Politics*** and the naturalistic view of rnan as a political animal became the starting point of all future social and political philosophy. to which he also contributed his doctrine of the fundamental agreement between individual and common good and his elaboration of the idea of natural law.

Duns Scotus (c. 1265–1308) extended. in a sense, the province of philosophy. His theory of the "univocity of being," contrasted with Thomas Aquinas' "analogy of being." allowed him to apply to God, significantly and positively. our categories of thought as expressed by means of the verb "to be." His Neoplatonic vision of a perfectly organized world in which various degrees of causality keep things closely knit together is coupled with an extreme doctrine of individuality: perfect knowledge is knowledge of individuals (but again, universals are somehow existent in things). On the other hand, our rational knowledge is limited — it even seems to he made insecure — by the absolute freedom of God. who might even change the order of the world. Duns's individualism and doctrine of God co-operated with Thomas' emphasis on experience to prepare the ground for the more extreme doctrines of the 14th century.

The 14th century was a period of constructive criticism: the process of assimilation was over, and philosophy had its own independent life. Absolute determinism or indeterminism. probabilism, empiricism and rationalism and extreme Averroism were being propounded. defended and faced. According to Petrus Aureolus (Peter of Auriole; d. 1321) knowledge is appearance of objects: we know what exists by direct impressions, more or less clearly. but without intermediaries; forms, essences and universals are fictions. For Nicolas of Autrecourt knowledge is a bundle of appearances giving probability, never certainty. According to William of Occam (*c.* 1300–49) we know onlv individuals, and only through our senses: the structure of the world, relations, classes. space and time are constructions of our mind. The order of our world of knowledge is the logic of our construction. Analyzing our language, we discover all that has been ascribed to the extramental world; only individual things resist this analysis. God's existence cannot be proved; even the "five ways" lead us beyond experience, away from the truth. Knowledge of God belongs to faith; according to which God is absolutely free; "laws of nature" or knowledge of immutable facts and entities would impair God's freedom. The fideistic side of these doctriries recommended them also to less extreme thinkers such as John Gerson and Pierre d'Ailly. The opposition to what was termed "nominalism" or "Occamism" failed to produce positive constructions; such "realists" as Walter Burley were not very original. Even the extreme deterministic doctrine of Thomas Bradwardine seems to be partly inspired by Occam's idea of God's absolute power. The Averroism of John of Jandun followed a middle course. A positive doctrinal contrast to those trends is to be found in the speculative mysticism of Johannes Eckhart (c. 1260–1327) and his follon-ers; by reviving the Neoplatonic doctrines of the unity of the real, of the negative nature of individuality and of the inherent need for every thing to annihilate itself in God. they strongly influenced later German philosophy.

"Free" inquiry into metaphysical issues mas accompanied by new developments in several sciences and sectors of philosophy. These included formal logic (Albert of Saxony) and the mental grammar of the *modi significandi* (Thomas of Erfurt); the doctrine of the independence of political life from ecclesiastical power and of the right of citizens to choose their rulers (William of Occam, Dante Alighieri and Marsilius of Padua); the theory of "impetus" and the numerical interpretation of qualitative changes (Jean Buridan, Thomas Bradwardine and Nicole Oresme); and the study of the nature of money (Oresme).

In the 15th and 16th centuries the main trends of thought of the 13th and 14th (Thomism, Scotism, nominalism) were kept alive in the schools (hence the term "scholasticism"); but Platonism and the idea of life as animating all things in nature inspired. outside the schools, more original thinkers. A restatement of Neoplatonism, bordering on mysticism and foreshadowing idealism, accompanied by a penetrating analysis of the incongruities of the traditional doctrines of definition and noncontradiction if metaphysically applied to things. was presented by Nicolas of Cusa (1401–64); the mathematical problems of the limits of infinite series are for him examples of the *coincidentia oppositorum*. This is the fundamental rule of a world where everything somehow includes everything else. where God (the expanded. "explicit" being) can be compared with things (the contracted. "implicit" being). Together with Marsilio Ficino (1433–99), Nicolas shared Gemistus Pletho's optimistic aspiration toward a universal philosophical religion.

In the latter half of the 16th century and early in the 17th, however. Platonism was interpreted in a more pantheistic and naturalistic vein by the south Italian philosophers Bernardino Telesio, Giordnno Bruno anti Tommaso Campanella. Telesio wanted to provide an explanation of nature that would start from "its own principles" and forgo all *a priori* doctrines; for Bruno, the whole world is a living "animal" that renders explicit what its essence (*i.e.*, God) contains implicitly; and Campanella professes an extreme animism (things "sense," they are because they sense: cognosccrc est *esse*). Pietro Pomponazzi (1462–1525), the leading Averroist. also tries to find in nature the solution to all problems; he thus denies the immortality of the soul. Direct concern with nature leads such men as Michel de Montaigne (1533–92) to pursue detailed observation of how beings, particularly human beings, behave: and their keen sense of realities in limited spheres is accompanied by scepticism as to the possibility of solving the "great problems" of philosophy. Similar interests. coupled with knowledge of mathematics and mechanics, made of Leonardo da Vinci (1452–1519) the pioneer of the new science of nature.

(L. M-Po.)

MODERN PHILOSOPHY

More than any other intellectual discipline, philosophy derives

its stimulus from events outside its own immediate sphere. Behind the rise of a new philosophy in the 17th century lay two major happenings the Reformation and the scientific movement initiated by Copernicus (1473–1543) and continued by Kepler (1571–1630) and by Galileo (1564–1642). The Reformation had little immediate effect on philosophical speculation, for the reformers laid primary stress on faith and inspiration rather than on reason and learning; it was not till the time of Kant that Protestantism found philosophical expression. Nevertheless, by challenging the old order in the sphere of religion Luther and Calvin facilitated its overthrow in other fields. The scientific movement, by contrast. exercised a ponerful and direct influence on philosophical thought almost from the first. The neu scientific attitude, with its emphasis on those aspects of natural phenomena nhich nere quantitatively comparable as opposed to those nhich were qualitatively different, had it is true. been partially anticipated in Platonism; and Platonism was not only influential in the thought of the early middle ages but had survived as an undercurrent throughout the period when Xristotle was in the ascendant. to be revived at the Renaissance in the manner just described. The break mith familiar conceptions was. however. sufficiently sharp to present an intellectual challenge of the first importance. It became imperative for thinking men to ask what were the implications of the new view of nature and to nhat extent they could be reconciled with existing beliefs in other fields, in particular that of religion. The great impression made by Descartes on his contemporaries owed much to the fact that he answered this question in a way which seemed to do justice to religion and to science at once. The whole of nature constituted a great machine; there was nothing in it—not even the human body—which could not be explained in mechanical terms. But the mind or spirit of man belonged to another order altogether an order to which God also belonged, and had to be dealt with in quite another way. Hence the new science could be admitted to the community of learning without its being necessary to show religion the door.

Cartesianism.—The common ascription to René Descartes (1596–1650) of the title "father of modern philosophy" has been disputed by some in favour of Francis Bacon (1561–1626). Bacon's reputation rose as that of Descartes fell The shortcomings of Descartes's philosophy of nature. cast in the form of a rigid deductive system, stood in contrast with Bacon's preoccupation with induction; and it was asked whether Bacon. a precursor of modern empiricism. had not a better grasp of the truth. In fact, however, Descartes's account of scientific method seems. despite its obvious errors. to correspond better than anything in Bacon to the procedures of the advanced physical sciences today. and historically there can be no question of the comparative influence of the two thinkers. For all his acuteness, Bacon could scarcely claim to have provided his age with a new philosophy; nor was it Bacon's ideas which. for good or ill. set the stage for philosophical discussion during the next 300 years.

Even the briefest sketch of the Cartesian system must take some account of its genesis, for Descartes is important not merely for his positive conclusions but also for the nay in which those conclusions were reached. He began, in effect. as a logician. Confronted by the confusion and stagnation which characterized many forms of learning in his day. he sought a method or standard procedure for attaining to truth in the sciences. The method. closely based on mathematics. was to start from premisses of uhich our knowledge was "sure and indubitable" and to proceed only to conclusions clearly seen to be implied by those premisses. But though he began as a logician, Descartes did not remain long on the purely logical level. Sceptical doubts about the applicability, as opposed to the internal consistency. of scientific systems had troubled him from an early date, and it was to quieten them that he proceeded to construct a metaphysic. The sceptical arguments which. he believed. showed the untrustworthiness for theoretical purposes of all sense judgments were powerless when directed against the existence of the self; for to doubt the self was itself to affirmit, since to doubt is to think. There was thus one firm fact on which knowledge could be built. What the argument proved, however, was very limited: only the existence of the self as a thinking thing, not that of body or matter. To prove the latter. Descartes maintained further steps were required We must first demonstrate the existence of God; then show that, if God exists. whatever we conceive clearly and distinctly must be true; finally establish that we have a clear and distinct idea of body or matter. Descartes proceeded to try to make good each of these points. The final system which emerged incidentally thought of by its author as no more than the prelude to a comprehensive philosophy of nature. was a simple dualism of mind and matter as separate substances, a substance being defined *(Principles of Philosophy*, i, 51) as "a thing which so exists that it needs no other thing in order to exist."

Modern historians of philosophy. notably Étienne Gilson, have stressed the extent to which Descartes's thought connects with mediaeval ideas; and the terminology in nhich his views found expression was certainly often that of his predecessors. Nevertheless. it nould be wrong to ignore the profound novelty of the Cartesian system as a nhole. We have already seen how by his metaphysical dualism Descartes met one of the primary intellectual needs of his age. in a manner which may now seem crude but was certainly effective at the time. by assigning distinct spheres of influence to scientists and to theologians. At the lowest estimate this must be counted a service. though perhaps an unintended one. to the cause of science. But the novelty did not stop there. The method sketched in the second part of the *Discourse on Method* and norked out in more detail in the unfinished *Rules for the Direction of the Mind* was revolutionary not only in its bold refusal of the name of knowledge to whatever was capable of being doubted, but still more in its author's conviction that "all the sciences are conjoined uith one another and interdependent" Knowledge was one and hence any suggestion that method should vary n-ith subject matter could be ruled out. This conclusion stood in such sharp contrast with the Aristotelian assumptions hitherto prevalent that men forgot that in many points Descartes and Aristotle were in agreement about scientific method. But it uas in the field known now as "theory of knonledge" that Descartes's thought was newest and most influential; indeed, he may be said to have discovered (or invented) the subject in its modern form. The famous arguments at the beginning of the *Meditations* provided a starting point for the many subsequent discussions of knonledge and certainty, uith the respective cognitive claims of sense and reason; while Descartes's contention in the same context that he could be certain that he had ideas but not certain that anything independent of himself corresponded to them generated the celebrated problem of the external world. It is worth noting that on this and similar topics philosophers of an empiricist turn of mind accepted Descartes's statement of the question equally with rationalists though they disagreed with his way of answering it. (See further KNOWLEDGE, THEORY OF; LOGIC. HISTORY OF.)

The power of Descartes's thought was clearly appreciated by his contemporaries and immediate successors and it was not long before a flourishing school of Cartesians developed *(see* CARTESIANS). Of these Nicolas Malebranche (1638–1715), who gave an Augustinian or Platonic twist to Descartes's doctrine of ideas, is perhaps the most notable. Among Descartes's own contemporaries there nere. however, two thinkers of major stature uho would certainly not have called themselves Cartesians, though each felt the force of Descartes's ideas: Thomas Hobbes (1588–1679) and Blaise Pascal (1623–62). Hobbes, remembered today primarily for his views on politics, agreed with Descartes in his acceptance of mechanical principles of natural explanation and in his confidence in the powers of human reason; where he differed from Descartes was in believing that nothing existed except matter in motion and thus that there was no such thing as mental substance. Pascal. a genius of the first order whose contributions to mathematics physics and Christian apologetics were alike remarkable, found himself entirely out of sympathy both with Descartes's observations on method, which struck him as much too dogmatic, and with his metaphysical synthesis, which he thought did something less than justice to religion. In a century notable for its intellectualism Pascal had the insight to ask if intellectualisin was

enough; but since he was not strictly a philosopher (and indeed doubted the value of any kind of constructive philosophy), his influence on subsequent philosophical thought was small.

Spinoza and **Leibniz.**—Benedictus de Spinoza (1632–77) and Gottfried Wilhelm Leibniz (or Leibnitz, 1646–1716) shared many of Descartes's fundamental assumptions as well as much of his terminology and were much preoccupied with difficulties which had arisen inside the Cartesian system, about the relationship of mind and body, the role of sense experience in knowledge and the question of innate ideas or a *priori* knowledge, as it was later to be called. In addition, Spinoza was so far in agreement with Descartes's account of method that he attempted to set out his own philosophical conclusions in the form of a deductive system in his *Ethics*. Nevertheless, each was too original a philosopher to be described as a mere follower of anyone.

Spinoza began by accepting the Cartesian definition of substance (quoted above) and went on to argue that there could be only one substance. which he called indifferently God or Nature. Descartes himself had allowed that mind and matter were substances only in a secondary sense for though each was otherwise complete in itself they each needed the concurrence of God in order to exist; God alone was "absolutely self-sustaining." Spinoza's version of this was to make mind and matter attributes of his single substance, the reality of which was, he said, presupposed by the reality of anything less than itself. God was to be thought of as a being of infinite attributes, but two attributes only were known to human beings. Since each attribute was complete in itself, interaction between the mental and the material was strictly speaking impossible; but since God manifests Himself in every attribute, whatever happens in one has its counterpart in all the rest. Thus to every mental event there corresponds a physical event, and vice versa.

The originality of Spinoza lay in his presenting a de-Christianized version of Cartesianism. Descartes had accepted the orthodox Christian conception of God as pure spirit endowed with will and intellect and had followed Augustine in laying particular stress on freedom of the will both in God and in man. All this disappeared in Spinozism. God was as much body as spirit, and there could be no question of His doing other than acting according to the necessities of His nature; free will was an illusion fostered by ignorance. Spinoza added that the philosopher could attain to freedom of a sort by recognizing the true nature of things and accepting it. It was in this sense that he sought to deliver men from "human bondage," as expressed in the eloquent concluding sections of the *Etkics*.

Spinoza's philosophy, though it had a semimystical side which was later to appeal to the Romantics, seemed in his own time to be dangerously close to materialism; Hume's (perhaps ironical) description of him as "that famous atheist" with his "hideous hypothesis" represented a common reaction. Certainly Leibniz, though he had known Spinoza personally as a young man, was anxious to avoid being thought to share his views. His own philosophizing can be represented as a sustained if not very successful attempt to avoid falling into Spinozism. Against Spinoza's all-embracing monism he maintained the existence of a vast number of individual substances, each complete in itself, of which the human soul was the most familiar example. These "monads" nere spiritual realities and, indeed, the only realities, for material things did not in the strict sense exist; it was only at the confused level of sense perception that men took them to be real. Each monad was self-determining, the internal nature of each being the source of whatever happened to it, though thanks to God the activities of all were harmonized. Determinism nas avoided (or so Leibniz thought) by distinguishing between truths of reason, which were logically necessary and therefore could not be other than they mere, and truths of fact, which mere contingent and depended only on God's decision to bring into existence the best of all possible worlds.

Leibniz had a mind which was at once highly acute and comprehensive in its range; on many points of detail he made suggestions which later philosophers found instructive. In some branches of philosophy, notably in logic, his ideas uere revolutionary. But he was not a gifted writer, and he lived at a time when a new method of philosophizing was beginning to come in, making his own approach appear dogmatic and uncritical. Except in his native Germany, a backwater in European culture at the time, his philosophical work had little immediate effect. *(See* further BODY AND MIND; IDEALISM; RATIONALISM.)

Locke and the "New Way of Ideas."—The new method of philosophizing just referred to owed its origin to John Locke (1632–1704). More than any other philosopher of his time Locke bridged the gap between two ages and two traditions, for though he shared much of the rationalistic outlook of the 17th century and icdeed was in some respects a very conservative thinker (as witness his political theory, which falls firmly into the natural law tradition), he even so initiated methods and procedures which were to be typical of the following century. His work led to a shift in the interests of philosophers and to a diminution in their ambitions.

Descartes, Spinoza and Leibniz had each sought to construct an elaborate metaphysical system, and Descartes at least had hoped to make his metaphysics the basis for a speculative physics. Locke, as he made clear in a famous passage at the beginning of his *Essay Concerning Human Understanding*, was more modest. "In an age that produces such masters as the great Huygènius, and the incomparable Mr. Newton," he wrote, "it is ambition enough to be employed as an under-labourer in clearing the ground a little, and removing some of the rubbish that lies in the way of knowledge." This task could be achieved if philosophers would turn their attention from the construction of systems to the examination of ideas and to the question of their significance; in more recent terminology, to problems of philosophical analysis. It was with the analysis and clarification of the idea of knowledge that the *Essay* was explicitly concerned.

What makes this passage of special interest is that here for the first time in modern philosophy there is suggested a clear division of function between philosopher and scientist, hitherto thought of as one. But Locke's innovations were not confined to this major step. He suggested not only a task for philosophers but also a way of solving philosophical questions: by the use of what he called the "historical, plain method." This was, in effect, an appeal to experience and, in particular, to the experience of consciousness as revealed in introspection. By taking this simple step, Locke believed, men could eliminate from their thought much pretentious but unfounded dogma, for instance that associated with the contemporary doctrine of innate ideas. Men had only to look at their own thoughts to see that there was nothing to be said for that doctrine. In introducing the "historical: plain method" Locke gave a psychological twist to philosophical investigation which remained a prominent feature of the study till the beginning of the 20th century.

Locke was neither a wholly consequential nor even a very powerful thinker, yet the *Essay* proved a fertile starting point for subsequent discussion. The problem of the origin of ideas, which so largely occupied 18th-century philosophers, was clearly stated there; and the ideas to which they gave particular attention, substance, "power" and self-identity, for instance, had all been examined by Locke. The difference between Hume and Kant about the function and status of *a priori* propositions arose, in effect! out of the treatment of knowledge in book iv. Similarly, Locke's interpretation of "reflection" as a kind of "inner sense" set the stage for later discussions of the problem of self-knowledge. On these and other points Locke may often have proved misleading, but that he was influential could not be denied. (See further CAUSALITY; INNATE IDEAS; PSYCHOLOGY. HISTORY OF.)

Sense and Reason in the 18th Century.— The 18th century, so often described as the Age of Reason, began philosophically with a sharp reaction against rationalism. The prestige of Descartes and the Cartesians slumped, partly because of the work of Locke. but still more because of the supersession of Cartesian physics by the less speculative theories of Newton. It was only in the field of mathematics, as Hume observed, that the claims of reason had been vindicated, anu they were successful there because what was in question was relations between ideas. not matters of fact. For knowledge of matters of fact and of existence, experi-

ence (by which was meant sense experience) was essential.

This movement toward empiricism, as it was subsequently called. had its counterpart in the ethical sphere when the intellectualistic accounts of such writers as Ralph Cudworth and Samuel Clarke gave way to the "moral-sense" theories of the 3rd earl of Shaftesbury and of Francis Hutcheson *(see* also ETHICS, HISTORY OF). It was carried to its farthest extent when Hume declared *(Treatise of Human Nature,* ed. by L. A. Selby-Bigge, p. 183, 1896) that belief *(i.e.,* what had traditionally been called "judgment") was "more properly an act of the sensitive, than of the cogitative part of our natures." It should be pointed out. however, that despite such remarks Hume's outlook was rationalist in a different sense. in so far as he attached no importance to immediate feeling or "enthusiasm" in the sphere of religion. In this respect he and other writers of the Enlightenment did not diverge from the Cartesian tradition.

'Hume's philosophy is partly built on certain theories of George Berkeley (1685–1753), who in turn was much indebted to Locke. The debt was, however, negative rather than positive. in so far as passages in the *Essay* set Berkeley thinking and provided him with premisses from which he drew conclusions of his own. These conclusions principally concerned the status of the so-called "external" world. Locke, following Descartes. had held that the immediate objects of human perception are ideas in the mind. but had added that we must suppose these ideas to be caused by independently existing material things. of which we could have no direct knowledge. Berkeley showed that. given Locke's premisses, no such inference was warranted. There could be no causal inference from the occurrence of ideas to the existence of "inert" material bodies, for nothing in experience justifies us in thinking that such bodies could be causes. and indeed we had difficulty in attaching a meaning to the very idea of such entities. The only possible cause of our ideas was a "spirit." Hence Berkeley drew two conclusions: first, that the familiar things of sense must be thought of as collections of ideas, having no existence "without the mind"; and second, that we must suppose the existence of an infinite spirit who excites ideas in us and thus makes our experiences correspond.

Berkeley's philosophy was written. as the title of his *Three Dialogues* put it. "in opposition to Sceptics and Atheists"; but it is doubtful whether it ever achieved much for the anticeptical cause. Plain men from Samuel Johnson onward have found its argument against matter paradoxical in the extreme. while its constructive side is too lightly sketched to be convincing. Historically. its main effect was on David Hume (1711–76), himself a notorious sceptic. who drew from it arguments to strengthen his own radical empiricism. The features in Berkeley on which Hume fastened were (1) his polemic against abstract ideas. which had been introduced by Berkeley to discredit the notion of material substance, but the antimetaphysical implications of which were, as Hume saw, much wider; and (2) his explanation of the causal relation as met with in nature as being no more than a relation of regular succession or. as Berkeley had it. of "sign" and "thing signified." Using (1) as a means of eliminating spiritual as well as material substance. Hume went on to argue that the analysis given in (2) was valid for all cases of causation, including the activities of human agents. All events are "loose and separate." no one happening relates intrinsically to any other. Connections between events there are. but they are external connections only, for "*A* causes *B*" means no more than, roughly, that (1) *A* precedes B in time; that (2) similar sequences have been observed in the past; and that (3) as a result there is a strong tendency in the mind to expect something like B when *A* occurs. It should be noticed that accepting this analysis of causality means recognizing that causal relations can hold only between what is capable of being experienced—a consequence which casts grave doubt on the use of the concept made by many earlier philosophers.

Hume's thought is misrepresented if we lay exclusive stress on his empiricism. There is another side to it. which he himself called "scepticism." though he used the word in a different sense from Berkeley's. The object of his scepticism was human reasoning. or rather that part of it which concerns questions of fact. the reasoning which we employ in history and in daily life as opposed to that n-hich we employ in mathematics. Hume pointed out that all such "probable" or "moral" reasoning. as he calls it. proceeds on a principle which cannot be proved, the principle that the future will resemble the past: and he argued that because our confidence in this principle cannot be rationally justified. it must be derived from custom and habit: that is. it must have a nonrational basis. Men therefore deceive themselves if they suppose that their possession of reason makes them superior to animals. for in this all-important matter both are in precisely the same case. Outside the field of strict demonstration. human thought and animal thought proceed on the same lines. *(See* further INDUCTION: SKEPTICISM.)

These challenging observations were little appreciated by Hume's contemporaries. The *Treatise of Human Nature,* as its author complained. "fell dead-born from the press"; and the two *Enquiries,* in which Hume served up his ideas again in a somewhat emasculated form. attracted little intelligent comment. It was not till the time of Kant that the force of Hume's thinking was recognized. Meanwhile his fellow countryman Thomas Reid (1710–96) sought to answer scepticism by elevating common sense to be the criterion of philosophical truth. in a way that interestingly anticipates the work of G. E. Moore in the 20th century. The Scottish school founded by him *(see* COMMON SENSE, PHILOSOPHY OF) was. however, largely undistinguished and left little permanent mark on philosophical thought.

The Enlightenment, Kant and Hegel.—The most striking feature of the intellectual life of the 18th century was the way in which traditional Christian beliefs. still largely accepted by Descartes and even by Locke. lost their hold over men's minds and gave way to a different creed. There were. of course. many educated men, including some of the most eminent. such as Newtop. who remained pious Christians: and indeed it was the exception rather than the rule for a man to proclaim himself an atheist or a materialist. But the atmosphere of the age. that of the Enlightenment. was hardly congenial to the claims of religion. Emphasis was everywhere laid on the need for tangible evidence and for clarity of thought. in a way hostile to anything that savoured of the mysterious. Science, which had already done so much to explain the wonders of nature. was confidently expected to proceed to fresh triumphs. and it was widely believed that these would be in the world of human affairs. Meanwhile the banishment of superstition and "metaphysics" (already a term of abuse) was an essential condition of further advance.

It is against this background that we must judge the philosophies of Kant and his successors. Kant himself was in many respects a child of the Enlightenment: he shared its great respect for science and sympathized with its humanist ideals. But he emphatically protested. in the name not so much of religion as of morality. against the prevailing tendency toward naturalism. The belief of the *philosophes* that the moral nature of man could be compassed in scientific terms was. he maintained. plainly false. His successors, notably Hegel, n-ent farther. Living at a time when Romanticism was in the ascendant, they put forward radical criticisms of the Enlightenment's whole outlook, alleging that its intellectualism stood condemned for utter failure to do justice to the rich individuality of things as we are immediately am-are of them and demanding a more adequate philosophy that should do just this. Yet it is notable that Hegel at least did not propose to turn the clock back to the simplicities of a prescientific age: if he questioned the omnicompetence of science. this did not blind him to its achievements. Whatever defects the Enlightenment's ideal of clear and precise thinking might have, it was no remedy to proceed to the opposite extreme and abandon the attempt to think altogether. Mere feeling was as one-sided and inadequate as mere thought.

Immanuel Kant (1724–1804) was a student at Konigsberg at a time when the prevailing philosophy in the German universities was that of Christian Wolff (1679–1754), a follower and popularizer of Leibniz. Kant, however, had the good iortune to be introduced by his teachers not only to the ideas of Leibniz but also to those of Newton, whom he never ceased to admire. His early work was as

much scientific as philosophical, and though the balance of his interests shiited later he continued to follow scientific developments with close attention. Philosophically, he was influenced by Hume as well as by Leibniz, while Jean Jacques Rousseau, with his emphasis on the priority of the moral over the intellectual nature of man, also affected his thought decisively. His development mas slow; it was not till the 1760s that he began to write philosophical essays of importance and not till 1781 that his first major work, the Critique *of* Pure Reason, was published. Thereafter he poured out an astonishing series of treatises on a wide variety of philosophical topics. His ideas were, more often than not, obscurely and pedantically expressed, but their force and originality were apparent irom the first.

The aim of the *Critique* of Pure Reason, in the words of its author, was "to abolish knowledge in order to make room for faith." The declaration can easily be misunderstood. Kant was far from being antirationalist in his general outlook; on the contrary, he pointed out — indeed overemphasized — the role of reason in natural science, and questioned its pretensions only when employed outside what he thought to be its proper sphere. The target of his polemic, in fact, was metaphysics, understood as a study which claimed to give knowledge of a suprasensible world. There were three issues, Kant declared, which were of fundamental concern to human beings: the existence of God, the freedom of the will and the immortality of the soul; and metaphysicians claimed to deal with each of these burning topics. Unfortunately for their pretensions, however, they had never been able to establish anything definitive on any one of them, and the time had now come, Kant thought, to make clear why they never had and never could. The truth was that such questions were beyond the competence of human reason, which could be put to work effectively only mhen it had empirical data on which to operate and could continue to function properly only if it remained within the sphere of experience. Since God and the soul as discussed by metaphysicians were not objects of experience, reason could decide neither for nor against them. But Kant did not draw the conclusion, as some later philosophers have done, that all talk about such topics must be meaningless; he argued rather that belief in God, freedom and immortality, though not capable oi justification on intellectual grounds, was none the less necessary for moral purposes. The moral agent, whether conscious of it or not, acted as if he accepted these beliefs, and indeed his'actions made no sense without them. Thus morals or "practical reason," as Kant called it, filled the gap which critical scrutiny of the pretensions of speculative reason had revealed. (See further ETHICS, HISTORY OF.)

Kant is important historically not only for his attempt at a large-scale synthesis but also for many of his detailed suggestions. He succeeded in sharpening many old issues and in bringing to the fore many new ones. Thus his dichotomy oi analytic and synthetic judgments, with the accompanying attempt to show that there are judgments which are at once synthetic and a *priori,* made possible a fresh treatment of the problem of innate ideas in the celebrated doctrine of categories. while his stimulating handling of the concept of teleology in the Critique *of Judgment* both illuminated old controversies and revealed iresh problems implicit in the language of the newly developing science of biology. For better or worse, his philosophical vocabulary affected the usage of philosophers for the nest century and more. His introduction of the notion of a "transcendental" argument, alleged to be neither deductive nor inductive, was part of an attempt to distinguish clearly between philosophy on the one hand and the empirical and exact sciences on the other; ii not wholly successful, it nevertheless called attention to logical questions which previous philosophers had overlooked. (See further CATEGORY; KANT, IMMANUEL; TRANSCENDENTALISM.)

Kant wrote his main works at a time of intellectual ferment in Germany, and his ideas had scarcely been made public beiore they were criticized by his younger contemporaries. The cautious empiricist strain in his disposition, his antipathy to speculation which could not be tested by evidence. his liking ior cut-and-dried formulas and sharp dichotomies — none of these mere to the taste of a generation already iniected with Romantic ideals. Johann Gottlieb Fichte (1762–1814), who at first claimed to be his disciple, developed Kant's ideas in a way that tended to play up the role of the a *priori* factor in knowledge, which Kant had recognized but strictly circumscribed, and to play down that of the empirical element. F. W. J. von Schelling (1775–1854) carried the same tendency farther and at the same time attempted a fresh metaphysical synthesis, in which the idea of life mas made central at the expense of the mechanical concepts on which Kant had laid particular stress. Neither of these writers made much of a lasting impression. however; the thought of both was too lightly sketched to bear serious examination. It mas not long beiore both mere superseded in the public eye by Hegel.

The reputation of Georg Wilhelm Friedrich Hegel (1770–1831) has varied more than that of any other major philosopher. Admired almost to the point of adulation by some of his contemporaries, he has subsequently been denounced as guilty of almost every intellectual crime. A metaphysical word-spinner, seeking to replace clear thinking and patient empirical inquiry by alleged speculative insight and intuition: the father of political fascism and the grandfather of political communism; an enemy to science and the patron of obscurantism: these are among the descriptions which have been applied to him. In fact his views were often sober in comparison with others current at the time; they were not deliberately obscurantist though they were oiten obscurely expressed; and if they were opposed to the intellectual and political ideals of the Enlightenment, the opposition was openly avowed and an attempt made to offer a rational justification of it.

The basis of Hegelianism, as already indicated, lay in a contrast between life as immediately experienced and thought as commonly conceived in the generation immediately preceding Hegel's own. Like Schelling, Hegel was opposed to the mechanical interpretation of nature favoured by the physicists and by Kant; but his philosophy was not biologically centred as Schelling's was. The models irom which he drew his key notion of a whole which combines unity with self-differentiation were rather, as his early writings show, certain human experiences and institutions; it is notable that his earliest criticisms of Kant were not of the latter's general philosophy but of his ethics. Hegel held that a more adequate logic than the logic of tradition was needed to think the world as it really is; and he believed that he had found the key to such a logic in his dialectical principle. Traditional logic applied only to the operations of the understanding (illustrated par excellence in the thinking of natural scientists), which certainly had their uses but could issue only in abstractions; dialectical logic alone was sufficiently supple to do justice at once to the similarities and to the differences of things.

Hegel was a great systematizer; and one result of his work was to reverse, temporarily at any rate, that tendency to make a modest estimate of philosophy's competence which had set in with Locke. The Hegelian philosopher, like Plato, took all knowledge and all existence for his province. What is more, Hegel was not content simply to affirm this as a matter of principle; he himself had considerable knowledge in many diverse fields and brought his philosophical theories to bear on all of them. Not surprisingly, the degree of success that he achieved in attempting a uniiorm philosophical interpretation of a wide variety of phenomena varied; he himself showed more understanding in some fields than in others, and his principles (which sprang irom reflection on particular conceptual schemes) could not be applied with equal iacility to all types of material. Later critics have tended to fasten on those parts of his system, philosophy of nature in particular, in which he was least successful. From the historical point of view, however, it is well to stress not these, where his influence was negligible, but rather his writings on such topics as religion, law, aesthetics and history, where he often displayed real insight and where his detailed suggestions have proved of interest even to those who disagree with his philosophy. (See HEGEL, GEORG WILHELM FRIEDRICE; ETHICS, HISTORY OF.)

19th and 20th Centuries.—Philosophy after the death of Hegel no longer presents the spectacle of order which it is possible to discern without undue distortion in the thought of the two preceding centuries. There were a number of reasons for this state of affairs. One was quite simply that, in the rest of the 19th century at any rate, no major thinker of outstanding originality arose to dominate the philosophical scene. Men of ability worked at the subject, but they mostly followed one of the existing traditions rather than tried to branch out on lines of their own. The fact that many of them were professional teachers in universities, well acquainted with the work of past philosophers, may be partly responsible for this. At all events it is noteworthy that the publication of Charles Darwin's *Origin* of Species in 1859, while it had its philosophical repercussions, led to no development of importance inside philosophy in the way in which Galileo's work had led to Descartes and Newton's to Kant. A further factor was the increasing effect of national differences on philosophical practice. Descartes, Spinoza and Leibniz were men of international repute, who had their correspondents in most of the countries of western Europe; that one was a Frenchman, one a Dutch Jew and the third a German had little importance. But by the end of the 18th century the most original and significant contributions to European philosophy were being made by men who wrote a language which few outside Germany could understand and whose background included elements, such as German mysticism, which were certainly not the common possession of the whole continent. The result was not only that Kant and Hegel won little general appreciation in their own lifetimes, but, more serious, that philosophers in different countries tended to conceive of their subject on widely different lines. While Germans tried to construct elaborate metaphysical systems: Frenchmen carried on the Enlightenment tradition of empirical psychology as practised, for instance, by E. B. de Condillac, and Englishmen engaged. in philosophical analysis in the manner of Locke and Hume. There was indeed, as the remainder of this article will show, a good deal of cross-fertilization among these different strains; yet, to speak broadly, the divergences remained and indeed were still to be found in the middle of the 20th century.

It will be possible here to give only the brieiest of sketches of some of the main philosophical currents after Hegel.

Hegelian Influence.—The system of Hegel came under sharp attack within a few years of its author's death, yet Hegelian ways of thinking were persistently influential throughout the 19th century. The notion that philosophy is a synoptic study appealed to the age, and there were many attempts, by writers who acknowledged no debt to Hegel as well as by professed Hegelians, to construct metaphysical

syntheses. Herbert Spencer (1820–1903), who tried to apply the concept of evolution throughout the sciences, may be mentioned as belonging to the first class; even Auguste Comte (1798–1857), despite the hostility to metaphysics which was so prominent a part of his "positive" philosophy, recalls Hegel in his attempt to present a unified picture of the whole of knowledge and in trying to find a law of development in history. Comte's preoccupation with the social sciences also has its parallel in Hegel. The "dialectical materialism" of Karl Marx and Friedrich Engels is easily the most celebrated system to admit indebtedness to Hegel, though few non-Communists have ranked it high from the purely philosophical point of view. Among more academic thinkers who continued the Hegelian tradition or felt Hegel's influence may be mentioned Thomas Hill Green, Francis Herbert Bradley, Josiah Royce, Alfred North Whitehead, Henri Bergson and Benedetto Croce (see further NEO-HEGELIANISM).

In Germany a revival of Hegelian studies in the early 20th century, initiated by Wilhelm Dilthey, himself in some respects a latter-day Hegelian, led to renewed interest in Hegel's first writings, where his criticism of the Enlightenment's outlook is developed without any of the rigidity of the later system. One result of this has been that certain of Hegel's doctrines and techniques are reflected in the work of writers who, at first sight, stand in a very different tradition; the most notable example of this unexpected reflection occurs in the work of Martin Heidegger (see below).

Empiricism and Logical Analysis.—Throughout the period of the Romantic movement and its philosophical counterpart there were philosophers in Great Britain and France who remained true to the ideals of the 18th century. Jeremy Bentham (1748–1832), whose main debts were to the associationism of David Hartley, to C. A. Helvétius and, through these two, to Hume, is only the best-known example. His follower James Mill (1773–1836), more important as a philosopher if less noteworthy for his practical influence, is another instance. The Benthamites as a group were strongly rationalist in their outlook; they were also passionately convinced that mental phenomena can all be explained in natural terms. They could see only coniusion, or worse, in talk about philosophy's needing to engage in "transcendental" arguments, or in attempts to distinguish the faculties of reason and understanding. As a contemporary said, the Germans were "metaphysically mad," an opinion which seemed to be confirmed when S. T. Coleridge spoke up for them in Biographia *Literaria*.

Bentham and James Mill would doubtless have described themselves as empiricists, yet neither contributed much to the theory of empiricism (Bentham was primarily interested in ethics and politics and hlill in psychology). James's son John Stuart Mill (1806–73) is more notable in this connection. J. S. Mill's *System* of Logic (1843) contains a iairly comprehensive restatement of the case for empiricism. as well as an attempt to work out the inductive logic which he thought to be of far greater utility than the deductive logic of tradition. Mill had little difficulty in exposing the hollow character of the "intuitions" on which his opponents, whose affinities were with the Scottish school, mostly relied; but the case that he made out for his own positive principles was iar irom watertight, as Bradley and others were later to show. It is astonishing, indeed, that he could have written so naively with the discussions of Hume's Treatise before him. (*See* iurther INDUCTION; LOGIC, HISTORY OF.)

Mill's conception of deductive logic was wholly conservative; he equated "ratiocination," as he called it, with syllogism and took his account of syllogism, on the formal side at least, entirely from Aristotle. The rest of the century, however, saw considerable changes in the state of formal logic, changes which, in time, had important philosophical repercussions. George Boole (1815–64) in his *Mathematical Analysis* of Logic (1847) began a process which served to bring out the restricted and incomplete character of the common textbook account of deduction. 30 far from all demonstration's being syllogistic, syllogism was only one of a wide variety of patterns of demonstrative inference. Meanwhile Gottlob Frege (1848–1925) was concerning himself with questions about the foundations of mathematics (a subject on which Mill had touched unsatisfactorily) and arguing that logic and arithmetic were continuous, since arithmetical notions can all he explained in purely logical terms. The work of Boole and of his successors was brought together with that of Frege and the whole extended and given definitive expression in the *Principia Mathematica* (3 vol.; 1st ed., 1910–13) of A. N. Whitehead and Bertrand Russell.

This work more than any other gave impetus to the analytic and empiricist movements which became so prominent a feature of philosophical life in the English-speaking countries in the first half of the 20th century. It should be pointed out, however, that the supporters of these movements were by no means united in their philosophical outlook. They fell into two main groups. The first: deriving from Bertrand Russell (1872–) himself, had as its program the introduction of scientific method into philosophy. Metaphysics having been set aside, in the approved Enlightenment manner, as nonsense, there yet remain residual problems ior the philosopher to solve, a proccss which can be accomplished by the introduction of a carefully defined technical vocabulary and the full use of modern logical techniques. Rudolf Carnap (1891–), formerly of Vienna, later of California, was, apart from Russell, the most illustrious representative of this way of thinking in the 1950s. The other group owed most to George Edward Moore (1873–1958), originally associated with Russell in his criticism of Bradley, and to the later work of Ludwig Wittgenstein (1889–1951), also a iormer associate of Russell's. Moore developed a "defence of common sense" which led him to assert the correctness of the plain man's everyday convictions in face of the sceptical doubts raised by philosophers. Wittgenstein generalized his procedure to show the hollow character of many of the traditional problems of philosophy, including those still taken seriously by the other group of analysts; philosophical puzzles, as he called them, arose out of inattention to the manifold nuances of speech and could be cleared up by examining those nuances with care.

Both groups of logical analysts agree in recommending the resolution of philosophical difficulties by linguistic methods; in this respect their work constitutes a break with the tradition oi psychologism which goes back to Locke. But whereas Russell and Carnap sought for an "ideal" language which should be free of philosophical ambiguity? Wittgenstein did not even recognize the possibility of philosophy's having a special vocabulary of its own. To introduce technical terms in philosophy was to generalize prematurely, a disease to which philosophers were all too prone. The philosopher should neither generalize nor try to explain; he should only describe. And, ii he described correctly, any temptation to make false generalizing statements mould disappear. (*See* iurther LOGICAL POSITIVISM.)

Pragmatism and *Antirationalism*.—Where a British philosopher calls himself an empiricist, an American tendc to call himself a pragmatist. Not that pragmatists would allow an absolute antithesis between the two. William James (1842–1910), who did most to put pragmatism on the philosophical map, described himself as a "radical empiricist"; and C. S. Peirce (1839–1914), who invented the word "pragmatism," not only shared the common empiricist interest in natural science but had a far better grasp of scientific procedures than any oi his British contemporaries. Historically, the difference between the two doctrines rests on the fact that, whereas British empiricism looks straight back to the 18th century, American pragmatism, despite James's suspicion of Bradley with his "block universe," clearly owes a debt to Hegel. The debt comes out in the distrust of formal logic shown by such a writer as John Dewey (1859–1952) and in the related refusal to consider concepts and statements in isolation from the contexts in which they are used. The Hegelian polemic against the "abstractions" oi the pure understanding reappears here.

There is a iurther and more substantial difference which deserves to be noted. The British empiricists, irom Locke to Russell, tended to assume with Descartes (and for that matter with Plato) that there are always two distinct components in knowledge: the knowing subject and the known object. They agreed with Descartes again that knowledge ideally occurs where the subject, which they identified with mind, is in the presence of, or directly acquainted with, the object, so that the latter can be grasped by the former. The whole operation is conceived as passive, like seeing: the object imprints itself on the mind without effort on the mind's part. This analysis is decisively rejected by pragmatists. The typical cognitive situation for them is one where an animate body seeks through its sense organs to learn about its environment, with a view to acting on it later. A living thing is most truly itself not when it is passive but when it is doing something, with the result that knowledge is an activity and, for that matter, an activity of the whole organism. It should be obvious that this divergence brings to light a profound contrast of metaphysical outlooks, a contrast which may even reflect a significant difference of national temperaments. (See further PRAGMATISM.)

James is sometimes described as "anti-intellectualist" because he said that men's "passional and volitional" natures were, in certain circumstances, entitled to consideration when it was a question what to believe; the same charge was brought against Henri Bergson (1859–1941) for arguing that the intellect is a practical instrument which distorts the nature of fact even if it distorts it to good biological purpose, and ior maintaining that the road to ultimate truth must accordingly be through "intuition." Later thought, however, showed a more thoroughgoing antirationalism than is to be found in either of these writers. Soren Kierkegaard (1813–55), a Danish theologian, developed a bitter criticism of what he took to be the panlogism and optimism of his older contemporary Hegel. The notion that reality can be comprehended by reason, however refined that faculty was taken to be, broke down in face oi the facts, for there were elements of the "absurd" in the real world which could not be fitted into any tidy intellectual scheme. It was decision, Kierkegaard argued, which introduced these elements. No amount of comprehension of the facts of a situation would make a man's mind up; a man had to commit himself when he made a decision, and his doing so was a leap in the dark which at once affirmed his existenee and could not in principle be predicted. Kierkegaard had little influence in his own time or immediately after (though some oi his views have parallels in the thought of Arthur Schopenhauer and Friedrich Nietzsche); but the rediscovery of his work in the 20th century gave his outlook wide currency. The German philosopher Martin Heidegger (1889–), the first part of whose obscure but original work Sein *und Zeit* appeared in 1926–27, was profoundly affected by him; and it is from the thought of Kierkegaard and of Heidegger that the various existentialist philosophies which were so popular on the continent of

Europe immediately after World War II drew most of their ideas. (W. H. W.)

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PHILOSOPHY AND PHILOSOPHICAL STUDIES.

"Philosophy" is a word whose range of usages can scarcely be explained without some account of its history. It is derived from the composite Greek noun φιλοσοφία which means the love or pursuit of wisdom. Herodotus uses the corresponding verb φιλοσοφεῖν when writing of Solon's travels in search of knowledge; and Thucydides puts it into the mouth of Pericles in his account of the famous funeral speech about the Athenian way of life. In these passages it suggests especially the attempt to satisfy curiosity; but σοφία like the English word "wisdom," implied not only wide knowledge but also sound judgment about the values of different things in life (*i.e.,* about what is most worth pursuing for its own sake) and even sometimes shrewdness in practical decisions; so that φιλοσοφία was in origin a very general word for the pursuit of mental excellence. Pythagoras is said to have been the first to call himself a philosopher (φιλόσοφος), but we know so little for certain about him that we cannot tell what nuances of meaning the word had in his usage. In the Platonic dialogues it is often used by Socrates to describe a man engaged in the sort of inquiry that he himself pursued; and there can be little doubt that the historical Socrates called himself a philosopher, while disclaiming the title of σοφός, which was given traditionally to Solon and the other sages of antiquity. There is here the beginning of a specialized or technical usage of the word, and Plato's representation of Socrates has had so great an influence on western thought that philosophy is still thought of as a study which deals for the most part, though not exclusively, with the subjects of Plato's dialogues and proceeds by the Socratic method.

The earliest of the Greek thinkers whose names were afterward included in histories of philosophy recognized no divisions of knowledge. The records of their sayings contain material of all sorts, from speculations about the constitution of the world by condensation and rarefaction of a single stuff to reflections about forms of government, and from observations of eclipses to advice on the management of children. By the end of the 5th century B.C., however, arithmetic, geometry, astronomy and music had been recognized as distinct studies. They are the μαθήματα, or disciplines, from which the word "mathematics" is derived, and for a long time they retained their special position as the first of the special sciences; thus they were still grouped together as the *quadrivium* in the curriculum of seven liberal arts taught at the mediaeval universities. The historical Socrates seems to have had no more than an intelligent layman's appreciation of these studies, and we are told that he gave up speculation about the nature of the physical world in order to concentrate attention on the search for definitions of universal notions and especially of those notions that have to do with human conduct and human character. But in the dialogue of Plato called the *Republic* he is represented as saying that the mathematical studies are a necessary preliminary to philosophical training. According to the scheme of education outlined there, anyone who would be a philosopher must learn the interconnections of the various sciences that are commonly taught separately, and no one can hope to make progress who lacks the power of *synopsis* (*i.e.,* of seeing things together). But all this is preparatory to the understanding of a system in which all "forms" (*i.e.,* characters in which individual sensible things may participate) have their places determined by their relation to the supreme Form of the Good.

It is difficult to work out any really convincing development of the scheme suggested by Plato in this dialogue. where his thought seems to be most ambitious; and we may reasonably suspect that Plato himself was unable to produce any detailed formulation that satisfied him. For he had recourse on various occasions to various analogies and sometimes even used the language of mystical illumination. But there can be found here already a number of features which recur constantly in the work of those later writers who are coinmonly accounted philosophers and which may therefore be taken as marks of philosophical thought.

Plato's Four Marks **of** Philosophical Thought.—First, there is the notion of a study in which the various special sciences are to be related together and understood as parts of one system. In recent times the increase of knowledge has been so rapid that it is difficult if not impossible for anyone to be master of the whole of a science such as chemistry, and we have therefore much more reason than Plato ever had to be worried about the dangers of specialization in education. So long as our plans for counteracting these evils do not take us beyond the boundaries of a single science, such as chemistry, we do not think that they have any connection with philosophy; but if we are more ambitious and try to provide a conspectus of all the sciences, this seems to us still a philosophical enterprise. To make clear the distinction between the a *priori* and the empirical sciences and to show the relations within the latter group between the physical, the biological and the psychological sciences—these are philosophical tasks, whether or not they are performed by professional philosophers. So too is the clarification of notions of high generality such as that of causation. If, as in physics, the development of a science makes it necessary to raise questions about concepts of this level, the scientist who tries to answer them is conscious that he is engaged for the time being in philosophy. Sometimes, indeed, the word "philosophy" is used popularly to mean any formulation of very general basic principles for a practical activity such as politics or strategy.

Second, there is a contrast between sensible appearance and intelligible reality. Only those are philosophers who "contemplate things as they are in themselves and as they exist ever permanent and immutable" and "set their affections on that which in each case really exists" (Plato, *Republic,* 479–480). According to Plato's account, the realm of appearance is the ordinary world of γένεσις, or happening, about which we can never have more than opinion, while the realm of intelligible reality is the timeless system of mathematical objects and of "forms" such as goodness and justice (*i.e.,* the realm of ideas in the original sense of the word "idea," from which our modern colloquial usage is derived through a long and devious history). In the thought of some later philosophers (*e.g.,* Leibniz, Kant and Hegel) the contrast of sensible appearance and intelligible reality is drawn in a different way, and it may therefore be objected that our second common trait is no more than a superficial resemblance in terminology. Yet, however it may be evaluated, the resemblance is there; it can be found in the works of Indian and Chinese philosophers uho have not been bewitched by the powerful magic of Plato's style and also in the philosophical utterances of modern physicists, who are certainly not Plato's disciples, though subject to his influence, like all other men of western civilization.

Third, in Plato's writings there is the suggestion that there

can be no finally satisfactory account of the system of the sciences which does not connect all reality with the Form of the Good by showing why it is best that things should be as they are. In the *Republic* he makes Socrates assert that the Form of the Good is the source both of being and of intelligibility. Almost certainly Plato did not wish to identify it with the god of whom he speaks in other places; but his language in this passage is like that of theists, and the intellectual satisfaction which he promises is like that which many later philosophers have hoped to furnish by relating all things to God. In Plato's argument the study which enables certain carefully selected guardians of his state to understand the system of "forms" by relating each to the Form of the Good is supposed to be also of the greatest practical importance because it enables the guardians to discern the best way of life for men and so to guide their fellow citizens aright; and again similar claims have been made by many later philosophers on behalf of their study. When men speak of a philosophy, they commonly mean a very general account of things which is likely to affect the outlook or emotional attitude of those who accept it (*e.g.*, by making them more contented or more confident) and also possibly to influence their conduct by making them prefer some course that they might otherwise have found uninteresting or even distasteful. In the west such claims have most often been made on behalf of systems which are in some way descended from Plato's, but talk of philosophy as a world view which affects practical life is to be found also among thinkers whom Plato would condemn as heretics (*e.g.*, among materialists of the Marxist persuasion). Nor is this surprising, since to most persons of any education "philosophy" still suggests the pursuit of wisdom.

Fourth, the intellectual insight of the philosopher-guardians in Plato's *Republic* is supposed to be gained by practice of a special method called dialectic. If we may judge by etymology, this word originally meant the art of discussion, but it was used by Zeno of Elea as a name for his own technique of establishing a conclusion by showing that the opposite thesis. put forward by a critic. led to self-contradiction. One of the difficulties in the interpretation of Plato's account of philosophy is to know whether he fully accepted Zeno's account of philosophical method and, if so. how in detail he thought this would help him to carry out his program. There is a less strict sense in which Socrates might be said to have practised dialectic when he asked his companions for definitions and then tested their suggestions for consistence with ordinary usage. In Aristotle's works an argument is called dialectical when it proceeds from commonly received opinions as distinct from premisses already known to be necessarily true. In later times, for example among the Stoics and again in the middle ages, the word "dialectic" was often used as a general name for logic; and later still it was applied by Hegel and Marx to a special pattern of development by thesis, antithesis and synthesis which they supposed to be characteristic of philosophical thought. Clearly there is room here for a great deal of misunderstanding, and we may suspect without much uncharitableness that a great deal of misunderstanding and muddle has in fact occurred. But it is safe to say that when philosophical method has been explicitly distinguished from the method of other studies it has commonly been held to consist in the clarification of concepts by a technique like Zeno's *reductio ad absurdum.*

"Natural Philosophy" and "Moral Philosophy."—Here, then, in Plato's work we can find four marks of that kind of thought which we in retrospect call philosophical. But it was a long time before the name "philosophy" came to be restricted in ordinary usage to such thought. In the work of Aristotle and his successors for many centuries it still covers all that now would be called science. When he required a name for the Platonic study, including his own criticism of Plato's theses. Aristotle called it "first philosophy"; but the collection of treatises which he wrote about it came to be called the *Metaphysics*, because it was placed "after the *Physics*" (μετὰ τὰ φυσικά) in the ordering of his works by his pupils. His other works were treatises on logic (though not under that name), physics. botany. animal anatomy and physiology, psychology, ethics, politics, rhetoric and poetics. For many centuries to come these treatises were regarded as sections in an encyclopaedia of philosophy; and, long after their authority had been attacked by thinkers of the Renaissance, the subjects of nhich they treated were still described as parts of philosophy. Apparently this usage continued in England when it had become obsolete in some other countries; at the beginning of the 19th century Hegel found it curious that opticians and the like should advertise themselves in English learned periodicals as "philosophical instrument makers." And even now there are survivals of the usage in the titles of certain old foundations: the *Philosophical Transactions* contain papers of all sorts submitted to the Royal society; and there are professors of "natural philosophy" who are engaged on nuclear research.

When the term "natural philosophy," which is a rendering of Aristotle's "physics," was appropriated in the 17th century to the new natural science of Galileo and Newton, it became customary to use the phrase "moral philosophy" to cover not only the field of Aristotle's "ethics" and "politics" but also psychology and all the other traditional parts of philosophy except logic. When he published his first work in 1739, David Hume called it *A Treatise of Human Nature, Being an Attempt to Introduce the Experimental Method of Reasoning Into Moral Subjects.* Except in such survivals as the name of the moral science faculty at Cambridge, the usage has now disappeared, but the explanation of its origin throws light on the development of men's conception of philosophy.

After the time of Aristotle, observational science was continued for a time in the museum of Alexandria and in some of the medical schools, but it ceased to have any place in the curriculums of the philosophical colleges which existed side by side in Athens until the time of Justinian. It is true that the Stoics and the Epicureans talked much of physics in their courses of instruction; but they meant by "physics" speculative systems of cosmology not subject to empirical test, and the philosophers of each school valued their own system chiefly for the bearing that they thought it to have on the way in which men should think of themselves and of their destiny. Thus universal determinism was an important doctrine for the Stoics because it suggested to them an attitude of religious resignation such as that found in Cleanthes' *Hymn to Zeus;* and atomism (which was later to inspire great scientific discoveries) found favour with Epicureans such as Lucretius because it could be made to furnish arguments against superstition. When a young man of Cicero's age went to study philosophy in Athens, the lectures that he heard consisted mostly of arguments for a certain way of life. No intelligent man could find a sufficient guide in the public religion of the time, and an interest in philosophy was not a sign that a man was more unsettled than his neighbours but rather a sign that he was more serious. All the schools preached imperturbability (*i.e.*, the calm which we still call philosophical), but they differed in the accounts which they gave of the good life; and so it was, for example, no accident that in the imperial period many great servants of the state belonged to the Stoic school.

The idea of philosophy which educated men of the 17th and 18th centuries got from their classical reading was that of a study concerned before all else with ends and duties; it was therefore not surprising that they called it moral philosophy when they wished to distinguish it from the new experimental science, then called natural philosophy. If they had read the works of the mediaeval schoolmen, they might perhaps have come to think of philosophy as something more ambitious; but they had no taste for the metaphysical subtleties of St. Thomas Aquinas or of Duns Scotus. Moreover, apart from all literary influences, there was a special reason why they should be interested at this time in moral philosophy. According to the new physics, nature was like a vast machine and all its parts, including living bodies, like smaller machines. If this was correct. how could men be held responsible for their behaviour? How indeed could purposive action of any kind be explained? Stoics and Epicureans had both said that all things were corporeal, but in their time such a declaration meant little more than a rejection of Platonism, because their natural philosophy was vague and undeveloped. Having said that souls consisted of a special sort of matter. they had been

content to go on talking about their thoughts and actions in the usual nay. Now such talk seemed silly, because men had come to think of matter as that which obeyed the laws of mechanics and this conception left no room for spiritual attributes. At this time there was therefore a great need for some account of human life which would show how talk of purpose and responsibility could be reconciled nith talk of mechanical regularity, and the attempt to find such an account was not unreasonably called moral philosophy, though it included difficulties that had never seriously worried the ancients.

Many of the books written to satisfy this need had titles such as *An Essay Concerning Human Understanding*. Sometimes the authors explained their choice by saying that they thought philosophy must begin nith an examination of the faculties by which men acquire knonledge, but there were many nho thought that a correct theory of knowledge nould provide also an immediate solution of the problem about the status of minds and their connection with bodies. In their different ways Spinoza. Leibniz. Berkeley Hume, Kant and Hegel all held this view of the task of philosophy Dugald Stewart probably went too far when he wrote at the beginning of the 19th century for the *Encyclopedia Britannica* (8th ed , vol i, p 227) that a change in the pursuits of philosophers had so altered the meaning of the word "metaphysics" that it nas now applicable to "a11 those inquiries. which have for their object to trace the various branches of human knouledge to their first principles in the constitution of our nature." But it is true that all ph~losophyother than natural science was thought to be concerned with the mind. If, as sometimes happened. the title "moral philosophy" seemed too narrow. it was replaced by the fuller phrase "mental and moral ph~losophy."

Philosophy Distinguished From the Special Sciences.— Since the middle of the 19th century it has become customary to describe physics, chemistry and biology as natural sciences rather than as branches of natural philosophy. and some parts of what was once called mental and moral philosophy have also attained independent status. Psychology, economics comparative philology, social anthropology and the theory of political institutions are all now established as empirical sciences. We may hesitate to call them natural sciences, "nature" being still used in some contexts to make a contrast with "man"; but we no longer count them parts of ph~losophysince they are now studied by specialists without regard to the other parts of the traditional field. In the 20th century even formal logic has become independent as the basic discipline of mathematics. What then is left for the philosopher? Only a study like that nhich Plato prescribed for his guardians, but one which is inevitably more complicated than his because of what has happened in the interval.

When we in our time say that philosophy is concerned with the relations of the sciences. we must take account of the distinction between the *a priori* and the empirical sciences and. within the latter group. of the distinctions betneen the physical, the biological and the psychological. None of these distinctions is wholly nen. but none of them could norry the ancients as they norry us. Plato was content to say that the study of the sensible world never deserved the name of science. and even Aristotle, uho was himself a good observer, had no clear conception of the inductive method by nhich the empirical sciences have advanced since the 17th century. There are also now difficulties of another kind that arise from the development of philosophy itself since antiquity. The demands that Plato and Aristotle hoped to satisfy seem to be natural in the sense that they arise whenever men think seriously about their situation; but it has been argued that some of them are misconceived and that there must therefore be included within the scope of ph~losophythe question whether some parts of the traditional enterprise are possible. Discussion of this matter is not wholly nen : it began with the sceptics of antiquity and was reviled many times notably by Hume and Kant in the 18th century. But it has become especially important in the 20th century when philosophy has been finally disentangled from the special sciences and criticism is more vehement than ever before.

No one wishes to deny that there are genuine problems about the relations of the sciences that can be solved only by hard thinking. The status of a ***priovi*** truth in relation to empirical science—in particular, the problem of the foundation of mathematics—is obviously one such. Another that looks as though it could never be solved by empirical methods is that of the connection between mind and body. From time to time we may despair of our ability to answer these questions, because none of the suggestions that has been put forward seems satisfactory and we can think of nothing better; but to admit this is not to say that there are no such questions. Similarly. no one wishes to deny that the hard thinking required to solve philosophical problems must be dialectical in a large sense of that word; *i.e*, not Hegelian or Marxian, but simply thinking in which we clarify concepts by exhibiting the relations betweem them and showing that denial of these relations would lead to absurdity. Many modern philosophers follow G E Moore in calling such thinking "analysis," and some use that nord as a synonym for philosophy much as Plato used his nord "dialectic." There are advantages in the adoption of a new name for the philosophical method. since "dialectic" may lead to misunderstandings for the reason explained above. But "analysis" in its turn may introduce the misleading suggestion that it is the business of philosophers to find what Lord Russell once called logical atoms.

So far there is no radical departure from the Platonic tradition. On the other hand, there has been strong opposition in the 20th century to all talk of a distinction between appearance and reality (in any but the common-sense way in which it may be said that someone appears bad-tempered but is really quite amiable) and to all talk of justifying a religious outlook by proving something about the norld as a whole (as. for example. that it was created by a benevolent God or that it will inevitably evolve toward some highly desirable consummation such as a classless and stateless society). The writers who are most active in this opposition sometimes call themselves positivists: but unlike Auguste Comte, who invented the name. or Kant. who preceded Comte in rejection of transcendent metaphysics. they do not base their case on the supposed difficulty or impossibility of getting any knowledge about objects that cannot be investigated by the methods of the positive sciences. Their thesis is more like the contention of Hume that it makes no sense to speak of such objects, but is based on considerations about language derived in large part from Ludnig Wittgenstein.

Positivist Criticism.— At first the philosophers of this modem positivist school maintained that no utterance in statement form could be literally significant unless it was either (a) a tautology, interesting only as an expression of conventions for the use of words, or (*b*) verifiable in experience. According to one epigrammatic formulation of their view, the meaning of a statement is the method of its verification. Taken strictly. this thesis commits the holder not only to phenomenalism (*i* e , to the doctrine that statements about material objects are reducible to statements about the sense experiences to be expected in various conditions) but also to solipsism (i e., to denial of the existence of other minds) and even to the assertion that statements about the past are meaningless unless they can be taken as predictions of the experiences which would be said to establish their truth. Phenomenalism was once favoured by many philosophers, in particular by positivists like Ernst Mach who disliked talk of imperceptible physical objects such as atoms; but solipsism is a doctrine that no one outside a lunatic asylum can find congenial, and the reduction of statements about the past to statements about the future is plainly absurd. There have therefore been various attempts to avoid these unpleasant consequences; it was argued by some enthusiasts. for example. that the really important task for a positivist philosopher is to show the possibility of the unification of science by the formulation of all significant statements in the language of physics. Whether this thesis about the sufficiency of the language of physics is true or false (and it seems to be false), it clearly involves a large departure from primitive positivism, since modern physics is full of statements about objects that are essentially imperceptible.

When theoretical physicists constantly make successful use of hypotheses about electrons that are much farther from the realm

of common sense than any speculations of St. Thomas about the behaviour of angels. even those who pride themselves most on the hardness of their heads must allow that there can be no objection in principle to talk of nonsensible objects. But critics of traditional philosophy may still argue with justice that it is powerless to prove all those propositions about suprasensible objects which have been asserted by philosophers in the past; for instance, such propositions as that the world was created by a benevolent God or that souls survive the death of their bodies. For the special method of philosophy is dialectical analysis, and it is evident (or can be made so without much difficulty) that a proof of such a proposition cannot be merely the clarification of a concept. In the past there has been some confusion about this because different kinds of inquiry have not been distinguished clearly one from another. Thus the proposition that there is a God has been taken by most people to be one that can receive empirical confirmation (*e.g.*, from events that look like answers to prayers), and philosophers who have tried to prove it have usually made some appeal to empirical evidence. But this same proposition has also been treated by some philosophers as one that cannot be weakened empirically (*e.g.*, by the absence of events that look like answers to prayers). The two views are incompatible, since no hypothesis can receive confirmation from experience unless it is also at least open to infirmation by experience. Another example of such confusion is to be found in the Marxist account of the evolution of society. According to its supporters, this is not only a scientific theory, well supported by historical evidence and useful for the making of predictions, but also a metaphysical principle that could never be thrown into doubt by the failure of the predictions which enthusiasts professed to have derived from it.

Since the peculiarity of such theses was first nqticed it has sometimes been suggested that it is characteristic of metaphysics to present as a *priori* truths propositions which could be established, if at all, only empirically. This is an unfortunate generalization (or, on another interpretation, an unfortunate proposal for a definition), because the work of Xristotle called *Metaphysics* contains only one book to which the criticism applies. For the most part he and his followers have discussed under this title such questions as the status of universals, the existence of substances (or basic entities) and the nature of causation: in short, problems that can be solved only by dialectical analysis, since they arise from puzzlement about concepts.

Clarification and Discovery. — In an account of the task of philosophy in the 20th century it is not necessary to strike out Plato's suggestion that dialectic will lead to knowledge of the nonsensible; for even positivistic philosophy is concerned with abstractions. But it must be appreciated that this study is something quite different from the concern with nonsensible objects noted in theology or in modern physics. Whereas the theologian and the physicist both profess. to give us information of which we should otherwise have no inkling. the philosopher, whose work is clarification. not discovery. can only set the familiar in a new light. As Socrates said, the answers to the questions which he asks must be known already in some fashion, though never before explicitly formulated Admittedly. philosophers in all ages have discussed questions about the existence of God and the survival of human souls, and many have professed to give proofs or disproofs of these theses. But this is not surprising; for such inquiries are closely connected nith the conceptual inquiries of the philosopher. If. for example, the immortality of the individual soul were proved empirically, we should say that the conclusion was of philosophical interest, not only because it has in the past interested some persons called philosophers, but also because the settlement of the question would involve the drawing of conceptual boundaries in a field which has so far been mapped only with dotted lines and pictures of monsters.

It may perhaps be thought curious that empirical discoveries should have any bearing on conceptual Inquiries: for we have an inclination to say that all questions about meaning must be settled before any questions about fact can be raised. But this is a mistake. In ordinary language, as distinct from the language of a strictly axiomatized system such as geometry, the boundaries of the applicability of nords are not drawn in advance of all applications; on the contrary, such rules as exist are established by usage. and it is often quite easy to think of circumstances for which there is as yet no rule. When the need arises, a rule is established by the adoption of some analogy which seems decisive at the time, and from then on the language is more determinate than it was before.

"Soul," which is the key word of the example. does not occur in ordinary talk. except in such phrases as "the life and soul of the party." It has, indeed, a usage in religious contexts but this depends on assertions that have not been verified in a fashion generally acceptable to scientists or even developed imaginatively to any satisfying degree of detail. We are therefore unable to understand exactly what we are asked to believe. Sometimes it seems relatively easy to imagine situations in uhich we should feel constrained to say that the survival of a soul had been proved; but at other times the supposition seems senseless. because personal identity is connected so intimately with bodily continuity that no incidents of the kind described by spiritualists could ever satisfy us. Getting messages through a medium from a dead man would undoubtedly be something like getting messages through the post from an absent friend; and, if the latter is to be taken as evidence of personal survival. why, it may be asked should not the former also? On the other hand, the survival of a friend who sends messages through the post cannot consist solely in our receipt of the letters; we must assume that he wrote the letters and dispatched them. Do we know even in outline what it means to say that the soul of a dead man has sent a message through a medium? And if not. what is the use of making the remark? The bewilderment which these reflections produce is a sign of the incompleteness of our intellectual map; but the recognition of that incompleteness is itself a philosophical achievement. In ordinary life continuity of memory and bodily continuity are both used as criteria of personal identity. Often one is used without the other, but only because they alnays give the same result when they can be applied together; and so our present use of the word "person" is tied to both, though we might come to use the word differently if the normal association of phenomena were not maintained.

Philosophy and Language. — In the latest phase of the philosophical movement started by Wittgenstein there is no longer any attempt to formulate a general principle for distinguishing between sense and nonsense, not because the supporters of the movement are less critical of the utterances of older philosophers but because they have come to appreciate that language is much more complicated than they once supposed and may therefore "go wrong" in very many different ways. According to this view, ordinary language — that is. the language in which men conduct their practical affairs — is part of the way of life to which it belongs, and all philosophical troubles arise from perversion of it. Words and phrases have meaning not necessarily by standing for things, as proper names may be said to do, but by having a customary use in communication. So long as speakers observe the customs. what they say must at least make sense. though it may of course be unfortunate in various ways. If. however, speakers depart from ordinary usage and introduce novelty. there is always a danger of their talking nonsense, even though the novelty has been suggested by an analogy with something in ordinary usage. Bad philosophy is the theorizing which arises in such situations. and good philosophy consists in making clear the conventions that have been violated. When ne are caught by bad philosophy. we are like flies trapped in a bottle; we buzz about continually, hurting ourselves against invisible barriers, unless we are clever and patient enough to crawl out slowly by the way by which we came in. In short, good philosophy is just liberation from bad philosophy, and its method is a therapeutic technique something like that of psychoanalysis.

It is not difficult to find examples of bad argument into which great philosophers have been led by false linguistic analogies. One about nhich there is no longer any serious dispute is the ontological argument for the existence of God. According to this, God must exist, because we mean by "God" a being such that nothing more perfect could be conceived, and there would there-

fore be a self-contradiction in saying that God does not exist. The reasoning is obviously based on the assumption that the word "exists" may be said to ascribe a perfection; that is, a character for the possession of which a thing is to be praised. But the word "exists" is not in fact used to ascribe a character to things. When we say that a so-and-so exists. we mean that something is a so-and-so: *i.e.,* we assert a proposition which is entailed by every proposition to the effect that a particular thing is a so-and-so. This truth has been accepted as a notable result of analysis in the philosophy of logic, and so there is here a clear case in which good and bad philosophy are related according to the account given above. It would be a serious mistake. however, to suppose that the history of philosophy is nothing but a succession of linguistic muddles. Even the debate about the ontological argument has an interest that is not explained by this description. In a society whose language did not allow for an assertion of existence by any such formula as "God exists" or "God is," the argument could never have occurred to anyone; but what made it seem plausible to Anselm and to a number of very intelligent men after him was something in their religious attitude. They used the word "God" to refer to the object on which that attitude could be appropriately directed, and it seemed to them plainly absurd to say that God's existence was contingent; *i.e.,* that there might have been no God. Now the fact that men have a disposition to take up a certain attitude furnishes no proof of the existence of anything that would be an appropriate object of that attitude; and it might be contended that our ancestors fell into a new and even more serious mistake when they passed from polytheism. with its stories of the birth of the gods, to monotheism, with its assertion of the absolute independence of God. But if there was any such mistake, it occurred long before anyone thought of the ontological argument, and there can be no satisfactory philosophy of religion which ignores this fact.

So too in other fields of philosophy, linguistic confusions when they occur are only incidental to larger problems that cannot be posed or solved without reference to the progress of the special sciences. Men do indeed misuse their language from time to time, but when such misuse has a philosophical interest it is a symptom rather than a cause of intellectual malaise. The patient who has brought himself to a metaphysical neurosis by a purely grammatical eccentricity does not exist outside the imagination of the would-be therapist. Nor is it much better to say. as some modern philosophers do, that all philosophical questions are concerned with "logical grammar." For if "logical" is to be taken in its usual sense (*i.e.,* as signifying connection with the science of logic). the statement is false: and no one has explained any other sense for the word that allows the statement to be both true and useful.

Relation of Philosophy to the Sciences.—The chief point of interest that has emerged from modern attempts to characterize philosophy is the importance of distinguishing dialectical or analytical inquiries about meaning from empirical inquiries about fact. Recognition of this should produce a becoming modesty in those who profess philosophy, but it should not make them abandon the Platonic ideal of a study that is synoptic, gives mastery of abstractions and leads to wisdom of attitude. By continuing to make the last of these traditional claims they do not commit themselves in advance to support of any religious system but simply undertake to present things in such a light that men's feelings may be reasonably grounded. The need for this is especially obvious in moral philosophy, since persons who are conceptually muddled often manifest great moral earnestness in defense of positions that are quite irrelevant to morality. But the need remains the same in all philosophical inquiries, including even discussions of the foundations of mathematics. For it is obvious to a careful observer that persons who put forward theses about the nature of mathematics are emotionally involved. and while it must be supposed that some of them are just confused. it must also be allowed that a certain attitude may perhaps be a necessary condition for the making of discoveries. Thus it can scarcely be an accident that no great mathematician has ever accepted the conventionalist view according to which mathematical truths are manmade.

It follows from the account of philosophy given here that it is impossible to summarize its results in the way appropriate to an article on any of the special sciences. The results of the philosophical work that has been done in the past are to be found in the present organization of studies. It cannot, indeed. be claimed yet that there is a single, coherent world view; but apart from the observations and hypotheses of scientists, there are some pieces of conceptual framework about which there is no serious disagreement among educated men. These are the principles used for the classification of studies in the universities and in encyclopaedias. In order to convince himself of their philosophical character the reader need only contrast. say, the *Encyclopædia Britannica* with Pliny's *Natural* History and notice that. the intellectual progress of the intervening 2.000 years has involved a clarification of ideas of explanation as well as an accuniulation of discoveries. If anyone claims that the clarification of ideas was incidental to the development of the special sciences. we can agree without difficulty; for the distinction made here between clarification and discovery is not supposed to be a division of labour among different faculties.

Organization of Philosophical Studies.—There must nevertheless be some division of academic labour in the modern world, since it is no longer possible for any one man to be a leader in all branches of learning. Perhaps Leibniz, who died in 1716, was the last universal scholar. and his life is a warning rather than an example. In this situation the teaching of philosophy is more difficult than ever before, but also more important. Since no one can hope to contribute much to the clarification of ideas in mathematics n-ho is not himself a mathematician: or to the clarification of ideas in physics who is not himself a physicist, and so on throughout the table of the sciences, it seems inevitable that there should be evolved a number of philosophical disciplines corresponding to the various branches of study whose concepts need investigation. We have philosophy of mathematics (or the theory of foundations). philosophy of physics (including cosmology), philosophy of history (no longer understood in the Hegelian sense as the setting out of a plan to be realized by events, but consisting in a study of historical ideas and methods), philosophy of law (or jurisprudence), philosophy of criticism (or aesthetics), philosophy of language and philosophy of religion. We may expect to hear also of philosophy of biology and philosophy of psychology. Whereas previously many scientists were frightened by talk of philosophy (and not without reason, since professional philosophers were sometimes obscurantists who opposed the growth of new studies), it seems now to be admitted that discussion of the philosophy of his subject (preferably in connection with its history) may be a useful part of the education of a future specialist.

Although some philosophical studies can be distributed among the various faculties of a university in the way suggested. there are others, including some of the most important. that cannot be associated with any specialism because the ideas with which they deal are common to all studies or not involved in any.

First there is epistemology, or the theory of knowledge and its relation to experience, to belief and to language. For Plato this was already an important philosophical inquiry, and in the 17th century it came to be regarded as the necessary preliminary to all other philosophical studies. The reasons for which epistemology obtained this primacy may have been bad; but if philosophy is the dialectical clarification of concepts. it may reasonably be expected to include some explanation of the need for such clarification. and the explanation should come early in a systematic course of study. At the beginning we need some examples of philosophical work taken from one of the special branches of philosophy mentioned above; but when we have learned to distinguish this kind of inquiry from others, we can profitably investigate the nature of the thinking that gives rise to it. This leads on naturally to a philosophical inquiry about the status of minds in the world.

Next there is metaphysics. Here belong not only the task of clarifying very general notions. such as those of substance and causality, but also attempts to throw light on the relations of the

sciences (in particular of physics and psychology) by philosophical method. System building has led to so many failures in the past that it must always be regarded with caution; yet it is important that the project should never be wholly abandoned by academic persons. For if academic persons behave as though they had no interest in the intellectual questions that seem most important to other men, the gap that they leave will soon be filled by others less qualified.

By the study and transmission of the history of thought academic persons can at least make it possible for men to see modern difficulties in perspective, and if the difficulties are of a sort to be solved by philosophical analysis, this is some contribution toward a solution.

Third there is ethics, or the philosophy of moral judgment. This cannot be assigned to any specialism other than philosophy itself, because moral judgment is not an activity for experts but something in nhich we are all authorities. In the past the teaching of ethics has often been confused nith casuistry (*i.e.,* the attempt to set out a detailed moral code by the compilation of moral judgments on situations of all possible varieties) or with exhortations to virtue. Like all other branches of philosophy, ethics is in fact a theoretical study in which we try to clarify concepts. If it has more immediate practical importance than any of the others. that is because muddles about the fundamental notions of morality can have serious consequences in human action. (W. C. K)

PHILOSTRATUS, "THE ATHENIAN" (c. 170–245), the author of the Life of *Apollonius* of *Tyana,* which he dedicated to Julia Domna. wife of Alexander Severus and mother of Caracalla (see APOLLONIUS OF TYANA). He wrote also Lives of the Sophists, *Gymnasticus* and *Epistolae* (mainly of an erotic character). Very little is known of his career. He was probably born in Lemnos, studied and taught at Athens and then settled in Rome. He is said by Suidas to have been living in the reign of Philip (224–249). The common authorship of *Apollonius* and Lives of *the* Sophists is presumed from internal evidence. The Lives are not biographical but picturesque impressions. The *Gymnasticus* contains interesting matter concerning the Olympic games and contests. The *Letters* breathe the spirit of the New Comedy and the Alexandrine poets; portions of Letter *33* are almost literally translated in Ben Jonson's "Song to Celia," "Drink to me only nith thine eyes." The Heroics, formerly attributed to Philostratus the Athenian but probably by another Philostratus ("of Lemnos"), is a disquisition on the heroes of the Trojan War. His other work is the Eicones, ostensibly a critical description of 64 pictures in a Neopolitan gallery.

PHILOXENUS, of Cythera (435–380 B.C.), Greek dithyrambic poet. On the conquest of the island by the Athenians he was taken as a prisoner of war to Athens, where he was purchased by the dithyrambic poet Melanippides, who educated him and set him free. Philoxenus afterward lived in Sicily, at the court of Dionysius, tyrant of Syracuse, whose bad verses he declined to praise; in consequence he was sent to work in the quarries. He later traveled in Greece, Italy and Asia, reciting his poems. and died at Ephesus. According to Suidas. Philoxenus composed 24 dithyrambs and a lyric poem on the genealogy of the Aeacidae. His dithyramb seems to have been a sort of comic opera, and the music, composed by himself, of a debased character. His masterpiece was the Cyclops, a pastoral burlesque on the love of the Cyclops for the fair Galatea, written to avenge himself upon Dionysius. who was wholly or partially blind of one eye. Aristophanes parodied it in the *Plutus* (290). Philoxenus' popularity is attested by a complimentary resolution passed by the Athenian senate in 393.

PHILOXENUS (Syriac, AKSENAYA) (*fl.* c. 500) of Mabbog, one of the best of Syriac prose writers and a champion of Monophysite doctrine was a Persian, born at Tahal in the district of Beth Garmai east of the Tigris. Educated at Edessa, Philoxenus soon attracted notice by his strenuous advocacy of Monophysite doctrine, and on the expulsion of Calandio (the orthodox patriarch of Antioch) in 485 was ordained bishop of Mabbog (Hierapolis) by his Monophysite successor Peter the Fuller. Probably during the earlier years of his episcopate Philoxenus composed his 13 homilies on the Christian life. Later he revised the Syriac version of the Bible and with the help of his chorepiscopus Polycarp produced in 508 the so-called Philoxenian version, used by the Monophysites during the 6th century. He bitterly opposed Flavian II, who had accepted the decrees of the council of Chalcedon and was patriarch of Antioch from 498 to 512. In 512 the Monophysites finally ousted and replaced him by their partisan Severus. But Justin I, nho succeeded Anastasius in 518, was less favourable to Severus and Philoxenus, and in 519 they were sentenced to banishment. Philoxenus was sent to Philippopolis in Thrace and afterward to Gangra in Paphlagonia, where he met his death by foul play in 523.

PHIPS or PHIPPS. **SIR WILLIAM** (1651–1695), colonial governor of Massachusetts, was born Feb. 2. 1651, at Woolnich. Me.. near the mouth of the Kennebec river. In 1687, with a commission from the British crown, he found after a search of many years a wrecked Spanish treasure ship for which he was knighted by James II and appointed sheriff of New England. Poorly educated and ignorant of law, Phips could accomplish little and returned to England. In 1689 he returned to Massachusetts He was appointed commander of an expedition against the French in Canada which sailed in April 1690 and easily captured Port Royal. A larger expedition led by Phips in July against Quebec and Montreal ended disastrously. In 1690 he returned to England and with Increase Blather urged a restoration of the colony's charter, annulled during the reign of Charles II. The crown, at Mather's suggestion, appointed him the first royal governor under the new charter. On reaching Boston in May 1692, Phips found the colony in a disordered condition and, though honest and persevering. he was unfitted for the position. Numerous complaints to the home government resulted in his being summoned to England to answer charges. While in London awaiting trial, he died Feb. 18, 1695.

PHITSANULOK, a province (changwat) and town in north central Thailand. Pop. (1956 est.) 296.358. Area 3,729 sq mi. The province extends from the Laos border in the northeast to the Nan-Yom river system in the southwest. The population is concentrated in the western plains. the eastern districts of Nakhonthai and Wangthong being isolated and underdeveloped. The province is a major producer of rice and has several commercial rice mills. The provincial capital Phitsanulok, pop. (1957 est.) 26.778. is situated about 240 mi. from Bangkok on the railroad to Chiengmai, which runs along the east bank of the Nan. During most of the Ayutthayan period (1350–1767), Phitsanulok town ranked second in size and importance to the royal capital; two of the greatest kings of the era, Naresuan and Ekathotsarot. were native sons. Near the centre of the old walled city is one of Thailand's most revered Buddhist temples. Wat Phra Si Rattana Mahathat. which houses an early bronze Buddha famed for its beauty. The town's commercial centre, which lies south of the city walls, grew rapidly after the construction of the motor road to Sukhothai and Tak in the 1940s. (G. W. SK.)

PHLEBITIS, a medical term for inflammation affecting veins. A distinction is being made between an inflammation of the vein with a blood clot (thrombophlebitis) and a noninflammatory clot in a vein (phlebothrombosis).

Usually the venous condition results from inflammation in tissue surrounding the vessel and extending to its walls. The vein becomes thickened and can be recognized as a definite, perhaps reddened. and very painful cord if it is a superficial vein. When the inflammation extends to the inner coat of the vessel and nutrition of the lining endothelium is impaired, local clotting of blood occurs, the clot being adherent to the vessel wall where it is first formed and extending upward and downward within the lumen (see THROMBOSIS AND EMBOLISM). From the primary focus clotting extends also into the tributaries of the vein, thus inducing widespread obstruction to the return of blood from the part with consequent edema. The condition calls for complete rest because of the danger of dislocating the clot and causing embolism, the danger being greatest when the condition is septic. In most cases, under rest, the inflammation subsides and the primarily affected vein becomes permanently occluded by newly formed

fibrous tissue, but circulation in the part formerly drained by the vein is restored by the opening up of collateral channels. In some regions phlebitis is particularly dangerous; *e.g.*, the lateral sinus to which inflammation from middle ear disease may extend with subsequent cerebral abscess or purulent meningitis or general pyemia. In such cases surgery is the sole hope for the patient.

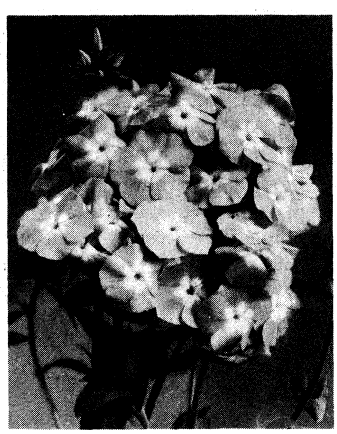
PHLOGISTON: *see* CHEMISTRY: *Theory of Phlogiston.*

PHLOGOPITE, a mineral of the mica group used as an insulator for electrical purposes. Mica mined in Canada and Ceylon is mainly phlogopite, a magnesium mica differing from biotite (black mica) in containing little iron. Sometimes brownish-red and coppery in appearance. it is named from the Greek for "fiery-looking." Usually yellowish-brown, sometimes quite colourless and transparent, it often has a silvery lustre on the cleavage surfaces, hence the names "amber mica" and "silver mica" for some varieties. Phlogopite occurs chiefly as scales and plates embedded in crystalline limestones. The cleavage flakes are not so elastic as those of muscovite (white mica). In Canada it occurs with apatite in pyroxene rocks associated with Laurentian gneisses and crystalline limestones. The principal mining district is in Hull county, Quebec, and near Burgess in Lanark county, Ontario. In Ceylon the mineral forms irregular veins, rarely exceeding one or two feet in width, traversing granulite, especially near the contact of this rock with crystalline limestone. . For the chemical formula and optical and other characters, *see* MICA.

PHLOX, the type genus of the phlox family (Polemoniaceae); the genus consists of about 60 species, mostly perennial hardy plants of great beauty, natives of North America (one Asian), with entire, usually opposite, leaves and showy flowers generally in terminal clusters. Each flower has a tubular calyx with five lobes, a salver-shaped corolla with a long slender tube and a flat flaring edge. The five stamens are given off from the tube of the corolla at different heights and do not protrude beyond it. The ovary is three-celled with one to two ovules in each cell; it ripens into a three-valved capsule. Many species and varieties are tall herbs yielding a wealth of bloom throughout the summer and early autumn. They require a deep, rich, rather heavy loam and a cool moist position.

The dwarf perennial species and varieties, the moss pinks of gardens (P. *subulata),* are suitable plants for the rockery, and as edging to beds and borders. They are trailing and tufted in habit, the branches rooting at the nodes. They succeed in poorer soil and drier situations than the tall kinds. Seed is seldom produced. Propagation is effected by cuttings in July and early August (placed in a cold frame) and by division of the plants, which should be lifted carefully and cut into rooted portions as required. The tufted kinds decay in patches in winter if the situation is too moist.

Phlox drummondi (often called Texan pride) and its numerous varieties are annual, small-growing, hairy plants up to 1½ ft. in height. flowering profusely during the summer months. For earlv flowering they should be sonn indoors in March and April and transferred out-of-doors in June; they succeed if sown out-of-doors in midspring, but the flowering season is later and shorter.



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PHLOX (PHLOX DRUMMONDI)

The tall-growing border phloxes are divided into early and late flowering kinds respectively, the former derived mainly from P. *glaberrima* and *P. carolina,* the latter from *P. maculata* and *P. paniculata,* both common in moist woods in eastern North America. Over 200 horticultural varieties comprising some of the finest garden perennials have been derived from these by selection and hybridization. Phlox come in a large variety of colours, but there are no yellows or true blues. Many of the popular garden sorts have been successfully grown in England; P. *drummondi* and varieties: *P. subulata* and some of the taller border sorts are widely used there as colourful garden subjects.

Since practically all the phlox species are natives of North America, with handsome representatives in every section of the Cnited States, adoption of the genus as the floral emblem or national flower of the U.S. has been urged.

The so-called blue phlox (really a mauve colour) or wild sweet william (P. *divaricata*) is found throughout the woods of east coastal and southern North America. The night phlox is *Zaluzianskya capensis* and the prickly phlox is *Gilia californica.*

(N. TR.)

PHNOM PENH, capital of Cambodia, is situated 125 mi. N.W. of Saigon at the confluence of the Mekong river and the Tonle Sap. The estimated population in 1958, including communities of far eastern nationalities and Europeans, was 400,000.

According to the legend of the town's history, a woman called Penh came in the 14th century to live on the slopes of the hill (Phnom in Cambodian) overlooking the town. A bronze statue of Buddha, which she found in a tree trunk, swept to the foot of the hill during a flood and attracted a crowd of pilgrims, many of whom settled in the vicinity. In 1434 King Ponhéa Yat built his capital on the site. Subsequent kings chose Oudong, but in 1865 King Norodom I once again established the capital in Phnom Penh.

It is a picturesque town at the centre of which is the royal palace with its silver pagoda, throne room and museum. As well as archaeological museums there is the Jayavarman VII art museum. In the associated art school the traditional crafts of weaving and goldsmith's work are taught with modern adaptations. Mimed performances of Buddhistic and Brahminical legends are given by the Royal Company of Cambodian Dancing Girls, wearing gorgeously embroidered clothes. There are schools and a Buddhist university for Pali and Buddhist studies. Although 173 nautical mi. from the sea, Phnom Penh is a major trading port in the Mekong valley. It is accessible all year round to shipping. Cattle, dried fish, rice, maize! cotton and pepper are the chief items of trade. Textiles and soft drinks are manufactured. Steamers connect Phnom Penh with Saigon and many towns on the Mekong and Tonle Sap. Excellent roads lead to Saigon, Angkor and Bangkok; Phnom Penh is also connected by road with Kompong Som, the new seaport being built on the Gulf of Siam about 137 mi. from the capital. There are railways to Bangkok, Saigon and (via Bangkok) Singapore. The airport, from which services operate to Bangkok, Hong Kong and Saigon, is at Pochentong, 5 mi. from the city.

PHOCAEA (mod. *Fokia* or *Fokha),* an ancient city on the western coast of Asia Minor, famous as the mother city of Marseilles. It was the most northern of the Ionian cities, and was situated on the coast oi the peninsula which separates the Gulf of Cyme, occupied by Aeolian settlers, from the Hermaean gull, on which stood Smyrna and Clazomenae. According to Herodotus the Phocaeans were the first of all the Greeks to undertake distant voyages, and made known the coasts of the Adriatic, Tyrrhenia and Spain. Eventually they determined to seek a new home in the west, where they already had flourishing colonies; *e.g.,* Alalia in Corsica and Massilia (mod. *Marseilles*).

Phocaea continued to exist under the Persian government, but greatly reduced in population and commerce. Though it joined in the Ionian revolt against Persia in 500 it was able to send only three ships to the combined fleet which fought at Lade. But a Phocaean took the supreme command. The modern town in the immediate neighbourhood, still known as Fokia, was founded by the Genoese in 1421 on account of the rich alum mines in the neighbourhood.

PHOCAS, East Roman emperor (602–610), a Cappadocian.of humble origin. He was only a centurion when chosen by the army of the Danube to lead it against Constantinople. A revolt within the city resulted in the abdication of the reigning emperor Maurice and the elevation of Phocas to the throne: he proved incapable of governing. When the African governor Heraclius declared against him, Phocas was deposed with scarcely a struggle (610). He died in the same year on the scaffold.

PHOCION, Athenian statesman and general, was born about 402 B.C., the son of a small manufacturer. He became a pupil of Plato and in later life was a close friend of Xenocrates. Under

Chabrias he distinguished himself in the great sea-fight of Naxos (376), and subsequently won the confidence of the allies by his justice and integrity. In 351–349 he entered the Persian service and helped to subdue a rebellion in Cyprus. Henceforward he always held a prominent position in Athens. and although he never canvassed he was elected general forty-five times in all. In politics he is known chiefly as the consistent opponent of the anti-Macedonian party. He countered the eloquence of Demosthenes and his supporters by the plain facts of Athens' situation. He helped to defend Aeschines in 343, and secured lenient terms from Philip after the disaster of Chaeroneia (338). He also rendered good service in the field: in 348 he saved the force operating against the philo-Macedonian tyrants in Euboea by the brilliant victory of Tamynae. Under the Macedonian predominance his reputation increased. Though by no means inclined to truckle to the Macedonians, as is shown by his protection of the refugee Harpalus and his spirited campaign in defense of Attica in 322, he won the confidence of the conquerors, and in the restricted democracy which Antipater enforced he became the virtual ruler of Athens. On the restoration of the democracy in 318, Phocion was deposed. He fled to Polyperchon, but was sent back to be tried at Athens. The assembly shouted Phocion down and condemned him to death unheard. Not long after, the Athenians decreed a public burial and a statue in his honour.

See Plutarch, *Life of Phocion;* Holm. *Gk. Hist.* vol. iii. (Eng. trans., London, 1896).

PHOCIS, an ancient district of central Greece (now two departments, Phthiotis and Phocis; area 1,620 sq.mi. and 802 sq.mi.; pop. 148,322 and 51,472, respectively), bounded west by Ozolian Locris and Doris, north by Opuntian Locris, east by Boeotia and south by the Corinthian gulf. The massive ridge of Parnassus (8,061 ft.) traverses the heart of the country. Between this and the northern frontier range of Cnemis (3,000 ft.) is the narrow fertile valley of the Cephissus, along which lie most of the Phocian townships. South of Parnassus the small plains of Crisa and Anticyra are separated by Mt. Cirphis. Phocis was mainly pastoral.

Its early history is obscure. Its population was reckoned Aeolic, but the dialects are of the West-Greek group, more akin to Doric. There was a tradition that the Phocians once owned land round Daphnus opposite Euboea, and had their frontier at Thermopylae. Later restriction of territory was due to the hostility of Boeotia and Thessaly. The latter in the 6th century even raided the Cephissus valley. In early days Phocians controlled the sanctuary of Delphi. But Delphi constantly strove for independence and about 590 B.C. induced a coalition of Greek states to proclaim a "Sacred War" and free the oracle from Phocian supervision. Thus Phocian influence at Delphi was restricted to the possession of two votes in the Amphictyonic Council.

During the Persian invasion of 480 the Phocians at first joined in the national defense, but their irresolute conduct lost Thermopylae for the Greeks; and at Plataea they were on the Persian side. In 457 an attempt to control the head waters of the Cephissus in the territory of Doris brought a Spartan army into Phocis in defense of the "metropolis of the Dorians." A similar attack on Delphi in 448 was again frustrated by Sparta, but not long afterwards the Phocians recaptured the sanctuary with the help of the Athenians, with whom they became allied in 454. When Athenian land-power declined, Phocian friendship waned, and in the Peloponnesian War Phocis was nominally an ally of Sparta, and had lost control of Delphi.

In the 4th century Phocis was constantly endangered by Boeotian oppression. After helping Sparta to invade Boeotia during the Corinthian War (395–394), the Phocians received assistance from Sparta in 380, but afterwards submitted to the growing power of Thebes. Phocians took part in Epameinondas' earlier inroads into the Peloponnesus, but abstained from the campaign of Mantineia (370–362). In return for this negligence the Thebans secured a penal decree against them for religious offenses from the Amphictyonic synod (356). The Phocians, led by two capable generals, Philomelus and Onomarchus, replied by seizing Delphi and using its riches to hire mercenaries with whose help they invaded Boeotia and Thessaly, and though driven out of Thessaly by Philip of Macedon, maintained themselves for ten years, until the exhaustion of the temple treasures and the treachery of their leaders placed them at Philip s mercy. In 339 the Phocians began to rebuild their cities; in 338 they fought against Philip at Chaeroneia; in 323 they took part in the Lamian War against Antipater, and in 279 helped to defend Thermopylae against the Gauls.

During the 3rd century Phocis passed into the power of Macedonia and of the Aetolian League, to which in 196 it was annexed. Under Roman rule its league was dissolved, but was revived by Augustus, who also restored to Phocis the votes in the Delphic Amphictyony which it had lost in 346 and enrolled it in the new Achaean synod. The Phocian League is last heard of under Trajan.

See Strabo, pp. 401, 418, 424–425; Pausanias x. 1–4; E. Freeman, *History of Federal Government* (ed. 1893), pp. 113–114; G. Kazarow, *De foederis Phocensium instztutzs* (Leipzig, 1899); B. Head, *Historia numorum* (1887), pp. 287–288. Pauly-Wissowa *s.v.*

PHOCYLIDES, Greek gnomic poet of Miletus, contemporary of Theognis, was born about 560 B.C. A few fragments of his "maxims" have been preserved (chiefly in the *Florilegium* of Stobaeus). A complete didactic poem called Ποίημα νουθετικόν or γνῶμαι, and which bears the name of Phocylides, is now considered to be the work of an Alexandnan Christian of Jewish origin who lived between 170 B.C. and A.D. 50.

See fragments and the spurious poem in T. Bergk, *Poetae lyrici graeci,* ii. (4th ed., 1882); J. Bernays, *Über das Phokylideische Gedicht* (1858); *Phocylzdes, Poem of Admonition,* with introduction and commentaries by J. B. Fenling, and translation by H. D. Goodwin (Andover, Mass., 1879). There is an English verse translation by W. Hewett (Watiord, 1840), *The Perceptive Poem of Phocylzdes.*

PHOEBE (*Sayornis phoebe*), the name given to a familiar American bird belonging to the family *Tyrannidae* (the "American flycatchers"). Distinguished by its dark crown-cap, olive-grey plumage, and the white outer vane to the outer tail feather, the phoebe breeds in eastern North America from the south-west Mackenzie southwards, wintering in southern U S A. and Mexico. The bulky nest of moss and mud, lined with grass, hair and feathers, is placed on a beam or under a bridge or bank, often close to or on a building. Say's phoebe (*S. sayi*) is a more westerly species, abundant west of Kansas and Nebraska. The black phoebe (*S. nigricans*) has a more southern range.

PHOEBUS, a common epithet of Apollo (*q.v.*).

PHOENICIA, in ancient geography, the name given to that part of the seaboard of Syria and Lebanon which extends from the Eleutherus (Nahr el-Kebir) in the north to Mt. Carmel in the south, a distance of more than 2° lat. These limits, however, mere exceeded at various times; thus, north of the Eleutherus lay Aradus and Marathus, and south of Carmel the border sometimes included Dor and even Joppa (Jaffa). The harbours which played so important a part in antiquity are nearly all silted up, and, with the exception of Beirut, afford no safe anchorage for large modern vessels. Sidon, Tyre and Aradus, though now connected with the mainland, were built originally upon islands; the Phoenicians preferred such sites, because they were convenient for shipping and easily defended against attack.

The chief towns of ancient Phoenicia. as we know of them from the Amarna tablets (15th century B.C.) and from Egyptian, Assyrian and the Old Testament documents were the following: Acco (now Acre or ʿAkkā, Judg. i. 31), Achzib (now ez-Zib, ibid.), Ahlab (in Assyrian Mahalliba, *ibid.*)—three towns on the coast south of Tyre, Kānāh (Josh. xix. 28). Tyre (Phoen. Sōr, now Sūr), Zarephath or Sarepta (1 Kings xvii. 9 [now Sarafand]), Sidon (now Ṣaidā), Berytus (Biruta in Egyptian. Biruna in the Amarna tablets. now Beirūt), Byblus (in Phoen. and Hebr. Gebal, now Jebeil), Arka, 80 mi. north of Sidon (Gen. x. 17, now ʿArkā), Sin (Assyr. Siannu, ibid.), Simyra (Gen. x. 18, now Ṣumrā), Marathus (non Amrit) not important till the Macedonian period, Arvad or Aradus (in Phoen. Arwād. now Ruād Gen. x 18; Ezek. xxvii. 8, 11), the most northerly of the great Phoenician towns:

Race and Language.—The Phoenicians nere an early offshoot from the Semitic stock. and belonged to the Canaanite branch of it. The Phoenicians themselves believed that they had migrated from an eastern shore, probably meaning Babylonian.

By settling along the Syrian coast they developed a strangely un-Semitic love for the sea, and advanced on different lines from the other Canaanites who occupied the interior. They called themselves Canaanites and their land Canaan; such is their name in the Amarna tablets, *Kinaḫḫi* and *Kinaḫni;* and with this agrees the statement assigned to Hecataeus (Fr. *hist.* gr., i. 17) that Phoenicia was formerly called Χνᾶ (*Chnâ*) a name which Philo of Byblus adopts into his mythology by making "Chna who was afterwards called Phoinix" the eponym of the Phoenicians (Fr. *hist.* gr., iii. 569). In the reign of Antiochus IV. and his successors the coins of Laodicea of Libanus bear the legend "Of Laodicea which is in Canaan" (Cooke, North-Semitic Inscriptions, quoted as *NSI.,* No. 149 B 8); the Old Testament also sometimes denotes Phoenicia and Phoenicians by "Canaan" and "Canaanites" (Isa. xxiii. 11; Obad. 20; Zeph. i. 11), though the latter names generally have a more extended sense. But "Sidonians" is the usual designation both in the Old Testament and in the Assyrian monuments (Sidunnu); and even at the time of Tyre's greatest ascendancy we read of Sidonians and not Tyrians in the Old Testament and in Homer; thus Ethbaal, king of Tyre (Jos., Ant., viii. 13, 2) is called king of the Sidonians in 1 Kings xvi. 31. In the Homeric poems we meet with Sidonioi, *Sidoniē* (Od., iv. 618; *Il.,* vi. 290; *Od.,* xiii. 285; Il., vi. 291) and Pkoinikes, *Phoinikē* (Od., xiii. 272, xiv. 288 seq., etc.), and both terms together *(Od.,* iv. 83 seq., *Il.,* xxiii. 743 seq.). And the Phoenicians themselves used Sidonians as a general name; thus in one of the oldest Phoenician inscriptions (CIS., i. 5=*NSI.,* No. 11), Hiram II., king of Tyre in the 8th century, is styled "king of the Sidonians." But among the Greeks "Phoenicians" was the name most in use, *Phoinikes* (plur. of Phoinix) for the people and *Phoinikē* for the land. The former was probably the older word and may be traced to *phoinos*="blood-red"; the Canaanite sailors were spoken of as the "red men" on account of their sunburned skin.

Language.— Inscriptions, coins, topographical names preserved by Greek and Latin writers, names of persons and the Punic passages in the *Poenulus* of Plautus, all show conclusively that the Phoenician language belonged to the North-Semitic group, and to that sub-division of it which is called the Canaanite and includes Hebrew and the dialect of Moab. A comparison between Phoenician and Hebrew reveals close resemblances both in grammatical forms and in vocabulary; in some respects older features have been preserved in Phoenician, others are later, others again are peculiar to the dialect; many words poetic or rare or late in Hebrew are common in Phoenician. Hence we may conclude that the two languages developed independently from a common ancestor, which can be no other than the ancient Canaanite, of which a few words have survived in the Canaanite glosses to the Amarna tablets (written in Babylonian). But in forming an estimate of the Phoenician language it must be remembered that our material is scanty and limited in range; the Phoenicians were in no sense a literary people; moreover, except the inscriptions found at Gebal, now Jebeil, (10th century) and NSI. No. 11, most of the inscriptions are subsequent to the 6th century B.C.; the majority belong to the 4th century and later, by which time the language must have undergone a certain amount of decay. Indirectly, however, the Phoenicians rendered one great service to literature; they took a large share in the development and diffusion of the alphabet which forms the foundation of Greek (Herod., v. 58) and of all European writing. The Phoenician letters in their earlier types are practically identical with those used by the Hebrews, the Moabites, and the Aramaeans of north Syria (NSI., Plates xii., xiii). They passed through various modifications in the course of time; after leaving the mother country the script acquires a more cursive flowing style on the stones from Cyprus and Attica; the tendency becomes more strongly marked at the Punic stage; until in the neo-Punic, from the destruction of Carthage (146 B C.) to the 1st century AD., both the writing and the language reached their most degenerate form. As a rustic dialect the language lasted in north Africa till the 5th century A.D. In his sermons St. Augustine frequently quotes Punic words. The oldest specimens of Phoenician writing at present known have been found at Gebal. In 1922 Montet unearthed the sarcophagus of Ahiram, incised with a Phoenician inscription in an archaic form of lettering, which bears a close resemblance to the inscription of Abi-baal, discovered some years ago on the same site.

History.— The Phoenicians, in imitation of the Egyptians, claimed that their oldest cities had been founded in remote antiquity; but no certainty can be attached to the traditional chronologies; *e.g.,* Herod., ii. 44; Justin, xviii. 3; Menander in Jos., Ant., viii. 3, 1 and c. Ap., i. 18.

Phoenicia comes into history proper c. 1600 B.C., when the Egyptian empire began to extend in the direction of Asia under Ahmosi (Amasis) I.; who carried his arms into Syria, and conquered at least Palestine and Phoenicia, the latter being the country called Da-hi on the Egyptian monuments (Miiller, As. u. *Eur.,* p. 181), Thothmes III. (1503–1449) repeated and consolidated the 'earlier conquest, and established Egyptian suzerainty over all the petty states of Syria and Phoenicia (*see* EGYPT: History). For the geography and civilization of Canaan about 1400 B.C. we have valuable evidence in the Egyptian papyrus Anastasi I., which mentions Kepuna (Gubna, Gebal-Byblus) the holy city, and continues: "Come then to Berytus, to Sidon, to Sarepta. Where is the ford of Nat-'ana (?Nahr el-Ḳāsimīyeh, or a town)? Where is 'Eutu (?Ushu, Palaetyrus)? Another city on the sea is called a haven, D'ar (Tyre) is its name, water is carried to it in boats; it is richer in fish than in sands." But the fullest information about the state of Phoenicia in the 15th and 14th centuries B.C. comes from the Amarna tablets, among which are many letters from the subject princes and the Egyptian governors of Phoenicia to the Pharaoh. It was a time of much political disturbance. The Hittites (*q.v.*) were invading Syria; nomads from the desert supported the invasion; and many of the local chiefs were ready to seize the opportunity to throw off the yoke of Egypt. The towns of Phoenicia were divided; Aradus, Simyra, Sidon supported the rebellion; Rib-addi, the regent of Byblus, and Abi-melech, king of Tyre, held out for Egypt; but while all the towns made professions of fidelity, they were scheming for their own interests, and in the end Egypt lost them all except Byblus. The tablets which reveal this state of affairs are written in the language and script of Babylonia, and thus show indirectly the extent to which Babylonian culture had penetrated Palestine and Phoenicia; at the same time they illustrate the closeness of the relations between the Canaanite towns and the dominant power of Egypt. After the reign of Amenophis IV. (1376–66) that power collapsed altogether; but his successors attempted to recover it, and Ramses (Rameses) II. reconquered Phoenicia as far as Beirut, and carved three tablets on the rock beside the Nahr el-Kelb (Gressmann, Texte *u.* Bilder[2] ii. Pl. lxv.). In the reign of Ramses III. (c. 1200) many great changes began to occur owing to the invasion of Syria by peoples from Asia Minor and Europe, which ended in the establishment of the Philistines on the coast near Ashkelon. The successors of Ramses III. lost their hold over Canaan; the 21st dynasty no longer intervened in the affairs of Syria; but Sheshonk (Shishak), the founder of the 22nd dynasty, about 928 B.C. endeavoured to assert the ancient supremacy of Egypt (cf. 1 Kings xiv. 25 sqq.), but his successes were not lasting, and, as we learn from the Old Testament, the power of Egypt became henceforward ineffective.

Independence of **Phoenicia.**—Between the withdrawal of the Egyptian rule in Syria and the western advance of Assyria there comes an interval during which the city-states of Phoenicia owned no suzerain. Gebal had kings of its own, Ahiram, Ithobaal, Abi-baal, in the 10th century, as recent excavations have shown. The history of this period is mainly a history of Tyre, which not only rose to a sort of hegemony among the Phoenician states, but founded colonies beyond the seas (p. 769). From 970 to 772 B.C. the bare outline of events is supplird by extracts from two Hellenistic historians, Menander of Ephesus and Dius (largely dependent upon Menander), which have been preserved. by Josephus, Ant., viii. 5, 3 and c. *Ap.,* i. 17, 18. From the data given in these passages we learn that Hiram I., son of Abi-baal, reigned in Tyre from 970 to 936 B.C. The Tyrian annals, more-

over, alluded to the connection between Hiram and Solomon. Before this time, indeed, the Phoenicians had no doubt lived on friendly terms with the Israelites (cf. Judges v. 17; Gen. xlix. 13); but the two nations seem to have drawn closer in the time of Solomon. 2 Sam. v. 11, which brings David and Hiram together, probably antedates what happened in the following reign. For Solomon's palace and temple Hiram contributed cedar and fir trees as well as workmen, receiving in exchange large annual payments of oil and wine, supplies which Phoenicia must have drawn regularly from Israelite districts (1 Kings v. 9, 11; cf. Ezek, xxvii. 17; Ezr. iii. 7; Acts xii. 20; Jos., *Ant.* xiv. 10, 6); finally, in return for the gold which he furnished for the temple, Hiram received the grant of a territory in Galilee (Cabul, 1 Kings ix. 10–14). This alliance between the two monarchs led to a joint expedition from Eziongeber on the Gulf of Xkaba to Ophir (?on the east coast of Arabra, see Ophir) for purposes of trade. The list of Hiram's successors given by Josephus indicates frequent changes of dynasty until the time of Ithobal I., priest of Astarte, whose reign (887–855) marks a return to more settled rule In contrast to Hiram I., king of Tyre, Ithobal or Ethbaal is styled in 1 Kings xvi. 31 "king of the Sidonians," *i.e.,* of the Phoenicians, showing that in the interval the kings of Tyre had extended their rule over the other Phoenician cities. Under Ethbaal further expansion is recorded; Botrys north of Byblus and Aoza in north Africa are said to have been founded by him (Jos., Ant., viii. 13, 2); the more famous Carthage owed its origin to the civil discords which followed the death of Metten I. (*c.* 851), his next successor but one. According to tradition, Metten's son Pygmalion (c 860–814) slew the husband of his sister Elissa or Dido; whereupon she Aed and founded Carthage (*q.v.*) in Libya (Justin, xviii. 4–6). At this point Josephus's extracts from Menander end, see Schrader, KAT., 3rd ed. 12G ff.).

Assyrian Rule, 876–605 **B.C.**—From the time of Ethbaal onwards the independence of Phoenicia was threatened by the advance of Assyria. In 868 B C. Assur-nasir-pal II. "washed his weapons in the great sea," and exacted tribute from the kings of Tyre, Sidon. Byblus and other cities, including Arvad (*Keilinschr. Bibliothek,* i. 109). The inscriptions of his son Shalmaneser III. mention the taking of tribute from the Tyrians and Sidonians in 842 and again in 839; the Byblians are included at the latter date, and among the kings defeated at Karkar in 8j4 or 853 was Metten-baal, king of the Arvadites (ibid., pp. 141, 143, 173). Thus Shalmaneser established a supremacy which lasted for over a hundred years and was acknowledged by occasional payments of tribute In 741 Tiglath-pileser III. mentions on his tribute-lists "Ḥirûm of Tyre"; and here a piece of native evidence becomes available. An early Phoenician inscription (CIS. i. 5 = *NSI.* No. 11), engraved upon the fragments of a bronze bowl, mentions a certain governor of Qarth-hadasht (or Karti-Hadasti. "New City," *i.e.,* Citium), "servant of Hiram king of the Sidonians to Baal of Lebanon," showing that this Hiram II. was not only king of Tyre. as the Assyrian inscription calls him, but of Sidon too: and further, that by this time Tyre has established a colony in Cyprus (q v.). In Tiglath-pileser's Philistine campaign of 734 Byblus and Xradus paid tribute. and a king of Tyre, Metten. nas forced to do the same (*KB.* ii. 23). For the period which follows a certain amount of information is furnished by Menander (in Jos, *Ant.*, ix. 14. 2). Elulaeus IX., in Assyrian Luli, nho ruled under the name of Pylas, mas king of Tyre. Sidon. and other cities at this time (c. 725–690), and at the beginning of his reign suffered from an invasion by Shalmaneser V.; this was probably the expedition against Hoshea of Samaria in 725; "the king of Assyria . . . overran all Phoenicia, but soon made peace with them all and returned back." In the reign of Snrgon Phoenicis itself seems to have been left alone, though Cyprus submitted to him in 709; but in the reign of Sennacherib Elulaeus joined the league of Philistia and Judah, in alliance aith Egypt and Ethiopia, nhich aimed at throwing off the oppressive ty ranny of Assyria. In the great campaign of 701 Sennacherib came down upon the revolting provinces; he forced Luli, king of Sidon. to fly for refuge to Cyprus, took his chief cities, and set up Tuba'lu (Ethbaal) as king, imposing a yearly tribute (KB. ii. 91). The blockade of Tyre by sea, significantly passed over in Sennacherib's inscription, is described by Menander; the Assyrian king, however, so far accomplished his object as to break up the combination of Tyre and Sidon, which had grown into a powerful state. At Sidon the successor of Ethbaal was Abd-milkath; in alliance with a Cilician chief he rebelled against Esarhaddon about the year 678, with disastrous consequences. Sidon was annihilated; Abd-milkath fell into the hands of Esarhaddon, who founded a new Sidon on the mainland, peopled it with foreigners, and called it after his own name. The old name, however, survived in popular usage; but the character of the city was changed, and till the time of Cyrus the kingdom of Sidon ceased to exist (KB. ii. 12j seq., 145; KAT^3., 88). Tyre also came in for its share of hardship. Elulaeus was followed by Baal, who in 672 consented to join Tirhaka, the Ethiopian king of Egypt, in a rebellion against Assyria. Esarhaddon, on his way to Egypt for the second time, blockaded Tyre, but he did not capture the city itself. His monument found at Zenjirli represents the great king holding Baal of Tyre and Tirhaka of Egypt by cords fastened in their lips; there is no evidence, however, that he actually took either of them prisoner (Gressmann, Texte u. Bilder^2, ii. Pl. lxiii.). Early in the reign of Assur-bani-pal Tyre was besieged again (668), but Assur-bani-pal succeeded no better than his predecessors. Nevertheless Baal submitted in the end, along with the princes of Gebal and Arvad, Manasseh of Judah, and the other Canaanite chiefs; in the island of Cyprus the Assyrians carried all before them (KB. ii. 149 seq., 169, 173). On his return from the Arabian campaign Assur-bani-pal severely punished the rebellious inhabitants of Ushu (Palaetyrus) and Akko (ibid., 229). In Phoenicia, as elsewhere, Assyrian rule created nothing and left nothing behind it but a record of barbarous conquest.

The **Neo-Babylonian** Period, 605–538 **B.C.**—In the last crisis of the dying power of Assyria the Egyptians for a short time laid hands on Phoenicia; but after their defeat at the battle of Carchemish (605), the Chaldaeans became the masters of western Asia. Jeremiah's allusion (xxv. 22) in 604 to the approaching downfall of the kings of Tyre and Sidon and the coastland beyond the sea, *i.e.,* the Phoenician settlements on the Mediterranean, seems to imply that the Phoenician states recovered some measure of independence; if they did it cannot have lasted long. In j88 Apries (Pharaoh Hophra) made an attempt to displace the Chaldaean supremacy; he defeated Tyre and Sidon, and terrorized the other cities into submission (Herod., ii. 161; Diod. Sic., i. 68). Some of the Phoenician chiefs, among them Ithobal II., the new king of Tyre, while forced to yield to a change of masters, were bold enough to declare their hostility to the Babylonians. This state of affairs did not escape the vigilance of Kebuchadrezzar. After the fall of Jerusalem he marched upon Phoenicia; Apries withdrew his army, and the siege of Tyre began. For 13 years the great merchant city held out (585–573; Jos., c. Ap., i. 21: cf. Ezek. xxvi. 1 seq.). Ezekiel says that Nebuchadrezzar and his host had no reward for their heavy service against Tyre, and the presumption is that the city capitulated on favourable terms; for Ithobal's reign ends with the close of the siege, and the royal family is subsequently found in Babylon. The king appointed by Kebuchadrezzar was Baal II. (574–564), after whose death a republic was formed under a single suffete or "judge" (*shōfēt*). Josephus (*loc. cit.*) is again our authority for the changes of government which followed until the monarchy was revived. At length under Hiram III. Phoenicia passed from the Chaldaeans to the Persians (538), and at the same time Amasis II. of Egypt occupied Cyprus (Herod., ii. 182). There seems to have been no struggle; the great siege and the subsequent civil disorders had exhausted Tyre, and Sidon took its place as the leading state. About this time, too, Carthage made an effort for independence under Hanno the Great (538–521), the real founder of its fortunes; the old dependence upon Tyre was changed for a mere relation of piety observed by the annual sending of delegates (*θεωροί*) to the festival of Melkarth (Arrian, ii. 24; Polyb., xxxi. 20, 12). The disasters which befrll Tyre during this and the foregoing period might suggest that its prosperity had been seriously damaged. But Tyre always counted for

more in commerce than in politics; and in the year 586, just before the great siege, Ezekiel draws a vivid picture (ch. xxvii.) of the extent and splendour of its commercial relations.

Constitution.—At this point it is convenient to mention what little is known about the constitution of the Phoenician states. All Canaanite analogy speaks for kingship as the oldest form of Phoenician government. In the native inscriptions the chief of the city in Phoenicia itself and in Cyprus is always called king. The royal houses claimed divine descent, and the king could not be chosen outside their members. His power. however, was limited by the wealthy merchant families, uho possessed great influence in public affairs. The priest of Melkarth at Tyre was the second man in the kingdom. Associated with the prince was a council of elders; such was the case at Gebal (Byblus) from the earliest times to the latest (Ezek. xxvii. 9); at Sidon this council consisted of 100 members (Diod., xvi. 45), perhaps also at Tyre (NSI. p. 129). Inscriptions of the 3rd and 2nd centuries B.C. mention a *Rab* (chief) in Sidon, Cyprus and Gaulus (Gozo); what nis position was it is difficult to say; in the colonies he may have been a district governor. Luring Nebuchadrezzar's time, as we have seen, a republic took the place of the monarchy at Tyre, and the government was administered by a succession of suffetes (judges); they held office for short terms, and in one instance two ruled together for six years. Much later, in the 3rd century B.C. an inscription from Tyre mentions a suffete (NSI. No. 8) without adding more to our kno ledge. Carthage, of course, was governed by two suffetes, and these officers are frequently named in connection with the Carthagininn colonies (NSI. p. 115 seq.); but we must be careful not to draw the inference that Phoenicia itself had any such magistrates. Under the Persians a federal bond was formed comprising Sidon, Tyre and Aradus, whose duty it was to contribute 300 triremes to the Persian fleet (Herod., vii. 89), the lesser towns being under the command of the great cities. But federation on a larger scale was never possible in Phoenicia, for the reason that no sense of political unity existed to bind the different states together. Commercial interests dominated everything else, and while these stimulated a municipal life not without vigour, civil discipline and loyalty were but feebly felt. On occasion the towns could defend their independence with strenuous courage; the higher qualities which make for a progressive national life the Phoenicians did not possess.

The Persian Period, 538–333 **B.C.**—Phoenicia now became part of the fifth satrapy of the Persian empire, and entered upon a spell of comparative peace and growing prosperity. At this period Sidon occupied the position of leading state; in the fleet her king ranked next to Xerxes and before the king of Tyre (Herod., viii. 67); her situation afforded advantages for expansion which Tyre on its small and densely populated island could not rival. In the first half of the 4th century Straton I. (in Phoen. 'Abd-'ashtart or *Bod-'ashtnrt)* was king, c. 374–362. He cultivated friendly relations with Athens, indicated in a decree of *proxenia* (Michel, Rec. *d'inscr.* gr. No. 93=*CIG.* No. 87); and the extent to which phil-Hellenic tendencies prevailed at this time in Sidon is shown by the royal sarcophagi, noble specimens of Greek art, which have been excavated in the necropolis of the city. It was in the reign of Straton that Tyre fell into the hands of Evagoras, king of Salamis, who had already supplanted Phoenician with Greek civilization in Cyprus (Isocr., *Evag.*, 62, Paneg., 161; Diod. xv. 2). Straton made friends with Nicocles, son of Evagoras, and with him came to an untimely end through their implication in the great revolt of the satraps, 362 B.C. A new revolt of Sidon against the Persians took place under King Tennes; with the aid of Nectanebus of Egypt, the Sidonians carried the rest of Phoenicia with them and drove the satraps of Syria and Cilicia out of the country. Tennes, however, betrayed his people and opened the city to Artaxerxes III.; then he was executed after he had served the ends of the great king (346 B.C.; Diod., xvi. 41–45). The last king of Sidon was Straton II. ('Abd-'ashtart, 346–332) before the Persian empire came to an end.

Towards the close of the 5th century the Phoenician coins begin to supplement our historical sources. From the time of Darius the Persian monarchs allowed their satraps and vassal states to coin silver and copper money at discretion. Hence Aradus, Byblus, Sidon and Tyre issued a coinage of their own, of which many specimens exist; the coins are stamped as a rule with the emblem or name of the city, sometimes with the ruler's name. Thus from the coins of Byblus we learn the names of four kings, 'El-pa'al, 'Az-ba'al (between 360 and 340 B.C.), Adar-melek, 'Ain-el; from the coins of the other cities it is difficult to obtain much information. The native inscriptions, however, now become available, though most of them belong to the period which follows, and only a few have been discovered in Phoenicia itself. One of the earliest of these is the inscription of Byblus (CIS. i. 1=*NSI.* No. 3), dating from the Persian period; it records a dedication made by Yehaw-milk, king of Gebal, and mentions the name of the king's grandfather, Urimilk, but the exact dates of their reign are not given.

The Macedonian Period, 333–69 **B.C.**—When Alexander the Great entered Phoenicia after the battle of Issus (333 B.C.), the kings were absent with the Persian fleet in the Aegean; but the cities of Aradus, Byblus and Sidon welcomed him readily, the last-named showing special zeal against Persia. The Tyrians also offered submission, but refused to allow the conqueror to enter the city and sacrifice to the Tyrian Heracles. Alexander was determined to make an example of the first who should offer opposition, and at once began the siege. It lasted seven months. With enormous toil the king drove out a mole from the mainland to the island and thus brought up his engines; ships from the other Phoenician towns and from Cyprus lent him their aid, and the town at length was forced in July 332; 8,000 Tyrians were slain, 30,000 sold as slaves, and only a few notables, the king Azemilkos, and the festal envoys from Carthage who had taken refuge in the sanctuary of Melkarth, were spared (Diod., xvii. 40–46). It is not unlikely that Zech. ix. 2–4 refers to this famous siege. For the time Tyre lost its political existence, while the foundation of Alexandria presently changed the lines of trade, and dealt a blow even more fatal to the Phoenician cities.

During the wars of Alexander's successors Phoenicia changed hands several times between the Egyptian and the Syrian kings. From the year 275 "the people of Tyre" reckoned their era (CIS. i. 7=*NSI.* No. 9, cf. 10). The Tyrian coins of the period, stamped with native, Greek and Egyptian symbols, illustrate the traditional relations of the city and the range of her ambitions. A special interest attaches to these silver tetradrachms and didrachms because they were used by the Jews for the payment of the temple tax as "shekels of the sanctuary" (NSI pp. 351, 44).

Among the Phoenician states we know most about Sidon during this period. The kingship was continued for a long time. The story goes that Alexander raised to the throne a member of the royal family, Abdalonymus, who was living in obscure poverty and working as a gardener (Justin, xi. 10; Curt., iv. 1; Diod., xvii. 47 wrongly connecting the story with Tyre). In 312 Ptolemy, then master of Phoenicia, appointed his general Philocles king of the Sidonians, and a decree in honour of this king has been found at Athens (Michel, No. 387, cf. 1,261); but he cannot have reigned long. For at the end of the 4th and the beginning of the 3rd century we have evidence of a native dynasty in the important inscriptions of Tabnith, Eshmun'azar and Bod-'ashtart, and in the series of inscriptions (repeating the same text) discovered at Bostan esh-Shēkh near Sidon (*NSI.* Nos. 4, 5, 6 and App. i.). With Bod-'ashtart, so far as we know, the dynasty came to an end, say about 250 B.C.

After the death of Antiochus IV. Epiphanes in 164 B.C., the kingdom of the Seleucids began to collapse. Berytus was destroyed by the usurper Trypho in 140 B.C. Tyre in 120 and Sidon in 111 received complete independence, and inaugurated new eras from these dates. Byblus and Tripolis fell into the hands of "tyrants" (Strabo, xvi. 2, 18; Jos., Ant., xiv. 3, 2); from 83–69 B.C. the entire kingdom was held by the Armenian Tigranes.

Roman Rule.—At last in 64 B.C. Pompey arrived upon the scene and established order out of chaos. Phoenicia was incorporated into the Roman province of Syria; Aradus, Sidon, Tyre and Tripolis were confirmed in their rights of self-government and in

the possession of their territories. Under the beneficent government of Rome the chief towns prospered and extended their trade; but the whole character of the country underwent a change. During the Macedonian period Greek influences had been steadily gaining ground in Phoenicia; relations with the Greek world grew closer; the native language fell into disuse. and from the beginning of the Roman occupation Greek appears regularly in inscriptions and on coins, though on the latter Phoenician legends do not entirely vanish till the 2nd century A.D.; while the extent to which Hellenic ideas penetrated the native traditions and mythologies is seen in the writings of Philo of Byblus. For the purposes of everyday life, however, the people spoke not Greek, but Aramaic. As elsewhere, the Roman rule tended to obliterate characteristic features of national life, and under it the native language and institutions of Phoenicia became extinct.

Navigation, Trade, Colonies.—The Phoenicians were essentially a seafaring nation. Fearless and patient navigators, they ventured into regions where no one else dared to go, and, always with an eye to their monopoly, they carefully guarded the secrets of their trade routes and discoveries, and their knowledge of winds and currents. At the beginning of the 7th century B.C. a Phoenician fleet is said to have circumnavigated Africa (Herod., iv. 42). To the great powers Phoenician ships and sailors were indispensable; Sennacherib, Psammetichus and Necho, Xerxes, Alexander, all in turn employed them for their transports and seafights. Even when Athens had developed a rival navy Greek observers noted with admiration the discipline kept on board the Phoenician ships and the skill with which they were handled (Xen., *Oec.*, viii.); all the Phoenician vessels from the round merchant-boat (γαῦλος — after which the island of Gaulus, now Gozo, near Malta, was called) to the great Tarshish-ships, the "East-Indiamen" of the ancient world, excelled those of the Greeks in speed and equipment. As E. Meyer points out, the war between the Greeks and the Persians was mainly a contest between the sea-powers of Greece and Phoenicia. At what period did Phoenicia first rise to be a power in the Mediterranean? We are gradually approaching a solution of this obscure problem. Recent discoveries in Crete (*q.v.*) have brought to light the existence of a Cretan or "Minoan" sea-power of remote antiquity, and it is clear that a great deal of what used to be described as Phoenician must receive quite a different designation. The Minoan seapower was at last broken up by invaders from the north, and a Carian rule became dominant in the Aegean (Herod., i. 171; Thucyd., i. 4, 8). It was a time of disorder and conflict due to the immigration of new races into the ancient seats of civilization, and it synchronized with the weakening of the power of Egypt in the countries which bordered on the eastern Mediterranean. This was in the 12th century B.C. The Tyrian trader saw that his opportunity was come, and the Aegean lay open to his merchant vessels. Where much is still obscure, all that seems certain is that the antiquity of Phoenicia as a sea- and trading-power has been greatly exaggerated both in ancient and in modern times; the Minoan power of Cnossus preceded it by many centuries; the influence of Phoenicia in the Aegean cannot be carried back much earlier than the 12th century B.C.

A vivid description of the Phoenicians' trade at the time of Tyre's prosperity is given by Ezekiel (xxvii. 12–25), and it shows how extensive were their commercial relations not only by sea, but by land as well. It was they who distributed to the rest of the world the wares of Egypt and Babylonia (Herod., i. 1). From the lands of the Euphrates and Tigris regular trade-routes led to the Mediterranean with trading-stations on the way, several of which are mentioned by Ezekiel (xxvii. 23). In Egypt the Phoenician merchants soon gained a foothold; they alone were able to maintain a profitable trade in the anarchic times of the 22nd and 23rd dynasties (825–650 B.C.), when all other foreign merchants were frightened away. Though there were never any regular colonies of Phoenicians in Egypt, the Tyrians had a quarter of their o n in Memphis (Herod., ii. 112). The Arabian caravan-trade in perfume, spices and incense passed through Phoenician hands on its way to Greece and the west (Herod., iii. 107). Between Israel and Phoenicia the relations naturally were close; the former provided certain necessaries of life, and received in exchange articles of luxury and splendour (Ezek. xxvii. 16–18). Israelite housewives sold their homespun to Phoenician pedlars (Prov. xxxi. 24 R.V.M.); in Jerusalem Phoenician merchants and money lenders had their quarter (Zeph. i. 11), and after the Return we hear of Tyrians selling fish and all manner of ware in the city (Neh. xiii. 16), and introducing other less desirable imports, such as foreign cults (Isa. lxv. 11). The Phoenician words which made their way into Greek at an early period indicate the kind of goods in which the Phoenicians traded with the west, or made familiar through their commerce; the following are some of them—χρυσός, χιτών, βύσσος, ὀθόνη, μύρρα, νάβλα, κύπρος, φῦκος, μνᾶ, παλλακίς, βαίτυλος. Another article of commerce which the Phoenicians brought into the market was amber.

The Phoenician colonies were all supposed to have been founded from Tyre: with regard to the colonies in Cyprus and north Africa this was undoubtedly true. Cyprus possessed resources of timber and copper which could not fail to tempt the keen-eyed traders across the water, who made Citium (from Kittim, the name of the original non-Semitic inhabitants) their chief settlement, and thence established themselves in Idalium, Tamassus, Lapethus, Larnaka, Qarth-hadasht (Karti-hadasti) and other towns. In the inscriptions of the 4th to 3rd centuries, the Phoenician potentates in the island call themselves "kings of Kition and Idalion" (N.S.I. pp. 55–89).

Homer represents the Phoenicians as present in Greek waters for purposes of traffic, but not as settlers (*Il.*, xxiii. 744). They occupied trading-stations on some of the Aegean islands and on the Isthmus of Corinth. One of their objects was the collection of murex, of which an enormous supply was needed for the dyeing industry; specially famous was the purple of the Laconian waters, the isles of Elishah of Ezek. xxvii. 7. But a great deal of what was formerly assigned to Phoenician influence in the Aegean at an early period—pottery, ornaments and local myths—must be accounted for by the vigorous civilization of ancient Crete. In the Greek world the Phoenicians made themselves heartily detested by their passion for gain (Plato, Rep. iv. 436 A.).

Farther west in the Mediterranean Phoenician settlements were planted first in Sicily, at Heraclea or Ras Melqarth; the islands between Sicily and Africa, Melita (Malta) on account of its valuable harbour, Gaulus and Cossura were also occupied (Diod., v. 12); and a beginning was made with the colonization of Sardinia and Corsica; but farther west still more permanent colonies were established. It was the trade with Tarshish; *i.e.*, the region of Tartessus in south-west Spain, which contributed most to the Phoenicians' wealth; it was said that even the anchors of ships returning from Spain were made of silver (Diod., v. 35). From Gadeira (Punic *Gādēr*, Lat. Gades, now Cadiz), the Sidonian ships ventured farther on the ocean and drew tin from the mines of north-west Spain or from the richer deposits in the Cassiterides; *i.e.*, the Tin Islands. These were discovered to be, not a part of Britain as was imagined at first, but a separate group by themselves, now known as the Scillies; hence it is improbable that the Phoenicians ever worked the tin-mines in Cornwall.

The rich trade with Spain led to the colonization of the West. Strabo dates the settlements beyond the Pillars of Hercules soon after the Trojan War (i. 3, 2), in the period of Tyre's first expansion. Lixus in Mauretania, Gades and Utica, are said to have been founded, one after the other, as far back as the 12th century B.C. Most of the African colonies were no doubt younger; we have traditional dates for Aoza (887–855) and Carthage (813). A large part of north-west Africa was colonized from Phoenicia; owing to these first settlers, and after them to the Carthaginians, the Phoenician language became the prevailing one, and the country assumed quite a Phoenician character.

In the days of Tyre's greatness her power rested directly on the colonies, which, unlike those of Greece, remained subject to the mother-city, and paid tithes of their revenues to its chief god, Melqarth, and sent envoys annually to his feast. Then at the beginning of the 8th century B.C. the colonial power of Tyre began to decline; on the mainland and in Cyprus the Assyrians

gained the upper hand; in the Greek islands the Phoenicians had already been displaced to a great extent by the advancing tide of Dorian colonization. But as Tyre decayed in power the colonies turned more and more to Csrthage as their natural parent and protector. For effective control over a colonial empire Carthage had the advantage of situation over far-away Tyre; the traditional bonds grew lax and the ancient dues ceased to be paid, though as late as the middle of the 6th century Carthage rendered tithes to the Tyrian Melqarth. And the mother-country cherished its claims long after they had lost reality; in the and century B.C., for example, Sidon stamped her coins with the legend, "Mother of Kambē (*i.e.*, Carthage), Hippo, Kition, Tyre" (NSI. p. 352).

Manufactures, Inventions, Art.—From an early date the towns of the Phoenician coast were occupied, not only with distributing the merchandise of other countries but with working at industries of their own; especially purple-dyeing and textile fabrics (*Il.*, vi. 289 sqq.), metal work in silver, gold and electrum (*Il.*, xxiii. 741 *sqq.*; *Od.*, iv. 615 *sqq.* xv. 458 *sqq.*), and glass-work, which had its seat at Sidon. The iron and copper mines of Cyprus (not Sidon, as Homer implies, *Od.*, xv. 424) furnished the ore which was manufactured into articles of commerce. Egyptian monuments frequently mention the vessels of gold and silver, iron and copper, made by the Dahi, *i.e.*, the Phoenicians (W. M. Müller, *As. u. Eur.*, 306); and in Cyprus and at Nimrud bronze and silver paterae have been found, engraved with Egyptian designs, the work of Phoenician artists (see table-cases C and D in the Nimrud gallery of the Brit. Mus.). The invention of these various arts and industries was popularly ascribed to the Phoenicians, no doubt merely because Phoenician traders brought the products into the market. But dyeing and embroidery probably came from Babylon in the first instance; glass-making seems to have been borrowed from Egypt; the invention of arithmetic and of weights and measures must be laid to the credit of the Babylonians. The ancients believed that the Phoenicians invented the use of the alphabet (*e.g.*, Pliny, *N.H.*, v. 13, *cf.* vii. 57; Lucan, *Bell. Civ.*, iii. 220 *seq.*); but it is unlikely that any genuine tradition on the subject existed, and though the Phoenician theory has found favour in modern times it is open to much question.

The art of Phoenicia is characterized generally by its dependence upon the art of the neighbouring races. It struck out no original line of its own, and borrowed freely from foreign, especially Egyptian, models. Remains of sculpture, engraved bronzes and gems, show clearly the source to which the Phoenician artists went for inspiration; for example, the uraeus-frieze and the winged disc, the *qnkh* or symbol of life, are Egyptian designs frequently imitated. It was in the times of the Persian monarchy that Phoenician art reached its highest development, and to this period belong the oldest sculptures and coins that have come down to us. A characteristic specimen of the former is the stele of yehaw-milk, king of Gebal (*CIS.* i. 1), in which the king is represented in Persian dress, and the goddess to whom he is offering a bowl looks exactly like an Egyptian Isis-Hathor; (Gressmann, *Texte u. Bilder*², ii. Pl. ccviii.). The whole artistic movement in Phoenicia may be divided into two great periods: in the first, from the earliest times to the 4th century B.C., Egyptian influence and then Babylonian or Asiatic influence is predominant, but the national element is strongly marked; while in the second, Greek influence has obtained the mastery, and the native element, though making itself felt, is much less obtrusive. Throughout these periods works of art, such as statues of the gods and sarcophagi, were imported direct at first from Egypt and afterwards mainly from Rhodes. The finest sarcophagi that have been found in the necropolis of Sidon (now in the Imperial Museum, Constantinople) are not Phoenician at all, but exquisite specimens of Greek art. The Phoenicians spent much care on their burial-places, which have furnished the most important monuments left to us. Thus, on the site of Gebal, now Jebeil, the French excavators, under the leadership of Montet, 1921–23, have unearthed the fine sarcophagus of Aḥîram, Egyptian in style, and engraved with the earliest Phoenician inscripition so far known; see Gressmann; Texte *u. Bilder*², i. 440; ii. 189–192 and Pl. ccliv. (1927). Besides busts and figurines, which belong as a rule to the Greek period, the smaller objects usually found are earthen pitchers and lamps, glass-wares, tesserae and gems. 'Of buildings which can be called architectural few specimens now exist on Phoenician soil, for the reason that for ages the inhabitants have used the ruins as convenient quarries. Not a vestige remains of the great sanctuary of Melqarth at Tyre; a few traces of the temple of Adonis near Byblus were discovered by Renan, and a peculiar mausoleum, Burj al-Bezzāq, is still to be seen near Amrit; excavations at Bostan esh-Shēkh near Sidon revealed parts of the enclosure or foundations of the temple of Eshmun (NSI. p. 401); the conduits of Ras el- 'Ain, south of Tyre, are considered to be of ancient date.

Religion.—Like the Canaanites of whom they formed a branch, the Phoenicians connected their religion with the great powers and processes of nature. The gods whom they worshipped belonged essentially to the earth; the fertile field, trees and mountains, headlands and rivers and springs, were believed to be inhabited by different divinities, who were therefore primarily local, many in number, with no one in particular supreme over the rest. It seems, however, that as time went on some of them acquired a more extended character; thus Ba'al and Astarte assumed celestial attributes in addition to their earthly ones, and the Tyrian Melqarth combined a celestial with a marine aspect. The gods in general were called *'elōnīm, 'elim;* these plurals go back to the singular form 'El, the common Semitic name for God. The god or goddess was generally called the Ba'al or Ba'alath of such and such a place, a title which was used not only by the Canaanites, but by the Aramaeans (Be'el) and Babylonians (Bel) as well. There was no one particular god called Ba'al; the word is not a proper name but an appellative, a description of the deity as *owner* or *mistress;* and the same is the case with Milk or Melek, 'Adon, 'Amma, which mean *king, lord, mother*. The god himself was unnamed or had no name. Occasionally we know what the name was; the Ba'al of Tyre was Melqarth which again means merely "king of the city"; similarly among the Aramaeans the Ba'al of Harran was the moon-god Sin. Sometimes the god received a distinguishing attribute which indicates an association not with any particular place, but with some special characteristic; the most common forms are Ba'al-hammān, the chief deity of Punic north Africa, perhaps "the glowing Ba'al," the god of fertilizing warmth, and Ba'al-shamēm, "Ba'al of the heavens" (*cf.* Dan. xii. 11, xi. 31, etc.). The latter deity was widely venerated throughout the north Semitic world. The worship of the female along with the male principle was a strongly marked feature of Phoenician religion.

To judge from earliest evidence on the subject, the Ba'alath of Gebal or Byblus, referred to again and again in the Amarna letters (*Bêlit ša Gubla*, Nos. 68–125), must have been the most popular of the Phoenician deities, as her sanctuary was the oldest and most renowned. The *mistress of Gebal* was no doubt 'Ashtart (Astartē in Greek, 'Ashtōreth in the Old Testament, a name which is obviously connected with the Babylonian Ishtar, and, as used in Phoenician, is practically the equivalent of "goddess." She represented the principle of fertility and generation; the common epithets Κύπρις and Κυθέρεια (of Kuthera in Cyprus), Cypria and Paphia, show that she was identified with Aphrodite and Venus. Though not primarily a moon-goddess, she sometimes appears in this character, and Herodotus describes her temple at Ashkelon as that of the heavenly Aphrodite (i. 105). We find her associated with Ba'al and callrd "the name of Ba'al"; *i.e.*, perhaps his manifestation. Another goddess, specially honoured a t Carthage, is Tanith; she is regularly connected with Ba'al on the Carthaginian votive tablets. Two or thred other deities may be mentioned here: Eshmun, the god of vital force and healing, worshipped at Sidon especially, but also at Carthage and in the colonies, identified by the Greeks with Asclepius; Melqarth, the patron deity of Tyre, identified with Heracles; Reshef or Reshūf, the "flame" or "lightning" god, especially popular in Cyprus and derived originally from Syria, whom the Greeks called Apollo. A tendcncy to iorm a distinct deity by combining the attributes of two produced such curious fusions as Milk-'ashtart, Milk-ba'al. Milk-'osir, Eshmun-melqarth, Melqarth-resef, etc. As in the case of art and industries so in religion the Phoenicians readily assimilated foreign ideas. The influence of Egypt was specially strong.

(loser intimacy with the Greek world naturally brought about modifications in the character of the native gods, which became apparent when Ba'al of Sidon or Ba'al-shamēm was identified with Zeus, Tanith with Demeter or Artemis, 'Anath with Athena, etc.; the notion of a supreme Ba'al, which finds expression in the Greek βῆλος and βααλτίς or βήλθης (the goddess of Byblus), was no doubt encouraged by foreign influences. On the other hand, the Phoenicians produced a considerable effect upon Greek and Roman religion, especially from the religious centres in Cyprus and Sicily. A great number of divinities are known only as elements in proper names. It was the custom among the Phoenicians, as among other Semitic nations, to use the names of the gods in forming proper names and thus to express devotion or invoke favour; thus Hanni-ba'al, 'Abdmelqarth, Hanni-'ashtart, Eshmun-'azar.

The proper names further illustrate the way in which the relation of man to God was regarded; the commonest forms are *servant* ('abd, *e.g.,* 'Abd-'ashtart), *member* or *limb* (bod, *e.g.,* Bod-melqarth), client or *guest* (ger, *e.g.,* Gereshmun).

Sacred Objects and Worship.— Probably like other Canaanites the Phoenicians ofiered worship "on every high hill and under every green tree"; but to judge from the allusions to sanctuaries in the inscriptions and elsewhere, the Ba'al or 'Ashtart of a place was usually worshipped at a temple, which consisted of a court or enclosure and a rooied shrine with a portico or pillared hall at the entrance. In the court sometimes stood a conical stone, probably the symbol of Astarte, as on the Roman coins of Byblus. Stone or bronze images of the gods were set up in the sanctuaries; and besides these the *baetylia* (meteoric stones) which were regarded as symbols of the gods. Pillars, again, had a prominent place in the court or beiore the shrine; but it is not known whether the sacred pole *('asherah),* an invariable feature of a Canaanite sanctuary, was usual in a Phoenician temple. The inscriptions mention altars of stone and bronze, and from the sacrificial tariffs which have survived u-e learn that the chiei types of sacrifice among the Phoenicians were analogous to those in the Old Testament. The practice oi sacrificing human victims was resorted to in times of great distress or to avert national disaster; it was regarded as a patriotic act when Hamilcar threw himself upon the pyre aiter the disastrous battle of Himera. The god who demanded these victims, and especially the burning of children, seems to have been Milk, the Molech or Moloch of the Old Testament. In this connection may be mentioned the custom of burning the chief god of the city in effigy, or in the person of a human representative, at Tyre and in the Tyrian colonies, such as Carthage and Gades. Another sacrifice mas regularly demanded by Phoenician religion; women sacrificed their virginity at the shrines oi Astarte in the beliei that they thus propitiated the goddess and won her favour. These temple prostitutes are called *qedēshīm qedēshōth, i.e.,* sacred men, women, in the Old Testament (Deut. xxiii. 18; I Kings xiv. 24, etc.). Other persons attached to a temple were priests, augurs, sacrificers, barbers, officials in charge of the curtains. masons, etc.; we hear also of religious gilds and corporations, perhaps administrative councils, associated with the sanctuaries.

Mythology and Religious Ideas.— No doubt the Phoenicians had their legends and myths to account for the origin of man and the universe; to some extent these would have resembled the ideas embodied in the book of Genesis. Two cosmogonies have come down to us which, though they differ in details are fundamentally in agreement. The one, of Sidonian origin, is preserved by Damascius and received at his hands a Neoplatonic interpretation; the other and more elaborate work mas composed by Philo of Byblus; he professed that he had used as his authority the writings of Sanchuniathon, an ancient Phoenician sage, who again derived his information from the mysterious inscribed stones in the Phoenician temples. Philo's cosmogony has been preserved, at least in fragments, by Eusebius. It cannot, however, be taken seriously as an account of genuine Phoenician beliefs. At the same time Philo did not invent all the nonsense he has handed down; he drew upon various sources, Greek and Egyptian, some of them ultimately of Babylonian origin. He shows at any rate that some sort of a theology existed in his day. It is evident that the gods were regarded as being intimately concerned with the lives and fortunes of their worshippers. The vast numher of small votive tablets found at Carthape prove this; they were all inscribed by grateful devotees "to the lady Tanith. Face of Ba'al, and the lord Ba'al-ḥammān, because he heard their voice."

The care which the Phoenicians bestowed upon the burial of the dead has been alluded to above; pillars (*maṣṣēbōth*) were set up to commemorate the dead among the living; if there were no children to fulfil the pious duty, a monument mould be set up by a man during his lifetime. Any violation of the tomb was regarded with the greatest horror. The grave mas called a resting-place, and the departed lay at rest in the underworld with the *Refāim,* the weak ones. The notion prevailed, as it did also among the Greeks and Romans, that it was possible to communicate with the gods of the underworld by dropping into a grave a small roll of lead inscribed with the message, generally a curse, which it was desired to convey to them.

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PHOENIX, capital and largest city of Arizona, U.S., and seat of Maricopa county, occupies approximately 188 sq.mi. of an arid saucer-shaped valley formed by the Salt river, midway between El Paso and Los Angeles. The city is the commercial focus of large irriqation projects, important to its growth. which are fed from the Roosevelt dam. 70 mi. N.E. The hub of an area of scenic grandeur, it is also a health and tourist centre.

The Salt river valley was occupied as early as 1300 A.D. by prehistoric Indians known to anthropologists as Hohokarn (*q.v.*) or "the people who have gone." They developed a system of primitive irrigation canals. erected early buildings and then vanished mysteriously. An historic gap followed until the first white men came during the American Civil War. One, an imaginative prospector, Jack Swilling, noticed the visible remnants of ancient Indian canals and realizing irrigation possibilities, organized an irrigation company. Canals and harvests followed and a crude village was founded.

An associate of Swilling's, Darrel Duppa, English adventurer and scholar, was impressed by the evidences of prehistoric culture. Like the legendary phoenix which, consumed by fire. arose from its own ashes. so. Duppa predicted. would the Salt river city be born from ancient Indian ruins. Thus the settlement was named Phoenix. Incorporated in 1881, it acquired its first railroad in 1887. Phoenix, with a population of about 3,000, became the seat of the territorial government in 1889, and remained the capital when Arizona attained statehood in 1912. The city has been council-manager governed since 1914.

The economy is based on agriculture, tourists and manufacturing. The fertile Salt river valley produces long staple cotton, forage, vegetables and fruits. Manufacturing. almost nonexistent before 1940, later became the chief source of income. Aircraft and electronic components, aluminum extrusions, air-conditioning equipment and many small manufacturing enterprises add to the economic wealth of the city.

More than 30 secondary schools and Phoenix college, a two-year college established 1920, are in the city proper. Independent school districts are in outlying communities. Parks, playgrounds. an adult recreational centre, an active little theatre, a professional winter theatre, a symphony orchestra and professional baseball provide recreational and cultural opportunities. Notable annual events are the Copper Bowl parade and football game, the World's Championship rodeo and the Arizona state fair.

The state capitol consists of an original building of native tufa and of neoclassic design. with two additional wings for the house of representatives and the senate. These buildings are set in a 10-ac. park, where trees and shrubs indigenous to the region are represented. I'apago park (1,094 ac.) lies within the city limits to the east and to the south is the city's South Mountain park of 14,000 ac.

The Phoenix standard metropolitan statistical area comprising Maricopa county includes: Mormon-founded Mesa, site of the state experimental farm: Glendale, a farming community with nearby Luke air force base; and Tempe, location of Arizona State university (established in 1885 as Arizona Territorial Normal school). A post-World War II population boom, with Arizona's warm climate and clear air (85% average "possible" sunshine) as the main enticements, made Phoenix one of the fastest growing cities in the United States. Between 1950 and 1960 its population increased from 106,818 to 439,170 within the city limits and from 331,770 to 663,510 within the metropolitan area. (Jo. S.)

PHOENIX, a fabulous bird, sacred to the sun (Gr. *Plzoinix,* apparently "bright-coloured"; *phoinix* also means "a palm-tree").

From statements in a large number of classical and postclassical authors. ranging from the 5th century B.C. (Herodotus, perhaps Hecataeus) to the middle ages (Isaac Tzetzes), the following account is obtained: The phoenix was a large bird of very gorgeous plumage, having, according to one or two authorities, a sweet voice. It was always male. the only one of its kind, and lived a long time (various authors give periods ranging from 500 years, the commonest account. up to 12.954; Tacitus, *Annales,* vi, 28, 4, gives 1,461 years, which is an Egyptian Sothis period).

At the expiration oi that time it made itself a nest of twigs of spice trees, on which it died by setting the nest on fire and burning itself alive. From its body, its ashes or the nest, which it had fertilized, came forth another phoenix, either perfect or at first in the shape of a white grub. This young bird, as soon as it was strong enough, took up the body of its father, covered in spices, or the ashes, nest and all, and flew to Heliopolis in Egypt, where it deposited them on the altar of

the sun. There are numerous variants in detail; sometimes the phoenix goes to Egypt to die, having produced its offspring before dying.

It was not doubted by the majority that the phoenix really was seen now and then in Egypt; Tacitus, *Annales*, and Pliny, *Historia Naturalis*, x, 2, mention recorded appearances, genuine and otherwise. Attention is thereiore drawn by A Wiedemann to the facts that a bird of the stork kind, the bennu or *bannu*, was sacred at Heliopolis and connected with the local sun worship, and, moreover, that its name also means a palm tree. This certainly gives a plausible origin for some parts of the Greek story and accounts for Herodotus's statement (ii, 73, 1) that he saw a picture of it in Egypt; ior the *bennu* is to be found on surviving monuments. But it fails to account for the persistent statement that the phoenix is not a native of Egypt, but lives in Arabia, Assyria, Ethiopia or India, nor does the real or pictured *benny* at all resemble the phoenix as described. Hence it is likely that the ultimate origin of the story, however it may have reached Greece, is to be sought in the mythology of one or another of these countries.

Many commentators still understand the word חול, chol, in Job xxix, 18 (in King James version, "sand"), to apply to the phoenix. This interpretation is perhaps as old as the (original) Septuagint, and is current with the later Jews. Among the Arabs the story of the phoenix was coniused with that of the salamander; and the samand or samandal is represented sometimes as a quadruped, sometimes as a bird. It was firmly believed in. for the incombustible cloths woven of flexible asbestos were popularly thought to be made of its hair or plumage, and were in fact called by the same name. The 'anka (Pers. *simurgh*), a stupendous bird like the roc (rukh) of Marco Polo and the *Arabian Nights*, also borrows some features of the phoenix According to Kazwini (i, 420) it lives 1,700 years, and when a young bird is hatched the parent of opposite sex burns itself alive.

PHOENIX, an important genus of palms native to Africa and Asia. The date palm (Phoenix dactylifera) is a member of the genus. and several other species are grown in the open in warm regions for ornament. See DATE PALM; PALM.

PHOLIDOTA, an order of placental mammals, comprising only the scaly anteaters or pangolins of Asia and Africa. The pangolins were at one time grouped with the true anteaters, sloths and armadillos in the order Edentata, mainly on account of their likeness to the South American anteaters in the absence of teeth, the weakness of the jaws, the enlargement of the salivary glands and the length of the wormlike, extensile tongue; and to the armadillos in the possession of a hard dermal exoskeleton. But the resemblances to the edentates are adaptive and due to similarity of diet and of habitat. The exoskeleton is of a totally different type from that of the armadillos, since it consists of large, erectile, overlapping horny scales, composed of cemented hairs, there being no trace of bony matter in the skin They show, indeed, no resemblances to the edentates of any systematic importance and differ from them fundamentally in many anatomical characters

The head is short and conical. with functionless facial whiskers and a moist elongate muzzle; the ear sometimes has a distinct pinna, but may be represented by a vertical slit only The legs are short: but the feet, whose five toes are armed with large claws (curved on the forefeet), vary in structure according to habit. The tail, sometimes excessively long and prehensile and sometimes comparatively short, forms. nith the hind legs, a kind of tripodal support. The anus and external genitalia are situated close together on an eminence formed mainly by the enlarged anal glands, and the anus is sunk in a depression into which the ducts of the glands open; both the penis (male) and clitoris (female) are quite small.

Pangolins range in Asia from north India and south China to Ceylon and Borneo and in Africa from Sierra Leone and Uganda to the Cape of Good Hope. There are several different kinds. Some are almost entirely arboreal, some purely terrestrial and others intermediate in habitat; all, however. are nocturnal and are able to swim a little. They feed mostly on termites, ripping open the nests of these insects with the strong claws of the forefeet. Their means of defense are emission of a repulsive odour from the large anal glands and rolling into a compact ball with the hard, often sharp, erected scales presented to the enemy and the soft-skinned hairy underside protected from injury.

There are several fairly distinct types, all usually referred to genus *Manis* and to the family Manidae, but there is some dispute about the scientific names In the Asian pangolins the hinder end of the breastbone is shaped like the blade of a spade. having a convex posterior edge and two forwardly directed spinous angles. To this group belong the northern Indian and Chinese eared pangolin, the Indian and Ceylonese thick-tailed pangolin and the Javanese and Bornean pangolin, all of which differ in many external characters.

In the African pangolins the end of the breastbone is prolonged into two long rods running back to the posterior ribs. There are two groups differing in habitat and correlated structural characters. the terrestrial. including the so-called giant pangolin, with the feet and tail adapted for ground life; and the arboreal containing the small west African pangolins, which differ from all other pangolins in being exclusively adapted to life in the trees, the tails being exceedingly long and prehensile, and the feet with only four functional toes, the upper side of the forefoot being without scales.

The earliest evidences of the Pholidota are the bones of a large pangolin, indistinguishable from those of the African gaint pangolin. found in a cave in Madras. India. These remains date to the Pleistocene. beginning about 1,000,000 years ago.

PHONEMATICS: *see* LINGUISTICS; PHONETICS.

PHONETICS is the study of speech sounds, their physiological production and acoustic qualities. It deals with configurations of the vocal tract used to produce speech sounds, the resulting acoustic patterns and the manner of combining sounds so as to make syllables, words and sentences. On another level it compares the speech sounds of different languages.

Phonetics, since it is part of the analysis of the phenomenon of human language and speech behaviour, contributes to the fields of anthropology, linguistics, psychology, sociology and related fields. Furthermore it has several practical objects: (1) to help in learning to pronounce foreign languages; (2) t~ contribute to speech therapy; (3) to record previously unwritten languages and to develop writing systems for them; (4) to develop more efficient electrical and electronic speech transmission systems (speech compression).

History.—Although phonetics as an independent field of study did not come into being until the 19th century, speculations regarding the nature and origin of human speech, usually connected with magical or religious practices, are found in ancient civilizations. The use of alphabetic or syllabic notation, as opposed to pure ideographs, to record human speech shows an at least intuitive knowledge of speech units and their relationships. One of the earliest attempts at a systematic description and classification of speech sounds was that of the Sanskrit grammarians. whose work came to its climax with Panini (4th century B C). From the classical era until the end of the 17th century, however, more emphasis was placed on the process of phonation rather than on an explicit analysis of speech units. Such descriptions can be found among the works of Hippocrates, Aristotle, Galen and, later, Leonardo da Vinci. Near the end of the 18th century considerable interest was shown in speech synthesis. In 1791 Wolfgang von Kempelen invented a machine which could produce speechlike sounds.

During the 19th century a number of recording devices, such as the kymograph, became available for the quantitative measure of speech phenomena. These devices, along with the artificial palate and X-ray photography, gave impetus to the quantitative study of the physiology of speech. Comparable studies in the acoustic structure of speech were made available through Helmholtz resonators and phonographic devices By 1881, when Eduard Sicvers published his *Grundzüge* der Phonetik, phonetics had become an independent discipline. While the quantitative aspects of speech developed into experimental or instrumental phonetics under the influence of the abbé Jean Pierre Rousselot, another group of phoneticians became preoccupied with the classification of speech sounds and the creation of a notation system for recording speech in a written form. Leaders among this group were Paul Passy, Henry Saeet and Daniel Jones, all of them prominent in the sponsorship of the International Phonetic association nhich was inaugurated in France in 1886. The association soon drew up the International Phonetic Alphabet, which was designed to be applicable to all languages and which has become not only the most widely used phonetic alphabet but also the basis for many suc-

ceeding systems.

Jan Baudouin de Courtenay (1845–1929) is credited as being the first to insist on the distinction between the speech sound and the phoneme, although Henry Sweet (1845–1912) also was aware of the necessity to make this distinction. With the formation of the Cercle Linguistique de Prague in 1926, led by V. Mathesius, N. S. Trubetskoi, Roman Jakobson and S. Karcewski, new impetus was given to the development of phonemics and phonemic theory as distinct from phonetics.

After World War II, improvements in recording devices made available such instruments as the sound spectrograph, which permitted the analysis of speech sounds in great detail, and brought the acoustic study of speech sounds into the foreground. The interest in speech phenomena on the part of communication engineers and others outside the field of phonetics gave rise to an unprecedented study of all aspects of human speech.

Phonetic Analysis.—Speech sounds are recorded and analyzed in two general ways, either by ear or by machine. In the former method, the phonetician listens to a person speaking and writes what he hears in the symbols of a phonetic transcription system, recording in as detailed a manner as he can or as suits his purpose. In the latter method, speech is recorded with an instrument such as the oscilloscope, kymograph, spectrograph or X-ray camera. This usually transforms the speech behaviour into a visual form which can then be measured, and various samples of speech can be compared. In either case, when the object of the analysis is to describe the speech sounds of a given language, the nature and mode of formation of every speech sound of the language must be ascertained with the greatest possible accuracy; long passages of the language must then be transcribed phonetically as accurately as possible with the object of finding out how the sounds may be grouped into distinctive sounds, or phonemes. The usage of the particular language as regards the duration of sounds, the stress of syllables and the intonation (pitch, musical accent) of words and sentences must be examined in detail. To obtain the best

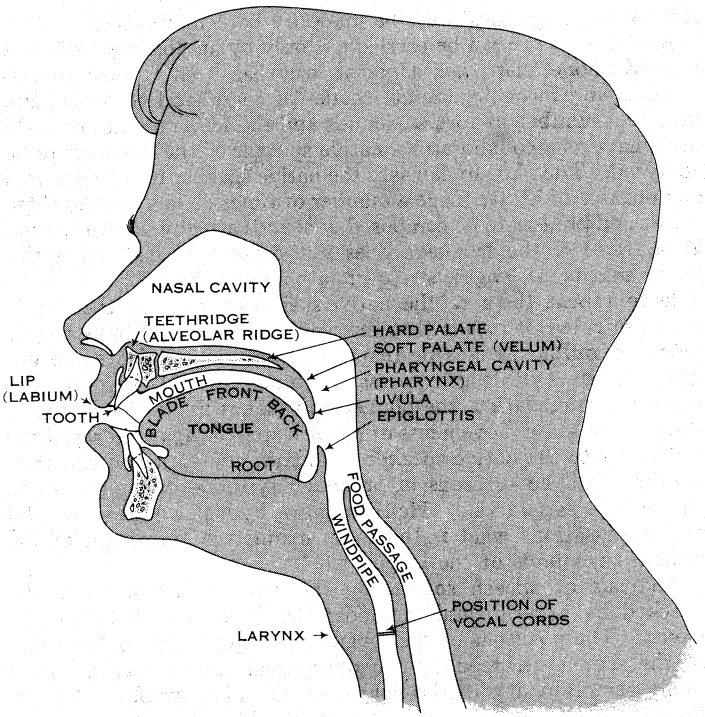

FIG. 1.—THE ORGANS OF SPEECH

TABLE I.—*The International Phonetic Alphabet*

		Bilabial	Labio-dental	Dental and alveolar	Retroflex	Palato-alveolar	Alveolo-palatal	Palatal	Velar	Uvular	Pharyngal	Glottal
Consonants	Plosive	p b		t d	ʈ ɖ			c ɟ	k g	q ɢ		ʔ
	Nasal	m	ɱ	n	ɳ			ɲ	ŋ	ɴ		
	Lateral Fricative			ɬ ɮ								
	Lateral Nonfricative			l	ɭ			ʎ				
	Rolled			r						ʀ		
	Flapped			ɾ	ɽ					ʀ		
	Fricative	ɸ β	f v	θ ð | s z | ɹ	ʂ ʐ	ʃ ʒ	ɕ ʑ	ç j	x ɣ	χ ʁ	ħ ʕ	h ɦ
	Frictionless Continuants and Semivowels	w | ɥ	ʋ	ɹ				j (ɥ)	(w)	ʁ		

Vowels	Rounded	Front	Central	Back
Close	(y ʉ u)	i y	ɨ ʉ	ɯ u
Half-close	(ø o)	e ø	ə	ɤ o
Half-open	(œ ɔ)	ɛ œ		ʌ ɔ
Open	(ɒ)	æ ɐ a		ɑ ɒ

(Secondary articulations are shown by symbols in brackets.)

OTHER SOUNDS.—Palatalized consonants: t̠, d̠, etc. Velarized or pharyngalized consonants: ɬ, ɖ, ʐ, etc. Ejective consonants (plosives with simultaneous glottal stop): p', t', etc. Implosive voiced consonants: ɓ, ɗ, etc. r̆ fricative trill. ʊ, ɻ (labialized θ, ð, or s, z). ɺ, ǯ (labialized ʃ, ʒ). ɻ, ɭ, ɺ (clicks, Zulu *c*, *q*, *x*). l (a sound between ɾ and l). ʍ (voiceless w). ɪ, ʏ, ʊ (lowered varieties of i, y, u). ɜ (a variety of ə). ɵ (a vowel between ø and o).

Affricates are normally represented by groups of two consonants (ts, tʃ, dʒ, etc.), but, when necessary, ligatures are used (t͡s, t͡ʃ, d͡ʒ, etc.), or the marks ‿ or ‿ (f‿s or t‿s, etc.). c, ɟ may occasionally be used in place of tʃ, dʒ. Aspirated plosives: ph, th, etc.

LENGTH, STRESS, PITCH.—ː (full length). ˑ (half length). ˈ (stress, placed at beginning of the stressed syllable). ˌ (secondary stress). ˉ (high level pitch); ˍ (low level); ˊ (high rising); ˏ (low rising); ˋ (high falling); ˎ (low falling); ˆ (rise-fall); ˇ (fall-rise).

MODIFIERS.—˜ nasality. ̥ breath (l̥ = breathed l). ̬ voice (s̬ = z). ʻ slight aspiration following p, t, etc. ̩ specially close vowel (e̩ = a very close e). ̞ specially open vowel (e̞ = a rather open e). ̫ labialization (n̫ = labialized n). ̪ dental articulation (t̪ = dental t). ʲ palatalization (ż = ʒ). ̺ tongue slightly raised. ̻ tongue slightly lowered. ̹ lips more rounded. ̜ lips more spread. Central vowels ï (= i̽), ü (= ʉ̽), ë (= ə̽), ö (= ɵ̽), ë, ɔ̈. ̍ (e.g. n̍) syllabic consonant. ̯ consonantal vowel. ʃˢ variety of ʃ resembling s, etc.

results, investigations must be made by both methods.

Analysis by ear can be carried out only by an observer who is a trained phonetician; *i.e.,* a person who has been trained to distinguish and recognize minute shades of sound and recognize and imitate a number of foreign sounds and sound combinations. He must have as a collaborator a native speaker of the language to be analyzed. The phonetician asks the native speaker to repeat words and phrases of his language a number of times. He may find these words and phrases to be composed of sounds already known to him. If so (and if the language does not present special difficulties in the matter of length, stress or intonation), he will at once be able to repeat them to the native's satisfaction. If the native is not satisfied, it means that the word or phrase contains one or more unfamiliar sounds or that the language contains some unusual features of length, stress or intonation. To acquire the correct pronunciation, the phonetician makes fine adjustments in the positions and movements of his own speech organs in repeating the words to the native speaker. He tries one variation and then another until he succeeds in pronouncing the word or phrase to the native's satisfaction. He then knows by his own muscular and tactile sensations what is the exact manner of formation of the unfamiliar sounds of the language.

Analysis of speech sounds by the acoustic method may be checked by experimental methods; *i.e.,* investigation by instruments. The positions of the tongue and velum (soft palate) and of the shapes assumed by the pharyngeal cavity may be more easily ascertained with the help of X-ray photography. Indications of tongue positions may also be found by the use of a special kind of artificial palate.

Phonetic Symbols.—In nearly every language the number of distinguishable sounds is greater than the number of letters in the Roman (Latin) alphabet. It is therefore impossible to represent most languages unambiguously by means of the ordinary Roman letters only. Any "romanic" phonetic system, therefore, whether designed as a current orthography or as a transcription for the use of language learners, must contain new letters to supplement those of the present Roman alphabet.

Classification of Speech Sounds. — Table I, showing the International Phonetic Alphabet (IPA), taken in conjunction with the chart of the organs of speech (fig. 1), shows the chief principles of sound classification. The meanings of most of the technical terms describing the various classes of sounds are self-evident. Attention may be called, however, to the following, which require some explanation: The back of the tongue is the part which lies normally opposite the soft palate; the front is the part which lies normally opposite the hard palate; the blade is the part which lies normally opposite the teethridge (upper gum, alveolars). Palatal consonants are those formed by the front of the tongue against the hard palate, such as the English sounds of *y* or the German *ch* in *ich.* Retroflex consonants are those made by the tip of the tongue against the hard palate, such as the Hindi sounds of ट ड. (See also VOICE; PRONUNCIATION.)

Intonation. — An important branch of phonetics is that which deals with intonation, or the rise and fall in the pitch of the voice. In the languages called tone languages (*e.g.,* Chinese and most Sudanic and Bantu languages) intonation is used to distinguish one word from another. Thus in Cantonese the syllable *fan* said with a high falling tone means "divide"; said with five other tones it means "powder," "sleep," "burn," "courageous" and "duty," respectively. In the Sechuana language (Bantu) of South Africa, *metse* said with a mid-level tone on each syllable means "villages," but with a mid-level tone on the first syllable and a high-level tone on the second it means "water."

In languages which are not tone languages intonation affects the meaning of whole sentences, but it is not an integral part of any word. Intonation gives expression to sentences; it conveys shades of meaning which cannot conveniently be expressed by other means. Thus in English the two meanings of I *beg your pardon* ("I am sorry" and "What did you say?") are distinguished by intonation. It is not practicable to mark this kind of intonation in orthography, though slight indications of it may be given by the use of punctuation marks or italics.

Phonetic Description. — The sounds of speech are usually described either in articulatory or in acoustic terms.

Articulatory descriptions are based on the parts of the vocal tract which are used in forming a given sound (*see* fig. 1). For instance, vowel sounds can be classified according to several positions of the articulators such as the tongue, the lips and the degree of mouth opening. Fig. 2 shows the tongue positions for several vowels. Fig. 2 (left) shows a series of front vowels, so-called because the tongue is bunched forward in the mouth as opposed to the back vowels in fig. 2 (right) in which the tongue is bunched toward the back of the mouth. In fig. 2 (left) the letter [i], which is the phonetic symbol for the "ee" sound in "meet," is the highest of the front vowels, and [a] as in "cat" is the lowest of the front vowels, since the tongue is not so high toward the roof of the mouth. In fig. 2 (right), [u] as in "who" and [a] as in "father" are the highest and lowest back vowels, respectively.

In some languages, such as Russian and Spanish, it is more efficient to describe the vowel sounds in terms of lip rounding and mouth opening. In such languages [i] is described as an unrounded close vowel since the mouth opening is slight and the lips are not rounded or pursed as they are in [u], which is a close rounded vowel. These two vowels differ from the vowel [a] which is open and has no significant rounding or unrounding. (It is rather difficult to drop the jaw and purse the lips at the same time!) Nasal vowels are produced by dropping the velum (soft palate) so that the nasal passage is open. (In the case of nasal vowels, the air does not usually pass through the nose, which is used only as an additional resonator for the sound.)

Consonantal sounds are described in terms of point of articulation. For instance, [p] is called a bilabial because both lips are brought together to produce the sound, as opposed to the [t], which is called a dental sound because the tip of the tongue is at or near the upper front teeth. Both of these differ from [k], which is articulated with the back part of the tongue somewhere in the region of the velum; hence it is called a velar sound. Consonants are also described in terms of the activity of the air stream in the mouth and the activity of the vocal cords. When the vocal cords are vibrating the sound is said to be a voiced sound; otherwise it is voiceless. When the air stream must pass through a narrow opening, as in [f] or [s], the sound is called a fricative. The air stream is continuous in the fricatives but interrupted in the plosives or stops ([p], [t], [k]).

In the case of the nasal consonants such as [m] and [n], the velum is dropped, as it is for nasal vowels, and part of the air stream passes through the nose. Finer degrees of articulation are shown in the IPA chart (Table I).

In describing the acoustic qualities of speech sounds it is convenient to consider their source and transfer functions. The former refers to the kind of excitation involved; *i.e.,* whether the sound is periodic or random (turbulent). When the vocal cords vibrate they produce a complex periodic wave form composed of a fundamental and its harmonics. On spectrograms (narrow band) such a wave form appears as a series of horizontal lines, longer or shorter depending on the duration of the sound. When the air stream is caused to pass through a narrow constriction, as in the fricatives (*e.g.,* [s], [f]), the spectrogram shows a gray smear

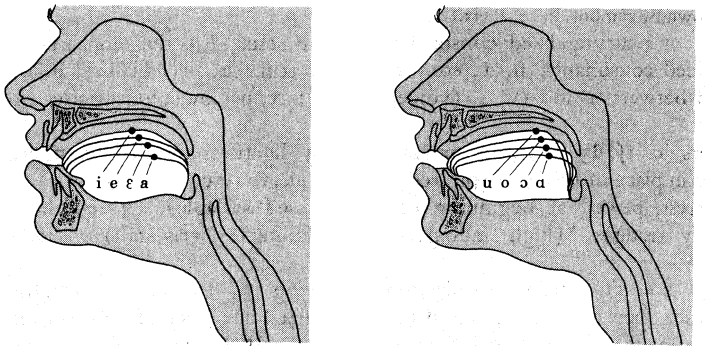

FIG. 8.— TONGUE POSITIONS OF (LEFT) THE FRONT AND (RIGHT) THE BACK CARDINAL VOWELS

covering the entire frequency range.

The various cavities in the vocal tract act as resonators which either reinforce or cancel out some frequencies or frequency regions of the original excitation function. Hence it is convenient to consider the source function to be the substance of the sound and the transfer or resonance function as its form. In vowels, for instance, the source is periodic and the resonators cancel out certain groups of harmonics and reinforce others. **A** typical sound spectrogram of a vowel resembles music notation paper, a series of staves composed of lines, with blank spaces between. Such a staff of harmonics is called a formant or a bar, and indicates a resonance region.

Except under very special circumstances, these formants are independent of the pitch or fundamental frequency at which the vocal cords are vibrating, since they are given their form by the shape of the resonating cavities in the vocal tract. Since the vocal tract assumes a different shape for each of the vowels, as explained above, the resonances or formant frequency regions of each vowel differ from those of other vowels.

It has been found that the vowels of most languages can be differentiated by describing the lowest two (or three) formants, which occur between 250 and 3,000 cycles per second (c.p.s.). Thus the two significant formants of the [i] sound occur at the lower and higher limits of this region, those of the [u] both at the lower end of the region and those of [a] in the centre of the region.

When the source function is not periodic, the resonators also reinforce certain frequency regions and cancel out others, but these regions are usually called resonance regions rather than formants. Thus a spectrogram of [s] will show a gray smear in a high-frequency region (around 6,000 c.p.s.) and [f] a weak smear at a very-low-frequency region. The stops differ from the fricatives in the way they begin. The stops begin abruptly and have a short spike-like appearance on spectrograms, whereas the fricatives begin smoothly and are longer in duration.

The Phoneme. — The only significant difference between the English words "ban" [bæn] and "man" [mæn] is in the first sound. While both are labial sounds, one is a nasal and the other is a stop. When a word can be transformed into another word by such a change, the two sounds are said to be distinctive or phonemic. They are, or they represent, two different phonemes. Phonemics (an alternate term, phonematics, is preferred by some linguistic authorities) is the analysis of the distinctive sounds or phonemes of a language.

Phonemic distinctions differ from one language to another, hence each ianguage has its own set of phonemes or distinctive sounds. For instance, in Czech there is a difference between long and short vowels: *náraz* [na:ras], "shock"; *naráz* [nara:s], "at once." This distinction does not hold for most varieties of English, although there is a phonetic difference in vowel length between "hit" [hɪt] and "hid" [hɪ:d]; changing the length of the vowel in "hit," however, will not transform it into another word, and the same holds true for shortening the vowel in "hid." Phonemic transcriptions indicate only the distinctive qualities of the sounds and are enclosed in slanted lines to differentiate them from phonetic transcriptions, which are not committed to indicating only distinctive differences:

	Phonetic	*Phonemic*
"hit"	[hɪt]	/hɪt/
"hid"	[hɪ:d]	/hɪd/

When two words differ by only one phoneme, such as English "bat" /bæt/ and "sat" /sæt/, the words are said to be a minimally distinct pair. In a minimally distinct pair of words, if there is a difference of only one distinction between the two phonemes in question, then the two phonemes are minimally distinct phonemes. Thus in English "pat" /pæt/ and "bat" /bæt/, /p/ and /b/ are both stops, both are bilabial and the only difference is that /p/ is unvoiced (or tense) and /b/ is voiced (or lax). The phonemes /b/ and /s/ in the previous example are not minimal because one is a fricative, the other a stop; one is bilabial, the other is dental; one is voiced and the other is unvoiced.

Distinctive Features. — For both phonetic and phonemic purposes it is often necessary to describe the relations existing between sounds, the "structure" of relations between the phonemes of a language. Most phoneticians and linguists achieve this end

*TABLE 11.—Distinctive Features of American English**

Compact	Grave	H	T				W		
			P		F		N	J	V
0	0	h							
−	−		t	d	s	z	n	j	ɪ
±	−		ʃ	ʒ	ʃ	ʒ	ŋ		ɛ
+	±		k	g	θ	ð	1	r	æ
+	+		p	b	f	v	m	w	a
±	+								ɜ
−	+								u
Consonantal		−	+	· t	+	+	+	−	−
Vocalic		−	−	−	−	−	+	+	+
Continuous		0	−	−	+	+	0	0	0
Tense		0	+	−	+	−	0	+	−

*P = stop; F = fricative; N = sonorant; J = semivowel; V = vowel; H = /h/; T = Turbulent; W = Nonturbulent.

Source: L. G. Jones, "English Consonantal Distribution," in *For Roman Jakobson,* p. 246 (Mouton, The Hague, 1956).

by using the phonetic classifications, either articulatory or acoustic (or both), such as those outlined above. A system for describing these distinctive features in binary terms was developed by Roman Jakobson and his collaborators shortly after World War II. This system describes the phonemes of a language in terms of the presence or absence of a small number of distinctive features based on articulatory or acoustic terms.

Table II shows such an analysis based on one variety of American English. The plus (+) indicates the presence of that feature, the minus (−) its absence, the zero (0) its irrelevance. The (t) sign usually is used only where the feature can be described in terms of a scale of such values as high, mid or low, and is avoided wherever possible.

This type of classification, utilizing as it does the binary notation system of the mathematical theory of communication, can be used to great advantage wherever phonetics and phonemics play a role, from the learning of foreign languages to the development of more efficient electronic speech compression systems.

See also LANGUAGE; LINGUISTICS.

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PHONOGRAPH, an instrument for reproducing sound by transmitting to the air (directly or indirectly) the mechanical vibrations of a stylus in contact with a sinuous groove in a moving record. In a wider sense a phonograph is any instrument for reproducing recorded sound. In this expanded view the record may be mechanically, optically (photographically) or magnetically recorded and reproduced as sound by appropriate apparatus.

Information on related phases of sound reproduction can be found in the articles HIGH-FIDELITY SOUND SYSTEMS; LOUDSPEAKER; and TAPE RECORDING, MAGNETIC. This article consists of the following parts:

I. History
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I. HISTORY

A prototype of the phonograph appeared in 1857 when Leon Scott constructed a device he called the Phonautograph, which recorded, as a wavy line on the smoked surface of a rotating cylinder, the movements of a diaphragm or other vibrating body. The first record of vibrations which could be played back to reproduce sounds was invented by Thomas A. Edison in 1877. The record was in the form of indentations pressed into a sheet of tin foil by the vibrating recording stylus, which was attached to a diaphragm. The tin foil was wrapped around a cylinder that rotated as the sounds were being recorded. A thread on the shaft moved the cylinder axially as it rotated, so that the record groove was helical. A small helical groove having the same pitch was cut in the surface of the cylinder, and the recording diaphragm and stylus were positioned to bring the groove directly under the slightly rounded point of the stylus, thus making it easier to produce the indentations in the tin foil. The sound waves were recorded as variations in the depth of the groove. For reproduction the groove was again run under the stylus tip, with only enough pressure to maintain contact with the groove bottom. The term "embossing" has been widely used to designate the method of recording in which the groove is impressed in a yielding material by a rounded point.

Edison took steps toward the exploitation of his invention, which he called the phonograph, but he was soon diverted to the development of the incandescent lamp and electric power systems. Several years after the first flare of publicity which followed Edison's demonstrations, Alexander Graham Bell became interested in the phonograph, and with two associates, Chichester A. Bell and Charles Sumner Tainter, began experiments in Bell's "Volta" laboratory in Washington, D.C. They had best results with an arrangement much like Edison's except that their machine cut or engraved the groove in a cylindrical surface of wax with a sharp tool carried by the vibrating diaphragm. This gave much better sound reproduction than had been possible with Edison's indented tin foil. In 1885 C. A. Bell and Tainter applied for a U.S. patent on this principle and other features of their developments, and in 1887 they organized a company to manufacture and sell Graphophones, as they called their machines. Edison returned to his experiments with the phonograph, and he too became convinced of the superiority of the engraved wax groove.

Various promotional and organizational activities took place in the next few years, the most important results of which were that the Columbia Phonograph Co. became the manufacturing and selling organization for the Bell and Tainter developments, and rights under both the Edison and the Bell and Tainter patents became available to both the Columbia and Edison companies.

1. Disc Recording.—Another inventor, German-born Émile Berliner, was responsible for a radical departure in sound recording. The initial Step in Berliner's recording operation resembled that of Scott's Phonautograph, except that Berliner's mechanism traced its wavy line as a spiral on a flat disc, instead of as a helix on a cylindrical surface. The disc was of zinc, coated with a thin layer of fatty substance which protected it from the action of acid except where the scribe had traced its line. An acid bath then left a groove, the width and depth of which could be controlled by the duration and strength of the acid treatment. Berliner thus obtained a record which could be played by means of an appropriately designed reproducing mechanism.

However, he did not contemplate using this etched master as the record to be played; rather, a negative was made from the master by electroforming, and the negative then was used to mold records in some thermoplastic material, a procedure that subsequently became standard. Berliner first proposed using vulcanite or hard rubber as the molding material, but he later found a company that could mold records for him in a material much like that which later became common for all records. Berliner's records were far harder and more durable than the waxes of which the cylinders were being made. The harder material, plus somewhat greater amplitudes due to the fact that the recording stylus did not have to work against any cutting resistance, made somewhat greater volume possible in the reproduced sound.

Of still greater importance to the success of Berliner's discs, however. were the ease of molding from a flat surface and the fact that he could make his grooves deep enough to guide the reproducing stylus across the record without the need for an auxiliary feed screw. It was to the latter feature that the most important of Berliner's patent claims were directed.

Small-scale manufacturing of the Gramophone, as Berliner

called his machine, was started in 1894. The Gramophones were much simpler than the cylinder machines of Edison and Columbia, and could be sold relatively cheaply, while records for them could be made at much lower cost. But driving the record by means of a hand crank was unsatisfactory for anything but demonstrating a principle. Berliner recognized the need for a clockwork drive and controlled speed. He sought outside help, and the problem was eventually brought to Eldridge R. Johnson, who operated a small machine shop in Camden, N.J. Johnson soon worked out a practical design for a spring-driven motor with a friction governor, and in a short time (1896) was building for the Berliner Gramophone Co. not only the spring motors but all the mechanical parts of the Gramophones. Besides developing the spring motor, Johnson made various improvements in the Gramophone, including a better "sound box," the principal features of which were retained with little change throughout most of the history of the acoustic phonograph.

Johnson's experiments soon convinced him that the noisiness of the Gramophone records arose from the roughness of the etched surfaces, and he began to study the possibilities of cutting the groove in wax as Bell and Tainter had done; however, instead of recording the vibrations as variations in depth of the groove (commonly called vertical or hill-and-dale recording), he followed Berliner's practice of recording them as sidewise deflections of a groove of uniform depth (commonly called lateral recording). Johnson mastered the techniques of rendering the wax surface conductive by dusting with graphite and then electroplating, thereby producing a "negative" of the grooved wax. This negative, built up in the plating process to sufficient thickness for needed strength, could then be used to press records in thermoplastic material. The records so made were much clearer and less noisy than those produced by Berliner's process.

For several years the sale of Gramophones and records grew and Berliner prospered, but in 1900 his one sales outlet stopped ordering, and then a court injunction was obtained by competitors (based on alleged infringement of a detail patent) forbidding his company to make or sell Gramophones. Johnson had an enlarged factory and a large inventory of machines. He decided to do his own selling. He started with an advertising campaign featuring greatly improved records produced by a newly developed process and offering a free sample. The business grew and prospered.

In addition to his own technical contributions Johnson now had a going business to offer in exchange for rights under the basic Berliner patents. In Oct. 1901 a new company was formed, the Victor Talking Machine Co., the stock of which went partly to Johnson and partly to Berliner, with the controlling interest in Johnson's hands.

A serious threat to the Victor company arose shortly after its formation, when the Columbia company acquired a patent describing and claiming the process of recording by cutting a laterally varying groove of constant depth in wax, exactly as Johnson was doing. The Columbia company was just beginning to make disc machines, but in so doing it was sure to fall afoul of Berliner's patents. Rather than engage in costly litigation the Victor and Columbia companies arranged for cross-licensing. Thenceforward, competition was in terms of such factors as costs, merits of machines, prestige and quality and popularity of available records.

2. European Developments. — The beginnings of the phonograph business in Europe were limited largely to the activities of sales agents from the already established American companies. Demonstrations of Edison's tin-foil machine were given in 1878 in England and Germany, where they created much interest but little else. A decade later Edison made a serious effort to extend his beginning business by demonstrating his wax cylinder system for many distinguished persons and making recordings of the voices of celebrities. The prices of machines imported from the U.S. were too high for any considerable sales for private use, but, as in the United States, many people were willing to pay a small fee to satisfy their curiosity and hear a machine talk.

As an attraction for their tavern, two Frenchmen, Charles and Emil Pathé, procured a phonograph from England. But when customers showed more interest in the possibility of buying a phonograph than in the other Path6 business, the brothers decided to start making phonographs. They started with a small shop and by 1894 were doing a thriving business, making machines and wax blanks. They were also active in recording, using mechanical methods of duplicating the records, and by 1899 had a large list of available cylinders, principally of popular French singers.

In Italy there was no large market for machines, but the music-loving public would pay at some public installations to hear their favourite operatic songs.

Aside from a short-lived venture of making Gramophones in their simplest (hand-cranked) forms, started in 1889 by a German toymaker, there was little commercial phonograph activity in Europe, except that of the Pathé brothers, until the arrival of emissaries from the then-prospering Berliner group: William Barry Owen in 1897 to establish a branch in England, and Joseph Sanders in 1898 to help Émile Berliner's brother start a record pressing plant in Hanover, Ger. By this time the quality of reproduction had reached a point that made the Gramophone of interest as a source of home entertainment and that induced well-known artists to permit their voices to be recorded. Owen eventually interested certain British investors, and the Gramophone company was organized there in 1898; it imported parts from the U.S. and assembled Gramophones in England. Records, at least at first, were processed and pressed at the Hanover plant. As soon as machines and records became available, extensive advertising was begun, and in the autumn of 1898 sales reached the full capacity of the manufacturing facilities. Owen opened branches for Gramophone sales and recording activities in Berlin and in Russia and Austria, and finally in France and Spain. It was in Russia in 1900 that red labels were first used to distinguish recordings of celebrated artists. For these discs the size was increased from seven to ten inches. In 1899 Owen purchased for the Gramophone company the original painting of a dog listening to a phonograph, to which the name "His Master's Voice" was given. This was soon used as a trademark by the Victor company, and about a decade later also by the Gramophone company, whose records were designated by the initials "H.M.V."

Recording the lateral-cut gramophone discs in wax began in Europe as well as in the U.S. in 1900 but did not entirely supersede the etching system for a year or so.

3. Technical Developments in Acoustic Recording. — Aside from the great growth in the phonograph business and refinements from time to time in recording equipment and techniques, the history of the acoustic phonograph was marked by the following developments:

Methods of molding cylinder records of a relatively hard thermoplastic were introduced by the Edison and Columbia companies in 1901. Since these were announced as "gold molded," it is presumable that gold sputtering was used to give an electrical conducting surface to the wax original.

The Odeon company was formed in Berlin in 1903. The following year it introduced discs with recordings on both sides. Columbia began issuing double-sided records in 1908. Path6 began making hill-and-dale cut discs in 1906 and in 1908 offered 11-in. double-sided discs.

In 1908 Edison brought out cylinders of a new material which he called Amberol, which was harder than the materials previously used. By increasing the number of grooves per inch from 100 to 200 he could offer four minutes of playing time. In 1912 Edison introduced a further improvement in material; he called the new material, which was more resistant to abrasion, Blue Amberol. Roland Gelatt noted that the Blue Amberols were relatively noiseless and, when played with an Edison diamond reproducer, produced better results than any other type of music reproducer then available. In 1913 Edison began making discs and a phonograph to play them. However, he continued to make cylinders for owners of cylinder machines until his company ceased operations in 1929.

The advent of radio broadcasting in the early 1920s brought severe depression to the phonograph industry. The Columbia company went into receivership in 1923; the competition of the

fast-growing radio industry did not seriously affect the Victor company until *1925*. The introduction of electrical recording (by both Columbia and Victor), improved phonographs and combination radio receivers and phonographs soon brought recovery. The British Columbia company had fared much better than the U.S. company (now unaffiliated), and its president, Louis Sterling, bought controlling interest in the American company and took licences for both companies to use the new developments.

The Victor Talking Machine Co. was purchased by Radio Corporation of America in *1929*. Its plant at Camden, N.J., became the production centre for radio equipment as well as phonographs and records.

4. Horns. — The performance of an acoustic phonograph is greatly affected by the size and shape of the horn; and while there was little in the way of technical study during the era of the acoustic phonograph, there was some progress toward better horns. Ear trumpets and megaphones had long been familiar, and the developers of phonographs were quick to take advantage of what horns could do for their machines. The horns assumed various shapes according to the ideas of those who made them. The easiest horn to construct is of simple conical shape, but after about *1920* the exponential horn was the nearly universal choice of engineers. A theoretical analysis of its characteristics was published by A. G. Webster in *1919*, and the subject was further elucidated by C. R. Hanna and J. Slepian in *1924*.

An exponential horn is one whose cross-sectional area doubles with each increase of x inches in distance along the axis from the small end; or, if it is a round horn, the diameter doubles with each increase of $2x$ in axial distance. A small value of x therefore yields a horn of rapid flare, while a large value yields a slowly expanding horn. Every exponential horn has a critical frequency, known as its cutoff; below this frequency the horn is of practically no use, while for higher frequencies it will reproduce very effectively. The cutoff frequency is that at which the wave length is approximately $20x$; hence, to extend the range of response to lower frequencies, x must be made large. To avoid horn resonance, Hanna and Slepian recommended that the expansion be carried to the point at which the surface (of a horn of circular cross section) makes an angle of 45° with the axis. This results in a large bell or final opening.

From the time of the very first phonographs it was customary to funnel the total air displaced by a diaphragm into a horn opening of considerably smaller diameter. This results in greater loading of the diaphragm. reducing its tendency to resonate (*i.e.*, damping it) and deriving from it increased sound power. The volume of air nithin the sound box must be small so that appreciable compression will not take the place of air flow.

Horns can be bent or "folded" to conserve space without too seriously impeding their performance, provided the difference between the shortest and longest paths around the bend is not over about one-third the shortest wave length to be transmitted.

Comparing a conical horn with an exponential horn of the same length and initial and final openings, the cone expands much more rapidly at its small end and much more slowly near the large end. The result is that the conical horn gives some multiplication of air flow at frequencies well below the cutoff frequency of the exponential horn. and the output climbs gradually through a long range of frequency, without ever quite overtaking that of the exponential horn above its cutoff.

The horns of the early phonographs were in some cases frustums of simple cones, but more frequently they ended in a rapidly flaring bell. like a trumpet. In some cases the angle between side and axis increased toward the large end, giving a shape between that of a cone and an exponential horn. However, early horns were relatively small and were not designed to avoid resonances due to reflections at the bell. Some of the resonant points may have been regarded as desirable for increasing sensitivity. The feeble response at low frequencies was of less consequence, since there was little of low frequency on the records. Recording equipment was usually provided with larger horns, often of simple conical shape.

As experience accumulated, the sizes of horns increased, at least on the better machines. In *1906* the Victor company marketed a machine with the horn built into the cabinet. This facilitated increasing the horn size and also made it desirable to keep down the size of the middle part of the horn, thus favouring a shape somewhat closer to the exponential. The slight taper of the swinging pickup arm, which constituted the first part of the horn, increased the general resemblance to the exponential shape. In later models with larger cabinets, larger and still better-shaped horns were employed. However, it was not until the introduction of the Orthophonic design in *1925* that a definitely planned exponential expansion was followed, with considerable increase in length and with an end opening occupying practically the whole front of a large cabinet.

II. ELECTRICAL RECORDING AND REPRODUCTION

Prior to *1925* the phonograph had been developed almost wholly on an empirical or "cut-and-try" basis, with little theoretical analysis and all decisions based on listening tests. Recording was looked upon as an art, and rightly so, for the judgments of an experienced recording engineer as to balance and choice of selections were of utmost importance. Certain voices and instruments recorded well while others did not, and early recognition of poor qualities could often forestall wasted recording sessions. Details of recording equipment and practices were often treated as trade secrets. To the old-line phonograph organizations, the rapidly developing and expanding radio and electronics industries seemed almost unrelated to their own, and few of them sought any help from electronics technicians.

The great difficulty in all direct recording lay in the extremely limited amount of acoustical power which could be collected and applied to actuate the diaphragms of the record-cutting devices. Only in the electronics field was there such a thing as an amplifier capable of multiplying sound power a thousandfold and more, with almost no loss of quality. The initiative in the development of electrical recording was taken by the Western Electric Co. Some work looking toward phonograph applications had been started as early as *1915*, interrupted by the war, and then resumed soon afterward under the direction of J. P. Maxfield. The men who took part had extensive experience not only in amplifier applications but in the many electrical and mechanical problems encountered in telephone apparatus and transmission. Much use had been made of electrical-mechanical analogies which helped make experience in the electrical field applicable to mechanical problems and vice versa.

1. Theoretical Aspects. — In the development of electrical recording and reproducing apparatus an important principle of design of vibrational apparatus was introduced. The essential moving parts of either a recorder or reproducer have a certain amount of mass. Forces to actuate these masses must be produced magnetically in the case of the recorder or by the action of the record on the needle tip in the case of the reproducer. It is desirable to minimize the required forces. It happens that it is not necessary for all of the moving elements of either device to be combined into a single mass. In the recorder the armature of the electromagnetic motor can be separate from the stylus bar and stylus. In the reproducer the needle with its clamp and the lever which connects it to the diaphragm constitute one part; the diaphragm constitutes the other principal mass. If a phase difference can be permitted between the motions of the two related parts, the maximum force that must be applied to the needle to vibrate these masses can be practically halved. The introduction of an elastic connection or "compliance" permits this phase difference. In the recording cutter the torsional flexibility of a short shaft, between the motor armature and the bar carrying the stylus, offers the compliance, and there is another such flexible shaft between the stylus bar and a disk to which the mechanical resistance device is attached. The moment of inertia of each mass element, and the flexibility of each shaft, must be closely adjusted to predetermined values, and the structure of alternate masses and compliances (which is the mechanical equivalent of an electrical low-pass filter) must be terminated by a true mechanical resistance of correct value; otherwise there will be irregularities

in its response. A pure mechanical resistance is not easy to provide.

Some recording heads employed oil for viscous damping; others used special solid materials. In the case of the reproducing device employed in the Orthophonic Victrola, the compliance was provided by a springy "spider" through which the lever actuated the diaphragm, and the required mechanical resistance was obtained by the reaction of the air in the "sound box" and horn throat on the diaphragm. With appropriate proportioning of the sound box volume and the relative areas of horn throat and diaphragm, and with a sufficiently slowly expanding horn, the energy was radiated as useful sound and the diaphragm worked against a substantially pure resistance. The Orthophonic design not only reduced the reaction of the needle on the record but, because of its higher efficiency in radiating the vibrations, gave greatly increased sound output.

While the input impedance of the recording device was practically pure resistance throughout most of the frequency range covered, the springs that centred the motor armature between the pole pieces added a stiffness reactance which predominated over resistance below about 300 cycles per second (c.p.s.). The resulting characteristic of the recording system (expressed as stylus movement for constant electrical input) was of constant amplitude up to 300 c.p.s., and of constant velocity from 300 to 5,000 c.p.s., the upper limit being determined by the cutoff of the mechanical filter previously discussed. Were the constant velocity range extended much lower, the amplitudes at the lowest frequencies would be excessive, necessitating wider groove spacings.

Since the sound level needed for satisfactory operation with a microphone and amplifiers was far lower than had been needed for direct recording, the introduction of electrical recording made it no longer necessary to group the players close together around the recording horns, nor to resort to instruments of special construction. Orchestras and choral groups could perform under conditions similar to those to which they were accustomed in concerts. It was not necessary to give preference to instruments of high acoustical power nor to singers with powerful voices.

Licences were taken by the Victor and Columbia companies to use the Western Electric recording system and equipment, and to build phonographs utilizing the principles and design features described above. The name Orthophonic Victrola was applied to the Victor machine. The horn in this model had considerably greater length (six feet) and final opening area (about eight square feet) than any in previous machines, the rate of expansion being slow enough to make the horn effective down to 115 c.p.s. To accommodate the length within the cabinet the passages were bent or folded several times. The improvements in records and phonographs were quickly recognized and resulted in great increases in sales.

2. Electrical Reproduction. — Although the sound quality of the Orthophonic machine (which was nonelectrical) was excellent, the advantages of electrical reproduction — ease of control, high amplification and simplification by combining the phonograph and radio receiver — made it inevitable that the electrical system would sooner or later supplant the mechanical. The electrical loud-speakers of the early 1920s left much to be desired, and the transition would scarcely have taken place when it did were it not for the advent of a greatly improved loud-speaker described in April 1925 by C. W. Rice and E. W. Kellogg of the General Electric Co. It was marketed by Radio Corporation of America (RCA) in 1925 as a separate loud-speaker for radio, known as the Radiola 104. It has frequently been called the "dynamic cone speaker." In addition to employing the dynamic or moving-coil drive and a conical paper diaphragm (about six inches in diameter), it had the following features which were equally important to the successful results: a very flexible suspension of the diaphragm (fundamental resonance about 60 c.p.s.); a baffle to prevent air circulation between the front and back of the diaphragm; and an amplifier of adequate power capacity to avoid overloading. Prior to this, the means most widely employed for actuating loud-speaker diaphragms depended on the varying pull of a polarized electromagnet on an iron armature. To maintain the armature at the proper spacing from the magnet poles, it had to be held by a stiff spring, and therefore the very flexible diaphragm mounting was not feasible with such "magnetic motors." The first electrical phonograph using the new loud-speaker was the Panatrope of the Brunswick Balke Collender Co., first demonstrated in the autumn of 1925; it employed an electromagnetic pickup. Outstanding in its sound quality was the abundant bass. Early in 1926 the Victor Talking Machine Co. brought out several models of electrical phonographs, some of which were combined phonographs and radio broadcast receivers. These used pickups of the same (General Electric) design as the Brunswick, but for a short period the loud-speaker given preference was one utilizing a large horn built into the cabinet like that of the Orthophonic, with an electrical unit employing a relatively small diaphragm, driven by a balanced armature "motor." Another electrical phonograph which achieved considerable popularity was the Majestic, similar in general principles to the Brunswick but differing in design details.

The baffle loud-speaker offered an important practical advantage for use in homes, because the space requirements were much less than needed for horns of adequate size to give good bass, but for theatre and auditorium applications the directivity of horns was important and space was not so restricted. Designs varied, but practically without exception the horns were exponential in expansion rate and after about 1926 the diaphragms were coil driven. The improved loud-speakers for auditoriums, with improved pickups for reproduction from discs, were applied in the motion-picture field, and resulted in the rapid conversion from silent to sound motion pictures. The commercial realization of this change started in 1926, and the earliest commercially successful sound pictures made use of lateral disc records 16 in. in diameter operating at a turntable speed of 335 r.p.m. and synchronized with the motion-picture film. (See also LOUD-SPEAKER.) (E. W. KE.)

3. Evolution of Fine-Groove Records. — A number of factors played a part in the evolution of fine-groove records. The demonstrations by H. C. Harrison and H. A. Frederick in 1931 of their new hill-and-dale acetate records showed what could be done in greatly reducing surface noise through use of refinements in record processing and a pickup with low vertical force and low mechanical impedance; the pickup permitted use of softer record material, free of any filler such as was used in the shellac records. The development of feedback recorders, the vertical recorder by L. Vieth and C. F. Wiebusch, and the lateral feedback recorder by G. R. Yenzen, also helped contribute to low distortion, extended range and smoother response obtainable with a feedback control that included the vibrating system.

But there were obstacles to change in the home phonograph field, obstacles that applied in much less degree to broadcast transcription service. The first magnetic pickups had rather high output, so their signals could be fed to the first audio stage of radio receivers without additional amplification. But they were also of high mechanical impedance (stiff needle mounting), the correction of which would reduce the output, and high mechanical impedance necessitated high vertical force. Cost-conscious designers were reluctant to put in more amplification. Because there were in existence, millions of records hard and tough enough to stand such forces, incentive to make a change was lacking. It was not until H. J. Hasbrouck's work on elimination of noise from the pickup and record that a pickup having truly low mechanical impedance was adopted. This permitted reducing the vertical force on the stylus to a few grams, but such small forces were insufficient to trip some record changers; consequently, full advantage could not be taken of the new pickups without improvements in record changers.

The reduction in necessary vertical force was so great as to make it feasible to use stylus tips of reduced radius, resting against the sloping sides of the groove instead of on the bottom; furthermore, this could be done while using records of clear vinylite, free from fillers. The advantages of using a finer stylus tip — in reduced tracing distortion, in finer groove pitch and in permitting some reduction in linear velocities — had been realized for a number of years but were especially convincingly shown in the analytical papers of F. V. Hunt, J. A. Pierce and W. D. Lewis, who also demonstrated a practical design for a low force, jewel-tipped pickup. They also showed the superior tracing possible with

lateral-cut records, provided the spherical stylus tip maintained contact with the sloping side walls of the groove and cleared the bottom.

The dimensions of a record groove are determined by the lateral displacement of the groove resulting from the signal, or music, and by the dimensions of the reproducing stylus. It is evident that a reduction in either or both of these factors permits a reduction in the dimensions of the groove and thus makes possible a smaller record or a record having longer playing time. The use of less noisy record materials permits a reduction in the lateral displacement of the groove without reducing the signal-to-noise ratio. The use of pickups with a lower value of mechanical impedance permits the use of a smaller reproducing stylus. Experimental evidence proved that up to 300 grooves per radial inch and a reproducing stylus with a radius of 0.001 in. were practical.

The amount of distortion in the signal reproduced from the record groove increases as the stylus moves toward the centre of the disc—that is, as the relative circumference of the groove decreases and the relative speed of the groove past the stylus decreases. Therefore, the speed at which a disc record should rotate is related to the amount of recorded material it contains, and both speed and amount of material are governed by the circumference of the innermost groove that will give the maximum permissible distortion.

In addition, there is a definite relationship between the diameters of the outermost and innermost grooves that gives the maximum playing time per unit surface area. This relationship is such that maximum playing time for a disc of given size will be achieved if the diameter of the innermost recorded groove is one-half the diameter of the outermost groove; this relationship also is governed by the amount of permissible distortion in reproduction obtained from the innermost groove.

It is important to note that any major change in playing-time calls for a change in speed of the record in order to achieve the least area or amount of record material, as the case may be. This assumes no change in the other factors, such as the radius of the reproducing stylus, the lateral displacement of the groove or the reproduced distortion at the innermost groove.

Modern disc records are designed with full knowledge of these principles. Other factors of a practical nature have resulted in some deviations from the purely theoretical considerations of disc record design. In 1948 both Columbia and RCA introduced fine-groove records of clear vinylite. The Columbia version was 12 in. in diameter, rotated at 333 r.p.m. and had a maximum playing time of 30 minutes. The RCA version was seven inches in diameter, rotated at 45 r.p.m. and had a maximum playing time of eight minutes. After several months of testing the market, the change to fine-groove records became complete, with Columbia and RCA each making both versions.

The justification for these two records results from the wide difference in the playing time of "popular" and "classical" music. Each of the new records offered major improvements in cost, convenience and performance over the older 10- and 12-in. 78.26-r.p.m. records. (A. D. B.)

4. Stereophonic Phonograph Records.—Stereophonic phonograph records with two separate channels of information recorded in a single groove became a commercial reality in 1958, less than a year after the adopted system had been publicly demonstrated. A stereophonic system utilizes two or more independent channels, with separate microphones in recording and separate loud-speakers in reproduction, so arranged as to produce a sense of realism of recording hall acoustics and of location of the instruments of the orchestra with respect to directivity and depth. The effectiveness of stereophonic reproduction was demonstrated by the Bell Telephone laboratories in 1933 when the sound of an orchestra playing in Philadelphia was reproduced over loud-speakers located in Washington. The material was not recorded but was transmitted directly over telephone lines. Two-track stereophonic tape for the home became common in the 1950s, and Emory Cook produced some commercial stereophonic disc records, laterally recorded, in which the two channels of information were carried as separate inside and outside bands on the record; reproduction was through a forked arm carrying two pickups, one riding in each band.

The system finally adopted as standard used a dual-channel feedback recorder and a single stylus with its axes of movement inclined at 45° to the record surface, the pickup being designed to produce two practically independent signals in accordance with the motion components along the two (90° displaced) axes. Since the record groove is V-shaped and ordinarily has an included angle of 90°, the groove walls are 45° with respect to the record surface. Consequently, for the 45°–45° system the signal from one channel varies the position of one groove wall about a mean (no-signal condition) without changing the position of the other.

Operation at 45° provides a symmetrical arrangement that offers advantages both in design of recorders and reproducers and in quality of reproduction, since frequency response, distortion and other characteristics of the two channels are alike. In addition, good reproduction is possible over a single channel (monophonic) system since information from both stereophonic channels is contained in the resultant lateral modulation. However, due to the vertical modulation, monophonic pickups must have greater vertical compliance than normally required for lateral records. P. C. Goldmark recognized this problem in earlier work on stereophonic disc recording and proposed that the vertical modulation be dynamically held within limits that would not exceed the tracking capabilities of existing lateral reproducers. Such a record could be designated as "compatible" and could be reproduced either monophonically over phonograph systems designed for lateral-cut records or stereophonically over stereophonic systems. However, not wishing to risk possible reduction in quality, record manufacturers decided to follow the recommendation of the Record Industry Association of America and produce the two types of records, monophonic and stereophonic, separately. (H. E. R.)

III. RECORD MATERIALS AND PROCESSING

The early tin foil and other recording media ultimately were supplanted by materials of two general types: the wax disc (actually a heavy-metal soap with wax gel) intended for subsequent processing and duplication, and the instantaneous media intended mainly for playback directly from the embossed or engraved original record.

The necessary accuracy of the recorded groove can be judged by the requirements established for fine-groove records: that the bottom radius of the groove be less than 0.00025 in. and the width about 0.0025 in., giving a depth of about 0.00125 in. This is less than one-half the groove size of the 78-r.p.m. record.

In cutting or engraving the master record the stylus must be sharp and accurately ground so that the cut will be very clean. Lacquer-coated discs, usually on an aluminum base, were developed as an instantaneous recording medium, but because of the slightly rubbery nature of lacquer a smooth, low-noise groove was not obtained. The development of a burnishing facet on the stylus cutting edge resulted in quieter grooves but increased cross-modulation (echo) between adjacent grooves. The introduction of the heated cutting stylus about 1950 improved lacquer recording to the point where wax discs became practically obsolete for commercial master recordings.

1. Electroforming.—To make copies of the recording, dies must be made whose surface is a negative replica of the master record surface. Electroforming techniques which reproduce the surface to an accuracy of better than 0.000001 in. are utilized. In electroforming, the surface is made the cathode in an electrolyte solution containing the metal to be deposited. The neutralization (reduction) of the positive metal ions at the cathode surface forms a metal sheet whose thickness is proportional to the current and time.

Before this can be done, however, the master record surface must be made electrically conductive. Prior to 1938 wax recordings were made conductive by brushing graphite or bronze powder into the wax surface. In the 1930s Western Electric introduced gold sputtering, which was widely adopted by the major record manufacturers. With the improvements in lacquer discs and recording techniques, it was found that wet-silvering methods (*e.g.*, the chemical reduction of an ammoniacal silver solution such

as that used for silvering mirrors) led to improved results. By the early 1950s, in view of the more stringent requirements of the unfilled-plastic records and particularly the fine-groove records, lacquer discs with wet-silvering metallizing had been universally adopted by major record manufacturers.

After separation from the recording, the electroformed metal master disc can be used in a plastic molding press to press records, and in cases where only up to 100 or so records are desired this usually is done. In the case of commercial records, many pressing masters, called stampers, may be needed. Therefore, it has been the practice to electroform a metal positive from the metal master. This positive, called a "mother" or mold, can be played as a record for quality approval and then used to generate a number of stampers by electroforming. By using a metal master to generate a number of molds and each mold to generate a number of stampers, it is possible to make many stampers, and thus thousands of records, from each recording.

2. Record Materials. — Commercially, records are molded from thermoplastic materials, which become soft and flow under pressure when heated but when cooled to room temperature become rigid. Shellac, a natural thermoplastic, was used in combination with a finely ground filler such as clay for many years, but after the early 1930s synthetic thermoplastic resins gradually replaced it. High-quality record compositions without filler were first used for transcription records for radio broadcast. With the introduction of the fine-grooved records, use of the higher-quality compound became necessary to reduce the noise caused by the filler particles. Of the synthetic materials, the vinyl plastics are most commonly used for records.

IV. PHONOGRAPHS AND RECORD CHANGERS

1. Stylus Shapes and Materials. — Except for the Edison hill-and-dale phonograph, which had a diamond reproducer stylus, most phonographs prior to 1935 required frequent changes of stylus or needle. Heavy pickups, weighing from 100 to 200 g. and bearing upon the small area of contact at the tip of the stylus, can exert pressures far in excess of the strength of record materials. Shellac-compounded mixtures used in records included a large proportion of abrasive filler, usually fine limestone and clay, which soon ground the tip to conform to the groove shape. In this way the contact area between stylus and groove was increased materially, thus decreasing the unit pressure so that record wear was reduced. When, between 1933 and 1935, attempts were made to use sapphire styli with electrical pickups weighing 50 to 150 g., record wear was found to be excessive, probably because the sapphire could not quickly be worn sufficiently to reduce the unit pressures at the stylus tip to a satisfactory level. It was not until the introduction in the late 1930s of pickups weighing less than 35 g. that sapphire and diamond styli became practical. The lighter pickups also permitted the use of unfilled-plastic record materials.

When comparatively large forces were necessary to extract the signal from the groove, the output was affected by the type of needle used. A short, stubby steel needle resulted in high output with good high-frequency response, but this also brought out the surface noise of the record. With a longer, thinner-shanked and more flexible needle, the over-all output was reduced but the high frequencies were attenuated to a greater degree, making the surface noise less audible. Steel needles were used most commonly during this period, although "low-noise" fibre or thorn needles, more compliant than steel, also were used.

Steel needles had to be changed after every play with abrasive-filled records. In the 1930s chrome-plated needles, which could be used somewhat longer, were introduced, and needles with hard metal tips such as osmium were also available. With the advent of light-weight pickups, jeweled styli (sapphire and diamond) became predominant.

Record styli are made to precise specifications. The point should be spherical, tapering off to a 50° cone. For the 78-r.p.m. record a 0.003-in. point radius is desirable, and for the fine-groove records a 0.001-in. radius. Specifications for the stereophonic records call for a stylus point with a maximum radius of 0.0008 in.

There is no permanent stylus. Even a diamond point will wear with time. With light pickups a sapphire stylus should give satisfactory performance for about 1,000 hours of playing, a diamond about ten times this.

The needle should make contact on the sides of the groove for best reproduction. As the stylus wears, its sides become flat and the stylus rides more closely to the bottom of the groove. A stylus riding on the bottom of a record groove results in noisy and distorted reproduction. (A. M. MA.)

2. Reproducer or Pickup. — A phonograph pickup is a device which, when actuated by the record groove, will produce a usable signal proportional to the signal (music) recorded in the groove. Common forms of phonograph pickups produce an electric signal proportional to the amplitude or velocity of the signal in the record groove.

Phonograph pickup designers have explored nearly all of the known principles of electric generation, including the piezoelectric effect from certain crystals, variable resistance, variable capacity, variable magnetic flux cutting, variable magnetic reluctance and variable light-beam photoelectric effects. In general, it is possible to design a pickup using any principle that will produce an electrical signal from a mechanical signal. The selection of the principle and the design of the pickup is usually determined by cost, environmental conditions, etc.

Because of relatively high electric output, crystals of Rochelle salts, properly cut and designed into a pickup, have been extensively used in low- to medium-priced phonographs. Barium titanate and lead titanate zirconate also have been used, as these materials are less affected by moisture and temperature variations than Rochelle salts (*see* PIEZOELECTRICITY). Mechano-electromagnetic principles have found considerable use, moving-iron and moving-coil devices being commonest. Mechano-electro-capacity principles also have been employed.

Pickup designers, for the most part, have directed their efforts toward designs of low cost, low mechanical impedance, low distortion and high reliability. Low mechanical impedance has received considerable attention because its attainment permits a low value of stylus force. The less the stylus force, the less will be the wear of the stylus and the record groove. Concentrated effort on the part of pickup designers reduced the mechanical impedance to the point where only a fraction of an ounce of stylus force was necessary to hold the stylus in contact with the walls of the groove. It was this development which permitted the use of clear vinylite record materials and a stylus radius of 0.001 in. or less. To appreciate the magnitude of this accomplishment, it is only necessary to consider that many mechano-acoustic pickups required a stylus force of over six ounces with a stylus radius of 0.003 in.

Stereophonic pickup design followed the same basic principles used for monophonic pickups. The so-called universal pickups used for hill-and-dale and lateral transcription equipment were the forerunners of the 45°–45° stereophonic pickups. In the stereophonic pickup, it was the design objective to produce two independent signals using a single stylus actuated by two independent signals recorded in a single record groove. Thus the pickup has two independent electric generating units connected to and actuated by a common stylus.

3. Record Changers. — A record changer is a mechanism designed to permit a stack of selected records to be played without further attention.

While a number of early patents were granted on automatic record-changing devices, very few machines reached the hands of the public until after the mid-1930s. The low-cost, single-play phonograph attachment, for use with a radio, stimulated interest in the playing of records. As record collections grew, the need for record changers became apparent. By 1940 many manufacturers were equipping their phonographs with record changers.

The record-changing mechanisms were of varied designs. Commonest in the early period was the edge-selector type in which the records were placed over the centre spindle and supported at their circumference on two or more shelves. Blades or knives, above the shelves, sliced in between the bottom record and the next above to drop the bottom record onto the turntable. In an-

other design the record stack was supported at the centre on an offset portion of the spindle and at the circumference by a shelf. The top portion of the spindle was tilted slightly to provide stability to the stack. The shelf support included a mechanism designed to push the bottom record from the off-set portion of the spindle. Edges and centre holes of shellac records were damaged by these types of mechanisms.

After World War II, many improvements were made in record-changer mechanisms. The use of vinylite record material practically eliminated damage to the record by the selector mechanism. In addition, improvements were made in the turntable drive system, tone arm, tone arm landing and tripping mechanisms, etc. (A. D. B.)

4. Phonograph Motors and Drive Systems.—The first experimental machines were hand cranked, usually with some steadying effect by flywheels, but in one of his early patents Edison stressed the importance of correct and uniform speed. Battery-operated electric motors were soon used, but these were sensitive to changes in load and voltage; flyball governors were used to reduce speed variations. The most satisfactory of these governors were those with a friction disk, the friction of which increased rapidly if the speed exceeded the desired value. While Edison was reluctant to give up the electric motor, a spring-driven, governed motor developed by Frank Capp, a pioneer in many phonograph improvements, was demonstrated to Edison and adopted, and spring motors also were developed by the Columbia company and by Berliner. At the end of 1896 all three companies were using governed spring motors,

For recording, weight-driven machines with friction governors were used for many years. The weight supplied a constant torque, and the governor was connected to the turntable spindle through a worm gear. These were precision-built machines.

Electric motors did not come into very extensive use until radio-phonograph combinations were introduced, and then for many years the motor served only to provide a reasonably uniform driving torque, and friction governors, geared to the turntable, regulated the speed. The induction disk motor (like those used in watt-hour meters) was widely used in this manner. Small, high-speed, split-phase or shaded-pole induction motors with governors were among the many forms used during the 1930s, and a true synchronous motor, resembling a clock motor, was used in some machines. The latter had a multitoothed steel disk which, once started, was kept rotating by the intermittent pull of its toothed pole pieces.

"Rumble" due to vibration of the turntable or pickup pivot presents a problem. The vibration is primarily caused by the high-speed motor and transmitted through the motor supports or the speed-reduction system. Cushion mounting of the motor is therefore necessary. Problems arise because the ear is especially sensitive to slow pitch fluctuations. Successful filtering is increasingly difficult as the frequency of the disturbance is lowered. Belting between motor and turntable can give excellent results in reducing rumble. Transmission of rumble by the belts can be almost completely avoided. Very light, thin, flexible belts of exceptional uniformity are required, especially if one of the pulleys is small; usually, two stages of reduction are used. Friction drives with rubber tires also are widely used because the rubber tires can be ground to a high degree of concentricity. By grinding the end of the motor shaft in its own bearings (after balancing the motor), the shaft end can serve very satisfactorily for the first unit of the drive train, even though it is as small as $\frac{3}{16}$ in. in diameter. The inside of the flanged turntable, machined to concentricity, can be the final friction drive surface. The rubber tires can then be on the intermediate wheels. Since the load is light, the slip or "creep" is negligible. (E. W. KE.)

V. MAGNETIC RECORDING

The advantages of magnetic recording were quickly appreciated by the phonograph industry, once its excellent low-noise and audio-quality characteristics had been demonstrated. Greater recording time, immediate playback, the possibility of erasing and reusing the medium and the feasibility of editing, a feature never possible in disc recording, soon made magnetic tape a popular medium for phonograph recordings and broadcasting. In a very short time all original recordings were being made on magnetic tape; these were transferred, after editing, to discs.

Magnetic tape also offered another means of bringing recorded music into the home, with the advantage that more than one track could be recorded simultaneously, thus permitting stereophonic recording. Prerecorded tapes soon became available for home use for both monophonic and stereophonic reproduction. These appeared as two-track recordings on tape $\frac{1}{4}$ in, wide, on spools either seven or five inches in diameter, depending upon the playing time. The operating speed was $7\frac{1}{2}$ in. per second. For monophonic recordings each track was used separately and a total playing time of approximately one hour was possible. For stereophonic recordings where both tracks were used simultaneously the total playing time was about 30 minutes. After tape having a thinner base became available, the playing time was increased by about 50%, thus permitting a playing time of about 45 min. for a stereophonic recording. (See TAPE RECORDING, MAGNETIC.)

(H. E. R.)

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VI. PHONOGRAPH MUSIC

The day in 1877 when Thomas Edison reproduced his own voice on a tin-foil cylinder, reciting "Mary Had a Little Lamb," marked the beginning of an activity with potentialities unforeseeable even in the most extravagant dreams. Edison's "talking machine," generally regarded as an elaborate toy but offering the novelty of hearing one's voice reproduced, preserved the voices of many prominent people of the time, such as those of William Gladstone, P. T. Barnum and Robert Browning. An early musical recording was that of Brahms playing one of his own works.

Commercial recording was established in the 1890s and in spite of quantity production problems had an amazing growth. Many early records were of vaudeville skits, monologues and descriptive accounts, with some musical selections by bands, whistlers and singers. By the early 1900s many first-rank artists were to be heard on both discs and cylinders. The fact that the voice reproduced better than instruments made singers much in demand. Among the earliest artists to record were Medea Figner, Nikolay Figner and Enrico Caruso, whose great success undoubtedly influenced other artists favourably. In the United States, "Celebrity Disks" were issued by the Columbia company, followed by the Red Seal list of Victor. By 1910 nearly every first-ranking singer was represented on records. Orchestral accompaniment to vocal records began in 1906 after an unsuccessful start in 1900. Many instruments did not reproduce well; since brass instruments recorded better than others, there was a tendency toward their overemphasis, the musical result often being far removed from the composer's intention. Orchestras had to be small because of the necessity for grouping the musicians close around the recording horn. Among the first instrumental soloists to record were Pablo de Sarasate y Navascues, Joseph Joachim, Raoul Pugno, Fritz Kreisler, Jan Kubelik, Ignace Jan Paderewski, Eugène Ysaye, Vladimir von Pachmann and Efrem Zimbalist.

Recording of orchestral repertory began in London in 1909 when the Odeon company issued the Tchaikovsky Nutcracker Suite, played by the London Palace orchestra under Herman Finck. The increased interest in instrumental recording brought forth a variety of works, played by various orchestras, often in condensed versions. In the United States in 1912, the Columbia company engaged Felix von Weingartner to conduct an enlarged staff orchestra for several discs. In 1917 Columbia engaged the Chicago symphony under Frederick Stock, the Cincinnati symphony under Ernst Kunwald and the New York Philharmonic under Josef Stransky; and in

1918 Victor began a series by the Boston symphony under Karl Muck and by the Philadelphia orchestra under Leopold Stokowski. Chamber music made its appearance in 1916 in Europe with recordings by the London string quartet. An occasional full-length large work was recorded, one of the earliest being a La Scala performance of Leoncavallo's opera I *Pagliacci* under the composer's direction. The main interest, however, seemed to centre on the artist rather than the music.

The introduction of electrical recording in the 1920s marked the beginning of the second period of phonograph development, during which the emphasis shifted to production of complete works. The use of microphones eliminated crowding around a recording horn; this, along with improved quality of sound and increased tonal range. opened up new fields of instrumental literature. Record catalogues listed complete symphonies, operas and chamber works by nearly all the well-known composers of the past as well as works by many contemporaries. The composer and the composition, rather than the artist, became the chief points of interest. Ironically, progress in electronics, which made such technical advances possible in the recording field, served to work against increased use of the phonograph because of the rapid growth of radio broadcasting. World War II was another restraining influence, though the end of the war brought an increased activity in recording and several improvements in reproduction techniques, such as full-frequency-range recording introduced in England by the Decca company. The real revolution, which marked the beginning of the third great period of phonograph history, was the introduction of fine-groove records in 1948. Their almost total lack of surface noise, improved faithfulness of reproduction, and the fact that they allowed recording of complete works on one or two sides of a single record meant that the fine-groove records almost immediately supplanted older types.

A development of equal importance was the introduction of magnetic tape for making original recordings. In a time of rising production costs. the advantages of tape were obvious: no longer did soloists and orchestras have to repeat compositions many times to achieve a performance satisfactory for public sale on records; instead, sections containing flaws could be rerecorded and these sections could then be patched into the tape to make a final master tape from which the master disc was transcribed. Some critics maintained that the too-perfect results thus obtained lacked the realism of actual performance, but the reaction of musicians and record purchasers was in general enthusiastic. In addition, the mobility of tape-recording equipment made it much easier to record actual performances in concert halls and theatres, thus putting on discs many performances otherwise unattainable.

Tape-recording and playback equipment was available for home use, in both monophonic and stereophonic types, and recording companies offered extensive lists of prerecorded tapes; in general, when reproduced on good equipment, the quality of these tapes exceeded that of the best disc recordings.

The educational possibilities of the phonograph were realized early in such collections as the *History of Music by Eye and Ear,* edited by Percy Scholes, *Two Thousand Years of Music,* edited by Curt Sachs, and numerous other sets of similar nature. Other special issues were tests for measuring musical talent or accomplishment. discs for technical instruction of various kinds, missing-part records for learning chamber music and numerous others. A remarkable result of the new recording techniques was the issuing of many of what might be termed rerecorded old acoustical records, making it possible to hear artists of earlier days under more favourable conditions of reproduction. Popular music, of course, was one of the mainstays of the industry, the material made available in this field being even more complete than the extensive listing of the classical field. The popularity of dance bands on records began in 1913, gaining increasing interest each year. Folk songs from nearly every area of the world appeared both as special studies and as regular releases. Nonmusical lists. in addition to the usual numerous sketches. monologues and similar short offerings, showed an increasing number of complete plays and musical shows, as well as recordings of noted poets and authors reading from their own works. Of documentary importance as well as general interest were the collections of statements by prominent people and comments on newsworthy current events. Foreign language and other instruction, children's stories and Bible stories were among the many choices of instruction and entertainment made available. An important development for scholars was the establishment of archives by museums and libraries for preserving old and new records for their historical value.

Information regarding available records was to be found in magazines such as the *American Record Guide,* the *Gramophone* and *Disques,* devoted solely to dispensing record information, as well as in others having record sections. Numerous books on the subject were also published, some surveying the entire field and others dealing with only limited portions. (AY. D.)

PHONOLITE, in petrology, a group of alkaline lavas rich in nephelite (*q.v.*) and sanidine, an alkali (potash) feldspar (*q.v.*). The name is a Greek rendition of the German *Klingstein (phone,* "sound," and *lithos,* "stone"), referring to fine-grained compact lavas which split into thin, tough plates and give out a ringing sound when struck with a hammer. The presence of a feldspathoid mineral was suspected from gelatinization tests (decomposition by hydrochloric acid, with separation of gelatinous silica) as early as 1828, but it was not until 1867 that nephelite was shown to be a major constituent of the matrix.

The most important constituent of phonolite is alkali-feldspar, either sanidine or anorthoclase, which forms not only the bulk of the ground mass, but most of the large crystals in porphyritic varieties.

Nephelite rarely appears in large crystals but may occur either interstitially or in well-formed microphenocrysts. The principal ferromagnesian mineral is a pyroxene, titanaugite, aegirine or cores of the former mantled by the latter. Pyroxene in phenocrysts is sharply euhedral; in the matrix it occurs characteristically in slender unterminated needles, often so abundant as to impart a green colour to the rock.

Amphibole (*q.v.*) is practically confined to phenocrysts and is usually an alkaline variety, barkevikite, riebeckite or arfvedsonite. Feldspathoids other than nephelite may be present in accessory amount, the commonest being nosean, sodalite (*q.v.*) and leucite (*q.v.*). Glass has been reported occasionally but only in small amount.

Occurrences. — Mcst phonolites are of Tertiary or Recent age, but excellent examples are found at several localities in the Carboniferous strata of Scotland and also of Brazil. In terms of the numbers of recorded occurrences, though not perhaps in total volume, Tertiary or Recent phonolites are common in Europe, in the Auvergne (Mont Dore), the Eifel, the Laacher See and Bohemia. They have been described from a number of sites in the Mediterranean area, chiefly in Italy, as well as from Cripple Creek in Colorado, and the Black hills, South Dakota. The famous Devils Tower, Wyoming, is variously described as tinguaite or phonolite, depending on whether it is considered a plug or a flow.

Leucite phonolites are perhaps best known from the vicinity of Naples. Apachite, from the Apache mountains, west Texas, is an amphibole phonolite. Kenyite, from Mt. Kenya, east Africa, is rich in cossyrite and olivine. The phonolite of Ölbruck. Ger., a rather popular local building stone, is said to contain about 15% of noselite and 8% of leucite.

Phonolitic trachytes are found on St. Helena and a number of other oceanic islands. (F. Cs.)

PHORMION, Athenian admiral in the 5th century B.C., was the son of Asopius, of the deme Paeania. He first appears in 440 B.C. when he was sent with reinforcements to the Athenian troops before Samos.

In 432 he took out reinforcements to the force blockading Potidaea, took over the command from Callias and completed the circumvallation of the city. He seems to have stayed in the north-east. as in 431 he was co-operating with Perdiccas against the Chalcidians. In 430 he was sent with 30 ships to help the Acarnanians against the Ambraciots. That winter there followed the operations on which his fame is based. He was given 20 ships and stationed at Naupactus to effect a blockade of Corinth from that

side.

In the summer of 429 a superior Peloponnesian fleet arrived and was decisively beaten by Phormion. In a second engagement he was forced to retreat, but turned and again routed his pursuers. He was probably dead by 428.

See PELOPONNESIAN WAR.

PHORMIUM (NEW ZEALAND FLAX; also termed NEW ZEALAND HEMP). The plant (Phormium *tenax*) is a perennial of the Liliaceae family and is propagated either by rhizomes or by seed. While termed "New Zealand flax" and also "New Zealand hemp," the plant has no relationship to either flax (*Linum usitatissimum*) or hemp (Cannabis *sativa*). Phormium is a native of New Zealand and, while known to be adapted in many other countries, is not commonly grown for commercial fibre production in any country other than New Zealand.

The thick sword-shaped leaves grow in tufts from the tips of the rhizomes and reach a length of four to six feet. The flowering stem. which also starts from the tip of the rhizome, grows out through the centre of the tuft of leaves and reaches a height of 5 to 15 ft. The flowers are usually cross-pollinated though some self-pollination occurs. The parts above ground die soon after the flowering stage, but the plant continues to live from year to year by new growth from short, thick underground stems (rhizomes).

Much of the phormium fibre of commerce has come from harvesting the volunteer growth, but considerable quantities have been obtained from cultivated fields. The crop is adapted to a wide range of New Zealand soils, but the greatest yields have been obtained from well-drained swamp lands.

The plant is grown principally for the fibre which develops in the leaves, and which is separated from the nonfibrous tissues by a process of scraping and washing. This processing is done in fibre mills by means of special machines designed for the purpose.

The cleaned, dried fibre is arranged in hands ("heads") and then packed in bales, in which form it is exported. The fibre is similar in appearance to such other leaf fibres as abaca (Manila hemp), henequen (Yucatan sisal) and "true" sisal. Its principal use has been for twines and ropes. (A. H. WT.)

See H. J. Critchfield, "Phormium Tenax—New Zealand's Native Hard Fiber," *Econ. Bot.*, vol. 5 (1951).

PHORONIDA is a phylum of small, marine, wormlike animals which live in self-secreted tubes embedded in the sea bottom or attached to solid surfaces. They are found in shallow tropical and temperate waters of many parts of the world—Europe, North and South America, Australia, South Africa and Asia. Phoronids, constituting a small and relatively homogeneous group, are considered to be a separate phylum because they are structurally unique; they cannot clearly be related to any other group of animals. In the past, however, attempts were made to relate them to the Annelida, Mollusca and Chordata among other phyla. Two genera, *Phoronis* and Phoronopsis, and about 16 species are recognized.

Structure and Function. — In all phoronids the body is more or less elongate—most species ranging in length from less than a centiinetre to 20 cm.—and bears a crown of tentacles at one end. The tentacles are arranged in a double row surrounding the usually crescent-shaped mouth. The mouth is partly covered by a flap of tissue known as the epistome. The anus occurs at the same end of the body as the mouth and is borne on a small papilla located immediately outside the double row of tentacles. The digestive tract is therefore U shaped. The tentacles may form a slightly indented circle or a complex double spiral. Situated near the bases of the tentacles is a supporting structure made of connective tissue and known as the lophophore. Depending on the species, there may be from about 50 to over 300 tentacles, each one bearing fine hairs or cilia. The movements of the cilia create currents which carry food particles from the surrounding water into the mouth and waft waste particles away from the anus. Feeding and excretory currents have not been studied in great detail.

The digestive tract consists of esophagus, stomach. intestine and rectum. These various regions differ from one another in size and in the nature of the cells forming the internal lining. In some species there is a distinct muscular valve between the esophagus and the stomach. The junction of the stomach and intestine occurs at the proximal end of the body, that is, the end which does not bear tentacles, mouth and anus. The tentacular end of the body is known as the distal end. The food seems to consist chiefly of microscopic phytoplankton. Diatom shells may frequently be found in the digestive tract and in the fecal pellets.

There is a system of blood vessels in which circulate elliptical, nucleated corpuscles containing the red pigment hemoglobin, similar to the hemoglobin found in human blood. Two longitudinal vessels, known as the afferent and efferent vessels, are continuous with one another at the proximal end of the body. At the distal end both vessels connect with a pair of semicircular vessels located at the level of the lophophore, immediately below the tentacles. Within each tentacle is a single, blind vessel which branches into two at its base and so connects with both semicircular vessels. In the living animal the red blood corpuscles can easily be seen pulsating up and down in the transparent tentacular vessels. Associated with the longitudinal vessels are a blood sinus surrounding the digestive tract and a large number of short, blind vessels which are particularly numerous in or may be restricted to the proximal end of the body. Associated with these blood vessels is a jellylike tissue known as the fat body or the vasoperitoneal tissue. Among the large, semifluid cells of this tissue are a number of granules of varying size and shape. Some of them probably consist of guanine and may be considered to be deposits of waste material. Others may represent the products of hemoglobin breakdown.

The body cavity is subdivided by a series of long, thin membranes known as mesenteries, which extend from the digestive tract to the body wall. In most phoronids there are four such mesenteries dividing the body cavity into four longitudinal chambers. There is also a horizontal mesentery near the tentacular end of the body separating a lophophoral cavity from the four larger cavities occupying the rest of the body. In the living phoronid the body cavity is filled with a fluid which is responsible for the turgor or relative firmness of the otherwise soft body.

On either side of the papilla which bears the anus is a small pore connecting with an organ of excretion known as a nephridium. Each nephridium consists of a duct, coiled once on itself and continuous with a pair of funnels opening into two of the four larger body cavities. The walls of the funnels tend to be much folded and are heavily ciliated. The activity of the cilia probably creates a current in the body cavities which carries fluid waste into the funnels and eventually to the outside via the nephridial pores.

The body wall consists of an outer layer of epithelial cells and two layers of muscle fibres: the outer circular and the inner longitudinal. Many of the epithelial cells secrete a fluid which is used by the animal to build the tightly fitting chitinous tube in which it lives. The freshly secreted fluid is transparent and sticky, but on contact with water it gradually hardens. In some species the secreted tube becomes encrusted with tiny grains of sand, mud or shell which adhere to the surface. In many such cases the cemented particles are arranged to form a very even and beautiful mosaic. The tube is in most cases closed at the proximal end; from the distal open end the body may be extended a rather long distance. Most phoronids can shorten or lengthen the body considerably; this is accomplished by the muscles in the body wall contracting against the fluid in the body cavity.

The nervous system is also located in the body wall and consists chiefly of a nerve net lying immediately beneath the epithelial cells. This nerve net is continuous with a more dense concentration of nervous tissue in the horizontal mesentery. Extending from this region and running along, in or beneath the epidermis are one or two giant nerve fibres which taper and end near the proximal end of the body. The giant nerve fibres are known in all but one species and are probably related to the animal's ability to withdraw the body into the tube with great rapidity.

Reproduction and Natural History. — Reproductive tissue is formed from cells located on the thin walls of the short, blind blood vessels in the proximal part of the body. The phylum includes species in which individual animals are either male or female and other species in which each animal is a hermaphrodite and carries both male and female organs. As the reproductive

tissue grows along the walls of the blood vessels it displaces the surrounding vasoperitoneal tissue which shrinks proportionately. When the ova and spermatozoa are ripe, they are shed into the body cavity, find their way to the nephridial funnels and pass through these organs to the outside. In some species the sex cells simply pass out into the surrounding water where early development takes place. In others the ova are retained in the tentacular crown of the adult until each has developed into a tiny, transparent, free-swimming larva. The type of larva characteristic of the phylum Phoronida, an actinotroch larva, is distinguished chiefly by a ring of ciliated tentacles and a flap of tissue over the mouth.

The actinotroch larva may spend over a month swimming freely, feeding on plankton and increasing considerably in size. Eventually, it settles on the bottom and undergoes a metamorphosis whereby it is rapidly and drastically changed into a tiny adult phoronid. All phoronids can reproduce sexually. and in most cases the life history includes an actinotroch larva. Some species are known to reproduce asexually as well. by the apparently simple process of dividing the body into a number of segments, each of which then breaks off and develops into a new adult.

Many phoronids occur in vertical tubes placed just below the surface in intertidal or subtidal mud or sand flats. Other species form dense feltlike masses of intertwined tubes attached to rocks. pilings or logs in shallow water. In both these cases the tubes are encrusted with small particles of sand or shell. A third living habit concerns those phoronids which are found living inside closely fitting channels in limestone rock or in the discarded shells of bivalve mollusks. Phoronids appear to be widely distributed in temperate and tropical seas, but there are no records from polar regions.

See L. H. Hyman, *The Invertebrates:* vol. *5* (1959). (J. R. **Ma.)**

PHORORHACOS, a genus of extinct flightless birds of large size, known from Tertiary formations in southern South America. They appear to have been remotely related to the living seriema *(q.v.; Cariama cristata)* of that region. *Phororhacos* (family Phororhacidae) is included in the order Gruiformes, to which the living cranes (Gruidae) and rails (Rallidae) belong. Numerous parts of specimens have been found, and the most complete fossil specimen is P. *inflatus,* of which head: pelvis, limb bones and some of the vertebrae are recorded.

BY COURTESY OF BRITISH MUSEUM (NATURAL HISTORY)

RESTORATION DRAWING OF PHORORHACOS, AN EXTINCT BIRD

The skull in this bird is about 13 in. long, with the maxilla high in profile, much compressed laterally and terminating in a strong hook; the heavy mandible is curved upward at the tip. The long legs are strong though slender. the tibia being 15–16 in. long. The small size of the wing elements, the form of the shoulder girdle and the skeleton as a whole indicate a cursorial species unable to fly. From the form of the bill, the bird was apparently a formidable predator. It is estimated to have stood about three feet high at the shoulder.

The skull of another species, P. *longissimus,* is about *24* in, long with the beak 10 in. high. indicating a bird of gigantic size. An allied genus, *Andrewsornis,* described by *B.* Patterson from an incomplete skull and other fragments, had a slender 15-in.-long mandible and indications of a stronger wing. Another genus, *Mesembriornis,* has been recognized from Pliocene deposits (about 10,000,000 years ago). Several workers have described a dozen or more species from fragmentary bones in addition to those mentioned, but the relationships of several of these are doubtful. The family, the earliest known representative of which appeared in the latter part of the Oligocene epoch (more than 30,000,000 years ago), continued into the early Pliocene.

See Karman Lambrecht, *Handbuch der Palaeornithologie,* pp. 494–516, fig. 147–154 (1933) ; Bryan Patterson, "A New Phororhacoid Bird From the Deseado Formation of Patagonia," *Field Museum of Natural History Geological Series,* vol. *8,* no. 8, pp. 49–54 (1941). (A. Wt.)

PHOSGENE or CARBONYL CHLORIDE is a colourless, extremely poisonous gas. about three and one-half times heavier than air. having a stifling, nauseating odour resembling sour green corn or musty hay. It is primarily a lung injurant and even in small amounts may prove to be very harmful. It may act slowly, its full effects sometimes developing several hours after inhalation. It first came into prominence in World War I (1914–18), being used as an offensive poison gas either alone or mixed with chlorine. Phosgene was first synthesized in 1812 by John Davy. the ,British chemist. hy the reaction of carbon monoxide and chlorine in the presence of sunlight; hence the derivation of its name from the Greek *Phos* (light) and *genes* (born). It is manufactured by passing the two gases over a specially prepared charcoal catalyst *(see* CATALYSIS). The reaction is expressed chemically by the equation ($CO + Cl_2 = COCl_2$). It has also been manufactured by the reaction of oleum (fuming sulfuric acid) on carbon tetrachloride. By 1900. phosgene was being manufactured on an extensive scale by the Germans for use as an intermediate in the preparation of dyestuffs, its chief use at mid-20th century. A number of pharmaceutical preparations and industrial chemicals also involve its use. Phosgene is active chemically; it fumes in moist air and reacts with water to form hydrogen chloride (hydrochloric or muriatic acid) and. carbon dioxide: $COCl_2 + H_2O = 2HCl + CO_2$. Phosgene gas can be readily condensed to a liquid which boils at 8.2° C. (46.8° F.) at atmospheric pressure. It is ordinarily stored and transported under slight pressure in steel cylinders. although under certain circumstances, it is stored and transported as a solution in toluene. (A. V. C.)

PHOSPHATE ROCK, a sedimentary formation of marine phosphorite usually interbedded with shales or limestones. It occurs in many parts of the world and is mined in North Africa, Germany. the U.S.S.R., the Cnited States and several other countries. The name collophane is sometimes given to the massive. seemingly noncrystalline apatite *(q.v.)* that is the essential constituent of phosphate rock. It is composed largely of calcium phosphate. an important ingredient of bones. teeth and many shells. Other components include lime, silica. fluorine and carbonaceous (carbonate) matter. Phosphate rock is used in the preparation of fertilizers and as a source of phosphorus for matches and of phosphoric acids used in the chemical industries. It originated on the sea floor during several geologic periods at times and under conditions that favoured precipitation of the apatite from solution but retarded the addition of much land waste. For uses, occurrences. production, etc. *see* FERTILIZERS AND MANURES. *See* also MINERAL PHOSPHATES: PHOSPHORUS. (J. T. P.; X.)

PHOSPHATES: *see* PHOSPHORIC ACIDS AND PHOSPHATES.

PHOSPHORESCENCE: *see* BIOLUMINESCENCE; LUMINESCENCE.

PHOSPHORIC ACIDS AND PHOSPHATES. Phosphates are salts of phosphoric acid. Phosphoric oxide. P_2O_5 or P_4O_{10}, combines with water in three proportions to form $H_2O.P_2O_5$ or HPO_3, metaphosphoric acid: $2H_2O.P_2O_5$ or $H_4P_2O_7$, pyrophosphoric acid; and $3H_2O.P_2O_5$ or H_3PO_4, orthophosphoric or ordinary phosphoric acid. These acids each give origin to several series of salts. those of ordinary phosphoric acid being the most important. *See* also PHOSPHORUS: *The Oxyacids of Phosphorus.*

Orthophosphoric acid, H_3PO_4, a tribasic acid. is obtained by boiling a solution of the pentoxide in water; by oxidizing red phosphorus with nitric acid. or white phosphorus under the surface of water by bromine or iodine: and also by decomposing a mineral phosphate with sulfuric acid. It usually forms a thin syrup which on concentration in a vacuum over sulfuric acid deposits hard. transparent, rhombic prisms which melt at 41.7° C. After long heating the syrup is partially converted into pyrophosphoric and metaphosphoric acids. but on addition of water and boiling the ortho-acid is reformed. It gives origin to three classes of salts: $M'H_2PO_4$ or $M''(H_2PO_4)_2$; M'_2HPO_4 or $M''HPO_4$; and M'_3PO_4 $M''_3(PO_4)_2$ or $M'''PO_4$, wherein M', hl", M''' denote

a univalent, bivalent and trivalent metal. These correspond to H_3PO_4 in which one, two or three atoms of hydrogen, respectively, have been replaced by a metal. The three principal groups differ remarkably in their behaviour toward indicators. Those of the first type are strongly acid, the second are neutral or faintly alkaline, while the third are strongly alkaline and are decomposed by carbon dioxide: $Na_3PO_4 + CO_2 + H_2O = NaHCO_3 + Na_2HPO_4$. The salts of the types NaH_2PO_4 and $CaH_4P_2O_8$ may be obtained in crystal form, but those of the heavy metals are stable only when in solution. All soluble orthophosphates give with silver nitrate a characteristic yellow precipitate of silver phosphate, Ag_3PO_4, soluble in ammonia and in nitric acid. Since the reaction with the acid salts is attended by liberation of nitric acid: $NaH_2PO_4 + 3AgNO_3 = Ag_3PO_4 + NaNO_3 + 2HNO_3$, $Na_2HPO_4 + 3AgNO_3 = Ag_3PO_4 + 2NaNO_3 + HNO_3$, it is necessary to neutralize the nitric acid if the complete precipitation of the phosphoric acid is desired.

The three series also differ when heated: the trimetallic salts containing fixed bases are unaltered, while the monometallic and dimetallic salts yield metaphosphates and pyrophosphztes, respectively. Other common precipitants of phosphoric acid or its salts in solution are: ammonium molybdate in nitric acid, which on heating gives a canary-yellow precipitate of ammonium phosphomolybdate, $12[MoO_3] (NH_4)_3PO_4$, insoluble in acids but readily soluble in ammonia; magnesium chloride, ammonium chloride and ammonia. which on standing in a warm place give a white crystalline precipitate of magnesium ammonium phosphate, $Mg(NH_4)PO_4.6H_2O$, which is soluble in acids but highly insoluble in ammonia solutions, and on heating to redness gives magnesium pyrophosphate, $Mg_2P_2O_7$.

Of the organic phosphates, triphenyl phosphate, $(C_6H_5)_3PO_4$, is important, acting as a filler or "dope," and as a plasticizer. It is a colourless solid of m.p. 53° C. and b.p. 245° C.

Pyrophosphoric acid, $H_4P_2O_7$, is a tetrabasic acid which may be regarded as derived by eliminating a molecule of water between two molecules of ordinary phosphoric acid; its constitution may therefore be written $(HO)_2OP.O.PO(OH)_2$. It may be obtained as a glassy mass. indistinguishable from metaphosphoric acid, by heating phosphoric acid to 215° C. When boiled with water it forms the ortho-acid. and when heated to redness, the meta-acid. After neutrrilization, it gives a white precipitate with silver nitrate. Being a tetrabasic acid it can form four classes of salts; for example. the four sodium salts $Na_4P_2O_7$, $Na_3HP_2O_7$, $Na_2H_2P_2O_7$ and $NaH_3P_2O_7$ are known. The most important is the normal salt, $Na_4P_2O_7$, which is readily obtained by heating disodium orthophosphate. Na_2HPO_4. It forms monoclinic prisms (with $10H_2O$) which are permanent in air.

All soluble pyrophosphates when boiled with water are converted into orthophosphates.

Metaphosphoric acid, HPO_3, or more correctly $H_2P_2O_6$ as determined by vapour density, is a monobasic acid which may be regarded as derived from orthophosphoric acid by the abstraction of one molecule of water, thus $H_3PO_4 - H_2O = HPO_3$; its constitution is therefore $(HO)PO_2$. The acid is formed by dissolving phosphorus pentoxide in cold water, or by strongly heating orthophosphoric acid. It forms a colourless vitreous mass, hence its name "glacial phosphoric acid." It is readily soluble in water, the solution being gradually transformed into the ortho-acid, a reaction which proceeds much more rapidly on boiling. Although the acid is monobasic, salts of polymeric forms exist of the types $(MPO_3)_n$, where *n* may be 1, 2, 3, 4 or 6. They may be obtained by heating a monometallic orthophosphate of a fixed base, or a dimetallic orthophosphate of one fixed and one volatile base; *e.g.*, microcosmic salt. $MH_2PO_4 = MPO_3 + H_2O$; $(NH_4)NaHPO_4 = NaPO_3 + NH_3 + H_2O$. The salts are usually noncrystalline and fusible. Their solutions on boiling yield orthophosphates, while those of heavy metals give a trimetallic orthophosphate and orthophosphoric acid $3AgPO_3 + 3H_2O = Ag_3PO_4 + 2H_3PO_4$. Metaphosphoric acid can be distinguished from the other two acids by its power of coagulating albumen, and by not being precipitated by magnesium and ammonium chlorides in the presence of ammonia.

For perphosphoric acids, see PHOSPHORUS.

PHOSPHORITE, the name given to impure massive apatite (*q.v.*), or phosphate rock (q v.).

See also FERTILIZERS AND MANURES.

PHOSPHORUS. Phosphorus was first prepared in elemental form in 1669 by the alchemist Hennig Brand of Hamburg, who used the residue from evaporated urine as the source of the element. News of the discovery soon spread over Germany. Brand did not disclose to the public his method of producing phosphorus but he sold the secret to Johann Krafft of Dresden. The chemist Johann Kunkel sought to learn from Brand the method used, but found only that urine had been used as the source of the phosphorus. With this information Kunkel was able, after many trials, to duplicate Brand's accomplishment. Kunkel likewise attempted to keep the process a secret and, like Brand and Krafft, tried at various times to sell it.

Krafft exhibited samples of phosphorus in many countries; in 1677 he performed experiments with it before members of the Royal society in England. A few years later the British chemist Robert Boyle devised a method of preparing the element, and deposited with the secretary of the Royal society a description of his method which, however, was not published at the time. Boyle had little or no interest in alchemy. In Europe, however, many alchemists sought the philosopher's stone, and it was thought that such an unusual material as phosphorus might lead to the long-sought goal. It is of interest to note that Gottfried Leibnitz, the German mathematician, then librarian for Duke Johann Friedrich at Hanover, arranged a contract between Brand and the duke, under nhich Brand was to demonstrate his process and reveal his method.

It is easy to understand the widespread interest that was aroused in the 17th century by the discovery of such a remarkable substance as phosphorus. A substance which glowed in the dark and took fire spontaneously upon exposure to the air was something startlingly new and mysterious. It is indeed notable that an element so difficult to isolate should have been discovered through the unguided fumbling of an alchemist.

In the decades that followed 1680, methods for the preparation of phosphorus from various animal and vegetable materials were developed and, in some instances, published. It was not until 1775, more than a hundred years after Brand's discovery, that Karl Scheele published the much easier method of preparing the element from bones, which then became the chief raw material used as a source of phosphorus.

The Phosphorus Atom. — The chemical atomic weight of phosphorus is 30.975, and its atomic number of 15 indicates that there are 15 positive charges on the nucleus of the atom. Since the atomic mass number is 31, the nucleus is composed of 15 protons and 16 neutrons. The 15 electrons which revolve about the nucleus are arranged at three major quantum levels, usually referred to as the K-shell. the L-shell and the M-shell. There are two electrons at the first quantum level or K-shell. eight electrons in the L-shell, and five electrons in the M-shell.

In the nomenclature commonly used, the arrangement of the electrons about the nucleus of the phosphorus atom may be expressed as $1\ s^2,\ 2\ s^2\ p^6,\ 3\ s^2\ p^3$. In this expression the 1, 2, 3 refer to the major quantum levels or shells, the s and p to sublevels within the principal quantum levels. and the exponentially written numbers refer to the numbers of electrons at each sublevel.

The only stable isotope of phosphorus is P^{31}. Six unstable, radioactive isotopes have been produced: P^{28}, half life 0.28 sec.; P^{29}, half life 4.5 sec.; P^{30}, half life 2.5 min.; P^{32}, half life 14.3 days; P^{33}, half life 25 days; and P^{34}, half life 12.4 sec. Of these, only P^{32} is useful as a tracer element. Because of the important role that phosphorus compounds play in the chemistry of organic life. it is unfortunate that the only useful radioactive isotope has so short a half life in relation to the normal life cycle of higher plants and animals.

Occurrence. — Phosphorus does not occur free in nature. but its compounds are widely distributed and are found in many rocks and minerals. It ranks 11th in abundance in the lithosphere, of which the average content of phosphorus is about 0.12%. Some

of the common minerals of phosphorus are apatite [$Ca_{10}F_2(PO_4)_6$], a avellite [$Al_6(PO_4)_4(OH)_6.9H_2O$] and vivianite [$Fe_3(PO_4)_2.8H_2O$].

Large deposits of rock phosphate are found in many localities. These deposits are of great economic value as a source of phosphate in the manufacture of fertilizers. In the United States the deposits of Florida and Tennessee have been exploited extensively, and exploitation of the deposits of Utah. Wyoming, Idaho and Montana is increasing rapidly. In Africa the deposits of Algeria, Tunisia and Egypt are also mined on a large scale. All these deposits mere laid on the floor of shallow seas and are mostly the remains of myriads of aquatic microorganisms. The phosphate beds of the western United States are primary deposits nhich lie conformably with the shales, limestones and other formations of the region. whereas the main deposits of Florida. Tennessee and North Africa are secondary, being the residues from the leaching of phosphatic limestone.

Many textbooks of chemistry and technical articles erroneously refer to rock phosphate as tricalcium phosphate. $Ca_3(PO_4)_2$, although the phosphatic material present is actually a calcium fluorphosphate, or possibly hydroxyfluorphosphate, which gives the same X-ray pattern as the mineral apatite.

Phosphorus is one of about 20 elements essential to the growth and development of plants and animals. and the supply of phosphoric compounds in agricultural soils must he maintained. Where crops are removed, the supply of phosphorus ccmpounds in the soil may become the limiting factor in crop production. Large quantities of phosphorus compounds are used as a fertilizer and an extensive deposit of rock phosphate therefore represents a great natural resource.

Preparation. — Phosphorus may be prepared readily by heating metaphosphoric acid with carbon, or by heating a calcium phosphate mith carbon and sand. Carbon monoxide and phosphorus vapour are evolved in both processes.

In the modern industrial method for the production of phosphorus. rock phosphate, coke and silica pebble are charged continuously into a three-phase electric furnace. The electric energy serves only to heat the charge. which melts and reacts chemically with the coke and silica to produce phosphorus vapour and carbon monoxide which pass out of the furnace. while a molten calcium silicate slag accumulates in the furnace. Any iron compounds present as impurities in the furnace charge are reduced and the molten metallic iron then absorbs phosphorus to form ferrophosphorus which is heavier than the slag and therefore sinks to the floor of the furnace.

From time to time the furnace is tapped and the ferrophosphorus is cast into pigs. while the slag is granulated by means of jets of water. The granulated slag is composed chiefly of calcium silicate. The ferrophosphorus is used in making iron alloys but the market does not utilize all the by-product ferrophosphorus produced. Several methods were developed for the recovery of the valuable phosphorus from the ferrophosphorus but none was in commercial use at mid-20th century.

The stream of gas from the electric furnace consists principally of phosphorus vapour and carbon monoxide. After the gas is freed of dust and then cooled the phosphorus condenses to the liquid and eventually to the solid form. Because it ignites spontaneously when exposed to air, the usual practice is to store the phosphorus under water.

Physical Properties. — Phosphorus exists in several allotropic forms nhich will be discussed later. The ordinary variety, when pure, is a colourless. semitransparent, waxy solid at room temperature. but is usually slightly yellow because of impurities present

Although virtually insoluble in water, nhite phosphorus is slightly soluble in many organic liquids. in phosphorus trichloride. liquefied ammonia. and liquefied sulfur dioxide, and is extremely soluble in carbon disulfide. Its molecular weight in solvents. and in the vapour state, corresponds to a P_4 molecule. The atoms in the molecule are in a tetrahedral arrangement. the edge of the tetrahedron being 2.21 angstrom units.

When phosphorus vapour is heated, the dissociation of P_4 molecules into P, molecules becomes measurable at about 800° C. Spectrographic examination of hot phosphorus vapour indicates that P_4, P_2 and P molecules are present, but even at 1,200° C. the proportion of monatomic molecules is exceedingly small.

Some of the other physical properties of white phosphorus are given in the following table:

Specific gravity	1.83
Melting point	44.14° C. at 1 atm.
Boiling point	280.5° C. at 1 atm.
Heat of fusion	630 cal. ± 2 cal. per Pa mol.
Critical temperature	720.6° C.
Heat of sublimation	14,066 cal. per P_4 mol.
Hardness	0.5 on Mohs' scale
Atomic heat capacity	5.69 cal. per gram atom
Atomic volume	16.9 c.c. per gram atom
Surface tension	43.09 at 78.3° C. 35.56 at 132.1° C.
Index of refraction	1.8244 for the D line at 29.2° C.
Parachor	37.7
Entropy $S°_{298}$ (solid)	9.80 ± 0.02 cal. per gram atom per °C.

C_p, cal./mole P_4/° C., vnpour = $19.25 + 0.510 \times 10^{-3}T - 2.980 \times 10^{5}T^{-2}$

Allotropic Forms. — The data accumulated from the many investigations of the allotropic forms of phosphorus are voluminous, confusing and contradictory. In the present summary the statements are those for which the experimental evidence seems most consistent and convincing.

White phosphorus exists in at least two allotropic forms. The one that occurs under ordinary conditions of temperature and pressure is called the α form. It has a density of 1.83. At −77.8° C. the α form changes to a β form which has a density of 1.88. The crystal habit of the α form is cubic whereas that of the β form is hexagonal.

The β form is strongly doubly refractive and this makes it possible to observe the transition from the one form to the other by means of a polarizing microscope.

Red phosphorus can be prepared by heating the white variety at 250° to 300° C. in a closed container. The conversion is accelerated by a trace of iodine. Red phosphorus may be obtained also by exposure of phosphorus vapour to an electric glow discharge, to a spark discharge, or to a heated tungsten filament.

Red phosphorus does not ignite in air at ordinary temperature and is not dissolved by the usual solvents for white phosphorus. The red form melts in the range 590° to 600° C. and, as ordinarily prepared, is amorphous or microcrystalline. Its colour, density and other physical properties: as well as its chemical activity. are governed by the conditions under which it is formed. Upon prolonged heating, the ordinary amorphous form of red phosphorus undergoes progressive. exothermic, irreversible transitions to crystalline modifications. Thermal analyses, X-ray diffraction measurements and microscopic observations lead to the conclusion that there are certainly three and possibly five forms of red phosphorus. At one end of this series of transitional forms stands the variety obtained by the methods ordinarily used for the conversion of white phosphorus to the red form. The density of that variety may be as low as 1.9, and its X-ray pattern is diffuse, which establishes the absence of structural regularity. As the change progresses from one form to the nest, the X-ray pattern sharpens and becomes progressively more complex. The most highly crystalline modification obtained by the thermal aging of ordinary red phosphorus is probably at least monoclinic but the symmetry is usually distorted so that its optical properties are those of a triclinic crystal. This form has been called violet or metallic phosphorus. It seems best, however, not to increase the confusion with regard to red phosphorus by giving special names to any of the modifications.

Black phosphorus is deemed another distinct allotropic form of phosphorus and is obtained by subjecting white phosphorus to a pressure of 35,000 atmospheres at ordinary temperature or to 12,000 atmospheres at 200° C. This allotropic form is a flaky, crystalline inaterial that resembles graphite and has a density of 2.699. It is a conductor of electricity with a resistivity of 0.711 ohms per centimetre cube, and is not dissolved by any of the liquids that dissolve white phosphorus. Black phosphorus changes irreversibly into the red allotrope at about 550° C. under ordinary pressure.

Chemical Properties. — Phosphorus is a nonmetallic element and belongs in Group V of the periodic table. The subgroup to which it belongs includes the elements nitrogen? phosphorus,

arsenic, antimony and bismuth. The transition from nonmetallic to metallic elements as atomic weights increase is unusually sharp in this subgroup. It is also characteristic of the subgroup that corresponding compounds of the five elements do not resemble each other as closely as might be expected, even when the formulas are alike. Probability of resemblance is greatest in the hydrides, less in the halides, and least in the oxides. Even in the hydrides, however, the correlation of properties for corresponding formulas is poor.

The usual valencies of phosphorus are three and five. It would be expected from the arrangement of electrons in the phosphorus atom, that the valency due to exchange of electrons would be plus five when the outer shell is stripped of electrons, and minus three when the outer shell is filled by the capture of three electrons. The chemistry of phosphorus is complex, however, and the element forms many compounds wherein its valency is other than the simple kind due to loss or gain of electrons in the outer shell of the atom.

White phosphorus is relatively active. It glows in the dark and ignites spontaneously to form dense white fumes of the oxide P_4O_{10}.

It precipitates copper and lead from their solutions at ordinary temperatures and reacts with most metals to form phosphides at elevated temperatures.

Hydrides.—There are two well-known hydrides of phosphorus, namely PH_3 and P_2H_4. Phosphine, PH,, is a colourless, poisonous gas of characteristic odour. It can be produced by heating white phosphorus in a solution of potassium hydroxide, or by the hydrolysis of a solid phosphide such as Ca_3P_2. Phosphine solidifies at $-134°$ C. under its own vapour pressure of 27.3 mm., and there are at least four allotropic forms of the solid.

The hydrogen atoms of the phosphine molecule are replaceable by metals with the formation of unstable compounds such as PH_2K, PK_3, etc.

The hydride P_2H_4 is a liquid which boils at 52° C., solidifies at $-99°$ C. and ignites spontaneously. Other solid hydrides such as $P_{12}H_6$ and P_9H_3 have been reported, but X-ray studies of these solids indicate that they are probably solid solutions of PH_3 in phosphorus.

The monovalent phosphonium radical PH_4^+ is analogous to, although much less stable than, the ammonium radical NH_4^+. Phosphonium iodide is a colourless, crystalline solid formed by the interaction of phosphine and hydrogen iodide; the corresponding chloride and bromide are gases.

Halides and *Oxyhalides.*—The halogen compounds of phosphorus are numerous. In addition to simple halides such as PCl_3 and PCl_5, there are many mixed halides such as $PFCl_2$, PF_3Cl_2, etc. Theoretically there are 20 simple and mixed halides of trivalent phosphorus and 56 such halides of pentavalent phosphorus. In addition to these halides, not all of which have been prepared, there are phosphorus halides of the type P_2I_4 which is analogous to the hydride P_2H_4.

There are also many oxyhalides of phosphorus, of formulas POF,, $POCl_3$, $POFCl_2$, etc.; and for each oxyhalide there exists the corresponding sulfohalide, such as PSF_3, $PSFCl_2$, etc.

Oxides.—The three best-known oxides are: P_4O_6, usually called phosphorus trioxide and expressed as P_2O_3; P_nO_{2n}, sometimes written as P_2O_4 and called phosphorus tetroxide; P_4O_{10}, nearly always written P_2O_5 and called phosphorus pentoxide.

In addition to these three oxides. existence of an oxide P_2O_6 is indicated by considerable evidence, and some doubtful evidence suggests the possibility of P_4O and P_2O.

The oxide P_4O_6, phosphorus trioxide, is a colourless, crystalline substance which melts at 23.8" C. and boils at 175.4° C. It forms phosphorous acid in cold water and therefore may be said to be the acid anhydride of this acid, but it yields phosphorus, phosphine, phosphoric acid and other compounds when treated with hot water. The vapour density, the Raman spectrum and the electron diffraction pattern of phosphorus trioxide indicate P_4O_6 molecules and the molecular formula of the trioxide when dissolved in molten naphthalene is also P_4O_6.

Its heat of vapourization is 9,400 cal. per mole at the boiling point.

The oxide P_nO_{2n} is a lustrous, crystalline substance of density 2.537 at 22.6" C. The vapour at 1,400° C. has a density corresponding to molecules of P_7O_{14}. Phosphorus tetroxide reacts slowly in water with some evolution of phosphine but the principal products are phosphorous acid, H_3PO_3, and metaphosphoric acid, $(HPO_3)_n$.

The oxide P_4O_{10}, usually expressed as P_2O_5 and designated phosphorus pentoxide, is the main product obtained when phosphorus is burned in an excess of air. The vapour density, Raman spectrum and electron diffraction pattern agree in indicating a P_4O_{10} molecule of the T_d point group with a symmetry number of 12. This oxide exists in several forms which vary in appearance. The white, amorphous powder is the one most common but there is a vitreous, glasslike form and also a silky white form. The most volatile is a crystalline variety obtained by the sublimation of the ordinary white form in *vacuo*. The vapour pressure of this crystalline variety is one atmosphere at about 358° C.

Phosphorus pentoxide, P_4O_{10}, is an unusually effective agent for the drying of air. It hydrolyzes first to metaphosphoric acid. The water vapour pressure over this P_4O_{10}-acid mixture is not more than 10^{-5} mm. of mercury at room temperature. Its capacity for water absorption is low, however, since one gram of water will convert nearly eight grams of P_4O_{10} to metaphosphoric acid.

Sulfides.—The sulfides of phosphorus are not as closely analogous to the oxides as is usually the case with elements other than phosphorus. The sulfides P_4S_3, P_4S_5, P_4S_7 and P_4S_{10} are well known and there is some evidence for the existence of P_3S_6.

The **Oxyacids of** Phosphorus.—There are six well-known oxyacids of phosphorus, namely: hypophosphorous acid, H_3PO_2; phosphorous acid, H_3PO_3; hypophosphoric acid, $H_4P_2O_6$; metaphosphoric acid, (HPO,),; orthophosphoric acid, H_3PO_4; and pyrophosphoric acid, $H_4P_2O_7$.

The barium salt of hypophosphorous acid can be formed through the prolonged boiling of phosphorus with an excess of barium hydroxide. The over-all equation is:

$$8P + 3Ba(OH)_2 + 6H_2O = 2PH_3 + 3Ba(H_2PO_2)_2$$

The excess of $Ba(OH)_2$ is precipitated by means of CO_2 and the resultant $BaCO_3$ filtered off. Sulfuric acid then is added to the solution to free the hypophosphorous acid and to precipitate barium sulfate which then is removed. When the solution is evaporated, colourless crystals of hypophosphorous acid, H_3PO_2, appear. The acid is monobasic, and the Raman spectrum indicates that two of the hydrogen atoms in the molecule are linked directly to the phosphorus atom while the third hydrogen is in a P-O-H linkage. As written for organic acids. the formula would be H_2POOH. The acid and its salts are powerful reducing agents although they often react slowly.

Phosphorous acid, H_3PO_3, is a colourless, deliquescent solid which melts at about 72° C. It is a dibasic acid and is a strong reducing agent. It is prepared easily by drawing a stream of air through PCl_3 and then through cold water. The equation is:

$$PCl_3 + 3H_2O = H_3PO_3 + 3HCl$$

Hypophosphoric acid, $H_4P_2O_6$, is formed by the slow oxidation of moist phosphorus under special conditions. Although the formula may be written as $P_4O_6.2H_2O$, the acid is not formed when P_4O_6 is brought into contact with water. The dihydrogen, disodium salt. $Na_2H_2P_2O_6.6H_2O$ can be prepared through the slow addition of red phosphorus to a cooled, alkaline solution of sodium hypochlorite. Hypophosphoric acid is a colourless, deliquescent solid which decomposes when heated. It is a tetrabasic acid, with one, two, three or four replaceable hydrogens.

Theoretically, metaphosphoric, pyrophosphoric and orthophosphoric acids can each be obtained by the reaction of P_4O_{10} vapour with the appropriate amount of water; *i.e.*,

$P_4O_{10} + 2H_2O \rightarrow$ metaphosphoric acid
$P_4O_{10} + 4H_2O \rightarrow$ pyrophosphoric acid
$P_4O_{10} + 6H_2O \rightarrow$ orthophosphoric acid

Likewise, orthophosphoric acid can theoretically be dehydrated to pyrophosphoric and to metaphosphoric acid in succession.

However, phosphoric acids with compositions corresponding to these acids are not pure. simple acids, but are complex mixtures of several polymeric acids, the proportions of which depend upon the over-all concentration.

Metaphosphoric acid exists in several polymerized forms indicated by the general formula $(HPO_3)_n$. The salts of several of what were supposed to be the individual polymers are known by such names as Pascal's salt. Madrell's salt. Knorre's salt. Graham's salt, Kurrol's salt, etc. It has been found. however, that these supposed salts of individual polymers of metaphosphoric acid are mixtures of different complex polymers, the degrees of complexity of which have not been determined with certainty. The sodium salt of so-called hexametaphosphoric acid is formed by the heating of NaH_2PO_4 and is important industrially for the treatment of boiler feed water. In hard water this complex sodium phosphate forms soluble complexes with calcium ions and thereby prevents the formation of the usual insoluble calcium compounds responsible for boiler scale.

Pyrophosphoric acid, $H_4P_2O_7$, is a colourless solid. It is tetrabasic and, so far as the first replaceable hydrogen is involved, is a stronger acid than orthophosphoric acid. In aqueous solution it hydrolyzes slowly to orthophosphoric acid.

Orthophosphoric acid. H_3PO_4, is commercially the most important of the oxyacids of phosphorus. The acid and many of its salts find extensive industrial applications. Some of the most widely used salts of both metaphosphoric and pyrophosphoric acid are prepared most readily through dehydration of the appropriate orthophosphoric salt. Thus when the monosodium. dihydrogen salt of orthophosphoric acid is heated, sodium metaphosphate is formed:

$$n NaH_2PO_4 \rightarrow (NaPO_3)_n + n H_2O$$

And, likewise. when the disodium, monohydrogen salt of orthophosphoric acid is heated, the corresponding sodium pyrophosphate is formed:

$$2Na_2HPO_4 \rightarrow Na_4P_2O_7 + H_2O$$

Orthophosphoric acid is a tribasic acid and at ordinary temperatures anhydrous H_3PO_4 is a colourless, crystalline solid which melts at 42.3° C. to a syrupy liquid. It forms a hemihydrate $2H_3PO_4.H_2O$, which melts at 29.3° C.

Two methods are in common use for the manufacture of orthophosphoric acid. In the older method. rock phosphate is treated with sulfuric acid solution and the engendered calcium sulfate and other insoluble material filtered off. The impure solution of orthophosphoric acid can then be purified and concentrated. Because of the difficulties encountered in the removal of impurities and in the step of concentration, the phosphoric acid obtained by this so-called "wet method" is utilized almost exclusively in the manufacture of fertilizer superphosphate, for which purpose the impurities need not be removed from the acid. The modern method for the manufacture of orthophosphoric acid consists in the burning of white phosphorus in an excess of air to form P_4O_{10} which is cooled and the vapour hydrated to orthophosphoric acid mist, which is collected by means of an electrostatic precipitator. Acid of any desired concentration can be prepared by this method. The usual product contains about 80% H_3PO_4 and is relatively free from impurities. As produced in large industrial plants the acid usually carries some solid impurities in suspension and traces of dissolved impurities, the most objectionable of which is hydrogen fluoride. The suspension can be removed by filtration or settling. and most of the hydrogen fluoride by blowing air through the acid.

It will be noted that in the case of several of the oxyacids discussed above, not all of the hydrogen atoms that appear in the formula are replaceable by metals. Inasmuch as the most common co-ordination number of phosphorus is 4, it is instructive to consider the following co-ordination formulas:

$$[PO_4]H_3; \quad [P^{O_3}_{H}]H_2; \quad [P^{O_2}_{H_2}]H; \quad [P^{}_{H_3}]; \quad [PH_4]X$$

These formulas lead to the expectation that the hydrogens replaceable by a basic element would be three in the case of the orthophosphoric acid molecule, two in the case of the phosphorous acid molecule, and one in the case of the hypophosphorous acid molecule. The co-ordination formulas are in agreement with the observed facts in each case.

The fourth member in the above-listed series is known only through its organic derivatives and the fifth member is represented in phosphonium compounds.

Two other oxyacids of phosphorus have been described in technical writing, namely permonophosphoric acid, H_3PO_5, and perdiphosphoric acid. $H_4P_2O_8$. It is known that a double oxygen (peroxide) group can replace one of the co-ordination elements. Thus, permonophosphoric acid would be:

$$[P^{O-O}_{O_3}]H_3$$

and perdiphosphoric acid would be $H_2[O_3\,P\,O\text{-}O\,PO_3]H_2$.

The oxide P_4O_{10} is miscible with water in all proportions. Orthophosphoric acid contains 72.4% of P_4O_{10} equivalent, pyrophosphoric acid contains 79.8%, and metaphosphoric acid contains 88.75%. Compositions corresponding to these acids are solids under ordinary conditions. Compositions containing 75% to 76% of P_4O_{10} equivalent are liquid at room temperature. With small shift of the P_4O_{10} equivalent in either direction, solutions are obtained which will yield crystals when seeded at room temperature.

In the absence of seed crystals, however, the solutions can be strongly supercooled. Little is known about melting points in the composition range between pyrophosphoric and metaphosphoric acids.

Some Industrial Uses of Phosphorus and Its Compounds. --White phosphorus, as such, has but few industrial uses. In warfare it is used in incendiary bombs and for the generation of smoke screens. Red phosphorus finds its main use in the match industry, as does the sulfide P_4S_5.

The trichloride and the pentachloride of phosphorus are employed in the manufacture of organic chemicals.

Phosphorus pentoxide, P_4O_{10}, is used widely as a drying reagent in laboratories, but the oxide costs too much to permit its use for this purpose in industry.

Of the several oxyacids of phosphorus the one most widely used as such is orthophosphoric acid. This acid is used in dental cements, in the preparation of albumin derivatives, in the sugar and textile industries, and it serves as a substitute for the more costly tartaric and citric acids in the manufacture of food products such as jellies and essences.

Phosphoric acids are used as reactants in the manufacture of a large variety of phosphates of industrial importance. Of the sodium salts, the tripolyphosphate, $Na_5P_3O_{10}$, is used in the largest amounts.

Several other sodium salts also find wide uses.

When ground rock phosphate is treated with phosphoric acid a fertilizer known as superphosphate (sometimes called double or treble or triple superphosphate) is formed. The main reaction involved is indicated by the equation:

$$Ca_{10}F_2(PO_4)_6 + 12H_3PO_4 = 9CaH_4(PO_4)_2 + CaF_2$$

Monocalcium phosphate, $CaH_4(PO_4)_2$, has a P_4O_{10} (or P_2O_5) equivalent of more than 60% but the concentrated superphosphate made from ground rock phosphate carries only 48% to 50% of P_4O_{10} equivalent. Hundreds of thousands of tons of this superphosphate are made annually, but several million tons of a much lower grade superphosphate are made annually through the acidulation of ground rock phosphate with sulfuric acid according to the equation:

$$Ca_{10}F_2(PO_4)_6 + 6H_2SO_4 = 3CaH_4(PO_4)_2 + 6CaSO_4 + CaF_2$$

In this case the generated calcium sulfate is a diluent and the superphosphate made by this process contains 16% to 20% of P_4O_{10} equivalent.

Considerable tonnages of other phosphates such as $(NH_4)H_2PO$, and $(NH_4)_2HPO_4$ are also used in the fertilizer industry. The Tennessee Valley authority developed a process for the manufacture of a calcium metaphosphate fertilizer by the direct reaction between rock phosphate and P_4O_{10} vapour at about 1,100° C. This fertilizer carries 60% to 62% of P_4O_{10} equivalent.

Several of the phosphates of sodium, notably the so-called hexametaphosphate, tetrasodium pyrophosphate, $Na_4P_2O_7$, and trisodium phosphate, Na_3PO_4, are useful as water softeners. Disodium pyrophosphate, $Na_2H_2P_2O_7$, is used in electroplating baths and in tinning. Dicalcium orthophosphate. $Ca_2H_2(PO_4)_2$ (or $CaHPO_4$), is used as a supplement to animal and poultry food. It is also an excellent fertilizer but costs more than superphosphate upon the basis of P_4O_{10} equivalence.

Besides such inorganic phosphates as those mentioned above, several organic phosphates have industrial importance.

See also PHOSPHORIC ACIDS AND PHOSPHATES

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(H A Cs.)

PHOTIUS (c. 820–891), patriarch of Constantinople (858–867 and 878–886). The way to public life was probably opened for him by the marriage of his brother Sergius to the princess Irene, sister of Theodora, who, upon the death of her husband Theophilus in 842, had assumed the regency of the empire. Photius became captain of the guard and subsequently first imperial secretary. The dissensions between the patriarch Ignatius and Bardas, the uncle of the youthful Emperor Michael III, brought promotion to Photius. Ignatius was arrested and imprisoned (Nov. 858), and upon refusing to resign his office was illegally deposed, while Photius. although a layman, received all the necessary sacerdotal orders within six days, and was installed as patriarch in his place. Ignatius, continuing to refuse the abdication which could alone have given Photius' elevation a semblance of legality, was treated with extreme severity. His cause was subsequently espoused by Pope Nicholas in a manner highly offensive to the independent feeling of the Eastern Church, Photius felt himself the champion of Eastern Christianity against Latin pretensions; and when in 863 Nicholas finally anathematized and deposed him, he replied by a counterexcommunication. Meanwhile, the situation was suddenly changed by the murder of Photius' patron, Bardas, by order of the emperor Michael, who was himself assassinated by his colleague Basil in the following year (867). The fall of Photius immediately ensued; he was removed from his office and banished about the end of Sept. 867, a few days after the accession of Basil, and Ignatius was reinstated on Nov. 23.

About 876 Photius was suddenly recalled to Constantinople and entrusted with the education of Basil's children. On the death of Ignatius, probably in Oct. 878, Photius again became patriarch. In 879 the legates of Pope John VIII attended a synod convened at Constantinople, prepared to acknowledge Photius as legitimate patriarch, a concession for which John was much censured by Latin opinion. But John stood firm on outstanding points of difference, disowned his legates and again excommunicated Photius. Photius ignored John's action, but a palace revolution caused his banishment (886) to Bordi in Armenia. He is said to have died there on Feb. 6, 891.

Photius shows to no little advantage as an ecclesiastical statesman. His firmness was heroic, his sagacity profound and far-seeing; he supported good and evil fortune with equal dignity; and his fall was on both occasions caused by revolutions beyond his control. In erudition, literary power and force and versatility of intellect he far surpassed every contemporary.

The most important of the works of Photius is his renowned *Bibliotheca* or *Myriobiblon* (ed. I, Bekker, 1824–25), a collection of extracts from and abridgments of 280 volumes of classical authors (usually cited as *Codices),* the originals of which are now to a great extent lost. To Photius we are indebted for almost all we possess of Ctesias, Memnon, Conon, the lost books of Diodorus Siculus and the lost writings of Arrian.

The *Lexicon* (*Lexeon Sunagog*) was probably in the main the work of some of his pupils. The only manuscript of the *Lexicon* is the Codex Galeanus, at Trinity college, Cambridge (edited by S. A. Naber, 1864, with introduction on the authorities, critical commentary and valuable indexes) The *Amphilochia* is a collection of about 300 questions and answers on difficult points in scripture, addressed to Amphilochius, archbishop of Cyzicus (edited by Sophocles Oeconomus, 1858) Other similar works are his treatise in four books against the Manichaeans and Paulicians, and his controversy with the Latins on the Procession of the Holy Spirit His *Epistles* were edited by J Valettas (1864) A large number of his speeches and homilies were edited by S. Aristarches (1900) The only complete edition is Bishop Malou's in Migne's Patrologia graeca, ci–cv. R Reifzenstein in Der *Anfang* des Lexikons des *Photius* (1907) published a hitherto unedited manuscript containing numerous fragments from various verse and prose authors

See Cardinal Hergenrother, Photius, Patriarch von Constantinopel (1867–69).

PHOTOCHEMISTRY is the study of chemical reactions which are initiated (or otherwise influenced) by the absorption of light. Light in this context means a portion of the electromagnetic spectrum considerably more extensive than that occupied by visible light *(see* LIGHT) The visible spectrum embraces wave lengths between about 4.000 A (violet) and 7,200 Å (red), one angstrom unit (Å) being 10^{-8} cm. Radiations in the infrared, having wave lengths greater than 7,200 A, are only rarely of photochemical consequence: of far more importance is the ultraviolet region, extending downward from 4,000 A to below 1,500 Å.

The significance of photochemistry in research arises chiefly from its power as a tool in exploring the mechanisms of chemical reactions By the insight it provides into the intermediate stages of fleeting existence in chemical transformations, it contributes most significantly to the understanding of the kinetics of reactions. In some instances, moreover, the results of photochemical experiments can be made to provide information on the nature of the process of light absorption itself. On the practical side, photochemistry plays a role in many familiar phenomena. The most important application of a photochemical reaction is photography. The practical use of light simply as an agent for effecting chemical change is of less consequence and is confined to a relatively small number of reactions; among the few commercial applications may be mentioned the formation of vitamin D by ultraviolet irradiation of certain food materials, for example, milk, and the bleaching of linen by exposure to sunlight. Among biological photochemical reactions is one of supreme importance — photosynthesis, the production of carbohydrates from carbon dioxide and water by plants; this process is solely responsible for the synthesis of organic matter from inorganic and therefore ultimately for the maintenance of life on the earth.

Photochemical reactions are of many types, including synthesis and decomposition, oxidation and reduction, polymerization and depolymerization, hydrolysis, isomerization and even such not truly chemical transformations as phase (allotropic) changes. A more significant classification specifies whether the free energy is increased or decreased by the reaction. Thermodynamics (q *v.)* shows that chemical reactions which are spontaneous, *i.e.,* which proceed without external influence, must always result in a decrease of free energy. Most photochemical reactions are also of this type; in them the absorption of light merely accelerates a transformation which otherwise would proceed very slowly. In some cases the effect of light is that of a trigger: the illumination initiates a reaction which then runs to completion without the assistance of light. Thus a gaseous mixture of hydrogen and chlorine is ordinarily quite stable, but it will react with explosive violence when irradiated with light of appropriate wave length. Some photochemical reactions, however, actually effect an increase in free energy, the additional amount deriving from the energy of the light. All such reactions, of which examples are the formation of ozone from oxygen, the polymerization of anthracene, the decomposition of water and of ammonia, and photosynthesis, tend to reverse themselves after the irradiation has ceased, although some may do so extremely slowly. An instance is the oxidation of carbohydrates in the respiration of plants and animals; this is the biological reversal of photosynthesis. A historical and cardinal objective of photochemistry, not yet realized, is the efficient utilization on an industrial scale of solar energy incident on the surface of the earth, by conversion of the energy to chemical free

energy in a photochemical reaction of this second type.

The Equivalence Principle. — The foundation of the modern interpretation of photochemistry is the quantum theory (see QUANTUM MECHANICS), which has demonstrated that light is emitted and absorbed by matter, not in arbitrary amount, but in small but definite "packets" of energy. These units or quanta of light are called photons.

The energy of such quanta depends only upon the frequency of the light which they constitute; if ν is this frequency, the energy of a single quantum is:

$$\mathbf{E} = h\nu$$

In this, the fundamental relation of the quantum theory of radiation, h is a constant of nature called Planck's constant after the originator of the theory. The relation may alternatively be written in terms of the wave length λ of the light (this being related to the frequency by the formula $\lambda = c/\nu$, where c is the velocity of light):

$$\mathbf{E} = hc/\lambda = 12{,}400/\lambda \text{ when } \begin{cases} \lambda \text{ is expressed in Å} \\ \text{E is expressed in ev per photon} \end{cases}$$

Here the numerical value of the constant hc is given, since it is more useful than that of h in discussions of photochemical processes. The electron volt (ev) is the energy unit most commonly used in atomic physics. One electron volt is equal to 1.602×10^{-12} ergs. Thus a photon of green light, with a wave length of about 5,000 Å, has an energy of about 2.5 ev. Often, instead of a single photon, a number N of them is considered ($N = 6.02 \times 10^{23}$ is called Avogadro's number and is the number of molecules in a gram molecular weight, or mole, of any substance). This number of photons is called an einstein. For an einstein of photons the above formula becomes:

$$E = Nhc/\lambda = 286{,}000/\lambda \text{ when } \begin{cases} \lambda \text{ is expressed in Å} \\ \text{E is expressed in kg.cal. per einstein} \end{cases}$$

Thus an einstein of photons of green light has an energy of about 57 kg.cal. These energy units — electron volt for a single photon and kilocalorie (kg.cal.) for an einstein — are those most commonly employed in photochemical work.

The greatest single event for the interpretation of photochemical reactions was the enunciation by Albert Einstein, in a series of papers appearing shortly after the advent of the quantum theory (1905, 1912, 1916), of the principle of photochemical equivalence. It had then been known for almost a century that of the light impinging on a system only that part which is absorbed by the components of the system can be effective in causing photochemical transformation. This had been discovered by T. von Grotthus in 1817 and later rediscovered by J. W. Draper in 1843. Einstein's principle forged the link between photochemistry and the quantum theory of light by asserting that the initial or primary process is always the absorption of a single photon of light by one of the molecules participating in the reaction. The relation between the number of affected molecules and the quantity of absorbed light is thus one of remarkable simplicity. This simplicity may be obscured, however, by various secondary processes. Indeed, absorption of a photon does not ensure that a molecule will react at all. For a given molecule, photons of some wave lengths may be effective and those of others not. The mechanism of a photochemical reaction is therefore best described in two stages: interpretation first of the absorption act, or primary process, and then of the more or less clearly separable ensuing secondary processes, which are essentially chemical in nature. Except in rare cases the latter are quite uninfluenced by the light and would be the same if the primary products mere formed in some fashion other than by its action. The former step is a matter of pure physics. belonging to the province of the theory of spectra (see SPECTROSCOPY).

The effectiveness of light absorption in provoking chemical reaction can be readily understood on the basis of the quantum theory. Chemical kinetics (see REACTION KINETICS), the study of the speed of "dark" or nonphotochemical reactions, has shown that of all factors which affect the rates of chemical reactions, the most important one is usually the activation energy, which is the amount of energy that must be communicated to the primary reactants before reaction can occur. These reactions are also called thermal reactions because without external influence the only source of such activation energy is the heat energy of the molecules (see KINETIC THEORY OF MATTER).

Many thermal reactions are slow at ordinary temperatures, because for them the activation energy is many times greater than the average thermal energy at such temperatures, and it requires a relatively long time before a molecule will by chance acquire such an energy greatly in excess of the average. Thus for most thermal reactions that proceed at measurable speeds the activation energy is between 10 kg.cal. and 80 kg.cal. per mole, whereas the average thermal energy of a molecule at 20° C. is approximately 1 kg.cal. per mole. But an einstein of photons of visible light has an energy between 40 kg.cal. and 75 kg.cal., and an einstein of ultraviolet up to 200 kg.cal. or even more. Hence, absorption of light provides more than enough energy to initiate most chemical reactions. (In a sense, activated reactants in a photochemical reaction are so highly excited that they may be regarded as extremely hot entities reacting in a cold environment.) This simple consideration is generally valid, but it should not be inferred that light absorption will always accelerate a slow thermal reaction, or that if it does the reaction mechanism or even the products will be the same. Light absorption not infrequently leads to an entirely different sequence of events. (In such cases comparison of the thermal and photochemical reactions may afford valuable insight into both mechanisms.)

It should be emphasized, finally, that light absorption is not only a more powerful way to initiate reactions than thermal activation; it is also a way more susceptible of exact study, for it substitutes for the chaotic activation by collisions between molecules an activation that is qualitatively and quantitatively well defined and controllable.

The quantum yield, often called the quantum efficiency, of a photochemical reaction is defined as the ratio of the number of molecules of reactant chemically transformed to the number of light quanta absorbed. The equivalence principle implies that this quantity must always be equal to 1, but in reality such can be the case only for the efficiency of the primary process (which in general cannot be measured directly). Because of the secondary processes and their complexities, the over-all quantum yield usually differs from 1. This distinction was first clearly stated by M. Bodenstein (1913).

The Photochemical Primary Process. — The absorption of a photon by an atom must result either in excitation of its electronic system or in the removal of one of its electrons, a process called ionization. The absorption spectrum (see SPECTROSCOPY) of an atom shows at once whether absorption of a particular wave length of light leads to excitation or to ionization; in the latter case the wave length must lie in a broad region of continuous absorption, whereas in the former it must coincide with one of a number of sharply defined wave lengths at which absorption also occurs (discrete absorption — the individual regions are called absorption lines). Ionization is only rarely involved in photochemical reactions, since only for a few exceptional atoms has a photon in the visible or near ultraviolet region enough energy to remove an electron. In the case of excitation the atom has its energy increased by an amount exactly equal to the energy $h\nu$ of the absorbed photon. This energy can be subsequently lost in only two ways: by transfer in a collision to another atom or molecule or by the emission of a photon of light. Re-emission of the absorbed light is called fluorescence. Although the exception rather than the rule, it has great importance when it does occur. for observations of its spectrum. duration and intensity provide insight into the length of time during which the absorbed energy (or part of it) is retained by the activated atom and is thus photochemically available. *See* LUMINESCENCE.

Absorption of a photon by a molecule is a more complicated matter. As in the case of atoms, the energy may be retained for a short time and then re-emitted as fluorescence. or it may be completely or partially transferred to another molecule during a collision (after which the absorbing molecule may be left either

in the original or in a chemically altered state). But there are other possibilities. The first is photochemical dissociation. It was shown first by J. Franck (1925) that light absorption can dissociate a molecule into smaller fragments, and that for gases of diatomic or polyatomic molecules this occurs when the absorbed light has a wave length lying in a region of continuous absorption. (This type of continuous absorption must be distinguished from that giving rise to ionization; the latter occurs for molecules as well as atoms but is almost always confined to the extreme ultraviolet spectral region.) These fragments may be stable molecules, but usually they are free atoms or radicals which are very reactive chemically. Their presence may on occasion be shown directly: for example. a gas containing even a minute amount of CH_3 (methyl) radicals will remove a thin metallic film (lead: zinc, arsenic. etc.) when allowed to flow past it, and hydrogen atoms will strongly catalyze the interconversion of orthohydrogen and para-hydrogen. It is also possible to detect and measure the transient concentrations of certain free radicals by means of their own characteristic light absorption.

In addition to regions of continuous absorption, molecules also possess absorption bands, which are simply groups of closely spaced absorption lines. The immediate effect of absorption in such a band is excitation. just as for an atom; but, if the absorbed energy is greater than the bond energy, spontaneous dissociation of the excited molecule may nevertheless ensue. This may occur within 10^{-10} sec. after the absorption act; if it does the individual lines of the band will be diffuse, and the behaviour is called predissociation. If the components of the ahsorption band are sharp, this spontaneous dissociation usually does not occur; but even here, if the excitation energy is sufficient, dissociation can often be induced by collisions of the excited molecules with other atoms or molecules (this may be brought about by increasing the density of the reacting gas or by admixing a foreign gas) (O. Stern and M. Volmer, 1920).

Dissociation into radicals or atoms is the most common primary photochemical process, particularly in the case of gases irradiated with ultraviolet light. In this respect photochemical reactions differ from thermal reactions. which usually proceed by molecular rearrangements during or subsequent to collisions (because these require less energy than dissociation and therefore occur faster under thermal activation). However: in reactions induced by visible light (for example. photochemical reactions of organic dyestuffs) the absorbed energy is usually insufficient for dissociation, and the only explanation for the photochemical action is that excited molecules collide with appropriate reaction partners before their energy has been lost by fluorescence. At first sight this might seem inefficient. in view of the short period (normally of order of magnitude 10^{-8} sec.) which usually elapses between the absorption of a photon and its re-emission. However, in the case of a molecule containing many atoms, an excited molecule may undergo internal alterations of varied and complex nature. Thus, excitation of the electronic system by light may lead to an internal chemical (structural) transformation (formation of an isomer or tautomer of high energy). After a time which is long compared with 10^{-8} sec., the molecule may revert to its original state, often with the emission of light (called delayed fluorescence or phosphorescence). But by this temporary storage of activation energy the secondary photochemical process will have been separated by a considerable interval of time from the primary process of light absorption. and opportunity thus given for new modes of chemical interaction.

Secondary **Processes.**—As previously indicated, the action of light ends with the formation of the primary products (free atoms. radicals. excited atoms or molecules), and the further course of the reaction depends upon the interaction of these with each other and with additional entities present (original reactants. reaction products. impurities). These secondary processes present a great array of possibilities, the unraveling of which is the task of the investigator of each particular photochemical reaction. Some insight is attained from study of measurements of the quantum yield and its dependence on various variables. Whether the quantum yield is less than. equal to or greater than 1 is itself very illuminating. If it is less than 1, some of the absorbed quanta were ineffective. This may stem either from loss of energy by fluorescence or from deactivating collisions in which energy is dissipated into heat before it has had time to render photochemical action; in large molecules degradation of excitation energy into heat may even occur by conversion into vibrational energy within the molecule itself (internal conversion). If the primary process is a dissociation, the quantum yield may also be reduced by recombination of dissociation products. Back reactions are also possible; for example, reduction products may be reoxidized if air is present. (It is worthy of note that a small quantum yield does not imply that more than one photon must be absorbed by one and the same molecule before it will dissociate. For a given molecule the probability of absorbing a photon is very small, and the chance that, if it has absorbed one, a second will be encountered before the first is disposed of is infinitesimal. All known photochemical changes are in this sense single photon processes.)

If the quantum yield is somewhat but not greatly in excess of 1, the reaction of a fragment with another primary molecule is suggested. In this way more than one molecule can be altered by the single photon. An example is the photolysis (a general designation given to photochemical decompositions) of hydrogen iodide. This reaction is one of many studied by E. Warburg, whose classical researches on the equivalence principle (1911–21) form the foundation of modern quantitative photochemistry. Warburg obtained the following data:

Wave length A	Moles decomposed per kg.cal. absorbed	Quantum yield
2,070	0.0114	2.0
2,530	0.018	2.1
2,820	0.021	2.1

The yield, if expressed in moles of HI decomposed per kilocalorie of radiant energy absorbed (centre column), varies as the wave length is altered. But the quantum yield is constant within the accuracy of the experiments and, moreover, has the very simple value 2. The interpretation of this result is summarized by the following equations:

$$HI + h\nu \longrightarrow H + I \qquad (1)$$
$$H + HI \longrightarrow H_2 + I \qquad (2)$$
$$I + I \longrightarrow I_2 \qquad (3)$$

Reaction (1), the primary process, is the dissociation of the hydrogen iodide molecule; this part of the mechanism follows from the fact that the absorption in the spectral region used is continuous. Reaction (2) occurs much more often than would the reaction between two hydrogen atoms to give a hydrogen molecule, because the concentration of HI is very much greater than that of H. The analogous reaction for I:

$$I + HI \longrightarrow H + I_2$$

cannot take place because it requires energy (about 32 kg.cal. per mole, whereas reaction [2] evolves 35 kg.cal. per mole). Hence, reaction (3) is the only possible fate for iodine atoms. (That reaction is oversimplified as written. because recombination of two atoms has a quite negligible probability in a simple collision. It is necessary that they collide together with a third body—another molecule or the wall of the containing vessel—which acquires the energy liberated in the recombination; otherwise this energy must be retained in the diatomic molecule. dissociating it almost immediately.) The over-all result of reactions (1), (2) and (3) is the decomposition of two molecules of HI for each photon absorbed The photolysis of hydrogen bromide also occurs after a primary dissociation and with a quantum yield of 2. It is of interest to compare the photochemical decomposition of hydrogen iodide with the thermal decomposition. The latter is a bimolecular reaction nith an activation energy of 44 kg.cal. per mole. The mechanism is simple:

$$HI + HI \longrightarrow H_2 + I_2$$

It is to be noted that the photochemical primary process (1), in which an H—I bond must be broken, requires 71 kg.cal. per mole.

This explains why the thermal reaction proceeds by the energetically less demanding direct rearrangement.

If the quantum yield is much greater than 1, a chain reaction is indicated. In a chain reaction the initial impetus is passed on and on in a series of identical steps. so that one photon can be ultimately responsible for the transformation of many molecules. Thus. a fragment may decompose a stable molecule to form both a product molecule and another reactive fragment, which latter in turn undergoes a similar cycle.

Such chains may be very long. They are possible, of course, only in exothermal reactions. Chain mechanisms were first introduced in chemical kinetics by J. A. Christiansen and H. A. Kramers (1923), but their role in several photochemical reactions was demonstrated earlier by Bodenstein (1913) and by W. Nernst (1918). It was, indeed, the unequivocal evidence provided by large quantum yields that first established the correctness of chain mechanisms and pointed to the role of free atoms and radicals as active intermediates in chemical reactions. This has been perhaps the greatest contribution of photochemistry to the understanding of chemical kinetics.

The most familiar photochemical chain reaction is the union of hydrogen and chlorine to form hydrogen chloride. The reaction

$$H_2 + Cl_2 \longrightarrow 2HCl + 44 \text{ kg.cal.}$$

has negligible speed in the dark at low temperatures. When mixtures of the two gases are irradiated (with light of wave length less than about 5,000 Å), a chlorine molecule absorbs a photon and is dissociated into two chlorine atoms. There then ensues a chain reaction, one link of which is the pair of processes (Nernst, 1918):

$$Cl + H_2 \longrightarrow HCl + H$$
$$H + Cl_2 \longrightarrow HCl + Cl$$

That the chain may be extremely long has been known since 1913, when quantum yields as great as 10^5 were found by Bodenstein and W. Dux. The chains are broken by removal of either hydrogen or chlorine atoms. which may occur by recombination at a wall or in a three-body collision in the gas or by reaction with a variety of possible impurities or inhibiting substances added for that purpose. By taking extreme precaution to eliminate such chain-breaking substances, quantum yields as great as 4×10^6 have been achieved. At the start of the reaction the quantum yield is often observed to be small, only to rise after a certain induction period has elapsed. This effect mas discovered by Draper (1841) and was further explored by R. W. von Bunsen and H. E. Roscoe in their classical investigations of this reaction (1855–60). It is known to arise from the removal of free atoms by reactions with impurities present in the gas or residing in the vessel walls; the chains lengthen and the quantum yield becomes large as soon as the walls have been "cleaned" and the impurities destroyed. If the walls are initially clean and the gases pure, no such induction period is observed. (The effect of chain-breaking impurities is forcefully illustrated by some experiments on the photolysis of acetaldehyde: the quantum yield, normally several hundred, is reduced to about 1 by the addition of a small amount of nitric oxide. which is known to break chains in analogous thermal reactions.) The above mechanism has been verified by initiating the reaction with chlorine atoms formed otherwise than by photodissociation (for example. in electrical discharges or by the reaction 'of chlorine with sodium vapour) or by means of atomic hydrogen from a standard source. The most carefully studied inhibitor is gaseous oxygen. which breaks chains chiefly by collisions with hydrogen atoms and a third body, the radical HO, being formed in these collisions. The details of this, possibly the most extensively investigated of all photochemical reactions. are exceedingly intricate; the elucidation of many minor features, particularly as regards the various chain-breaking processes, remains to be accomplished.

Experimental Techniques. — Early experimenters employed sources of light emitting many wave lengths (for example, the continuous spectrum of the sun's radiation), but contemporary work usually demands the more informative results given by the use of monochromatic light. The most nidely used light sources are the arcs with iron or graphite electrodes and the mercury-vapour discharge. The first two provide intense radiation throughout the entire visible and near ultraviolet regions. The particular region of wave length desired must be isolated with a prism or grating monochromator (see SPECTROSCOPY), and the ultimate intensity is therefore comparatively low. The mercury spectrum consists of a number of well-separated lines, and many of these can be isolated for photochemical use by the interposition of appropriate filters of coloured glass or of certain solutions or gases which remove the undesired lines. If the mercury discharge tube is constructed of quartz, several strong lines in the ultraviolet become available. Among these is the intense resonance line at 2,537 A, the most widely employed source for photochemistry in the ultraviolet. Another resonance line at 1,849 A is also useful. For special purposes still other sources are available. The sodium-vapour lamp is a powerful source of the yellow line of sodium (a doublet of wave lengths 5,890 A and 5.896 A). Resonance lamps filled with other vapours can be made to yield monochromatic light at a variety of wave lengths in the visible and ultraviolet. Neon discharge tubes produce many intense lines in the yellow and orange parts of the spectrum. For the far ultraviolet, namely for wave lengths less than about 2,000 Å, high-voltage sparks between metal electrodes (*e.g.*, magnesium, aluminum, zinc) are commonly used. For work in the ultraviolet all optical parts (*i.e.*, portions of the equipment through which the radiation will pass) must be made of quartz or fluorite. Glass absorbs wave lengths below about 3,500 A; fused quartz, those below about 2,100 A; crystal quartz, those below 1,800 A; and fluorite, those below 1,350 A. At wave lengths less than about 2,000 Å the entire system must be made free of air, since in this region oxygen loses its transparency. For photochemical studies very intense sources of light are generally required. Since an illumination of one foot-candle of light of wave length 5,550 A entails 4.8×10^{12} photons falling on one square centimetre each second, it corresponds to only 8×10^{-12} einsteins per square centimetre per second. With a quantum yield of 1, this means that 8×10^{-12} moles or 2×10^{-7} c.c. of a gas (at room temperature and atmospheric pressure) will be transformed each second per square centimetre of illuminated surface. Therefore, unless the quantum yield is extremely large, intense sources with illuminations of hundreds or thousands of foot-candles are required if the chemical effect is to be measurably great within a conveniently short time.

The reacting substance is usually contained in a vessel in which a pair of opposite sides are made of thin sections of transparent material, in accurate parallel alignment. For visible light, glass is a satisfactory material for these windows; in the ultraviolet one of the three transparent substances mentioned above must be used. The light enters the vessel through one of these windows, and such of it as is not absorbed leaves through the other. If possible this reaction cell is maintained at a constant temperature by immersion in a thermostat. Should this be impossible, special precautions must be taken to ensure that the temperature of the reacting system does not vary during the exposure. In particular, care must be exercised to prevent any strong infrared radiation, which has a strong heating effect, from reaching the cell.

Measurement of the quantum yield devolves upon two distinct steps: determination of the number of molecules that have reacted in a certain interval of time and of the number of photons that have been absorbed in the same period. The first step is common to many branches of chemistry, and the appropriate method depends upon the special character of each case. Standard chemical analysis is a common one. For many gaseous reactions simple measurement of the variation in pressure is practicable. Analysis of a reactant or product can often be achieved by spectrophotometry, that is, by measurement of its light absorption at some nave length (not necessarily or usually the exciting one); this may be feasible not only for solutions but also occasionally for gaseous systems Other, more specialized analytical methods are applicable in some cases. In any event, the analysis must be quite sensitive, since as explained above the actual extent of chemical change is very small (and should be small, so that the reaction products do not interfere with the study by reacting with intermediates or by absorbing part of the incident light). But it need not be highly

accurate, for the second stage in the measurement can be made so only with greatest effort.

This second stage — determination of the number of photons that have been absorbed — often presents the most difficulty. When feasible, the reactants are made to absorb all of the incident radiation, so that only the absolute intensity of the latter will have to be established. (If this should not be possible, the fraction of the entering radiation which is absorbed by the reacting substance must be ascertained.) Instruments such as photoelectric cells, radiation thermopiles or bolometers provide the best means, but their accurate use requires considerable skill and patience. Photocells are the most sensitive and are easy to operate, but their sensitivity is strongly dependent on wave length, and they can therefore be used for intensity measurements only in strictly monochromatic light. Thermopiles and bolometers, aith surfaces blackened so as to absorb all incident radiation. respond equally to the light of all wave lengths and are therefore preferable for absolute measurements or for experiments in nonmonochromatic light, An alternative method occasionally preferred by photochemists is chemical actinometry. An actinometer makes use of a photochemical reaction, the quantum yield of which is already known; determination of the intensity of a light source requires simply the measurement of the rate at which the reaction proceeds with this source. The principle seems to have been applied first by H. de Saussure (1790), who employed the action of light on chlorine water. Draper (1843) utilized the photochemical union of hydrogen and chlorine. The most important actinometers in contemporary use are based on the photolyses of gaseous hydrogen iodide and of oxalate solutions sensitized by uranyl ions. Relative values of the light intensity may also be measured photographically. This method, which is in fact also actinometric, is convenient because the photochemical yield can be immensely increased by chemical development of the latent image, but is unfortunately not of great accuracy.

Determination of the Mechanism of Photochemical Reactions. — The initial stage in the investigation must evidently be the identification of the reaction products and determination of the conditions, such as wave lengths of exciting light, under which the reaction proceeds. The second stage may be the correlation of the reaction with the absorption spectrum of the absorbing reactant, and elucidation of the primary process. We have seen that this is more or less a matter of pure physics, although the photochemical results themselves may be of aid in complex cases, particularly for polyatomic molecules, for which the understanding of the spectroscopic processes has not progressed very far. But a third stage, in which the principal effort is almost invariably required, is the unraveling of the nature of the intermediate stages between initial reactants and final products. These intermediate reactions, although occasionally simple. are for most photochemical transformations more or less intricate and often involve (in minute concentrations) radicals, free atoms, or excited atoms or molecules which are quite unknown in ordinary chemistry and the existence of which must usually be inferred indirectly. Many of these intermediates are also encountered in analogous considerations of the mechanisms of thermal reactions, and others are known from physical studies of the interaction of light and matter.

The photochemist must correlate his deductions with knowledge gleaned from these related fields.

The experimental data from which the mechanism is determined should embrace values of the quantum yield for all significant variations in the following factors: concentration (or in the gaseous phase, partial pressure) of the reacting substances; concentration of the products; concentration of any added substance that is found to influence the reaction; presence and nature of impurities; temperature; wave length of the light; condition and available surface area of the walls of the reaction vessel (for a gaseous reaction); and nature of the solvent (for a solution). Not all of these variables need be studied for any given reaction, but the more extensively they are, and the more completely the results can be correlated with the mechanism, the more surely can the latter be considered to have been established.

The effects of varying the concentration in a photochemical reaction are utilized in deductions on the mechanism in the same way as for thermal reactions. Adding a foreign substance can lead to very useful information if one is found which has a specific influence. It is significant that most photochemical reactions are dependent on the temperature to only a slight extent (E. Goldberg, 1903). This is in marked contrast nith ordinary chemical reactions, the overwhelming majority of which are greatly accelerated by even a slight temperature rise. This difference arises from the fact that whereas activation in photochemical reactions is achieved by the absorption of light quanta. in thermal reactions it is brought about by rare molecular collisions in which much more than the average thermal energy is available, and the number of such collisions increases rapidly with rise in temperature. In certain instances, honever, photochemical reactions show a more or less pronounced temperature dependence; this will be the case when a secondary process has an appreciable activation energy. Changes in quantum yield when the wave length is varied may be very significant. Sometimes the primary process will be quite different in two different spectral regions. In the same spectral region, say in a band of continuous absorption, photons with the shorter of two different wave lengths mill have greater energy and will therefore cause the fragments to fly apart faster. This greater kinetic energy may have photochemical consequences; for example, it may serve as activation energy and make possible certain secondary processes or it may decrease the probability of recombination, especially in liquid systems (see below). The quantum yield of many photochemical reactions is independent of the intensity of the light (*i.e.,* the rate of photochemical change is proportional to light intensity), as it should be for processes initiated independently by single photons. When there is a dependence. however, valuable inferences concerning the mechanism can be made.

Finally, study of effects of the vessel walls (and of addition of an inert gas) provides information on the role and mechanism of the recombination of fragments.

Sensitized Photochemical Reactions. — In a sensitized photochemical reaction the light is absorbed not by one of the reacting substances but by an extraneous substance (called a sensitizer or photocatalyst) often added just for that purpose. The absorbed energy is subsequently transferred to or otherwise utilized for the transformation of the active material. One of the virtues of most photosensitizing substances chosen for laboratory research is that the absorption process is one that is familiar and fully understood. By means of photosensitization, reactions often can be effected by light to which the reacting substances are transparent. Photosynthesis. for example, is a reaction of two transparent substances, carbon dioxide and nater, which can occur in visible light because of sensitization by the green plant pigment, chlorophyll.

Simple photosensitized reactions were first studied by F. Weigert (1907), who found that irradiated chlorine accomplished a number of transformations, such as decomposition of ozone and oxidation of sulfur dioxide, without being itself altered. Important sensitizers in common use are various metal vapours. uranyl ion (in aqueous solution) and organic dyestuffs (for photography and photosynthesis). Mercury vapour, under illumination by the resonance line at 2,537 Å, is the one most commonly used for gaseous reactions. This radiation has an energy of 112 kg.cal. per einstein, so that an excited mercury atom can. for example, dissociate a hydrogen molecule (dissociation energy 103 kg.cal. per mole) in a collision (G. Cario and Franck, 1922). Atomic hydrogen is very reactive, and mixtures of hydrogen and various vapours containing a trace of mercury undergo interesting reactions when illuminated with the 2,537 Å line. Examples are the formation of ethane from ethylene (some decomposition and polymerization also occur), the formation of formaldehyde from carbon monoxide and the synthesis of water (and hydrogen peroxide). A few of the many other reactions sensitized by mercury when irradiated with this line are the formation of ozone from oxygen and the decomposition of nitric oxide and of ammonia. The cadmium resonance line. with wave length 3.262 A, has an energy of 88 kg.cal. per einstein; this sensitizer has not

enough energy to dissociate hydrogen, but it can form an excited hydrogen molecule which is reactive. For example, illumination of a mixture of ethylene and hydrogen containing a trace of cadmium vapour results in polymerizatiop (but does not lead to the formation of ethane, which would occur if the hydrogen were dissociated).

Liquid Systems.—A photochemical transformation may, like any chemical reaction, be profoundly modified when it occurs in the liquid state. The complicating factors arise chiefly from two circumstances: a molecule in a liquid may be considered to exist in a more or less continual state of collision with surrounding molecules; and the reacting, intermediate or product molecules may exhibit strong chemical interactions with the environment. A generalization deriving from the first of these was advanced by Franck and E. Rabinowitch in 1934. If the primary process is a dissociation, the two fragments will be compelled by the surrounding molecules of the liquid to stay in each other's neighbourhood for an appreciably long time and in this period will make numerous collisions. During such collisions recombination will be possible, because in the liquid system (in contrast with a gaseous one) the environment can function as a third body and take up the recombination energy.

The Franck-Rabinowitch principle thus asserts that in the liquid state the effective quantum efficiency of the primary process may be less than 1. Exceptions can occur. If the fragments react with surrounding molecules, for example, they could be removed before recombining; or, if the dissociated molecule is very complex, the chance that the fragments collide with the proper orientation may be small. But the principle is supported by many instances in which the quantum yield of a reaction is smaller in the liquid than in the gaseous state. An example is the photolysis of hydrogen iodide, which, as stated above, has the quantum yield 2 as a gaseous reaction; for solutions of HI in hexane, the quantum yield depends somewhat on the concentration and wave length but is always less than 2; for liquid HI it is 1.84. It should be mentioned that the principle does not apply if the primary process is not a dissociation. If it is an excitation, and dissociation follows only when induced by a collision, the yield of fragments may be greater in the liquid.

The individual nature of chemical interactions does not permit generalizations concerning interaction of photochemical reactants or products with neighbouring molecules. On the whole, chemical reactions in liquids present many perplexing impediments to their interpretation, and the present state of knowledge concerning them is far from satisfactory. This is particularly true for aqueous solutions containing ions.

In many cases the same reaction may be studied both in gaseous and in liquid systems, the latter being either a pure liquid or a solution. From such studies the influence of the liquid phase may be revealed. (When a solution is used it is essential that the light be absorbed by the reacting substance and not by the solvent. In the case of aqueous solutions, for example. this requirement restricts the wave length to values longer than 1,850 A; water is opaque to shorter wave lengths.)

Photochemical reactions in liquids present as great a variety as do gaseous reactions, and again only a few examples can be cited here. The isomerization of fumaric to maleic acid, and vice versa, is effected in aqueous solution by exposure to ultraviolet light. Absorption of a photon occurs at the double bond, so weakening it that rotation about the bond can occasionally take place. The quantum yield is low, indicating deactivating collisions in which energy is removed by the solvent before rotation can occur. Oxalic acid in aqueous solution is decomposed by ultraviolet light to a mixture of formic acid, carbon dioxide, carbon monoxide and water; the quantum yield is small, being 0 01 or less. This reaction can be sensitized by uranyl ion, in which case it proceeds in visible light as well, the quantum yield between 2.000 A and 5,000 Å being about 0.5. Another interesting reaction is the oxidation of aqueous solutions of sulfite ion. This takes place both thermally and photochemically by a chain mechanism. The reaction rate is very sensitive to the presence of minute amounts of certain inhibitors and accelerating agents, and the quantum yield of the photochemical reaction may exceed 50.000.

Solid Systems.—The photographic process is by far the most important photochemical reaction in a solid system. Although in practical use for more than a century, it has been investigated carefully from the viewpoint of photochemistry only since the 1920s (see PHOTOGRAPHY: Theory of Photography) and was not yet fully understood in the mid-1950s. The sensitive surface of a photographic plate or film consists of tiny particles of a silver halide (chloride or bromide) embedded in an emulsion of gelatin. Under the influence of light some of the molecules in certain particles are transformed into metallic silver, the halogen being taken up by the gelatin. The totality of these neutral silver atoms distributed throughout the emulsion constitutes the latent image, the latter being transformed and stabilized by chemical processing into the ultimate photographic image. Pure silver halides are almost insensitive to visible light, so that the emulsion must play an important role even in the primary process.

Photographic emulsions vary greatly, according to the method of preparation, in their sensitivity and in their colour response. The sensitivity to a particular spectral region often can be considerably augmented by adsorbing an appropriate sensitizing dye on the emulsion; the dye molecules absorb light quanta and transfer the energy to silver-halide particles. Appropriately sensitized photographic emulsions are among the very few photochemical systems that respond to infrared light.

Alkali-halide crystals are also photosensitive: they are coloured by ultraviolet light (E. Goldstein, 1896). The underlying primary process is closely related to that of photography; and because of this fact and of its great intrinsic interest, it has been studied extensively (R. W. Pohl and R. Hilsch and others). The absorption of a photon removes an electron. from a halide ion to form a halogen atom; this electron is either transferred to an adjacent, or more remote, positive ion, thus neutralizing it, or wanders through the crystal until it meets some sort of irregularity that attracts it.

It is the electrons in these irregularities, and the neutral alkali atoms, which absorb visible light and hence give the irradiated crystal its colour.

Photochemistry of the Atmosphere.—One of the most interesting photochemical systems in nature is the upper atmosphere of the earth. The photochemical reactions which occur there determine many details of the composition of the atmosphere and have an important influence on weather, on magnetic phenomena and on the direct transfer of radiation from the sun to the surface of the earth. The atmosphere is composed of nitrogen, oxygen, the rare gases (argon, neon. etc.), small amounts of water vapour and carbon dioxide and traces of a number of other substances. Under the influence of solar radiation two main effects occur. At very high levels, between about 100 km. and 300 km. above the ground, many atoms and molecules absorb light quanta of very short wave length (extreme ultraviolet) and are ionized. It is the large density of free electrons in this region, called the ionosphere (*q.v.*), that is responsible for the reflection of radio waves and thus makes ordinary radio communication possible. Of more relevance to familiar photochemistry, however, are the photoprocesses which cause part of the oxygen to exist as free atoms and ozone (*q.v.*).

The chief facts may be summarized as follows: most of the ozone is concentrated at a certain level in the stratosphere, the ozone content decreasing at higher and at lower altitudes. The maximum ozone density occurs at about 20 km.–25 km., the maximum concentration (approximately 0.001%) at about 40 km. The layerlike structure of the ozone region (and of the ionized regions) is a simple consequence of the exponential absorption of radiation in a medium in which, as in the atmosphere. the density declines approximately exponentially with height. The total amount of ozone, although roughly constant (to within about 10% of its average value), varies diurnally, seasonally and with latitude, with various less regular fluctuations superposed. This ozone, although present in relatively small amount, is of the utmost importance, for it completely absorbs the ultraviolet radia-

tion of the sun in the region from about 3.000 Å to 2,200 Å. (Oxygen itself, and nitrogen. absorb the shorter wave lengths.) Without such a protective covering life would be impossible on the earth's surface, for ultraviolet radiation of these wave lengths readily destroys most organic substances. (The presence, in the atmosphere. of oxygen, and hence also of ozone, is believed by some to be itself a result of processes of life—namely, of photosynthesis. In the early stages of the earth's history the atmosphere is supposed to have consisted chiefly of nitrogen, and the ultraviolet light, therefore, to have penetrated to the ground.)

Atomic oxygen is present in the upper atmosphere during the day in amounts which, relative to O_2, increase steadily with altitude. predominating over O_2 above about 100 km. The density of atomic oxygen attains a maximum at about noon but virtually vanishes shortly after sunset. The presence of O and of O_3 can be proved directly: of O_3, by chemical analysis of air near the surface and by spectroscopic analysis at altitudes up to 30 km.; and of O, by the spectral lines of oxygen atoms emitted by the sky and observed on a moonless night. Photochemistry provides indirect evidence of their presence by correlating results of many diverse observations with data from known laboratory reactions (S. Chapman. O. R. Wulf and others).

Of all the atmospheric constituents, only O_2 and O_3 absorb appreciably in the ultraviolet above about 1,450 Å. The primary processes, which show the sources of oxygen atoms, are:

$$O_2 + h\nu \longrightarrow O_2^* \ (\lambda \text{ between 2,400 A and 2,600 A})$$
$$O_2 + h\nu \longrightarrow O + O \ (\text{A shorter than 2,100 A})$$
$$\text{and } O_3 + h\nu \longrightarrow O_2 + O \ (\text{A shorter than 11,800 A})$$

The first of these processes leads to an excited molecule (indicated by the asterisk). because the absorbed energy is insufficient for dissociation. Dissociation. the second process, occurs either directly (continuoui absorption—wave length less than 1,750 Å) or following a collision.

Oxygen atoms may also be formed from an excited molecule by the reaction.

$$O_2^* + O_2 \longrightarrow O_3 + O$$

This is not an important source of atomic oxygen, because most of the radiation which can form excited oxygen molecules is absorbed by the ozone in more elevated regions. Oxygen atoms are removed by the processes:

$$O + O_2 + M \longrightarrow O_3 + M$$
$$O + O + M \longrightarrow O_2 + M$$

(Here M represents an atom or molecule which functions as a third body.) The first of these explains the quantum yield of 3 obierved in the laboratory formation of ozone from oxygen by wave lengths betneen 1 700 4 and 1,900 Å a photon dissociates one oxygen molecule, and each of the tno atoms so formed reacts with another oxygen molecule

The decomposition of ozone occurs by the reactions:

$$O_3 + O \longrightarrow O_2 + O_2$$
$$\text{and } O_3 + O_3 \longrightarrow O_2 + O_2 + O_2$$

and in daytime also by light absorption. The second of these is the thermal decomposition; laboratory experiments show it to have negligible velocity at the temperature of the stratosphere, which averages about −50° C. Lahoratary experiments on the photolysis of ozone give a quantum yield which may be as high as 7. This result is explained by a chain reaction, based largely on elementary processes given above. The precise mechanism, however, is not yet established. It is interesting to note that. as is usually the case, the laboratory experiments are complicated by reactions at the walls of the containing vessels.

Atmospheric photochemistry is unique in that there are no walls!

Photochemical Reactions of Biological Importance. — The energy which provides the motivating force for the functioning of life of all kinds reaches the earth from the sun and is transferred in the form of light quanta. Most of the ultraviolet radiation is removed by the upper atmosphere, so that it is the visible and infrared regions in which the surface of the earth is bathed. In the course of evolution many biological systems on all levels of complexity have acquired the ability to react with this light in very special ways.

Among such interactions the cardinal position is held by the process known as photosynthesis — the conversion of radiant energy into stored chemical energy by green plants. But there are others, interesting if less important; among them are the formation of vitamin D from ergosterol in the skin tissues of man by ultraviolet light, and sunburn and its physiological effects *(see* LIGHT AND RADIATION IN RELATION TO HEALTH). Doubtless there exist many more subtle interactions that are still unknown.

Photosynthesis, in its purely photochemical aspects. is still only partially understood, and its myriad complexities have been at once the despair and inspiration of investigators for more than a century.

The over-all chemical reaction

$$112 \text{ kg.cal.} + CO_2 + H_2O \longrightarrow \tfrac{1}{6} C_6H_{12}O_6 + O_2$$

is sensitized by the dye chlorophyll, the green pigment to which plants owe their characteristic colour. One of the remarkable aspects of this reaction is its large energy requirement. Since photosynthesis will proceed in red light, the photons of which have an energy of 35 kg.cal. per einstein, at least four photons are required to reduce each CO_2 molecule. (In reality the plants are less efficient; the smallest number with which they can contrive is not less than eight.)

Such a situation is unique in photochemistry. In all other known endothermal reactions a single photon has sufficient energy to give a net heat evolution. In the case of plant photosynthesis there must exist a mechanism of extraordinary delicacy and complexity to ensure that the energy. which is absorbed over an extended interval of time, is concentrated into the proper channels. (For further discussion *see* PHOTOSYNTHESIS.)

The mechanism of vision involves another photochemical reaction of fundamental importance in biology. The primary process is the absorption of a photon by a molecule of a dye located in the cells of the retina of the eye *(see* VISION). That this primary process is sensitive to changes in wave length is evidenced by the perception of colour. The mechanism of the intermediate processes whereby this absorption event engenders a nerve impulse is still unknown. Measurement of a quantum yield for light perception has shown this phenomenon to be almost incredibly sensitive: an impulse of only 100 photons can be detected by the human eye when properly conditioned, and it can be shown that about 90% of these are lost by refection, scattering and absorption in outer regions. Thus the eye is one of the most sensitive mechanisms for the detection of visible light known.

Radiation Chemistry. — Radiation chemistry is the study of chemical transformations caused by absorption of radiations of high energy. These include X-rays, which are electromagnetic radiations, the photons of which have an energy of many thousands of electron volts, and the radiations emitted by radioactive substances. The latter embrace not only electromagnetic radiations (γ-rays) but corpuscular (α- and β-) rays as well, and each particle or photon has an energy which may exceed 1,000,000 electron volts *(see* X-RAYS; RADIOACTIVITY, NATURAL). Various artificially produced radiations. such as fast neutrons, protons. deuterons and electrons, should also be included. Chemical reactions caused by such radiations have been studied from the time of their discovery; indeed. their effects on photographic emulsions were the first and are still an important means of detecting them.

Radiation chemistry is in a sense a larger field of which photochemistry is a subdivision. Interpretation of the reactions of radiation chemistry has not progressed far, however,. the major reason being that the primary process is always extremely complex. In the photochemical primary process a single photon is absorbed by a single molecule to produce a specific excited state; that is possible because the actual excitation energies of atoms and molecules lie in the same energy region — several electron volts — as the energies of light quanta in the visible and ultra-

violet spectral region. Quanta of X-rays and nuclear radiations have thousands to millions of times this energy, and each forms not one excited or ionized atom or molecule but a very great number of them. Moreover, a mixture of all possible excited and ionized atoms or molecules is produced by a single ray. For this and other reasons, an understanding of the mechanisms in radiation chemistry can be expected to come only slowly and with great difficulty Nevertheless, the subject is of great importance, particularly since the success in achieving nuclear chain reactors has made radioactive materials available in unprecedented variety and strength. Some of the more important applications are in the interpretation of radiation action on biological materials (cells, tissues, genes, etc.) on the basis of knowledge of radiation action on the cell constituents. A pre-eminent goal of radiation chemistry is the discovery of a way to utilize the vast amounts of energy now being largely wasted in nuclear reactors (by degradation of the energy of the various radiations into heat) by conversion of this energy into chemical free energy. This promises a technological significance which may transcend that of any artificial photochemical reaction.

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PHOTOELECTRICITY (literally, "light electricity") is the study of certain changes of an electrical nature induced in matter by light and other forms of radiation. When the primary result of the absorption of electromagnetic radiation by matter is the dissociation of the matter into electrically charged particles, the process is designated a photoelectric effect As commonly investigated, with radiation lying between the X-ray and infrared limits of the electromagnetic spectrum, the photoelectric effect results in the ejection of electrons from the atoms of which matter is composed. The γ rays whose energy exceeds 1 Mev (million electron volts) may create pairs of positive and negative electrons The γ rays whose energy is very large (~ 300 Mev) may create π mesons.

The study of the photoelectric effect was of major importance for the development of physical theory during the first two decades of the 20th century. The role played by the photoelectric effect during this period was largely due to the unambiguous manner in which it displayed the quantum properties of radiation which are not describable by the electromagnetic wave theory of James Clerk Maxwell. (See ELECTRICITY; ELECTROMAGNETIC WAVES)

In addition, observation of the behaviour of photoelectrons was of the greatest aid in solving the riddle of atomic structure. For these reasons a brief survey will be given of the early history of the photoelectric effect, after which the photoelectric effect of high-frequency radiation and of low-frequency radiation, applications of the photoelectric effect, and nuclear photoeffects are discussed.

This article, therefore, is divided into the following sections:

I. Historical Survey
II. Photoelectric Effect of High-Frequency Radiation
  1. Direction of Emission
  2. Compton Effect
  3. Auger Effect
III. Photoelectric Effect of Low-Frequency Radiation
  1. Metals
  2. Insulators
  3. Gases
  4. Photovoltaic Effects
IV. Applications of the Photoelectric Effect
V. Nuclear Photoeffects

I. HISTORICAL SURVEY

E. Becquerel, in 1839 reported that the illumination of one of a pair of metal plates immersed in a dilute acid solution altered the electromotive force of the cell. The decrease in the electrical resistance of selenium on illumination was discovered by Willoughby Smith in 1873 These photoelectric phenomena attracted great interest at the time of their announcement but remained unexplained and isolated observations.

In 1887 Heinrich Hertz observed that the behaviour of a spark gap was affected by illumination of the electrodes. W. Hallwachs investigated Hertz' observation and in the following year reported that a clean, insulated zinc plate acquired a positive charge on illumination with ultraviolet light. A negatively charged plate could be made to lose its charge by illumination. The effect was found to persist if the metal was placed in a vacuum.

In 1900, three years after the discovery of the fundamental particle of negative electricity. the electron, Philipp Lenard proved that the effects observed by Hallwachs were due to the ejection of electrons from the metal under the stimulus of radiation. It was quickly found that the effect was a common property of metals but that only a few (*i.e.*, the alkali and some of alkaline earth metals) were sensitive to visible light. In general, it was necessary to use ultraviolet radiation to provoke the effect.

J. Elster and H. Geitel discovered in 1900 that the number of photoelectrons emitted per second from the surface of a metal is proportional to the intensity of the incident radiation. Lenard established in 1902 the important fact that the maximum kinetic energy of a photoelectron depends only on the frequency of the incident radiation and is independent of its intensity.

According to Maxwell's theory, radiation consists of an electric and a magnetic field propagated through space in the form of a transverse wave. The constant velocity, c, of propagation in a vacuum is the product of the wave length of the wave and the frequency of vibration of the electric and magnetic vectors The energy transferred by the wave across unit area perpendicular to the direction of propagation in unit time is the intensity of the radiation and is proportional to the square of the amplitude of the electric vector.

It was believed that the electric field of the radiation exerted a force upon the electron which freed it from the atom to which it was bound. It was difficult to understand from the theory of Maxwell how the kinetic energy of the electron can be independent of the intensity of the radiation, which is fixed by the magnitude of the electric field.

This difficulty was ascribed by A. Einstein to a fundamental incompleteness of the Maxwellian wave theory of radiant energy. Einstein proposed that radiation possessed many of the properties commonly associated with material particles. In particular, he suggested that in a beam of radiation of frequency ν, the energy exists in the form of units of magnitude hν The names photon and quantum are given interchangeably to these units of radiant energy. Einstein viened the photoelectric process as one in which an electron absorbs a photon. The kinetic energy of the free photoelectron is the difference between the energy it has absorbed and the work it has performed in its escape from the forces binding it to the atom. Einstein proposed in 1905 the simple relation

$$T = h\nu - w \qquad (1)$$

between the maximum kinetic energy, T, of the free photoelectron and the frequency. ν, of the radiation. The constant w is the minimum work which the electron must perform to escape from the material to which it is bound. Einstein predicted that the consant h would be found to be the same constant which Max Planck had previously introduced into theoretical physics in discussing the emission of radiation from matter.

The experimental data available in 1905 did no more than suggest the correctness of these conclusions, but by 1916 the validity of Einstein's relation between the maximum kinetic energy of a photoelectron and the frequency of the absorbed radiation had been fully confirmed. This was largely the result of the beautiful experimental work of Robert Millikan, whose measurements

also determined Planck's constant, h, with great precision.

Photoelectric phenomena present another major difficulty to Maxwell's theory of radiation. It was estimated by Lord Rayleigh in 1916 that according to Maxwell's theory it would take a time of the order of several hours for an electron to absorb sufficient energy from a beam of radiation to escape from an atom. But Elster and Geitel had noted that the appearance of photoelectrons occurred simultaneously with the illumination of a metal surface. In fact, E. O. Lawrence and J. W. Beams, in 1928, found that the time lag between the incidence of radiation and the appearance of photoelectrons was less than 3×10^{-9} seconds. If the photoelectric effect is initiated by the collision of two corpuscles, the electron and the photon, then there is no difficulty in understanding the instantaneous character of the emission.

The success of the photon hypothesis in yielding the Einstein equation (1) and in interpreting other photoelectric phenomena stands in sharp contrast to the successful application of the wave theory of radiation to the field of interference and diffraction effects. *(See* LIGHT.) It appears that a dual character must be ascribed to radiation and that a complete description of its interaction with matter cannot be obtained by the consistent use of either a wave or a corpuscular theory. *(See* QUANTUM MECHANICS.)

II. PHOTOELECTRIC EFFECT OF HIGH-FREQUENCY RADIATION

Radiations whose wave lengths lie between 100 and 0.01 angstroms are termed X-rays. The angstrom unit of length, named in honour of the Swedish spectroscopist A. Ångstrom, is equal to a hundred millionth of a centimetre (1×10^{-10} m.). X-rays are commonly produced by the impact of fast electrons upon matter *(see* X-RAYS); y rays are of even shorter wave length and are emitted by the nuclei of radioactive atoms.

The photoelectric effect of high-frequency radiation in gases is easily demonstrated with an instrument known as an ionization chamber. This consists of a closed box filled with the gas, A thin window of metal foil or mica allows entrance of the X-ray beam. Inside the chamber are a pair of metal electrodes. By connecting the electrodes to the terminals of a battery an electric field is established between them. A gas under normal conditions is a good electrical insulator and no current will pass between the electrodes.

When X-rays enter the chamber, the photoelectrons and the positive ions formed from the atoms which have lost electrons are swept by the electric field to the electrodes and an electric current may be readily detected. The fast photoelectrons collide with the atoms of the gas and dislodge electrons from them so that the total number of electrons and positive ions is many times the number produced photoelectrically.

The photoelectrons produced by X and γ radiation possess very large kinetic energies and, therefore, very high velocities. The velocities commonly approach the speed of light and necessitate the use of relativistic equations in the discussion of their motion. The kinetic energies correspond to those acquired by

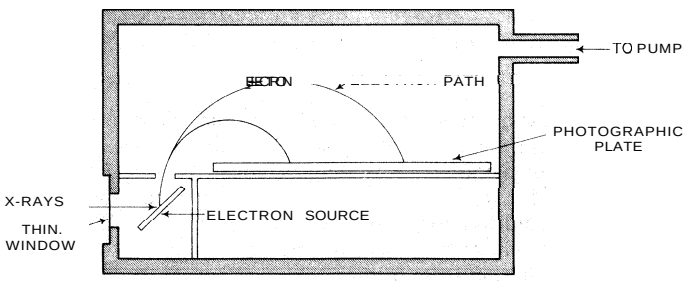

FIG. 1.—β-RAY SPECTROGRAPH. UNIFORM MAGNETIC FIELD PERPENDICULAR TO PLANE OF PAPER

electrons which have been accelerated by potentials of many thousands of volts.

With an instrument known as a β-ray spectrograph, H. Robinson and his coworkers performed some very informative experiments. This device, the use of which was introduced by O. Hahn, L. Meitner and C. D. Ellis, is illustrated in fig. 1. Robinson allowed X-rays of known frequency to impinge upon a solid placed in the position indicated. A fraction of the photoelectrons emitted by the solid pass through the slit and enter the evacuated chamber.

Here they are bent in arcs of circles by a uniform magnetic field of known magnitude. The photoelectrons then fall upon the photographic plate leaving developable traces. The position of the traces and the dimensions of the apparatus determine the radii of the circular arcs traversed by the electrons. A knowledge of these radii and of the magnitude of the magnetic field makes calculable the velocities of the electrons.

Robinson tested Einstein's equation with X-rays of known frequency. The energy lost by a photoelectron in escaping from an atom of a given chemical element (the quantity w) was found to assume several sharply defined values. This behaviour was direct evidence for the existence of atomic energy levels.

If radiation of unknown frequency is allowed to eject electrons from an element whose atomic energy levels have been determined. the unknown frequency may be determined by the use of Einstein's equation after measurement of the kinetic energies of the photoelectrons with the β-ray spectrograph. In this manner, Ellis and M. de Broglie examined the y rays emitted by many radioactive elements and established the very important fact that y-ray spectra are discontinuous as are the atomic spectra of the elements. This important work was the beginning of a spectroscopy of the nucleus and the establishment of nuclear energy levels.

1. Direction of **Emission.**—An important problem connected with the photoelectric effect is the direction of emission of the electron by the radiation. According to Maxwell's theory, radiation consists of a transverse wave. and the direction of emission should be the direction of the force exerted upon the electron by the electric vector which lies in a plane perpendicular to the direction of propagation of the radiation. This problem may be investigated by using the photoelectric effect of X-rays upon a gas in a Wilson cloud chamber. *(See* CLOUD CHAMBERS.)

The Wilson chamber is a vessel in which a gas may be supersaturated with water vapour by a sudden expansion. A fast electron ejected from an atom by the radiation strikes other atoms in its passage through the gas. In this manner it ejects electrons from the atoms of the gas leaving the atoms positively charged. Water droplets condense upon the ions thus formed and render visible the path of the high-energy photoelectron.

If X-rays of long wave length (*i.e.*, low frequency) are used to produce the photoelectrons it is found that the most probable direction of emission is in the plane perpendicular to the direction of propagation of the X-rays. As the frequency of the X-rays is increased, the majority of the photoelectrons are emitted in a direction which makes an angle less than 90° with the direction of propagation of the wave. This effect is explained by the fact that in the photoelectric process the electron receives not only the energy, hv, but also the momentum, $h\nu/c$, of the photon. It is only when the frequency of the radiation is greater than that of soft X-rays that the momentum of the quantum is large enough to have a discernible effect upon the direction of emission of the electron.

Neither Maxwell's theory nor the simple photon hypothesis of Einstein is entirely successful in its description of the experimental results. Maxwell's theory demands that all the electrons be ejected in the plane perpendicular to the direction of propagation of the radiation. The photon hypothesis predicts a definite angle between the perpendicular plane and the direction of emission which is approximately half that observed between the most probable direction of emission and the perpendicular plane. The quantum mechanical treatment of the problem has met with considerable success. The observed variation in the direction of emission is correctly described and the effect of the quantum momentum upon the direction of emission is greater than predicted by the photon hypothesis.

2. Compton Effect.—A most unusual type of photoelectric ef-

fect is that in which in the act of absorption of the photon its full energy is not given to the photoelectron but a fraction is scattered as a quantum of smaller energy. *(See* COMPTON EFFECT.)

This phenomenon was originally observed in experiments upon the scattering of monochromatic X-rays by solids. Among the scattered X-rays there is radiation of the same wave length as that of the primary X-rays and two types of modified X-rays of longer wave length. Atoms which have absorbed quanta may reradiate energy as fluorescent radiation.

This fluorescent radiation contains wave lengths which are characteristic of the absorbing atoms and independent of the wave length of the primary X-rays and of the angle of observation. There is also present a scattered radiation whose wave length is dependent upon the wave length of the incident radiation and upon the angle which the direction of observation makes with the direction of the primary radiation.

The existence of this last-mentioned type of scattered radiation was established and a simple explanation of its origin was given by A. H. Compton in 1923. Compton suggested that. if radiation has the corpuscular character ascribed to it by Einstein. a quantum of energy $h\nu$ and momentum $h\nu/c$ might be conceived as making an elastic collision with a free electron whose kinetic energy before the collision is negligible by comparison with that of the quantum. The laws of conservation of energy and momentum. uhen applied to the collision, give at once a relation between the energy of the scattered quantum and the angle at which it is scattered. Expressed in terms of the difference in wave length between the scattered and incident quanta the relation is

$$\Delta\lambda = \left(\frac{h}{mc}\right)(1 - \cos\theta), \qquad (2)$$

where $\Delta\lambda$ is the difference in wave length, and θ is the angle of scattering. The constants h, m and c which enter the equation are Planck's constant, the electron mass and the velocity of light, respectively.

This equation agrees very closely with the results of experiment. Observation with Wilson cloud chambers has made possible the detection of the recoil electrons. The simultaneous appearance of the scattered quantum and the recoil electron at the predicted angles has been observed by experiments in gases with Geiger counters.

3. Auger Effect.—It was observed by C. T. R. Wilson in 1923 that the absorption of an X-ray quantum by an atom is accompanied occasionally by the emission of two or more electrons. In such a case, only one of the electrons has a kinetic energy which depends upon the frequency of the quantum in the manner described by Einstein's equation. The kinetic energy of the other electrons is characteristic of the type of atom. These facts were established by P. Auger in an extensive investigation of the phenomenon.

The explanation of the Auger effect is as follows. A tightly bound electron is first ejected from the atom by the usual photoelectric process. Such an electron is one for which the constant w in Einstein's equation is large. After the act of photoelectric emission the atom is left with the excess energy, w. The atom can decrease its energy by transferring an electron from a higher energy level to the one vacated by the photoelectron. In the course of this transition the atom loses energy, usually by the emission of a quantum of radiation. Occasionally the energy freed by the transition is given to one of the electrons of the atom which is ejected.

Such an Auger electron will appear outside the atom with a kinetic energy which is the difference between that given to it by the atom and the energy lost in escaping from the atom. Since each of these energies is completely determined by the atom, the kinetic energy of the Auger electron is characteristic of the atomic species.

In stripping itself of its excess energy the atom may emit more than one quantum and several Auger electrons. The total energy so lost cannot be greater than w, the excess energy nith which the atom was left as a result of the initial photoelectric act.

III. PHOTOELECTRIC EFFECT OF LOW-FREQUENCY RADIATION

The wave-length region from 2,000 to 10.000 angstroms (A) is of primary importance for photoelectric studies. The opacity of air and most optical materials has severely limited work in the region below 2,000 A. The quanta of infrared radiation of wave lengths longer than 10,000 A possess so little energy that they produce photoelectric effects in few substances. Visible radiation, or light, includes the wave-length region from 4,000 to 7,000 Å.

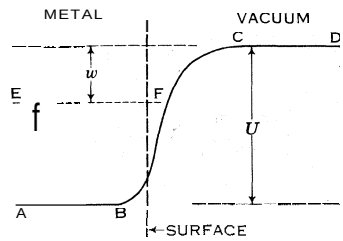

FIG 2.—ENERGY DIAGRAM FOR AN ELECTRON AT THE SURFACE OF A METAL

1. Metals.—The most important topic of investigation with low-frequency radiation has been emission from the surfaces of metals. In this case, the constant w of Einstein's equation is known as the work function of the metallic surface. A brief discussion of the structure of a metal is necessary in order to understand the significance of the work function.

The large electrical conductivity of metals is attributed to the presence of electrons which are not bound to particular atoms but are free to roam the interior of the metal. At the surface the electrons are subject to forces which prevent them from leaving the metal. The number of free electrons is of the same order of magnitude as the number of atoms. The minimum work which must be performed against the surface forces to extract an electron from the metal is the work function.

This discussion may be amplified by reference to fig. 2. The heavy solid line, ABCD, represents the potential energy of an electron in the neighbourhood of the surface. It is assumed that inside the metal the potential is constant as indicated by the horizontal part, AB, of the line. In passing through the surface the potential energy increases suddenly as shown by the portion, BC, of the line.

Outside the metal the potential energy is again constant along the line CD. To extract an electron, initially at rest inside the metal, would demand the work U. The electrons in the metal, however, have kinetic as well as potential energy. The kinetic energies vary between zero and a maximum value as indicated by the horizontal line, EF. The maximum kinetic energy of an electron inside the metal is K. The work necessary to extract the fastest electron and leave it with zero kinetic energy outside the metal is the difference between U and K, or w, the work function. The equation

$$h\nu = w \qquad (3)$$

determines the photoelectric threshold frequency. Radiation of smaller frequency is incapable of ejecting electrons. Equation (3) is the Einstein equation (1) with the kinetic energy T of the photoelectron set equal to zero. For most metals the photoelectric threshold is in the ultraviolet. Tungsten has a work function of 4.53 electron volts (ev) which corresponds to a threshold wave length of 2,730 A. This is well into the ultraviolet. Sodium has a work function of 2.28 ev or a threshold wave length of 5.400 A, which is in the green of the visible spectrum. The electron volt is a common unit of work or energy in photoelectric studies and is the work necessary to move an electron through a potential difference of one volt.

It has been found that the work function is extremely sensitive to the presence of traces of impurities upon the surface of the metal. If the characteristic work function of a metal is to be measured it is necessary to remove all traces of absorbed gas from the surface, preferably by prolonged heating at as high a temperature as possible in a very good vacuum.

If monochromatic radiation is incident upon the surface of a metal, the photoelectric yield (i *e.*, the number of electrons emitted for each quantum absorbed) is zero when the wave length of the radiation is longer than the threshold wave length. As the wave length of the incident radiation is made less than the thresh-

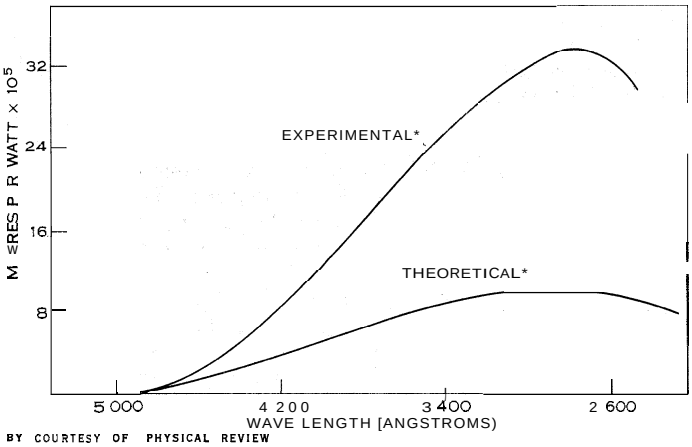

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FIG 3 —PHOTOELECTRIC YIELD OF BARIUM AS A FUNCTION OF WAVE LENGTH EXPRESSED IN AMPERES PER WATT OF INCIDENT RADIATION THE EFFECT OF REFLECTION IS INCLUDED IN THE THEORETICAL CURVE

old wave length, emission begins and the photoelectric yield increases with decreasing wave length. There exists a wave length for which the yield is a maximum and for shorter wave lengths than this the yield decreases. This behaviour is illustrated by the experimental curve of fig. 3 for the metal barium. As the wave length of the incident radiation decreases, its quantum energy increases and a greater fraction of the photoelectrons are able to escape from the metal. The existence of a maximum in the yield curve is not so immediately understandable. It results from the fact that the probability of absorption of a quantum by an electron decreases rapidly with increase of the frequency or decrease of wave length. This is a general feature of photoelectric absorption by electrons under all conditions.

The maximum in the photoelectric yield curve is then the result of a superposition of two effects. The shorter the wave length of the radiation the greater is the fraction of the electrons which will escape from the metal after the act of absorption. But the shorter the wave length. the smaller is the probability that any individual electron will absorb a quantum. For wave lengths less than that which corresponds to the maximum in the yield curve, the second effect is more important than the first.

Radiation incident upon the surface of a metal and not reflected is absorbed in a thin layer approximately a hundred thousandth of a centimetre in depth The photoelectrons must come from this layer. I. Tamm and S. Schubin suggested that the majority of the photoelectrons are produced in a much thinner layer at the immediate surface of the metal. If the potential energy of an electron inside a metal is constant as drawn in fig. 2, it is easily demonstrated that only at the surface can photoelectric absorption occur. In the act of absorption the electron increases its energy by the amount hv but its momentum increases by the negligible amount hv/c.

As a result, a free electron, which is one moving in a region of constant potential, cannot satisfy simultaneously the laws of conservation of energy and momentum during the act of photoelectric absorption of a quantum. The surface of the metal where the potential is rapidly changing may act as a third body and enable the conservation laws to be obeyed.

In actuality, the potential energy of an electron inside a metal is not constant and the possibility of photoelectric absorption by the electrons in the interior exists. Only photoelectrons produced in a thin layer approximately a ten millionth of a centimetre thick will have an appreciable probability of escape. however, since this is the order of magnitude of the distance traveled by an excited electron before making a collision with another electron in which it loses a substantial fraction of its energy.

Tamm and Schubin pointed out, however, that the threshold wave length for the emission of photoelectrons produced in the interior will be shorter than the threshold of the surface photoelectrons. Electrons at the surface can absorb quanta of any frequency and the work function of the metal determines the threshold. Selection rules, determined by momentum considerations, set a lower limit to the frequency of the quanta which may be absorbed by interior electrons. This lower limit of frequency varies from metal to metal but is always greater than the threshold frequency set by the work functionfor the surface photoelectric effect.

The theoretical curve of fig. 3 for barium was calculated according to the quantum mechanical theory of K. Mitchell, who assumed that photoelectrons are produced only at the surface of the metal. It is not known to what extent the neglect of photoelectrons from the interior of the metal affects the divergence betneen the calculated and experimental curves. It is probable that the discrepancies are primarily due to an inadequate treatment of the behaviour of the radiation near the surface of the metal, where it is reflected and refracted.

The work function depends slightly upon the temperature of the metal. The most important reason for this effect is the variation of the kinetic energies of the electrons in the metal with temperature At the absolute zero of temperature there is a definite upper limit to the kinetic energy of an electron as indicated in fig. 2.

At any finite temperature, the upper limit is not sharply defined but the probability that any electron possesses more than a definite amount of kinetic energy is small. An effect of this indefiniteness in the upper limit of the kinetic energy is that the photoelectric threshold is not well defined. R. Fowler and L. A. DuBridge developed approximate theories of the photoelectric effect which permit the determination of the work function that the metal would possess if the electrons were at the absolute zero of temperature. It is this fictitious work function which is usually tabulated and discussed.

If a metal is heated to a high temperature, an observable number of electrons obtain sufficient kinetic energy to escape. This is known as the thermionic effect. From the variation in the number of thermionic electrons with the temperature it is possible to determine the work function w. It is highly gratifying that work functions measured in this manner agree with the photoelectric work functions. This is especially true in so far as it affords a confirmation of the theory of Tamm and Schubin that, at least near the threshold, the photoelectrons are produced at the immediate surface of the metal.

It has been mentioned that the photoelectrons produced by a given wave length of radiation emerge with a distribution of kinetic energies and velocities. At one time it was thought that the electrons inside a metal were practically at rest and that the distribution of energies among the photoelectrons was the result of collisions of the electrons with atoms of the solid in their escape. If the photoelectrons originate at the surface, another reason for their distribution of kinetic energies must be found.

According to the model pictured in fig. 2 the reason for a distribution of energies is the fact that before photoelectric absorption takes place the electrons possess different kinetic energies. If all electrons absorb the same energy, hv, and if all suffer the same energy loss, w, in escaping from the metal, then the distribution of kinetic energies of the photoelectrons is an accurate replica of the distribution of kinetic energies of the electrons in the metal.

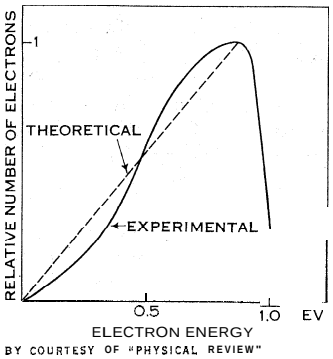

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FIG. 4.— ENERGY DISTRIBUTION OF THE PHOTOELECTRONS FROM SODIUM. THE WAVE LENGTH OF THE RADIATION 3,650 A; TEMPERATURE OF THE SURFACE. 25° C.

A comparison of the theoretical and experimental energy distributions of the photoelectrons from a sodium surface is shown in fig. 4. The agreement between the curves is particularly good for the most energetic electrons and provides a direct test of the Fermi-Dirac distribution function which is used to describe the variation with temperature of the kinetic energy of the electrons

in metals. The differences between the experimental and theoretical curves at low energies may be due to a slight velocity dependent reflection of the escaping electrons by the surface potential.

The photoelectric effect of contaminated metal surfaces has been studied in great detail. Many of these surfaces have high yields and very low work functions. They are, therefore. of great importance in the manufacture of commercial photocells. The properties of a surface which is widely used, known as the cesium-on-silver oxide surface, are almost entirely unexplained. The threshold is in the infrared near 12,000 Å and the yield is extremely large over the visible and near ultraviolet regions of the spectrum.

2. Insulators. — The topics of interest in the investigation of the photoelectric effect with dielectric solids are somewhat different from those with metals. Little work has been done upon the emission of photoelectrons from surfaces of insulators. The loss of electrons leaves the surface with a positive charge which prevents the establishment of a steady photocurrent.

Whereas the photoelectrons produced in the interior of a metal cause an unobservable change in its conductivity, the decrease in resistance of an insulator due to the presence of photoelectrons is readily detected. This phenomenon is referred to as photoconduction.

Typical insulating crystals, such as the alkali halides and the oxides of the light metals are quite transparent to visible and near ultraviolet radiation. Absorption by the electrons starts somewhere in the ultraviolet. The typical absorption spectrum begins mith a series of overlapping bands which are absorption lines broadened by the interaction of the electrons with the vibrating ions of the crystal lattice. Following these bands and overlapping them is a region of continuous absorption resulting from the photoelectric production of free electrons. In this region of the spectrum the absorption is so large that the radiation penetrates only a thin layer of material as in a metal. Experiments with photoconduction are usually performed with radiation absorbed in the long wave-length tail of the first absorption band.

In this case one cannot predict unambiguously whether photoconduction will result.

The reason for this statement is that absorption in the bands which precede the region of continuous absorption does not lead directly to the production of a free electron in the interior of the solid.

The electron is raised by the absorbed quantum to an excited state in which it is still bound to the positive charge left on the atom from which the electron originated. The electron and positive "hole" are not bound to an individual atom of the crystal but may move as a pair throughout the volume of the solid. The movement of this pair, or exciton, as it has been called, cannot lead to a shift of electrical charge and photoconduction. The exciton may obtain sufficient energy from the vibrating ions of the lattice, however, to enable it to dissociate into a free electron and a free positive charge.

In an electric field they may then move in opposite directions giving rise to a photocurrent. The temperature of the crystal determines the average energy of the vibrating ions and it is to be expected that if photoconductivity occurs because of thermal dissociation of excitons, it will disappear at a sufficiently low temperature.

Absorption of radiation in the long wave-length tail of the absorption band of an alkali halide crystal such as sodium chloride does not produce photoconductivity. Presumably the excitons are not thermally dissociated. Under the same conditions, photoconductivity is produced in the silver and thallous halides. In this case the question has been raised as to whether the absorption is not due to foreign impurity atoms.

Large quantum yields, approaching one electron freed for each quantum absorbed, are quite common. In the region of true continuous absorption and the direct production of photoelectrons, the measured yield becomes small. In the cases of diamond and zinc sulfide the photoconductivity disappears entirely. The reason for this is not understood but may, in some cases, be due to the two following effects. When the absorption coefficient becomes large the reflectivity of the crystal surface becomes large. The major fraction of the radiation does not enter the crystal, an effect which has been commonly overlooked. In addition, since the radiation is absorbed in a very thin layer at the surface, the concentration of photoelectrons is large and recombination is promoted.

The fate of a photoelectron in a crystal is a matter of interest. Through collisions with the lattice ions it rapidly loses the energy gained from the absorbed quantum and comes into thermal equilibrium mith the lattice. Finally, it will recombine with an atom which has lost an electron or will be trapped at an impurity atom, a crack, or other imperfection of the lattice.

It appears to be the rule rather than the exception that the photoelectrons in the interior of the crystal initiate secondary reactions. These may be of the most diverse types and have complicated enormously the study of the primary photoeffect. It is commonly observed that the primary photocurrent produces a more or less permanent decrease in the resistance of the crystal. In a few cases it has been possible to study this secondary current independently of the photocurrent proper.

The problem is further increased in complexity by the unavoidable presence of minute amounts of impurities. Concentrations of impurities of a few parts per 1,000,000 may determine completely the observed effects, either by acting as sources of photoelectrons or by trapping them and giving rise to secondary reactions.

An example of the last-mentioned effect is found in the silver halides. The formation of the latent image in photographic emulsions is the result of the production of photoelectrons in the interior of the small crystals of silver halide which are dispersed throughout the gelatin of the emulsion. The photoelectrons are trapped at specks of silver sulfide which are present as impurities on the surfaces of the crystals. The silver halide has a small number of positively charged silver ions wandering throughout the interstices of the crystal lattice and these are attracted to the trapped electrons.

The electrons and silver ions unite to form silver atoms. Submicroscopic clumps of silver atoms form the latent image which makes the silver salt susceptible to development by the proper chemical reagents.

Photoconductivity is a genera1 property of semiconducting solids. Semiconductors have a feeble. temperature-dependent, electronic conductivity which disappears at low temperatures where they become good insulators. The photoconductive properties of selenium and cuprous oxide have been known and used for many years. The pure elements silicon and germanium are semiconductors that exhibit photoconductivity when exposed to radiation whose wave length is less than 1.2 microns *(p)* and 2 *p,* respectively. One micron equals 10,000 Å. These threshold wave lengths correspond to the onset of strong optical absorption by the elements. The semiconducting compounds lead sulfide, lead selenide and lead telluride are extraordinarily sensitive to near infrared radiation when properly prepared in the form of thin films. Lead sulfide films are formed by vacuum evaporation followed by sensitization with oxygen or by chemical deposition from solution. Lead sulfide is a useful photoconductor for wave lengths less than about four microns. while the threshold wave lengths of lead telluride and lead selenide are near six microns and eight microns, respectively. Lead sulfide cells are commercially available and have numerous industrial and military applications. The military applications include not only infrared signaling but also the location of vehicles.

Trucks, tanks. ships, planes and missiles can be detected at long ranges by means of the infrared radiation emitted by heated parts or exhaust gases. Infrared search systems offer better optical resolution and less susceptibility to enemy "jamming" than do radar systems.

3. Gases. — The photoelectric effect in gases is of particular interest because the ejection of an electron from a free atom represents the simplest photoelectric process. Unfortunately, experimentation in this field is very difficult. The work necessary for the removal of the most weakly bound electron from the atoms or

molecules of the simple gases is large enough to place the photoelectric threshold in the neighbourhood of 1,000 Å. In this region of the spectrum there are available neither convenient high intensity radiation sources nor simple optical instruments. Common difficulties are the emission of electrons from the walls of the reaction vessel by scattered radiation and the occurrence of secondary chemical reactions which are induced by the primary photoelectric effect.

The photoelectric threshold frequency can be predicted very precisely from spectroscopic observations. Photoelectric emission of electrons from atoms or molecules which have been previously excited by absorption of a quantum frequently gives an apparent threshold at a lower frequency than the predicted one. While the available data are in qualitative agreement with the theoretical prediction that one electron is emitted for each quantum absorbed, a precision test of this point is lacking because of the experimental difficulties.

4. Photovoltaic Effects.—The photovoltaic effect consists in the generation of an electromotive force in a material on illumination. An electromotive force (e.m.f.) is the source of the electric field which produces a current in a closed circuit of conductors. The discovery of the phenomenon by Becquerel is mentioned in the *Historical Survey* section of this article. A similar effect was noted in 1876 by W. Adams and R. Day, who observed the generation of an e.m.f. on illumination of a junction of selenium and platinum.

The junctions of semiconductors and metals which exhibit a photovoltaic effect usually possess the property of being rectifiers. That is, the resistance of the junction depends upon the direction in which current is passed through the junction. Two of the most important junctions of this type are the selenium-metal junction and that between cuprous oxide and copper.

A theory of the photovoltaic effect at such junctions given by N. Mott appears to be at least qualitatively successful. In the case of the cuprous oxide unit there is a film, termed the blocking layer, of pure oxide of the order of a ten thousandth of a centimetre in thickness separating the copper and the impure bulk oxide.

The bulk oxide owes its semiconducting properties to the presence of an impurity which is an excess of oxygen. When radiation is absorbed in the oxide near the blocking layer, electrons are ejected from the oxide into the blocking layer. Within the blocking layer, there exists an electric field which drives the electrons to the metal. This results, in a closed circuit, in the production of a steady current. The field in the blocking layer exists because of the trapping of electrons from the copper by the impurities of the cuprous oxide, giving the oxide a negative charge with respect to the metal.

The cuprous oxide-copper photocell has a threshold in the neighbourhood of 14,000 Å and a maximum sensitivity near 6,000 Å. Another commercially important photovoltaic cell is that formed from the junction of a metal and selenium. Its characteristics are much like those of the cuprous oxide cell.

These cells are extremely convenient for many applications since they generate their own power and operate without the use of batteries or power supplies. The electromotive force generated by moderate illumination is sufficient to operate a low-resistance microammeter. Their stability is inferior to that of vacuum photocells. In addition, when amplification of the small e.m.f.'s is necessary it is an extremely difficult matter. The response to changes in illumination is slow so that they cannot be used for many applications.

The chief field of application is the qualitative detection of radiation and measurements where high precision is unnecessary as in light metres for photographic work. In photometric work of this type, the fact that the relative sensitivity of these cells to light of different colours is similar to that of the human eye is of particular importance.

A photovoltaic effect is produced when radiation is absorbed near a P-N junction (*see* TRANSISTOR) in a semiconductor Excellent photovoltaic cells have been constructed with silicon, germanium or indium antimonide as the semiconductor. The P-N junction is formed by adding to the pure semiconductor carefully selected impurities with the proper spatial distribution. Arsenic and boron are typical impurities used with silicon. The silicon crystal is prepared so that there is an abrupt transition from a region in which boron is the dominant impurity to an adjacent region in which arsenic is the dominant impurity. At the junction of the two regions there is a large electric field that accelerates free electrons produced by absorption of radiatibn. Silicon photovoltaic cells have an output voltage of approximately 0.5 and a threshold wave length near 1.2 μ. They are efficient converters of solar energy to electrical energy. The conversion efficiency of cells available in the late 1950s was about 10%, which is approximately half their theoretical efficiency. The earth satellite launched by the United States on March 17, 1958, with a Vanguard rocket utilized solar energy and silicon photovoltaic cells to power one of its radio transmitters.

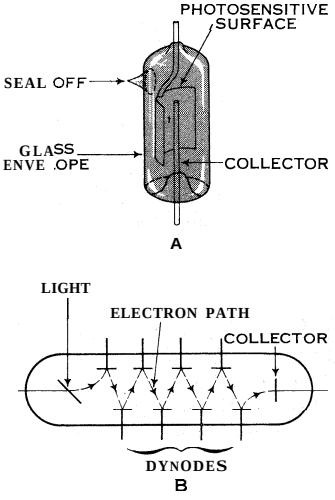

FIG. 5.—(A) PHOTOCELL. (B) DIAGRAMMATIC SKETCH OF PHOTOMULTIPLIER TUBE

IV. APPLICATIONS OF THE PHOTOELECTRIC EFFECT

The applications of the photoelectric effect are numerous and diverse. The ionization chamber which has been described is a standard instrument for the determination of X- and y-ray intensities. The determination of X-ray dosage in medical therapeutic work is performed in this manner.

The photoelectric cell illustrated in fig. 5 (4) makes use of the emission from a metal surface. Frequently the metal surface is present in the form of a thin film which is deposited upon a portion of the inner surface of the glass envelope. The photoelectrons are drawn to the collector by an electric field and the resulting electric current measured with a galvanometer. Some photocells are not evacuated but are filled with an inert gas such as argon. The photoelectrons on being accelerated to the collector dislodge electrons from the argon atoms. In this manner the total current set up in the photocell may be 10 to 100 times the initial photocurrent. Since the photoelectric cell is inherently a high-resistance device, it is adapted for use with vacuum tube amplifying circuits. This is a fortunate fact since the maximum current obtainable from a typical photocell is only of the order of a microampere.

To avoid the use of amplifying circuits the photomultiplier tube has been developed. This tube is illustrated in fig. 5 (B). In this device the photoelectrons are accelerated to the first of a set of auxiliary electrodes called the dynodes. The surfaces of the dynodes have the property of liberating several electrons for each electron which strikes them. In this manner the initial photocurrent is amplified as it passes from dynode to dynode. Such a device may have as many as ten dynodes and the current to the collector may be 100,000 times the primary photocurrent. The photomultiplier tube is manufactured in a size no larger than the ordinary photocell.

The scintillation counter is a device for the detection of y rays or high-energy nuclear particles. A y-ray photon or particle strikes a luminescent crystal and produces a brief flash of luminescence. A typical crystal is sodium iodide containing a trace of thallium as impurity. The photons of the luminescent radiation strike the cathode of a photomultiplier tube and eject photoelectrons that are amplified by the tube. If, as is commonly the case, the nuclear particle loses all its energy within the luminescent crystal, the number of luminescent photons and the magnitude of the output pulse of charge from the photomultiplier is a measure of the energy of the particle. The scintillation counter not only

can detect and measure the energy of individual nuclear particles and y-ray photons but does so in an incredibly short time. The speed of response of the counter is usually less than a microsecond and with crystals such as trans-stilbene may be as short as 0.006 microseconds.

The fundamental use of a photocell is to convert a change in the intensity of the incident radiation into a change in an electric current. This change in electric current may then be used to operate control or measuring devices. For example, a person approaching a doorway may interrupt a light beam which is incident upon a photocell. The abrupt decrease in photocurrent may be used to start a motor which opens the door or rings an alarm. The variations upon this usage are endless. In the manufacture or processing of materials photocells are used to detect imperfect articles and to actuate mechanisms which reject them. The speed and accuracy of such control is far greater than possible with a human operator.

In the production of sound motion pictures, a strip of variable density upon the photographic film is converted by a beam of light and a photocell into a fluctuating electric current which after amplification operates the loud-speakers. (See MOTION PICTURES.)

In television production the photoelectric effect is used to convert the light reflected from the object to be televised into an electric current. The electric current is reconverted by the radio transmitter into the long wave-length radiation termed radio waves. These are picked up by the receiver, transformed into electrical impulses and finally appear as a picture upon the fluorescent screen of a cathode-ray tube. (*See* TELEVISION.)

In scientific work photocells are used whenever it is desired to measure the intensity of a light beam with precision. They are, therefore, much used in the construction of photometric instruments. (*See* PHOTOMETRY.)

Finally, it should be noted that the photographic film, whose importance need not be reviewed, owes its light-sensitive properties to the production of photoelectrons by light in the interior of the silver halide crystals of the emulsion (see PHOTOGRAPHY).

V. NUCLEAR PHOTOEFFECTS

J. Chadwick and M. Goldhaber discovered in 1934 that the deuteron, the nucleus of the deuterium atom, will absorb a y-ray quantum and disintegrate. The disintegration products are a proton and a neutron. The proton is the nucleus of the hydrogen atom of which deuterium is an isotope. The neutron is an uncharged particle of approximately the same mass as the proton. A minimum quantum energy of 2,170,000 ev (2.17 Mev) is necessary to produce the photoelectric disintegration of the deuteron. The nuclei of many other atoms have been shown to exhibit a similar reaction. In all cases the photoelectric effect results in the ejection of a neutron.

A second important nuclear photoeffect is pair production. A y-ray quantum in traversing the neighbourhood of a nucleus may be annihilated and a positive and a negative electron created. This is a direct conversion of radiant energy into matter. In such a conversion, energy and mass are related by an equation due to Einstein:

$$E = mc^2, \qquad (4)$$

where E represents the energy converted into the mass m, and c is the velocity of light. With m taken as the sum of the masses of the positive and negative electrons, the minimum quantum energy E which is necessary for pair production is calculated as 1,020,000 ev. A quantum of greater energy will impart kinetic energy to the created electrons. This process is one of the most important mechanisms by which high-energy quanta interact with matter. The positive electron is unstable and soon after its creation combines with a negative electron, the pair being annihilated with the creation of one or two y-ray quanta.

The y-ray photons whose energy exceeds 150 Mev interact with protons and neutrons to create positively charged (a'), negatively charged (a−) and neutral (a^0) mesons. The charged a mesons have the same charge as that of an electron but have a mass that is 273 times that of the electron mass. They are unstable particles that decay into μ mesons and neutrinos with a lifetime of 2.6×10^{-8} seconds. The neutral a meson has a mass that is 264 times the electron mass and disintegrates into a pair of y-ray photons in about 10^{-15} seconds.

The interaction of a y-ray photon with a proton may either transform the proton into a neutron with the creation of a π^+ meson or create a neutral π^0 meson and leave the proton unchanged. Similarly, the interaction of a y-ray photon with a neutron may produce a proton and a π^- meson or create a π^0 meson without transformation of the neutron into another particle.

Pairs of a mesons and of μ mesons are also created by the interaction of y-ray photons of sufficient energy with nuclear particles. Since it is believed that mesons are responsible for the forces between nuclear particles, they are the subject of intensive research.

See LIGHT; ELECTRICITY; QUANTUM MECHANICS; SELENIUM CELL; TELEVISION; ATOM; NUCLEUS; see also Index references under "Photoelectricity" in the Index volume.

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PHOTO-ENGRAVING. One of the photomechanical processes, the generic term being applied chiefly to the making of etched metal printing plates or blocks (zinc, copper, brass, etc.), the design being in relief for typographical (letter-press) printing. Parts of the process are also used in the photo-lithographic and rotogravure processes for the production of plates and cylinders.

History.— The first specimens were produced, as far as can be ascertained, during the years 1859–1862 by Col. James in Southampton, by Gillot in Paris, Angerer in Vienna and Husnik in Prague. The name *Gillotype* was for many years applied in France and England to line etchings.

Photography was not originally used in their production, the image on metal being obtained either by manual design or by lithographic transfer. The introduction of the photographic negative permitted the reduction or enlargement of the original design for reproduction.

"Nature Autotypy," an early reproduction process, furnished copies of natural objects which, while imperfect reproductions in the sense of our present standards, were still good enough to convey the image in multiple editions. Leonardo da Vinci describes the method in his "Codex Atlanticus" (1490–1519): "This paper must be coated with lampblack mixed with sweet oil. The color of the leaves is thinned by applying white lead dissolved in oil, as printers do with typefaces and then it is printed as usual. The leaves (*i.e.* the impression) will appear dark in the depression and light in the raised parts. . . ." Several botanical publications of the late 17th and of the 18th Centuries were illustrated by this method and are still preserved.

Niepce's early attempts to etch photographic intaglio images on metal sensitized with asphaltum initiated but did not hasten progress in the photomechanical processes. As early as 1841 daguerreotypes were etched in galvanic baths for printing on gravure presses. Donné was the first to show proofs of etched daguerreotypes; Fizeau, Claudet, Berres in Vienna and Grove in England also etched them. Paul Pretsch in London etched them in 1856. He was the originator of the later spray or blast system employed today in etching and was also the first to discover the swelled gelatin process of which many splendid examples are still in existence. The negatives for his work were usually made by the photographer Roger Fenton, using the wet collodion process; the printing plates were electrotypes moulded from the hardened gelatin reliefs.

As early as 1862 Pretsch exhibited at the London Exhibition half-tone plates for letterpress printing. Poitevin, independent of Pretsch's work, pursued the same idea and produced relief electrotype printing plates from chromated gelatin originals. George Scamoni in Russia experimented and succeeded inde-

pendently in the same process. Swan and Woodbury in England produced the Woodburytype (1863).

In the development of reproduction processes, it was soon realized that the prime necessity for faithful reproduction consisted in finding a means for breaking up the continuous tones of photographs or drawings, reproducing in effect the quarter, half, and three-quarter tones of the subject. Graining and dusting of the printing surfaces, long employed, did not furnish the answer. Talbot recommended as early as 1852 in his gravure process the use of a gauze netting for breaking up the continuous tones into separate printing elements.

As in most inventions, the credit for the invention or discovery of the halftone process of photo-engraving cannot be awarded to any one man.

A one-line glass screen in which parallel lines were scratched on an opaque background is described in a French patent of December 14, 1857, by Berchtold. Burnett published a method of single- and cross-line screens for photography. Screens are mentioned in a patent of 1865 by the brothers Bullock. Egloffstein's patent of the same year can hardly be cited as his lines were engraved on steel and his process met with no success. Swan in 1866 also used line screens and so did Leggo in the United States in 1871, Jaffe in Vienna in 1877, Stephen H. Horgan in 1880. Meisenbach (1882) used a single-line screen which he turned at 90° after half the exposure was made.

To Frederic E. Ives of Philadelphia, Pa., U.S., is due the idea of the optical V which led to the present cross-line screen which he used in his halftone plates, the printing surface of which was a bichromated glue enamel coating.

To the brothers Louis F. and Max Levy, also of Philadelphia, must be accorded the perfected halftone screen (grating) which today is universally used and has not been excelled since 1888.

The Levy brothers coated selected plates of high quality optical glass with an etching ground, in which parallel lines were cut by means of a ruling machine.

The ruled lines were etched with hydrofluoric acid and filled in with Canadian balsam. The lines appeared in sharp contrast. The two diagonally ruled glass plates were faced at an angle of 90°, sealed and later bound together with aluminium frames.

One of the important contributions to the halftone process was the invention of the highlight process. F. J. M. Gerland patented such a method in 1883 and the Bassani Company a mechanical improvement in 1925. The outstanding difficulty in the early days of the process was its inability to meet the demands for printing in quantity, rapidity, and the danger of the ink filling up the spaces between dots. This required the use of highly coated, hard-surfaced and expensive paper. In the last twenty-five years, however, the process has been adapted to almost any kind of specification. Newspaper and poster plates are made through screens as coarse as 40 lines to the inch and pulp paper periodicals carry illustrations, sharp and full of colour, printed from plates up to 110 lines to the inch.

Colour Plates.—Photo-engraved colour plates are made to represent the subjects in the colours of the original colour photographs or coloured designs or from objects in their natural colours.

The early attempts to reproduce colour effects were the manual painting in of the different tints on black and white prints. Later stencils were used, but seldom for superimposed and colour combinations. The simplest form of colour reproduction followed the manual process and used photo-engraved key plates and different plates for each colour or shade. Later shadings and overlapping plates were used to achieve colour nuances and combinations by overprinting.

The three- and four-colour processes used in 1940 are based on a Latin Treatise of 1611 by Dominis who described the additive system of complementary colours. Isaac Newton described light in its colour spectrum (1666). The German Le Blon in 1722, living in Paris, was the first to use three-colour printing with red, yellow and blue printing plates. Clerk Maxwell, the English physicist, was the first to publish (1861) the theory of colour reproduction by means of three-colour light filters. Ducos du Hauron and Charles Cros, independently of each other, published in 1868 their three-colour processes. The discovery (1873) by H. W. Vogel of optical sensitization led to a great advance in the reproduction of colour copy in monochrome by the use of orthochromatic plates.

The brothers Lumière of Lyon, France, gave the craft the Autochrome which with other colour records by similar processes often serve as a colour guide when the original painting is not obtainable. Modern panchromatic plates are the result of the successive work of Vogel, Konig, Homolka, Eder, Miethe, Mees, Traube, Lehman, and other modern workers in the field of optical sensitizers. Colour separation negatives are made today on colour-sensitized gelatino-bromide dry plates or on colour-sensitized collodion emulsion. The old-fashioned hand-press in the engraver's shop is now replaced by power presses. Colour reigns and is in steady ascendancy.

Technique.—The accessories necessary for the production of photo-engravings are a camera, a corrected (process) lens with diaphragms, prism and screen. If the wet collodion process is used, properly cleansed glass and a silver bath are required; also the chemicals for development, fixing, and intensification, all of which are in the purely photographic department. The stripping department, where negatives are reversed unless made through a prism, requires stripping collodion and rubber solution, and $-inch thick glass upon which the negative films are reversed as to position, either singly or sometimes assembled in a combination form of line and halftone.

The photo-printing department is equipped with a mechanically operated whirler and vacuum printing frame, as well as a heating apparatus for the burning-in of the enamel image with which the polished copper has been coated.

The etching department is equipped with machines in which the plates are etched by hand, by mechanical rockers, by acid, spray, blast, or by electrolysis.

The routing department is equipped with routing machines, circular and jig-saws, planing, squaring, and mounting machines. Plates to be mounted on metal are usually sent to the electrotyper for that purpose.

The engraving room has heating and cooling devices, also small trays containing acid for re-etching small surfaces. Proofing presses range from the old-fashioned hand-press and special engraver's small power presses to large cylinder machines.

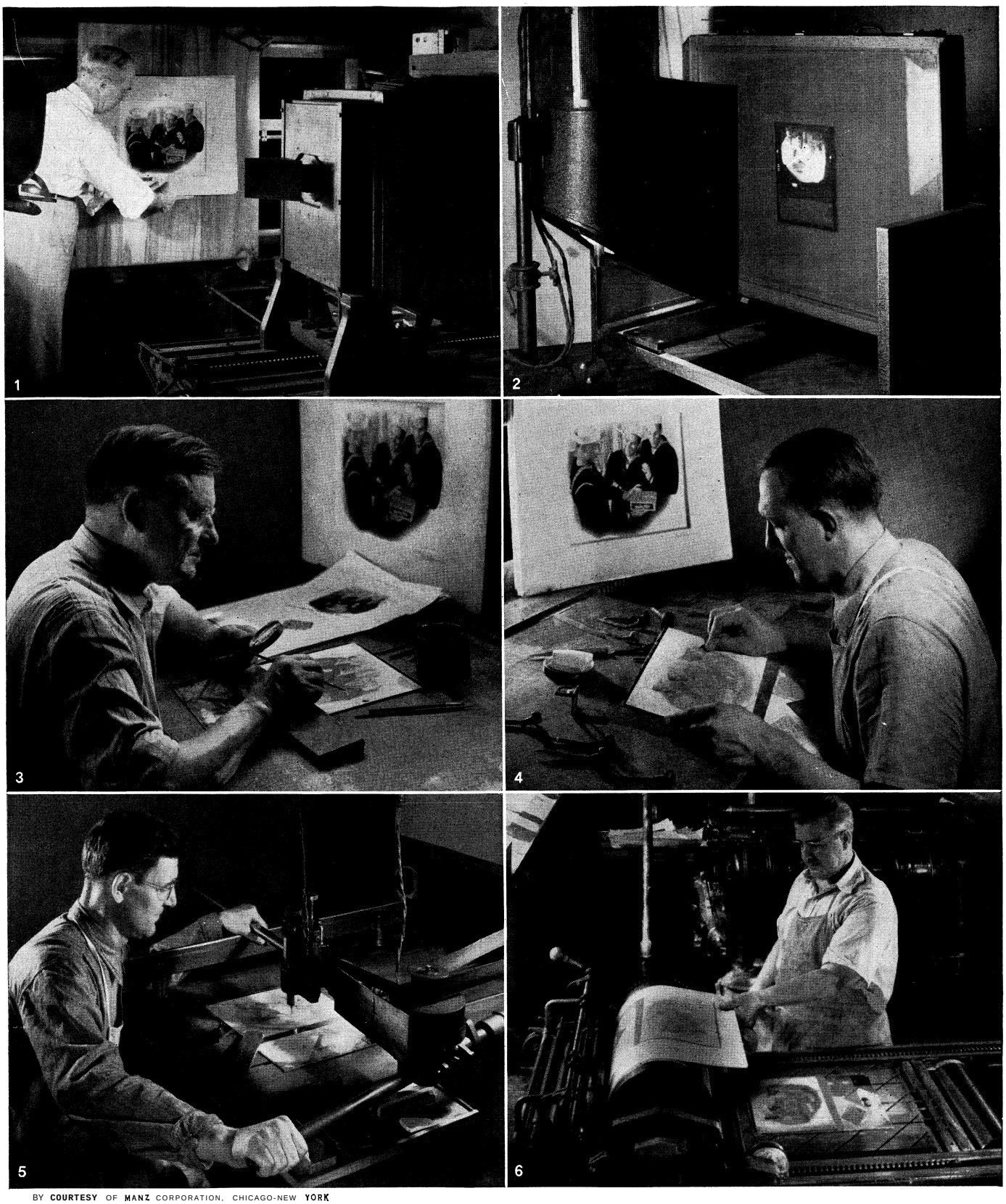
Line Plates.—When a negative of a line drawing which has to be made into a line plate has been obtained, a photographic print from it is made on to a piece of metal, usually zinc, which is first thoroughly cleansed. The plate is then coated with a bichromated ammonium solution, sensitive to light. The solution is poured over the plate which is then placed in a whirler in order to insure an even coating.

The negative is next placed with its film side to the coated zinc plate and put into a screw or vacuum printing frame with a plate glass front, in close contact. The printing frame is then exposed to light (usually electric arc), the time of exposure varying according to the density of the negative and the intensity of the light. The plate, after being slightly warmed, is rolled up with *a* greasy ink.

It is then placed in a tray of clean water and the surface gently rubbed over with absorbent cotton. Where the albumen coating has not been hardened by the action of light, it washes away, leaving those parts which have become insoluble by exposure to light on the plate.

The plate is dried by heat and defective lines retouched. The plate is then powdered with a finely ground topping powder which sticks to the ink providing an effective resist to the acid. The surplus resin is removed and the plate heated to melt the resin.

When the plate is cool, it is ready for etching, by placing in *a* diluted bath of nitric acid for the first etch; but before doing so, the margins and back of the plate are coated with a varnish which prevents the acid from etching away those parts which are to be left unetched.

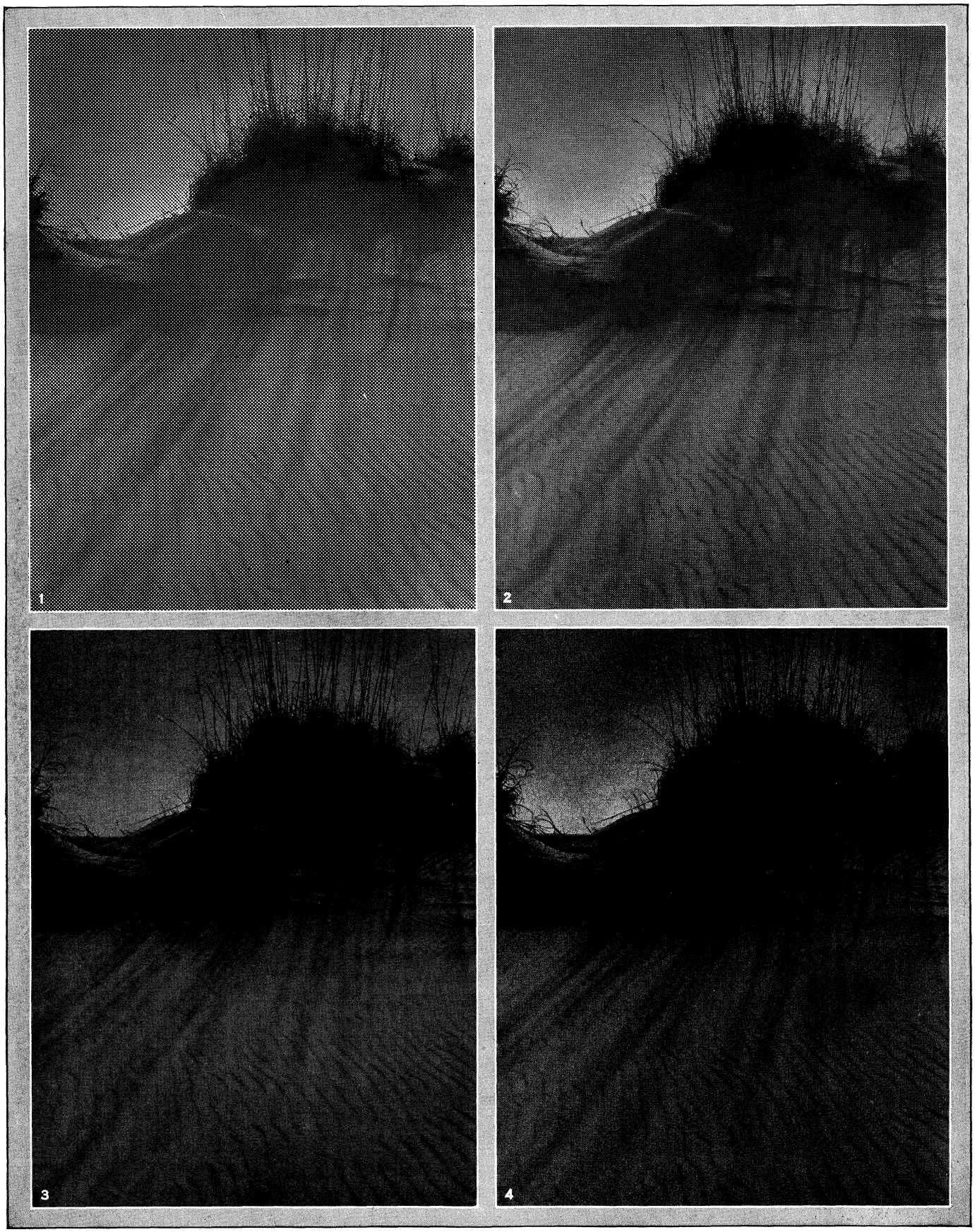


BY COURTESY OF MANZ CORPORATION, CHICAGO-NEW YORK

STAGES IN COLOUR PHOTO-ENGRAVING

1. Photographing a colour subject with a process camera. In the camera is a half-tone screen through which the image passes. The negative is thus divided into a great number of small "dots." In colour photo-engraving, four negatives are usually made, one for each of the primary colours (see Plate III)
2. The negatives are placed on sensitized metal, upon which the subject Is photographically printed
3. Etching the plates to subdue certain colours and bring others out, so that the final result will faithfully reproduce the original
4. Making further corrections in the colour values, by finishing and tooling the plates
5. Routing the plates, so that those parts which are not to be reproduced are removed from the printing surface
6. Pulling the colour proofs of the completed photo-engravings

PHOTO-ENGRAVING



PHOTOGRAPHS „A POEM IN SAND BY JOHN KABEL, BY COURTESY OF THE STERLING ENGRAVING COMPANY

EXAMPLES OF A SUBJECT REPRODUCED BY HALFTONE SCREENS OF DIFFERENT TEXTURES

1. 60 cross-line screen, used for printing on the cheaper grades of paper, such as newspapers and posters
2. 100 cross-line screen, used on machine-finished book paper
3. 133 cross-line screen, used on super-calendered and dull-coated papers
4. 175 cross-line screen, used when reproducing subjects containing fine detail printed on coated paper

COLOUR PRINTING
BY FOUR COLOUR PROCESS

PHOTOGRAPH, ENAT FROM THREE LIONS

Reproduction of a **painting,** a **photographic** transparency or **such** subjects as **wood** grain and **fabric is accomplished** by the halftone colour process. The early method of hand engraving has **been** replaced by a **photomechanical technique.** The reproduction may be **either** larger or smaller than the **original.** The **first** step in preparing four-colour printing plates from the Ektachrome shown above at the **left** is to make **colour-separation negatives** by means of filters on the **camera,** as **indicated** by the diagram. The transparency is **first** photographed through a blue-violet filter which **permits only its complementary** colour—yellow—to pass through the **lens** to the film. **Green, orange-red** and pale yellow filters are used to make negatives of the red, blue **and black values.** After metal printing **plates** are made, they are inked and **printed in the same** sequence shown above; *i.e.*, red on yellow, blue on yellow and **red,** and finally the black key plate for sharp detail.

The acid is agitated, either by rocking the bath by hand or by machines now generally used for this purpose, in which the acid is sprayed by means of air or mechanical action on to the surface of the plate. When the plate has been a short time in the bath, it is removed, washed and dried by heat, then powdered with "dragon's blood," applied in four directions so that all sides of the lines will be protected from the acid which is apt to "undercut" the lines. The plate is again heated, causing the resinous powder to melt and run down the sides of the etched lines, until the necessary depth is obtained.

A more recent practice which saves much time is flowing a zinc plate with a so-called "cold enamel" solution, eliminating the rolling up with ink. The plate is developed in alcohol and is then ready for etching.

The line process is occasionally used for colour work. The colours are generally made up of a number of "solid tints" or "stipple," the usual method being to take "key prints" from the etched "key plate," "stopping out" or painting in those parts required for the particular colour in which it will be printed. Where stipple or lines are to be introduced, shading mediums ("benday") are usually employed. These consist of gelatin or celluloid sheets with the design of the particular grain, dot, line or stipple in relief.

The film is rolled up with transfer ink and placed face downwards on the plate, which has been gummed over on those parts which are not required, pressure being applied by a roller or squeegee to those parts of the key plate which are to be printed in the particular colour.

Each colour requires a separate plate, which is rolled up, powdered and etched in the usual way.

Halftone Plates.—Halftone engraving is the process by which full-tone subjects in monochrome and colour are reproduced. The negative is made in the usual way, but to provide the necessary reticulated surface the exposure is made through a screen. This may be composed of grains (mezzograph), or what is most general, a series of lines running across each other at right angles. The cross-line screen consists of two sheets of thin plate glass, ruled with diagonal lines of mechanical exactitude. These are engraved into the glass, each piece of glass being ruled at right angles to the other. The lines are filled with a black pigment, leaving transparent spaces between. The two sheets of glass are placed face to face and sealed, the black lines crossing each other and leaving square transparent openings through which the light passes forming a halftone or dot image on the photographic plate or film.

Halftone screens are obtainable in various "gratings" or rulings, ranging from 40 to 400 lines to the inch, though for commercial use they rarely exceed 150 lines. The different rulings are used to suit the grade of work to be reproduced and the class of paper on which the illustration is to be printed. When printing on cheap, coarse paper, such as "news," a 60-line screen is usually employed.

Plates made with fine screens require printing on a highly finished or coated paper. For ordinary "black and white" commercial work, screens from 120 to 150 are used, and for fine colour reproductions, screens from 150 to 200.

The screen is secured in a holder and placed in the camera immediately in front of the photographic plate. The distance—an important factor—is governed by the particular ruling of the screen, the particular subject and the effect desired. When the negative is developed, the tones in the original are represented by a number of dots varying in area according to the tones of the original but of more or less uniform opacity.

The next operation is to make a print from the negative on to a metal plate, usually copper. The solution for coating plates is composed of water, fishglue and ammonium bichromate. The copper plate is polished to remove grease and foreign matter. The sensitive solution is poured on the plate which is then placed in a whirler to distribute the coating evenly.

After printing. the exposed halftone image is developed in water, after which the plate is sometimes placed in a bath of aniline dye, rendering it more visible. The margins and back of the plate are painted with asphalt or shellac to protect them from the acid.

The fishglue or enamel image, after being burned in, forms the acid resist. The plate is then placed in an etching bath of iron perchloride.

The plate is etched until the fine dots in the higher lights are as small as it is possible to etch them without undercutting the "dots."

The "re-etcher" or "finisher" then continues a series of fine etching by stopping out with an acid-resisting varnish those parts which have been rough-etched, and applying a series of local etchings for the purpose of recording the highest lights.

A proof is then pulled from the plate. compared with the original copy, and still further necessary alterations made. When approved, the plate is "finished" and mounted on wood or metal ready for the printer.

When a vignetted plate is required, the design and close surrounds are protected with varnish and the extreme edges are treated with acid so that the "dots" on the latter are reduced to the smallest point; gradually results are obtained until the dots merge into the white paper without showing a hard edge.

When pencil drawings are to be reproduced in halftone, it is usual to make a "high light" negative in which the high lights of the drawing and the paper on which it is made do not show a "screen." One of several methods may be employed.

(a) *direct,* when an over-exposed negative is made and certain stops used during the exposure, which tends to make the "dots" in the high lights overlap and become solid, the other tones being brought back to their correct relation by manipulative reduction of dot size;

(b) *the Bassani Apparatus,* which, attached to the camera, causes a slight circular movement of the halftone screen sufficient to veil the highlight dots and makes them disappear in the subsequent intensification of the negative;

(c) a patented diaphragm of the Waterhouse or Groesbeck type, used at one portion of the exposure to transpose the positions of the highlight dots and the spaces between them thus veiling the dots which disappear when intensified; and

(d) *the indirect method,* entailing the use of three photographic plates: first, a continuous tone negative is made of the original, which can be retouched; from this a positive is made through a screen; and from the positive a negative is obtained with the "dots" eliminated from the highest lights, which include the paper surface on which the drawing has been made.

Combination line and halftone plates are frequently made for commercial purposes, either by making two plates, and mounting finished line and halftone plates together; or by making two negatives, one in line and the other in halftone, stripping the films and combining them in their respective positions on one piece of glass which then forms the negative for printing on metal. In this way the combined design is etched on one plate and in one operation.

Halftone **Colour** Process.—When reproducing colour subjects by the halftone process, the plates are made in the same way as halftones, but the photographic plates must be colour-sensitive (panchromatic); when making the exposure the light not only passes through the prism, lens and screen but also is transmitted through what are known as "colour filters."

Generally considered, these are either dyed (coloured) films of gelatin cemented between two sheets of optical glass (and attachable to the lens by means of special holders), or they may be plain sheets of dyed gelatin, inserted in the barrel of the lens in a slot provided for Waterhouse stops.

The action of the filters is identical, in that the filter allows only rays of light of a certain colour to reach the photographic plate.

A special colour filter is used for each colour negative. Thus, a negative only records the colour and its component tints of one of the fundamental colours of the spectrum.

To make a negative for the yellow printing plate, a blue filter is used; for the red printing plate, a green filter, and for the blue printing plate, a red filter.

The light, passing through the respective filters, prevents the

colours and tints not complementary to the inks in which the printing plates are printed from being recorded on the special photographic plate.

As in the production of the halftone plate, the ruled screen is placed in front of the photographic plate, but for colour work, a circular screen, which can be turned at different angles, is used for each of the colour negatives.

The angles of the screen must be different for each colour to prevent a "pattern" or "moiré" effect when the three colours are superimposed in printing. For one colour, the screen angle is set at 45° from the vertical, and for the others at 75° and 15°, respectively.

The negatives are developed, printed on metal and etched in the same way as when making a monochrome halftone plate, but much fine etching, demanding great skill, has to be done in the reproduction of colour subjects.

The "fine etcher" must possess a good knowledge of colour and its analysis so that the final results will approximate the colour original. He must correct the deficiencies of the colour separations. This he does by a series of fine etchings, painting out certain parts and continuing the etching by local application of acid.

This operation may have to be repeated a number of times, and many proofs are pulled from the plates before final satisfactory results are obtained.

It is now usual to include a fourth colour plate when reproducing coloured subjects. This is usually printed in gray or black; the colour, however, is not dissected in the ordinary sense of the term, although a yellow filter is used. The fourth plate represents the whole of the tones in the original in their proper relation to each other, and becomes the key plate. The fourth printing allows for cleaner and more rapid working on the printing press, and at the same time provides a depth of colour and quality which, because of the scientific shortcomings of the process, are not always possible to obtain.

The plates are finished in the usual way, mounted usually on metal or sent unmounted to the printer along with progressive proofs which show the shades of colour used in the proofing and their sequence in printing.

Halftone colour negatives are made either by the direct or the indirect method. In the first instance, each colour negative is made in the same way as an ordinary halftone negative, but the exposure is made through a colour filter in addition to the screen, thus recording on the panchromatic plate one of the primary colours and its shades and constituting, when developed, one of the halftone negatives from which a plate will be made to print in a certain coloured ink.

The *indirect* method entails the use of three or four photographic plates for each colour. The first exposure provides a continuous tone colour-separation negative. It is obtained by making the exposure through a colour filter.

The full-tone negative can be retouched to assist in correcting colour values. From the full-tone negative a continuous tone positive is made and from it the screen negative.

This concludes an outline of the principles and processes of photo-engraving. The casual reader is warned against any attempt to use the chemicals and machinery mentioned. The necessary skill for their employment can be attained only after years of training and practical application of the process.

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(E. EN.)

PHOTOGRAMMETRY, in simplest terms, means "picture measuring." At the point where we cease using the simple aerial photograph and start making a map from it, we enter the realm of photogrammetry. It was in 1851 that the Frenchman, A. Laussedat, first compiled map data based upon measurements from photographs. Handicapped by the narrow field and imperfections of the photographic lenses of his time, Laussedat, who is known as the father of photogrammetry, is credited with the first conception of the possibilities of photogrammetry, though his efforts and those of others for many years resulted in little practical progress.

It was nearly 50 years after Laussedat's original conception of photogrammetry that the first practical work was done by E. Deville, a Canadian. About the end of the 19th century Deville took a stereoscopic pair of phototheodolite pictures (phototheodolite pictures are those taken from tripods on the ground, as contrasted with aerial pictures), and devised a simple stereoscopic machine for drawing a map from these pictures.

With the beginning of the 20th century progress in photogrammetry became much more rapid. Strangely enough, for a period of many years after Deville's original work, very little photogrammetry was practised on the American continent, while many experimenters scattered throughout central Europe were working upon apparatus for automatic plotting from phototheodolite pictures.

Practically all of the development which took place prior to World War I contemplated the use of phototheodolite pictures. There were many machines of European origin made for this purpose. These machines, in the simplest language, use a pair of pictures taken from the extremities of a measured base line. They measure and plot through various mechanical arrangements the intersection of the rays which formed the common images of the two pictures.

The phototheodolite method was very successful and economical, especially in regions like the Alps where the steep terrain afforded camera stations overlooking an extensive area. The method was also employed by the U.S. engineers and the U.S. geological survey in Alaska.

The entire basis of photogrammetry changed abruptly as a result of the introduction of practical aerial photography in World War I. The aeroplane afforded a superlative camera platform and flew rapidly from one exposure station to the next. Large areas could be covered in a single overlapping pair of photographs and blind areas which had been a serious handicap to the terrestrial method were minimized.

Along with the many obvious advantages of aerial photography came a series of complications. Whereas in terrestrial photogrammetry the length of the base subtending the two pictures is known, it is an unknown in aerial photography. Other unknowns in aerial photography are the precise elevation from which the pictures are taken, and especially the difference in elevation between an overlapping pair of pictures and the angle of inclination of the camera at the instant of exposure. The stereoscopic plotting machines which had been so laboriously developed for terrestrial photography thus became obsolete. A new double trend became manifest, for a universal plotting machine, on the one hand, and for a simpler product, planimetric maps and mosaics,

on the other.

The universal plotting machine utilized either terrestrial or aerial photography, and this type of machine dominated most of the period between World War I and World War II.

By 1945 terrestrial photogrammetry was used very little. Even large-scale maps of dam sights, for example, at 1:240, were produced by aerial methods. The quality was excellent and the method proved very economical. We thus find emerging from World War II aerial stereophotogrammetric processes, mosaics and a widely used system of reconnaissance mapping known as the Tri-Metrogon system.

Ordinary aerial photographs, just as they come from the camera, have a wide variety of uses without the application of any photogrammetric processes whatsoever. Thus, we find the air-view, or oblique photograph, employed for many illustrative purposes. This is the simplest and most widely understood application of aerial photography.

Uncorrected vertical contact prints are extensively used, especially in petroleum geology. Hundreds of thousands of square miles of territory have been photographed for this purpose, with the end product consisting of a complete set of stereoscopic. overlapping vertical prints. Ordinarily, these are accompanied by an index map which shows the relationship of each individual print to the survey as a whole. In this type of work the photographic laboratory work is simple and standard and the only aspect of the undertaking requiring experience is the flying itself.

Geometry of the Picture. — Early users of aerial photography discovered that a picture taken with camera axis vertical was only truly a map if the ground was flat and horizontal. Aerial pictures in the early days were said to be distorted. Some of this distortion was caused by qualities of the early lenses although this was a very small part of it. The major cause of this trouble is more correctly termed displacement. The picture is actually a conic projection. Thus, vertical objects such as telegraph poles situated in any part of the picture except at its exact centre

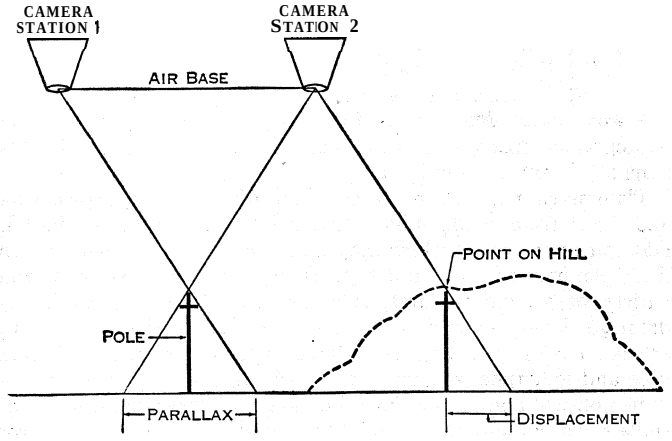


FIG. 1. — DISPLACEMENT BECAUSE OF DIFFERENCE IN THE HEIGHT OF OBJECTS AND PARALLAX. THE DISTANCE BETWEEN THE DISPLACED POINTS MEASURED PARALLEL TO THE AIR BASE. ARE HERE ILLUSTRATED

appear as radial images with the base of the poles toward the centre of the picture and the top displaced outward (fig. 1 and fig. 2). Another way of thinking of the picture is as a perspective with all vertical lines disappearing at a vanishing point at the centre of the picture. If, in place of the telegraph pole, we visualize a hill of the same height, the top of the hill will be radially displaced in relation to a lower datum just as the top of the telegraph pole was.

However, since these displacements lie along radial lines, the angle subtended by any two images at the centre of the picture, or, to be more accurate. at the nadir point. is a true angle.

While this displacement is very troublesome to the person trying to use an uncorrected contact print of mountainous terrain, it is the very essence of photogrammetry. Actually photogrammetry measures this displacement and all elevation data is derived from these measurements. The simplest form of stereoscopic plotting instrumehts measure the so-called parallax of the picture. This parallax is the measured difference between conjugate image points of objects lying at varying elevations. Thus, if the two overlapping images of the base of a telegraph pole are placed in registry the images of the tops will be in two radially disposed positions. Their separation, measured parallel to a line

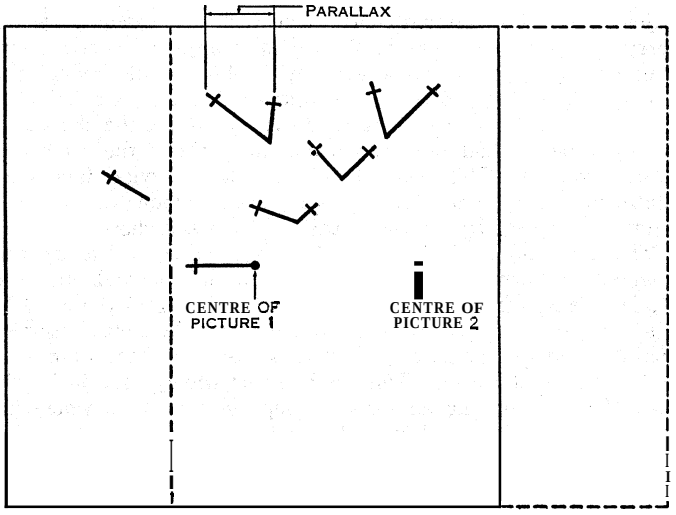


FIG. 2. — RADIAL IMAGES OF POLES OF SAME HEIGHT. PARALLAX THE SAME FOR THE SAME ELEVATION

connecting the picture centres, is the parallax of the top of the pole in relation to the base (fig. 2).

Systems of Control. — All photogrammetric processes depend upon control. Control is of two general kinds, viz., ground control and office control. By ground control we mean positions and/or elevations established by processes conducted independently of the aerial photography and the laboratory. Most ground control is established by conventional instrumental survey on the ground, or else uses a system of ground survey which has previously been established. We may thus say that the most common methods of ground control are astronomical determination of position, triangulation, traverse and levelling, either by spirit level or trigonometric levelling. These ground control operations are distinguished from office control operations which are done in the laboratory by radial control methods, aerial triangulation and similar processes.

Aerial Triangulation and Bridging. — Aerial triangulation consists of starting from some known ground control and extending by laboratory processes through a series of pictures. These processes are known as carrying forward control, or as bridging. Carrying forward of control is done in machines of the type of the stereoplanigraph and is accomplished by the successive adjustment of adjacent stereoscopic models upon each other. The stereoscopic model, for example, consisting of pictures 1 and 2, would be adjusted to known ground control. Picture 1 would then be replaced by picture 3, and while picture 2 remains unmoved in the plotting machine, picture 3 is adjusted to picture 2 until perfect stereoscopic correspondence is achieved. Then picture 2 is replaced by picture 4, and the process continues indefinitely.

The continental European schools are inclined to use this method extensively. Closure errors build up toward the end of a long series of pictures and have to be adjusted. A very long strip of pictures would not adjust so accurately as a short strip of pictures.

Another method of extending control in vogue on the continent of Europe is by the use of the radial triangulator, which is a machine performing the radial control operation more precisely (according to the users) than the graphical processes used almost universally by the Allies in World War II. In radial triangulation a pair of pictures which have been restituted is used (that is, the tilt has been minimized or eliminated, or provided for mathematically). Radial angles are measured at the nadir point to various image points. From a starting base of known length,

these angles are applied and the control thus extended by computation.

Bridging is a process of extending control between separated groups of ground control by means of the multiplex and similar instruments. The multiplex is set up with a plurality of projectors, sometimes as many as 20, each of which projects the image of one picture in the series. The first pair of projectors is adjusted to known ground control, and each subsequent projector carrying the next picture in the series is adjusted successively. This process goes on until control at the far end of the series is reached. The error existing at this point of closure is distributed by various formulae, which take into consideration the characteristics of the method, lens distortion, curvature of the earth and similar factors. This method was in 1946 in wide favour in continental Europe and had many supporters among users of the multiplex type of equipment in the U.S. and elsewhere.

The most universally used method of office control is the one originally known as the Arundel method in England, and the Bagley method in the U.S. The modern evolution of these methods. generally referred to as radial control, is the slotted templet method, widely practised both with slotted cardboard templets and slotted metal arms. This method was widely used in World War II for compiling all sorts of maps in territories where insufficient ground control existed.

The Slotted **Templet** Method. — The slotted templet method is a means of graphical triangulation. By this method a templet, most easily explained in the cardboard version, is made from each individual photograph. The principal point, or nadir point, and at least eight radial points around the edges are pricked through from the picture to the cardboard templet (fig. 3). A

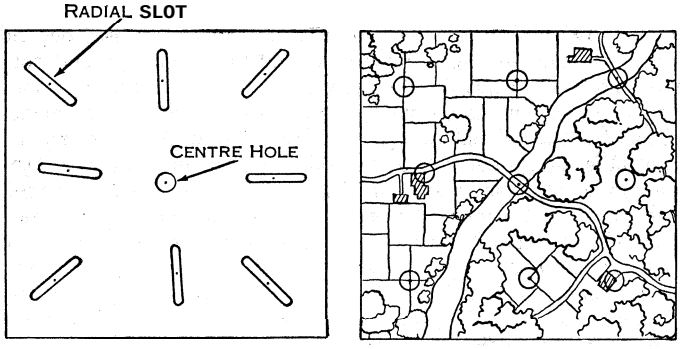


FIG. 3.— A SLOTTED TEMPLET IS MADE FROM EACH PHOTOGRAPH, AND THE SERIES OF OVERLAPPING TEMPLETS, WHEN ASSEMBLED, CONFORM THEMSELVES IN A GRAPHICAL TRIANGULATION NET

hole is punched at the centre prick mark of the templet, and through each of the outlying points a radial slot is cut. Because of the conventional 60%×30% overlap, each of these points is common to several pictures — sometimes as many as 6. The templets are then "buttoned up" with connecting posts through the intersecting slots, so that all the slots representing a given common point from the various pictures are assembled over a single post. These posts are like a flat-headed rivet with a hole through the stem. Previously, the known ground control points had been identified on the photographs and on the templets representing these photographs. The positions of these points are plotted on the assembly board and a post is secured immovably on these points. With these posts fixed and all others free at the intersection of the radial slots, the entire templet assembly expands or contracts to conform to the fixed ground control points, thus establishing a uniform scale throughout.

When the entire area is covered by the templets, each one of which represents one of the pictures, the posts at the various radial slot intersections represent the true position of a great many points. These points are then pricked through the hole in the post to the compilation board underneath the templet assembly thus affording an intensive control pattern from which subsequent processes may develop.

The slotted templet method affords excellent control for mosaics, planimetric maps and small-scale contour maps. In the case of large-scale contour maps with small vertical intervals, most photogrammetrists insist on ground control in each stereoscopic model. The slotted templet method is not quite accurate enough to control the setup of the plotting machine. Bridging and similar processes maintain accuracy by reducing the flight altitude, thus nullifying, in part at least, the theoretical advantage. Proponents maintain that bridging actually does result in control economies. This question is one of the most perplexing problems of photogrammetry.

Mosaics.—Mosaics have evolved from an uncontrolled and often misleading conglomerate assembly of pictures to a map of predictable accuracy and widely accepted usage. Most mosaics are compiled through the following steps:

(1) Scattered ground control.

(2) Nine points per picture, established by radial control (slotted templet).

(3) Comparison of the contact print with the control to determine what restitution is required.

(4) Restitution, consisting of the following:

(a) Enlargement or reduction of the picture as a whole, to compensate for varying altitude of the aeroplane and varying elevation of the ground.

(b) Tilt correction, to compensate for lack of verticality of the picture at the instant of exposure, and for average slope of the ground.

(c) Fractional treatment — the breaking up of the picture into small parts to compensate for irregular ground.

(d) Pyramiding — where the utmost in precision is required. This is a process of roughly contouring the picture and making a series of ratio prints, one for each tier of elevation, all from the same negative. The pictures are then cut on these approximate contours, and reassembled, with the picture for each higher contour being pasted over the lower one. Thus, the error may be reduced to plus or minus half the interval of the pyramiding.

(5) Stick-up and editing — this consists of superimposing on the mosaic: grids, geographical lines and names, marginal data, etc.

(6) Copying by quadrangles, on large plates or films.

(7) Reproducing by quadrangles,

(a) Photographically

(b) Lithographically, etc.

Planimetric Mapping. — Line maps as distinguished from photographic maps have two general classes: (1) planimetric maps; (2) topographic maps.

Planimetric maps delineate any kind of horizontal information and differ from topographic maps, which have contour lines in addition to the detail which may be shown on a planimetric map. Both planimetric maps and topographic maps may show a wide variety of ground features, such as roads, railroads, buildings, drainage, lakes, shore lines, swamps, cadastral data and many others. They may both show various types of grids, such as latitude and longitude, rectangular co-ordinates, etc. They can also show political and geographical boundaries, property lines and an endless variety of special data, such as land classification, crop classification, soil types, etc.

Planimetric maps are almost universally controlled on a slotted templet base. From this point on the methods of compilation differ depending upon the character of the aerial photography and the preferences of the compiler.

The soil conservation service of the United States department of agriculture, for example, compiles planimetric maps by projecting from a contact print onto a base compiled by slotted templet. The image is enlarged or reduced to conform to the control on the compilation board and the detail is then traced.

There are many other modifications of the system. Some organizations prefer, especially in country of steep relief, to establish radial intersections at intervals along all the principal features that are to be shown on the planimetric map. These intersections are then used to guide a draftsman, who fills in the features by hand, while looking at a photographic print.

Planimetric maps are also compiled from oblique photography. In instruments for this purpose, called photo alidades and similar names, a contact print or glass diapositive is observed in front of

a transit, the centre of rotation of which is placed in the position occupied by the rear node of the taking lens. Below the vertical axis of this transit and attached thereto is a blade similar to a conventional alidade, which plots the horizontal projection of the rays to the various points which are sighted through the telescope. The true position of these points is determined by intersections developed through observations on overlapping pictures.

Still another extensively used method of placing planimetric detail from the photograph onto the map is by means of the sketchmaster. This is a device on the camera lucida principle. Through a half-silvered mirror or split prism the picture and the compilation sheet are seen simultaneously. After establishing a good empirical registry between picture and compilation sheet, the detail is traced. Sketchmasters have been of three types, namely, vertical, oblique and universal. The first-class plots from vertical pictures only. The oblique sketchmaster, as its name implies, draws maps from oblique pictures such as the Tri-Metrogon wing pictures, while the universal sketchmasters will draw from either type of photography.

Tri-Metrogon System. — The Tri-Metrogon system derives its name from three K-17 cameras equipped with six-inch Metrogon lenses which are used as a unit. They are mounted with 1 axis vertical and the other 2 axes at 60° to the vertical and extending to the sides. Thus, the camera covers 7° or 8° above the horizon (fig. 4). This is an important factor since the position of the horizon in the pictures is used to determine the X tilt and the Y tilt. Since the horizon shows in each of the wing pictures and since each is subject to the same tilt conditions, there are two determinations which can be used as a check, one against the other. If one or both wing pictures show a clean-cut water horizon or a horizon on fairly flat, low land. the tilt can be determined with good accuracy. If the terrain is mountainous, a considerable amount of estimating enters into the determination.

The constants which should be known for satisfactory planimetric work from Tri-Metrogon photography are the focal length of each camera and the exact angular relationship among the three cameras.

In charting work the Tri-Metrogon photography is assembled by slotted templet processes. The templet of the vertical picture is made in conventional manner while the templets of the oblique pictures are made with the aid of a number of different kinds of equipment. Probably the photo alidade is the most accurate and satisfactory means of laying out the oblique templets although a number of types of simplified apparatus such as the rectoblique plotter, photoangulator, etc., are extensively used. The accuracy of the final result is to a large extent dependent upon the success in determining the title of the various pictures and the interlocking angles of the cameras.

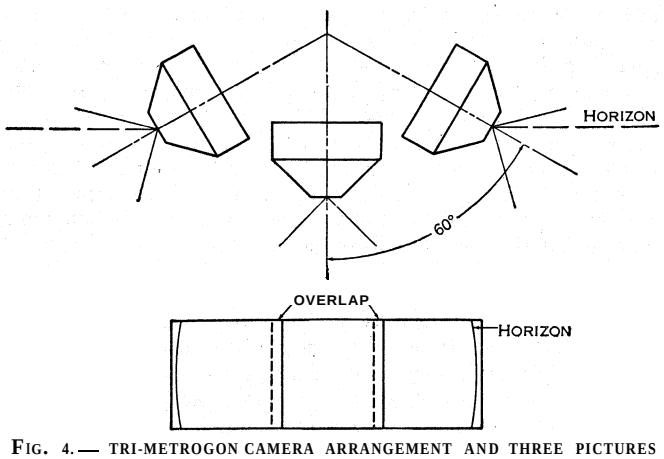


FIG. 4. — TRI-METROGON CAMERA ARRANGEMENT AND THREE PICTURES SHOWING VERTICAL AND TWO WING PICTURES

When the radial control plot has been completed by slotted templet the detail is put on the map with the aid of sketchmasters and other plotting devices of similar character. Small-scale charts have been made by this method covering a large part of the world.

Tri-Metrogon photography has also been used to some extent as the basis for topographic maps. For this use it presents many problems and few of the existing plotting machines get effective production from Tri-Metrogon photography. The depth of focus of the multiplex has proved inadequate for the great range of the oblique photographs and the excessive enlargement coupled with bad definition makes multiplex work fairly unsatisfactory. The stereoplanigraph has been fairly successful in mapping at scales for publishing at 1:25,000 from Tri-Netrogon photography. In this instrument also the enlarging factor becomes so great and definition so poor beyond the centres of the wing pictures (25°± below the horizon) that accuracy is seriously impaired. The stereoplanigraph has, however, done the most effective job of contouring from Tri-Metrogon photography.

Tri-Metrogon photography has been flown at various elevations up to 40.000 ft. The practical separation between flight strips depends upon many factors, the most important of which is atmospheric haze. Other factors are topographical relief and ground cover. Tri-Metrogon photography is generally usable to a total subtended angle of 110°. Under favourable conditions it can be used to a total subtended angle of 135° or 140°. Practically speaking, the principle point of the wing pictures is about the limit of successful coverage in terrain which contains considerable planimetric detail. Farther out than this, buildings, roads, etc.. become very indistinct.

Topography. — Topography is developed from aerial photography by two processes: (1) two-dimensional processes; (2) three-dimensional processes.

All stereoscopic measuring is accomplished through viewing a stereoscopic pair of pictures and measuring with a reference member known as a floating mark. The floating mark as used for measuring stereoscopically may be a single mark which is physically at the intersection of the two projected rays of a common image as in the multiplex, or it may be two marks which are fused into one just as the stereoscopic pictures are fused into one. When the two marks are superimposed on the pictures and correspond exactly with conjugate images of any point, they appear to touch the ground at that point. If the eyes must converge more to see the mark than to see the image, the mark will appear closer to the observer (higher) than the image of the ground. If the eyes diverge to see the mark in relation to the image, the mark appears to lie below the surface of the ground.

The floating mark, then, consists of a single reference point at the intersection of the rays of the multiplex or of two points

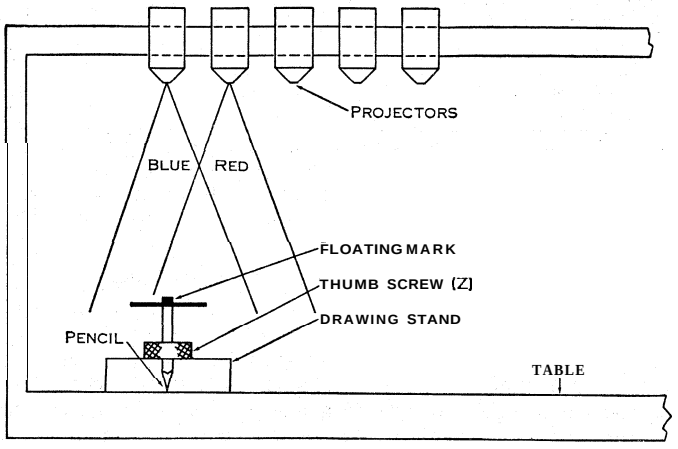


FIG. 5. — MULTIPLEX

The Multiplex projects an overlapping pair or series of pictures in correct three-dimensional relationship. .The images of complementary colours are viewed stereoscopically through spectacles with complementary coloured lenses. Drawing is accomplished by moving the drawing stand while keeping the floating mark in exact registry with the stereoscopic image

which the operator fuses into one on other types of equipment (figs. 5 and 6). The floating mark may be physically in contact with the pictures, or optically in contact with the image of the pictures in the more elaborate machines, and may be set for any desired ground elevation.

The above description of parallax measurement applies very aptly to the two-dimensional processes. In principle, it also applies to the three-dimensional processes but not quite so obviously.

Two-Dimensional Processes.—The two-dimensional processes are the simplest means of deriving elevation information from a stereoscopic pair of aerial photographs. The apparatus consists of

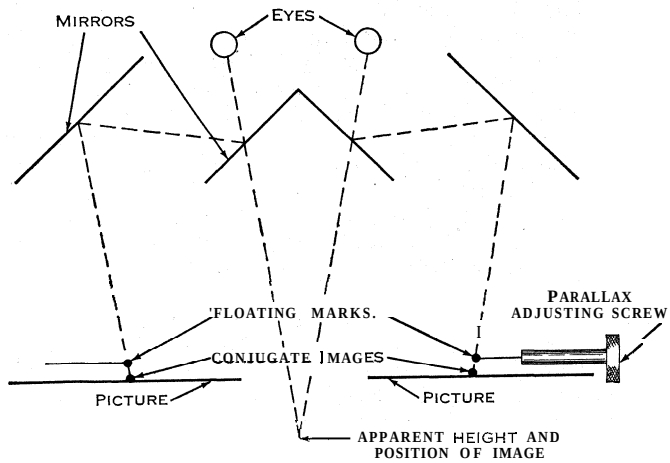


FIG. 6.— SIMPLE PARALLAX MEASURING STEREOSCOPE

a pair of stereoscopic pictures used in a stereoscope having a pair of marks in contact with the pictures. By setting the separation of the marks in accordance with the parallax of the desired elevation, and moving the mark along the exact ground surface of the stereoscopic image, a contour is drawn. All points of the same elevation have the same parallax in vertical photography. The parallax is set once only for each contour. In drawing planimetry a road may, for example, go up- and downhill requiring the parallax to be continuously changed. Maps drawn by the two-dimensional process emerge from the stereoscopic plotting instrument as a conic projection (fig. 7). It is a true conic projection only when the two pictures of the stereoscopic pair were rectified

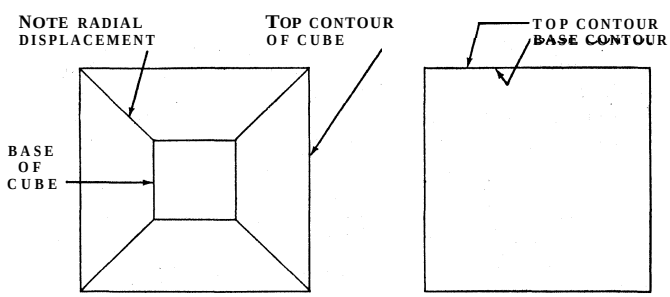


FIG. 7.— THE PHOTOGRAPH IS A CONIC PROJECTION AS ILLUSTRATED AT THE LEFT. THE MAP MUST BE ORTHOGRAPHIC. AS AT THE RIGHT. THIS CORRECTION IS MADE AUTOMATICALLY IN THE THREE-DIMENSIONAL PROCESSES, BUT IS AN ADDITIONAL OPERATION IN MOST TWO-DIMENSIONAL PROCESSES

(corrected for tilt) prior to their use. A great number of stereocomparagraphs, the best-known piece of equipment of this character, are in use. Acceptable maps can be made by this process even without using rectified photographs, providing a sufficient amount of ground control is available. Unrectified pictures will give reasonably good results with one point of known elevation for approximately every two square inches of photograph. The same pictures, if properly rectified, will give an excellent map with four known control points per stereoscopic model.

After the contours and planimetry have been traced off, the conic projection must be corrected. This means that each contour which is at a different scale in accordance with the distance from the taking camera to the ground and each planimetric detail which is similarly displaced must be proportionately corrected, elevation by elevation, in order to get a resulting orthographic map. This step may be accomplished by tracing the detail off by pantograph, or some similar device, changing the ratio for each change of contour; or it may be done in a projector by changing the projection ratio from contour to contour and tracing the orthographic map off on the projection screen.

Two-dimensional plotters go by such names as stereocomparagraph, contour finder, stereometer, parallaxer, etc.

Three-Dimensional *Processes*.—The three-dimensional process differs from the two-dimensional process in that the light rays which originally formed the image are reprojected from the image in miniature back to the ground (its mechanical representation).

If it can be imagined that the aerial camera remains in space in the same position in which the picture was taken and that the film after development is replaced in the camera and the camera used as a projector, each ray will return to the source from which it originated. Thus, if we now visualize two cameras retained in their spacial stereoscopic relationship, the conjugate rays from the two images of the common ground point when reprojected will fall back on that common ground point and intersect thereat. It also can be readily seen that if the cameras were moved together so that their separation was only half as great, that the rays now instead of intersecting at the true ground would intersect at a distance halfway between the cameras and the ground. In other words, we have cut the scale of the entire system in half. If now we move the cameras together so that they are only $\frac{1}{20,000}$ of the distance at which they were separated in the air, we can draw a map at precisely $\frac{1}{20,000}$ of the original scale. Similarly, the survey can be planned to produce a map at any desired scale.

The simplest example of the three-dimensional process is the multiplex. The original air pictures which may have been 9 in. x 9 in. are reduced for multiplex use to $\frac{1}{4}$ of their original size. This reduction permits very small projectors to be used which can be brought physically close enough together to get the desired scale. Full-scale projectors using a 9 in. x 9 in. picture could not be put close enough together. For example, if a scale of 1:10,000 is desired and the pictures were taken **3,000** ft. apart, the nodal points of the two projection lenses would be separated only $\frac{3,000}{10,000}$ **=.3** ft. or 3.6 in. Obviously, big projectors carrying 9 in. x 9 in. pictures could not be arranged this close together. But the multiplex with its $2\frac{1}{4}$ in. x $2\frac{1}{4}$ in. pictures can be so arranged.

The multiplex projectors will have lenses of perhaps 1.5-in. focal length, stopped down to a tiny aperture. Thus, at the focal plane of these lenses definition is sharp and for a considerable distance both sides of this plane the circle of confusion is small enough to be tolerable. In other words, the lenses have great depth of focus. This feature tends toward simplification of the multiplex system since the focus is sharp enough to draw a substantial band above and below the plane of most critical definition. Thus, without providing for any change of focus the multiplex operates effectively through a wide range of ground elevation.

Stereoscopic vision in the multiplex is by the anaglyph method. The two projectors or, in case more than two are used, alternate projectors carry filters of complementary colours, that is, red and blue. The observer wears spectacles with a red filter over one eye, a blue filter over the other. Thus, the two images are separated and sterescopic vision is made possible. The projected images are received on a drawing stand which is free to be moved around over the compilation sheet which is secured to a very flat table often made of slate or hand-scraped metal. The drawing stand carries a screen parallel to the surface of the paper which can be raised or lowered by a thumb screw. In the middle of this screen is a tiny point of light which serves as the floating mark and directly beneath is a pencil in contact with the compilation sheet, which draws as the stand is moved around. Thus, in drawing contours the screen is set at the desired elevation and the stand is then pushed around by hand. The operator observes the floating mark in relation to the plastic stereoscopic image and moves the stand so that the floating mark follows the surface of the ground without getting either above or below it. In drawing planimetry, the floating mark is caused to follow the feature, such as a road. The operator works the thumb screw of the screen, causing it and the floating mark to move up and down following the undulations of the feature.

Other three-dimensional processes use equipment of the stereo-

planigraph type. These machines include the Wild autograph, the Santoni stereocartograph and others.

All of these machines operate in a somewhat similar manner, the main difference being that the Porro principle is the basis of the stereoplanigraph whereas the other two machines mentioned have a mechanical representation of the nodal point and the light rays. The Porro system means that projection in the plotting machine is through a lens set at infinity focus and having identical optical characteristics with the lens of the aerial camera which took the pictures. Since projection through this lens is at infinity focus and the image on the stereoplanigraph must focus in the plane of the floating mark, an automatic focusing lens is interposed between the projection lens and the floating mark. This is a telephoto lens which is constantly accommodating for the changing distance between the projection lens of the picture holder and the floating mark.

The other type of machine such as the Wild autograph has a ray rod passing through the mechanical representation of the nodal point. This rod actuates an optical system which scans the photograph in such a manner that the point viewed is always the point which was formed by a ray of light passing through the lens at the same angle as the ray rod.

These machines have a mechanical base by means of which the scale is set. In the case of the stereoplanigraph (fig. 8), the distance between the two floating marks is varied by changing this base, and on other types of machines the distance between the ground extremities of the ray rods is determined by the base adjustment.

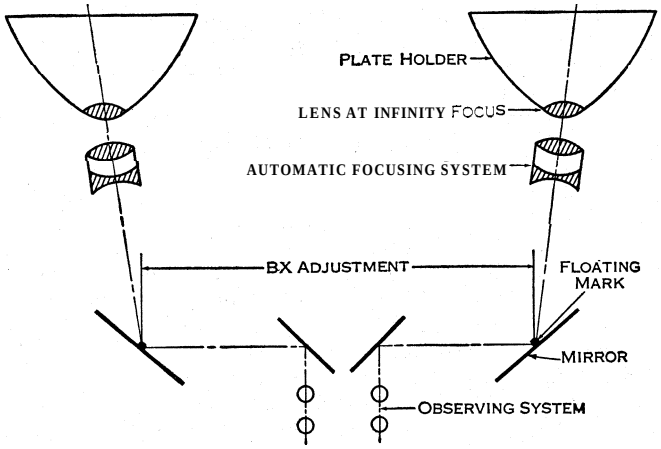


FIG. 8.— SCHEMATIC DIAGRAM OF STEREOPLANIGRAPH

In all machines of this general classification the picture holders, or plateholders as they are more frequently called, are arranged so that they can be given X tilt and Y tilt around the nodal point. After the stereoscopic model has been perfected the two plateholders together can be horizontalized by the application of common X tilt and common Y tilt. The bases of these machines also carry the BY and BZ adjustments. BY is an adjustment at right angles to the main base adjustment BX. BY is the equivalent of rotating the base in a horizontal plane. BZ is the adjustment for difference in the aeroplane elevation at the instant of exposure of the two pictures. Instead of lowering the camera, the floating mark or the base of the ray rod is raised in relation to the base, thus shortening the distance from nodal point to ground.

Stereoscopic pictures in a three-dimensional plotting machine can be put into perfect relative adjustment or correspondence without any reference whatever to the true horizontal. This is accomplished by a trial-and-error system which makes imperfections of adjustment manifest by vertical parallax. This is a splitting of the floating mark so that one mark appears above the other. When the adjustment is perfect no vertical parallax is present any place in the model. The subsequent process known as horizontalizing consists of moving the stereoscopic pair as a unit so that it bears the proper relationship to the base movements of the machine. Thus, before horizontalizing, the cameras (plateholders) will probably lie in some inclined plane relative to the X and Y tracks of the base. The scale will also generally need adjusting. Horizontalizing is accomplished by measuring the distance between known ground control points and adjusting BX to get the proper scale and by measuring the elevation of known points in the model and adjusting common X tilt and common Y tilt.

Drawing is accomplished by turning handwheels which actuate the X and Y movements and a footwheel controlling Z. The X and Y motion of the handwheels is transferred to a pencil on a plotting table.

This plotting table is connected to the stereoscopic machine through a gear box so that differential ratios may be established between machine and plotting table. It is not at all unusual to draw the map on the plotting table at six times the picture scale, and frequently the scale is enlarged as much as ten times horizontally.

This brings up one of the main criteria by means of which a stereoscopic survey is planned. There is very little relationship in most stereoscopic systems between the horizontal scale and the flight altitude, because the horizontal scale can be enlarged or reduced. The determining factor of the flight altitude is the accuracy required of the contours. Thus, plotting machines of the finest type can fly 2,500 or more times the permissible contour tolerance. From this elevation a map can be drawn in which at least 90% of all points tested will check out within ½ the contour interval.

The wide choice of plotting scales on the stereoplanigraph type of equipment gives it an advantage over the multiplex where the plotting scale is restricted by the depth of focus of the projectors.

One of the principal differences between the plotting machines of the stereoplanigraph type and the multiplex is the fact that with the multiplex drawing is accomplished by pushing the stand around over the compilation sheet, the elevation being changed by a thumbscrew. On the stereoplanigraph, drawing is accomplished by turning handwheels, the left hand controlling the X motion of the machine, and the right hand controlling the Y motion. On machines of the stereoplanigraph type the elevation of the floating mark is controlled by a footwheel. Thus, when drawing contours, the footwheel sets the proper elevation. At this setting the floating mark, like the floating mark of the multiplex, is restrained to movement in a given horizontal plane. For drawing planimetry with the stereoplanigraph, the operator looking through the stereoscope causes the handwheels to follow the ground feature and with the footwheel keeps the floating mark moving up and down to conform with the elevation of the surface of the ground.

Summary.— Aerial photography and photogrammetry augment but in no way eliminate ground surveying. In all photogrammetric processes a certain amount and often a considerable amount of ground surveying is required for control. There will often be areas to be mapped which are too small to justify the cost of flying an aeroplane to them or which are too remote to absorb this cost. There will also be areas obscured by vegetation. These areas will probably be mapped with a plane table just as they always have been.

There will also always be surveying on the ground actually to lay out projects which may have been designed from a photogrammetric map. It is not possible to drive a stake in the ground from an aeroplane and the construction project must therefore always be laid out by conventional survey processes.

Aerial photography greatly enriches the visual information obtainable about the surface of the ground. It frequently makes available a more complete visual inventory more rapidly and cheaply than could be obtained in any other manner.

Photogrammetry usually minimizes the more costly phases of conventional surveys by ground instruments. Whether a photogrammetric or a ground survey will be more practical involves a consideration of such factors as purpose of the survey, scale of map, contour interval, size of area, distance from operating base, character of ground cover, data to be shown on the map and character of the terrain. A study of the individual project will determine whether the survey should be by photogrammetric methods, by conventional ground methods or by a combination of both. (L. T. E.)

PHOTOGRAPHIC ART. Photography came into being through an artistic urge. Louis Jacques Mandé Daguerre was an artist, a scene painter whose illusionistic diorama was a landmark in Paris long before he announced, in 1839, his daguerreotype process. And William Henry Fox Talbot was led to make his simultaneous researches because he found it difficult to dram. It was not mere coincidence that photography came into being almost simultaneously with means of multiplying pictures in great quantities (lithography and wood engraving) and with semimechanical means of picturemaking (the silhouette and the physionotrace). The underlying chemical and optical principles had long been known, but the conception of using the light-sensitive property of silver salts to record the optical image of the camera did not occur until there was a demand for pictures following the rise of the bourgeoisie after the French Revolution.

The first criticism of photography was necessarily a comparison of it with painting or drawing, as no other standards of picturemaking existed. The Parisian painter Paul Delaroche. when questioned about the value of the daguerreotype to artists, went so far as to say that the "process completely satisfies art's every need." Photography's remarkable ability to record a seemingly inexhaustible amount of detail was marvelled at again and again. The critics regretted that. because of the great length of exposure, moving objects were not recorded. or were rendered blurry and indistinct. The inability of the first processes to record colours was disappointing, but as the critics were conditioned to black-and-white prints and drawings. this was not so serious a drawback as the harshness of the tonal scale. The technique of photography was at once recognized as a short cut to art. No longer was it necessary to spend years in art school drawing from the cast and from life, mastering the laws of linear perspective and chiaroscuro. As Daguerre boasted in a broadside announcement. "with this technique. without any knowledge of chemistry or physics, one will be able to make in a few minutes the most detailed views. . . ." But formal art education had a purpose over and above the mastery of technique. The discipline taught the student to observe. and it gave him a feeling for the significant moments of time and an intuitive sense of composition. Using photography as a short cut to picturemaking was dangerous, because it often led to superficial results. lacking in the qualities that distinguish a work of art from an illustration.

D. O. Hill and R. Adamson. — In the hands of artists, photography quickly showed its artistic possibilities. David Octavius Hill, a Scottish painter. became interested in Fox Talbot's calotype process. In 1843 he mas commissioned to make a group portrait of the disruption meeting of the Scottish churches. There were hundreds of figures to be painted. and in order to simplify this enormous task. Hill turned to photography. He enlisted the aid of Robert Adamson, a pioneer photographer: and together they made hundreds of portraits. They did not confine themselves to the members of the church meeting. but included people from all walks of life. Posing their sitters out-of-doors, in strong sunlight and with exposures measured in minutes of time, it is hard to understand how Hill and Adamson managed to retain that spontaneity which is so essential to the success of a photographic portrait. They photographed the fishermen and their wives at Newhaven, Scot., posing them in groups reminiscent of paintings, and some of their landscape photographs show a startling affinity to watercolour drawings. The work of Hill and Adamson was forgotten after the 186os and almost unknown when it was rediscovered in the early 189os by J. Craig Annan, who made modern prints from the original paper negatives.

Daguerreotypes in the U.S.—By universal consent, the United States led the world in the production of daguerreotypes. It has been claimed that the first portraits made by photography were produced in the United States. By the late 1840s, photography was a big business. Every city of size had its "daguerreian artist." and ingenuity led to the use of machinery and production-line processing. The work of the Boston, Mass., firm of Albert Sands Southworth and Josiah J. Hawes rivalled in artistic quality the best work of Hill and Adamson. The special quality of these two Boston daguerreotypists was their perception of the individual. Instead of the stereotyped lighting and posing formulas of the average daguerreotypist. they showed the greatest variety. and they did not hesitate to present their sitters unprettified and "as they were." Chief Justice Lemuel Shaw stands with crumpled coat and unruly locks of hair under a glare of sunshine; John Quincy Adams sits in his own living room; Lola Montez lolls over the back of a chair.

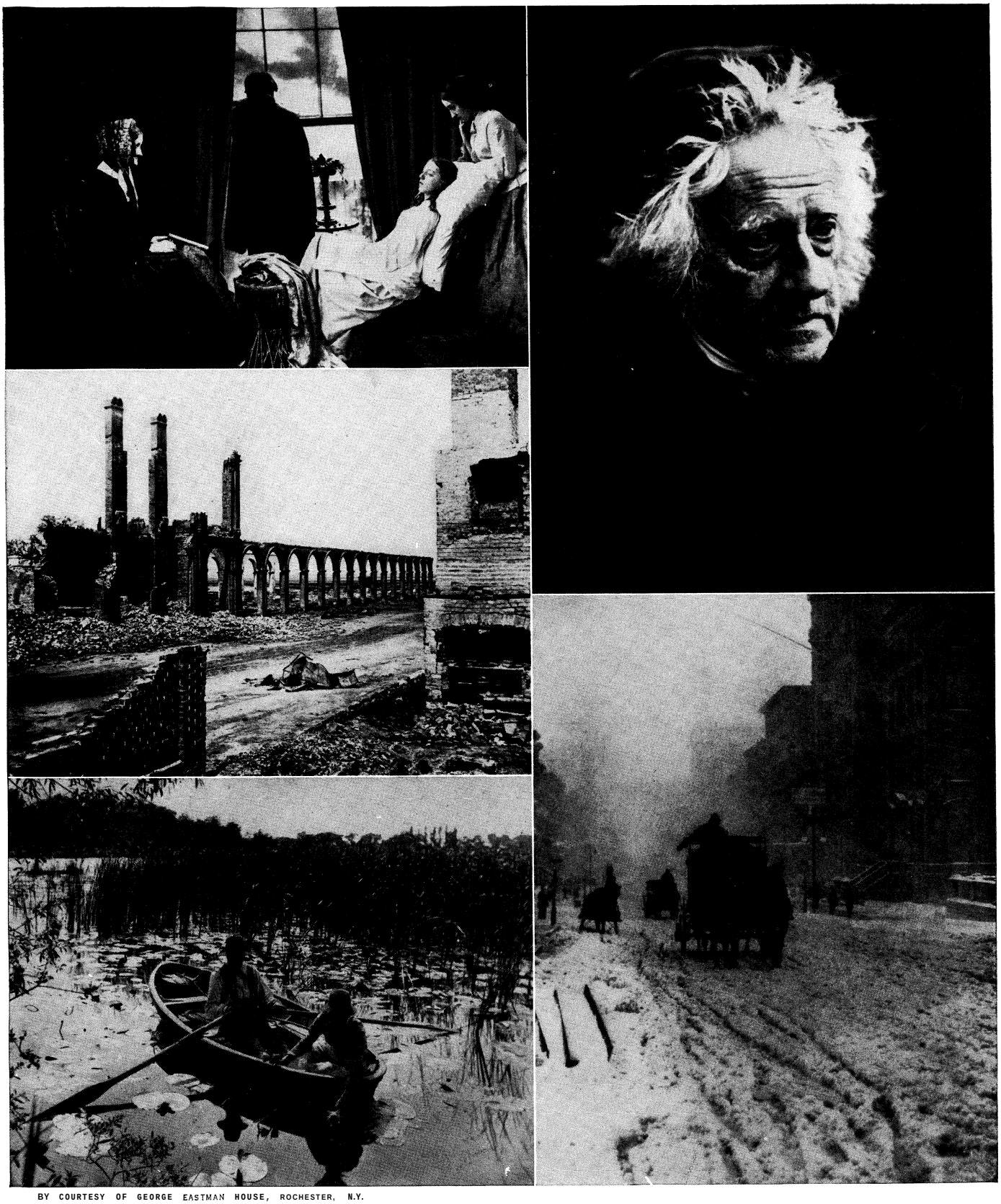
Formulation of an Aesthetic Theory. — In England the heyday of photography followed Scott Archer's invention of the wet collodion process in 1851. This new technique rapidly displaced and made obsolete the daguerreotype and calotype. Professionals had found the need of banding together; and the new process. which mas free from all patent restriction, attracted countless amateurs. Rallying points sprang up: in 1853 the Photographic society (renamed, in 189;. the Royal Photographic society) was formed in London; and in the next year the Société Française de Photographie was founded in Paris.

Up to this time there had been little conscious effort to impose artistic rules on the production of photographs. No particular distinction seems to have been made between photographs produced for an aesthetic intent and those made for documentary purposes. An exhibition of photographs. including examples of the work of Hill and Adamson, was shown at the Crystal Palace in London, 1851, in the section "Philosophical Instruments." In the preceding year Gustave Le Gray. a French professional. had sent eight photographs to a competitive art exhibition in Paris. They were accepted by the jury and catalogued as lithographs. When it became known that they were photographs, they were withdrawn by the organizing committee.

Photographic societies undertook to remedy this situation and began to examine the position of artistic photography in relation to scientific photography. At the first meeting of the Photographic society the president, Sir William Newton, who was a miniature painter by profession, read a paper "Upon Photography in an Artistic View" (*Journal of the Phot. Soc.*, i [1853]). His argument was that, except for scientific purposes. photography should depict natural objects "in accordance (as far as it is possible) with the acknowledged principles of Fine Art." One way in which the photographer could make his results "more like works of art," Sir William pointed out, was to throw the subject slightly out of focus. The extreme blue-sensitivity of wet collodion plates rendered the sky areas so dense that they appeared as blank paper on the print. To overcome this failure of the photographic process he recommended liberal retouching and free use of handwork on the negative.

Combination Printing. — An outcome of the urge to create photographs which would fit a priori concepts of art was the technique of making one print from several different negatives. The most iamous example was made by O. G. Rejlander, Swedish by birth, who had received an art education in Rome and was practising photography in England. It was a figure piece, 31 x 16 in. in size; printed from no fewer than 30 separate negatives. The picture was entitled "The Two Ways of Life." and showed, in allegory as obvious as it was sentimental, that the way of the blessed led through good works and the way of the damned through vice. The same models were used again and again. Rejlander, who described the technique in photographic journals, stated that his purpose was to show artists the possibilities of using photography, and for that reason chose a subject which enabled him to use nude models variously draped. The photograph was shown in the Manchester Art Treasures exhibition of 1857 and was purchased by Queen Victoria.

H. P. Robinson. — This technique stimulated Henry Peach Robinson! a professional photographer who had studied art as a young man. He became iamous with a five-negative combination print, "Fading Away," in 1858. The subject depicted a dying girl, and this was considered by critics as too painful a subject to be represented by art. .Perhaps the implied authenticity of photography bothered them, because painters had long presented subjects of far more painful nature. Robinson became a most articulate member of the Photographic society, and his teaching was even more influential than his photography. In 1869 appeared the



BY COURTESY OF GEORGE EASTMAN HOUSE, ROCHESTER, N.Y.

19TH CENTURY PHOTOGRAPHY

Top left: "Fading Away," by Henry Peach Robinson. Albumen print from three collodion negatives, **1858**

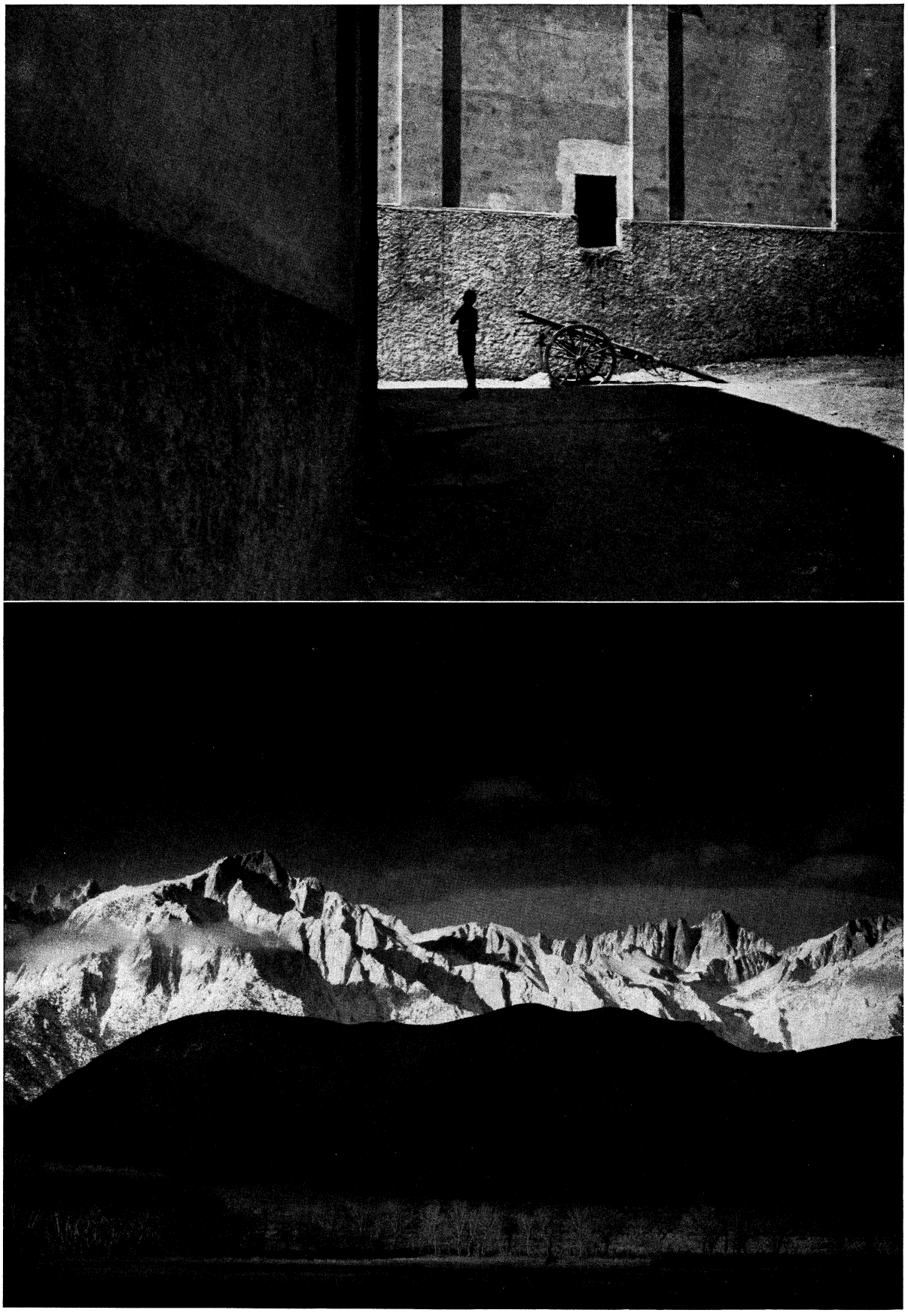
Top *right:* "Sir John Herschel," by Julia Margaret Cameron. Albumen print, **1867**

Centre left: "Ruins of the railroad depot, Charleston, S.C.," by George N. Barnard, cameraman of Mathew B. Brady. Wet plate negative, about **1864**

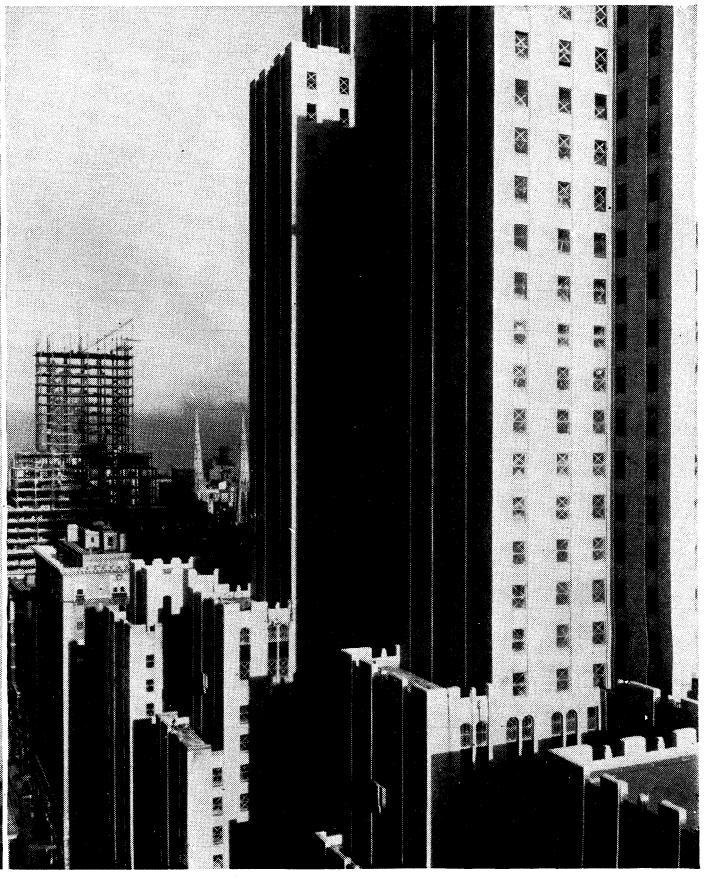
Bottom left: "Gathering Water Lilies," by Peter Henry Emerson. Platinum print, **1886**

Bottom right: "Winter on Fifth Avenue," by Alfred Stieglitz. Photogravure, **1893**

PHOTOGRAPHIC ART

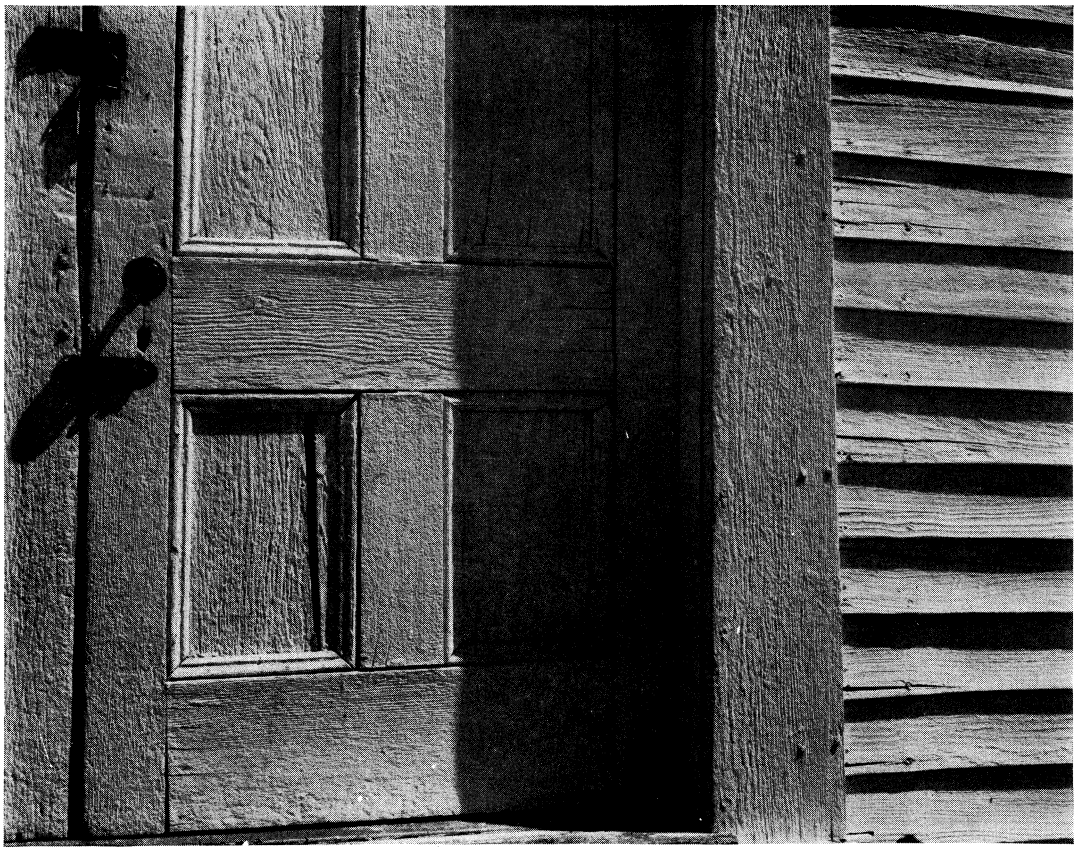


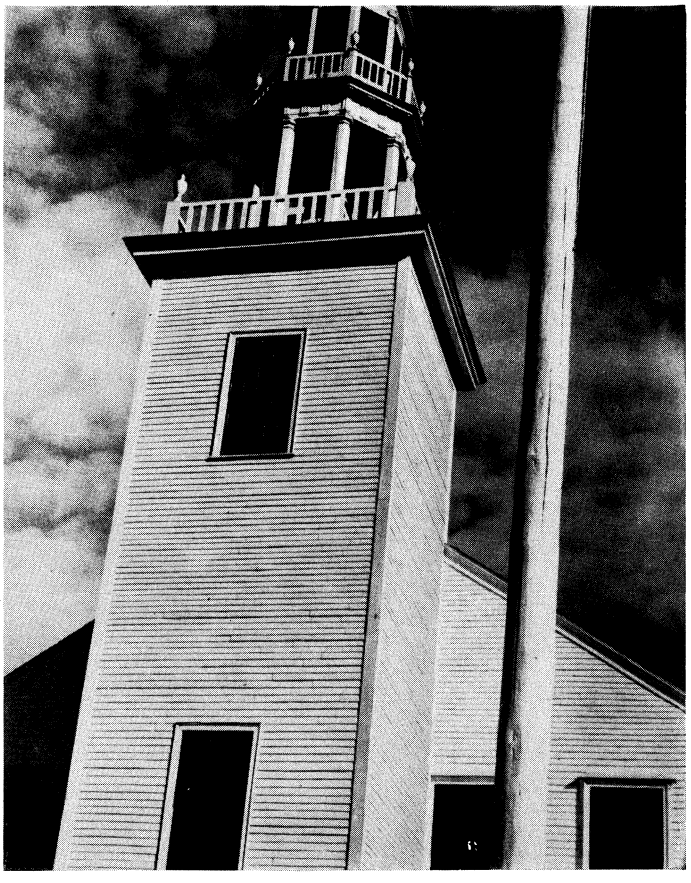
Top: "Intruder on Tiptoe," by Henri Cartier-Bresson
Bottom: "Sierra Nevada from Lone Pine. California," by Ansel Adams



Top: "Carl Sandburg," by Edward Steichen
Bottom left: " 'Celebration,' Martha Graham dancers," by Barbara Morgan
Bottom right: "New York City," by Alfred Stieglitz

PHOTOGRAPHIC ART





BY COURTESY OF (BOTTOM LEFT) "LIFE" MAGAZINE, COPYRIGHT BY TIME, INC

Top: **"Church. Hornitos, California," by Edward Weston**
Bottom left: **"The Thread Maker," by W. Eugene Smith**
Bottom right: **"New England church," by Paul Strand**

first of many editions and translations of his book, *Pictorial Effect in Photography*. Robinson went a step further than Newton; he offered photographers a set of rules. From a then outmoded handbook on painting, he borrowed compositional formulas the use of nhich, he claimed. would bring artistic success. The student was instructed to arrange his models in pyramidal compositions; and examples from the work of Sir David Wilkie, a popular painter of genre scenes, were given to show how this artist used the triangular form of composition. The importance of balance was stressed. and the opposition of light against dark was made clear. The fault of the book lay not only in the assumption that rules set up for one art form can be applied to another, but also in its intellectual and academic approach to art.

Robinson's work is, by modern standards of taste, weak and artificial. Not only did he practise combination printing. but he preferred to work in the studio, against painted backdrops and with props of natural objects, even foliage, mounted on casters. When he did photograph in the country, he took models with him, dressing them up to play the part of country girls, instead of turning to the genuine thing.

Mrs. Cameron. — Using. by accident or design, a lens of such poor quality that the image mas seldom sharp, Julia Margaret Cameron produced a remarkable series of portraits in 1864 and the following years. The success of these portraits, representing friends prominent in literary and artistic circles, cannot be laid to any technical trick, however because her genre studies, too obviously based on Pre-Raphaelite paintings, were weak and sentimental. The key to the success of the portraits lies in their intensity. "When I had these men before my camera," she related in her "Annals of My Glass House" (*Phot. J.*, lxvii, pp. 296–301 [1927]), "my whole soul has endeavoured to do its duty toward them in recording faithfully the greatness of the inner man as well as the features of the outer man. The photograph thus obtained has been almost the embodiment of a prayer."

Adam Salomon and Retouching. — An important influence came from France. The sculptor Adam Salomon introduced a new style of photographic portraiture. In place of the even and diffused lighting which was almost universal, he used a strong side light to give the so-called Rembrandt effect. He was a master of retouching. Arguments were frequent in the 1860s over the legitimacy of retouching, particularly of portraits. Some prints of Salomon were tested by the Edinburgh Photographic society in 1868 to ascertain "whether they were pure photographs or indebted to retouching for their beauty." It was found that they were retouched.

O. W. Holmes on Photography. — There was one form of photography in which retouching or any other form of handwork was virtually excluded, and that was stereographic work. The paired images which, when viewed properly, produce the most astonishing illusion of three dimensions, depend upon the most minute and exact differences in detail to render their startling effect, and this precision cannot be imitated manually. Love of stereographs led the C.S. physician and writer Oliver Wendell Holmes to write three articles in the *Atlantic Monthly* in which he put down the basis of a functional aesthetic which was almost diametrically opposed to what Newton had recommended in London. To Holmes the photograph had characteristics which no other art could rival. Far from regretting that the camera had not been used in accordance with the accepted rules of art, Holmes praised what appeared to some the defects of the process. "The very things which an artist would leave out, or render imperfectly, the photograph takes infinite care with, and so renders its illusions perfect. What is the picture of a drum without the marks on its head where the beating of the sticks has darkened the parchment?" (*Atlantic Monthly*, iii, p. 746 [1859]). "In a perfect photograph," he added, "there will be as many beauties lurking, unobserved, as there are flowers that blush unseen in forests and meadows." Holmes was but one voice against the many. The aesthetic value of straight photography was not generally recognized, and the work of those who recorded the battlefields of the Crimean and Civil Wars and who travelled throughout the world was overlooked by the aestheticians.

Naturalistic Photography. — The introduction of the dry plate in the 1880s attracted an increasing number of amateurs to photography. In comparison with the messy and awkward wet plates, even the uncertain dry emulsions were revolutionary. The photographer could buy ready-made plates and process them at his convenience. Soon he would be freed of his tripod.

Peter Henry Emerson felt the artificiality of the Robinson school, and he set against the latter's theories another viewpoint which he named naturalism, and which he described in his *Naturalistic Photography for Sfudents of the Art*, first published in 1889. He believed that photography was potentially a great creative art, and that it did not need to be bound down to rules set up for painting. "Naturalism," he wrote, "is an impersonal method of expression, a more or less correct reflection of nature wherein (1) truth of sentiment, (2) illusion of truth of appearance (so far as is possible) and (3) decoration are of first and supreme importance."

Emerson sought a scientific basis for pictorial photography. He analyzed the physiology of vision in order to find out how the camera can simulate human perception. He reasoned that since the eye sees distinctly only a small part of what lies before it, while the surrounding area appears indistinct, it should be possible to reproduce this phenomenon by control of focusing. Only a small part of the photograph should be sharp; the rest should be just slightly out of focus. Today we recognize that this theory of vision is fallacious, because the eye. unlike the lens of a camera, is a living organism, which scans the field of view constantly so that the mind receives a composite report and the impression of full detail. The naturalistic theory was an advance over Newton's. for Emerson believed that the photographer should rely entirely on controls which were themselves part of the photographic process. In addition to control through differential focusing, he advised the careful use of developing and printing methods.

Most especially, however, he took the camera out of the studio and into the fields and fens. He made several series of photographs of the strange amphibious life of the pheasants on the marshes, which were far removed from the artificial genre studies of Robinson. These he published in handsome folio volumes as original platinum prints or as superb photogravures.

In 1891 Emerson renounced his theory. He said that he had been led to take this step because the researches of F. Hurter and V. C. Driffield had proved to him that control could not be exercised by development. A great artist, he went on. had shown him that the mere reproduction or translation of nature was not art. Humbly he confessed that photography was not art and never could be. The fallacy of this argument lay, of course, in the definition of art. It appears that "art" and "painting" were almost synonymous to Emerson when he wrote his retraction. But he could not take back his words. Even the dramatic publication of a black-bordered pamphlet *The Death of Naturalistic Photography* was ineffectual.

The Linked Ring. — In his book Emerson had a good deal to say about photographic exhibitions. He felt that they were poorly organized. He recommended that photographs be framed in simple white moulding and that they be exhibited on one line in galleries, not plastered over the wall with the frames practically touching. And he felt that pictorial photographs should be isolated. instead of being lumped together nith work done for scientific, technical and other nonaesthetic purposes.

This issue caused a split in the Photographic society in 1892. A group of pictorially minded members. under the leadership of H. P. Robinson and George Davison, formed a society for the exclusive purpose of furthering "the development of the highest form of art of which photography is capable." (*Camera Notes*, 1901, p. 119, *The Camera Club of New York.*) The society was named the Linked Ring. They held annual exhibitions which they referred to as salons, a name borrowed from the painting world, and nhich demonstrated their artistic motivation. By 1901 it was their proud boast that "through the Salon the Linked Ring has clearly demonstrated that pictorial photography is able to stand alone and that it has a future quite apart from that which

is purely mechanical." *(Camera Notes,* 1901, p. 119, The Camera Club of New York.)

Stieglitz and the U.S. School.—In 1887 Emerson, judging a competition for the *Amateur Photographer,* awarded a prize to Alfred Stieglitz, a young American who was studying in Germany. It was the first award which Stieglitz had received; the first recognition of one nho was to carry pictorial photography to a high level, not only with his own work. but in his constant championship of all that has been progressive in photography and other forms of modern art.

When Stieglitz returned to the U.S. he found that photography was a fad, and that the New York Society of Amateur Photographers threatened to change their organization into a bicycling club. After serving as editor of the *American Amateur Photographer* for a number of years he organized a sympathetic group in the Camera club. New York city, and founded a handsome periodical. *Camera Notes,* nhich. devoted exclusively to pictorial photography. was outstanding for the unusually high quality of its illustrations. Stieglitz was one of the first to demonstrate the pictorial possibilities of the hand camera. He made photographs by night and under all conditions of weather. He showed that the lantern slide was a splendid form of pictorial presentation, and organized competitions, offering a prize cup to the Camera club.

In 1900 F. Holland Day brought to England a collection of the work of the new photographers who had emerged largely because of the guidance and the example of Stieglitz. The showing, although not fully representative, included the work of A. L. Coburn, Frank Eugene. Gertrude Kasebier, Edward Steichen and Clarence White. It was characterized by an emphasis upon aesthetic intent, by a variety of printing techniques and by subtle presentation. Day, addressing the Royal Photographic society, where the exhibition was held, referred to the exhibitors as the new school which "holds tenaciously that photography may be, if it is not yet, a fine art." (F. Holland Day, *The Photographic Journal* [Oct., 1900], Royal Photographic Society.)

The Photo-Secession.—Stieglitz and his friends, disturbed by the lack of standards and the general conduct of photographic exhibitions in the U.S.. formed in 1902 the Photo-Secession. They chose the word "secession" to show their split with the *status quo,* just as the German and Austrian painters had used the same word to make manifest their independence of officialdom. The record of the Photo-Secession is contained in the 50 issues of *Camera Work* which were published by Stieglitz between 1903 and 1917. The society had a gallery. known as "291" from the street number on Fifth avenue, New York city. where it was located. and there the group showed not only pictorial photographs. but other works of art as uell. *Camera Work* contains reviews of these exhibitions, photogravures and other reproductions of the highest quality. and stimulating essays.

The Photo-Secessionists were much concerned over the recognition of photography as a fine art. The independence of pictorial photography had been proved, but as yet little interest had been shown officially by art museums. In 1910 the group organized an exhibition of about 500 prints by leading pictorial photographers from all over the world in the Albright Art gallery, Buffalo, N.Y. The show created a sensation. Some of the exhibited prints were purchased by the gallery; for the first time photographs were admitted to an art museum on an equal footing with paintings and drawings.

Transition.— The last issues of *Camera Work* contained photographs by Paul Strand which showed a new approach. There were views looking down from unusual angles; there were bowls in quasi-abstract arrangement; there were striking unposed open-air portraits of a type which 20 years later were to be called candid. One of the first Photo-Secessionists, A. L. Coburn, made a series of photographs looking down irom a tall building, which he published as *New York From Its Pinnacles,* noteworthy for the way in which emphasis was thrown on form. He also made photographs devoid of subject matter. T'ortographs, which he contributed to *Photogranzs of the Year* in 1917.

There mas other evidence that new trends were coming to the surface at the close of World War **I.** Edward Steichen renounced both his painting and his prewar style of photography. which had been characterized by broad, simple effects often rendered by gum prints, a process nhich was readily adaptable to manipulation. He turned to a precise, clean-cut may of working, which he applied to illustration work. Charles Sheeler, a painter used the camera to record the stark beauty of Pennsylvania barns and the forms of industrial structures. Edward Weston gave up the soft-focus, often sentimental landscapes and figure pieces which had brought him fame and discovered the beauty of close-up details and isolated form, which he recorded in full detail and with brilliant contrasts. Alfred Stieglitz carried his work further; in 1924 he began the "Equivalents" series in which the ability of the camera to record nature gives may to its use as a creative instrument, capable of imparting the most intense emotional reactions. He found in the photographic series a ponerful means of expression A portrait, for example, consisted of many separate yet mutually related photographs.

Influence of Abstract Art.—In Europe. a similar revaluation of the photographic medium took place, largely under the influence of the Bauhaus, an experimental art school u-here much of the modern idiom of architecture and industrial design originated. A change in point of view led these experimenters to find out what they could learn irom photography, rather than be concerned about photography in relation to the other arts. They discovered that there was a photographic vision which in itself was aesthetically stimulating. Instead of deploring the distortions caused by the use of lenses of abnormally short or long focal length, they delighted in the new forms thus created. They tipped the camera up and pointed it donn. Around 1920 L. Moholy-Nagy, a painter residing in Germany, and Man Ray an American living in Paris, Fr., simultaneously and nithout knowledge of the other's work, made highly complex abstract compositions by placing objects directly on sensitized paper, which was then exposed to light. The objects not only left negative images of their profiles, but also, if they were translucent, gradations of light modulated by them. Aesthetically, these "photograms" or "rayographs" were the photographic equivalents of abstract paintings of the period; technically, they were revivals of Talbot's photogenic drawing process.

Later Photographic Art.—The experimental work of the 1920s served to break down the barriers of conservatism and to reveal that photography is an artistic medium with its own special characteristics. After 1930, two closely related trends became of increasing importance. On the one hand. there were those nho found the greatest challenge in using large cameras, from which to make contact prints, rich in detail and brilliant in tonal gradations. These photographers sought to produce prints which, like etchings or lithographs, would be of value as independent works of art, to be framed or kept in portfolios. On the other hand, there were those who wished to exploit to the utmost new technological developments in lenses, films and lighting equipment to capture the fleeting moment and to photograph things and places which could never before be recorded on film. These photographers tended to consider their prints only the means to the end of reproduction in books, magazines and newspapers.

The masters of the first group were largely American—Alfred Stieglitz, Paul Strand, Edward Weston and Ansel Adams. Their work was distinguished by an impeccable technique and by a rich pictorial imagination. They preferred in general to photograph by natural light, and they found their richest subject matter in the natural scene and architecture.

The miniature camera. which came to a state of perfection in 1932, found its greatest exponent in Henri Cartier-Bresson. This French photographer found that the poaerful lenses which can be used with this camera and the high-speed film made for it give him the opportunity to photograph "on the run" and to find compositions which exist for the briefest interval of time. To him the camera was "an extension of the eye," and his photographs—mostly of people—were characterized by their immediacy and by their unusual form. Light advances—the development of electric flash and the even more powerful electronic flash—gave the photographer yet another creative medium. Steichen pioneered in the use of electric light in his portraits of celebrities; Barbara Morgan

captured the very essence of the dance in her remarkable action photographs. Photographers who are primarily journalists, such as W. Eugene Smith, pushed their work beyond documentation.

Collections.—In comparison with the collecting of other forms of art. the building up of depositories of art photographs was noticeably sporadic. Both the Royal Photographic society in Great Britain and the Societé Française de Photographie in France have notable collections. In the United States the Smithsonian Institution, Washington, D.C.. was one of the first to build up a collection. It has a sizable representation of the work of the Photo-Secession. The most important collection of this influential group, however, is in the Metropolitan Museum of Art. New York city. The Museum of Modern Art. New York city. following the success of a large retrospective exhibition in 1937, formed a department of photography for the express purpose of collecting and exhibiting examples of artistic photography. The museum held important one-man shows, notably of D. O. Hill. Walker Evans, Paul Strand, Edward Weston and Henri Cartier-Bresson; illustrated monographs on these workers have been published. The National Gallery of Art. Washington. D.C.. acquired an extensive collection of Stieglitz photographs. The Brooklyn (N.Y.) museum also founded a department of photography, and in 1945 the Santa Barbara (Calif.) Museum of Art opened a gallery dedicated exclusively to photography. The George Eastman House in Rochester, N.Y.. has an important group of art photographs, and the holdings of the American Museum of Photography in Philadelphia, Pa.. include many art prints.

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TECHNIQUES OF PHOTOGRAPHIC ART

Anyone who has mastered a few simple instructions can make printable negatives with a pocket camera. Because it is impossible for the untrained beginner to achieve such acceptable results in any other medium. photography has sometimes been called the easy art. But to bridge the gulf between the taking of such casual snapshots and the production of photographs that can be classed as art is certainly no easy task. To the mastering of his tools and the perfecting of his technique, the photographer must devote just as much time and effort as does the musician or the painter. Since the nature of the photographic process determines the artist's approach, we must have some knowledge of the inherent characteristics of the medium in order to understand what constitutes the aesthetic basis of photographic art.

Photography must always deal with things—it can not record abstract ideas—but far from being restricted to copying nature, as many suppose, the photographer has ample facilities for presenting his subject in any manner he chooses. First, an infinite number of compositions can be achieved with a single stationary subject by varying the position of the camera. the camera angle or the focal length of the lens. Second. any or all values can be altered by change of light on the subject. or the use of a colour filter. Third, the registering of relative values in the negative can be controlled by length of exposure, kind of emulsion used and method of developing. And finally, the relative values in the negative can be further modified by allowing more or less light to affect certain parts of the image in printing. The photographer is restricted to representing objects of the real world, but in the manner of portraying those objects he has vast discretionary powers; he can depart from literal recording to whatever extent he chooses without resorting to any method of control that is not of a photographic (*i.e.*, optical or chemical) nature.

But the artist's use of these controlling powers must be conditioned by two factors: (1) the nature of his recording process and (2) the nature of his image. There is a frequent cause of mistaken understanding in the belief that the camera's image reproduces nature as the human eye sees it. On the contrary, its ability to record things as the unaided human eye can never see them is one of the most important attributes of photography. The human eye can focus on but one small area at a time: consequently, we observe an object or a scene only by letting our eyes rove over it in a series of short jumps. The assortment of images thus recorded are flashed to the brain which sorts and edits them, automatically discarding some as of no importance and emphasizing others. according to its individual conditioning. The impersonal camera eye makes no such distinctions; every detail within its field of vision can be recorded instantly and with great clarity. In the time the eye takes to report an impression of houses and a street the camera can record them completely. from their structure. spacing and relative sizes, to the grain of the mood. the mortar betneen the bricks, the dents in the pavement. The image that is thus registered has certain characteristics that at once distinguish it from the products of all other graphic processes. In its ability to register fine detail and in its ability to render an unbroken sequence of infinitely subtle gradations, the photograph cannot be equalled by any work of the human hand. For this reason any manual interference with the image at once destroys those very qualities that give the true photograph value as an art form. From these two facts we may draw an obvious' deduction: if the recording process is instantaneous and the nature of the image such that it cannot survive corrective handwork, then it is clear that the artist must be able to visualize his final result in advance. His finished print must be created in full before he makes his exposure, and the controlling powers enumerated above must be used. not as correctives. but as predetermined means of carrying out that original visualization. As in the mastery of any other graphic form. years of experience are necessary in photography before technical considerations can be made entirely subordinate to pictorial aims. The ability to prevision the finished print is the photographer's most important qualification and in order to attain it he must concentrate on learning to see in terms of his tools and processes. Having chosen the simplest possible equipment (so as not to complicate his task needlessly) he first learns by experiment the potentialities and limitations of each instrument and process. He must learn the field of his lens, the scale of his film and paper emulsions; he must learn to judge the strength and quality of light; he must learn to translate colours into their relative monochrome values and know how those values are affected by the use of different filters.

He must learn the kind of negative necessary to produce a given kind of print. and then learn what kind of exposure and development will produce that negative; then, having learned how those needs are fulfilled for one kind of print. he must discover how to vary the process to get other kinds of prints. Gradually. with experience. this knowledge becomes intuitive; the photographer sees a scene or object in terms of his finished print without having to think of these processes any more than a musician playing a piece thinks of the whereabouts of the next note he will sound or how much pressure he will use in sounding it.

The Print.—The value of the photograph as a work of art depends primarily on the photographer's seeing before exposure, but its artistic value can be determined only by an examination of the finished print.

Exposure records the photographer's seeing; developing and printing execute it; so no matter how fine the original vision, if it has not been faithfully carried out in subsequent procedures. the resulting print will suffer. The clarity of image and delicacy of gradation that characterize a fine photograph demand a special kind of surface for their best presentation. A rough surface destroys the integrity of the image; a smooth surface retains it. A shiny or reflecting surface enhances the beauty of image quality, while a dull or absorbing surface tends to obscure it.

For beautiful image quality. the best of the old daguerreotypes have never been equalled. The positives were made directly on the metal base and the small pictures were esteemed for their exquisite rendering of fine detail. The photo-painters, who did away with all things characteristically photographic, often used

papers of independently beautiful surface texture for their prints. The result of such a combination is that the paper competes with the image instead of becoming a part of it.

Among modern processes the nearest approach to the fine image quality of daguerreotypes is a waxed or glossy print. Unfortunately. glossy paper is still held in general disfavour among artist photographers. It is said to be harsh and cold and only suitable for commercial work.

These erroneous beliefs are partly a hangover from the heyday of photo-painting and partly a result of the difficulty of making good glossy prints. The glossy surface reveals the image with such clarity that minor blunders, which might escape detection on the more veiled, dull-surface papers, are at once exposed. However, the glossy surface has the advantage of a longer scale which makes it possible to reproduce more of the negative and allows a greater latitude in reproducing extremes of tone from the strongest to the most subtle and delicate. When a photographer speaks of the warm or cold tone of a print, he is usually referring to its colour—a cold blue-black as opposed to a warm green-black. But to use such variations of colour to emphasize the feeling of his picture is to misuse his medium. If he prints a snow scene blue-black so that it will look cold and a forest scene green-black so that it will appear warm, he is introducing a foreign element into his monochromatic process just as surely as if he coloured the print by hand. In black-and-white photography the effect of warmth or coldness should be communicated by the values in the print, whose colour should—at the extremes of the scale—be as nearly pure black and pure white as possible (use of obvious colour tone belongs in the province of colour photography). Obviously then, the longer scale of glossy paper gives greater opportunity of producing through the values in the print whatever effect is desired. And lastly, the luminous surface of the glossy paper, by making the image light-giving, comes nearer to rendering the effect of the original scene and so heightens the illusion of reality. A good glossy print reveals the delicacy of subtle gradation, the lucidity of tone and the brilliant clarity of image that are unique characteristics of the photographic process.

Subject Matter.—It is impossible to make any sharp distinction between the subject matter appropriate to one graphic medium and that more suitable to another. But in the case of photography we can at least draw a few general conclusions, based on an examination of the work of the past and our knowledge of the special properties of the medium. From the wet plate era we may draw two contrasting examples that serve to indicate a field of endeavour in which the photographer is least likely to be successful. On the one hand is the work of O. G. Rejlander and Henry Peach Robinson, two men who achieved prominence for their photographic work in England during the '50s and '60s. In their best-known pictures (Rejlander's Two Ways of *Life,* and Robinson's *Fading* **Away)** they attempted to depict allegorical and dramatic situations by combining a number of negatives of posed and costumed figures into composite prints. On the other hand is the work of Mathew Brady, Alexander Gardner and many anonymous photographers who documented the American Civil War. These men were bound by no artistic purpose; their sole aim was to record to the best of their ability every phase and aspect of the hostilities that their clumsy and limited equipment could encompass. Yet it is in these straightforward records that we perceive true photographic quality: here is the tremendous power and appeal of the camera's realism, the intensity of its vision undiluted; and these documents of the past still move us profoundly with their clear, objective picture of the horror and pathos of war. Beside these photographs the artistic efforts of Rejlander and Robinson appear self-conscious, stilted and artificial. Their carefully posed and costumed figures look absurd and unreal.

Now this comparison makes one fact apparent: the camera lens sees too clearly to be used successfully for recording the superficial aspects of a subject. It searches out the actor behind the make-up and exposes the contrived, the trivial, the artificial for what they really are.

But if the camera's innate honesty works any hardship on the photographer by limiting his subject matter in one direction, the loss is slight when weighed against the advantages it provides. For it is that quality that makes the camera expressly fitted for examining deeply into the meaning of things. The discriminating photographer can direct its penetrating vision so as to present his subject—whatever it may be—in terms of its basic reality. He can reveal the essence of what lies before his lens with such clear insight that the beholder will find the recreated image more real and comprehensible than the actual object.

The photograph isolates and perpetuates a moment of time: an important and revealing moment, or an unimportant and meaningless one, depending upon the photographer's understanding of his subject and mastery of his process. The lens does not reveal a subject significantly of its own accord. On the contrary, its vision is completely impartial and undiscriminating. It makes no distinction between important detail and meaningless detail Selection, emphasis and meaning must be provided by the photographer in his composition. Nowhere has the painter's influence had a more lasting hold on photography than in the field of composition. Photographers who have put to use every other resource of their medium still try to emulate the work of painters in this respect They consider composition as a thing apart, having no relation to a specific medium, but consisting of a set of tested rules and conventions that must not be contravened. To compose a subject well means no more than to see and present it in the strongest manner possible. The painter and the photographer will have two different ways of doing this because of the basic differences between their mediums. Its capacity for rendering fine detail and tone makes photography excel in recording form and texture. Its subtlety of gradation makes it admirably suited to recording qualities of light or shadow, and its ability to record sharply everything within the angle of lens vision from the immediate foreground to the distant horizon carries it far beyond the painter's province. The photographer cannot depend on rules deduced from finished work in another medium. He must learn to see things through his own eyes and his own camera; only then can he present his subject in a way that will transmit his feeling for it to others.

An intuitive knowledge of composition in terms of the capacities of his process enables the photographer to record his subject at the moment of deepest perception; to capture the fleeting instant when the light on a landscape, the form of a cloud, the gesture of a hand or the expression of a face momentarily presents a profound revelation of life.

The appeal to our emotions manifest in such a record is largely due to the quality of authenticity in the photograph. The spectator accepts its authority and, in viewing it, perforce believes that he would have seen that scene or object exactly so if he had been there. We know that the human eye is capable of no such feat, and furthermore that the photographer has not reproduced the scene exactly; quite possibly we would not even be able to identify the original scene from having seen the photograph. Yet it is this belief in the reality of the photograph that calls up a strong response in the spectator and enables him to participate directly in the artist's experience.

Conception and execution so nearly coincide in this direct medium that an artist with unlimited vision can produce a tremendous volume of work without sacrifice of quality. But the camera demands for its successful use a trained eye, a sure, disciplined technique, keen perception and swift creative judgment. The artist who would use his photographic powers to the full must have all these, plus the first requisite for the artist in any medium—something to say. (E. WN.)

PHOTOGRAPHY, the science and art of producing pictures by the action of light on chemically prepared (sensitized) materials (Gr. $\phi\omega s$, light, and $\gamma\rho\alpha\phi\epsilon\iota\nu$, to write).

The practice of photography depends upon the sensitiveness of silver compounds to light. When silver bromide, dispersed in a medium such as gelatin, is exposed to light, it undergoes a change as a result of which it becomes developable. When, after exposure, it is treated with a solution having reducing properties, termed a developer, the exposed bromide is reduced to metallic silver and forms an image corresponding to the intensity of light to which it was exposed. (See fig. 1.)

After development, the unexposed silver bromide is removed by a solvent which does not attack silver but dissolves the bromide, and the picture is then permanent and is said to be fixed. The picture thus obtained is a negative; that is, the light parts of the object are the blackest in the picture and the dark parts appear the brightest.

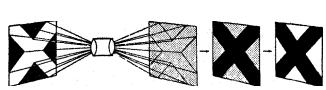

FIG. 1.—THE PRODUCTION OF A PHOTOGRAPH

In order to obtain a positive picture, in which the light and shade correspond to that of the original subject, the negative is printed. It is placed in contact with another piece of sensitive material which is exposed to light through the negative, and this gives in turn a positive image after development.

The operations required to produce a photograph are:

1. Preparation of the sensitive negative material.
2. Exposure in a camera.
3. Development; with the after processes, fixation, washing and drying.
4. Preparation of the sensitive positive material.

5. Printing.
6. Development, fixation, washing and drying of the print.

In the early days of photography all, of these operations were carried out by the photographer, but at the present time the sensitive materials. both negative and positive, are almost always made by manufacturing companies.

A wide variety of negative materials, cameras and printing processes are used in photographic operations. their selection depending upon the particular branch of photography under consideration. The chief branches are:

Amateur Photography, including both the casual taking of photographs for record or amusement and the serious pursuit of pictorial photography as an art.

Professional Photography, which may be subdivided into *Portraiture, Commercial Photography* and *Press Photography.*

Motion-Picture Photography (see MOTION PICTURES: *Motion-Picture Technology)* both professional and amateur.

Radiography, photography by means of X-rays, for medical, scientific and industrial purposes.

Applied Photography, including many uses of photography in connection with the arts and sciences, such as aerial photography, photomicrography, astronomical photography, medical photography, documentary photography, etc.

MATERIAL PHOTOGRAPHY

Negative materials are made by preparing a precipitate of silver bromide containing a small amount of silver iodide in a medium containing enough gelatin to enable it to be set to a jelly when cooled. This suspension is termed the *emulsion.* The melted emulsion is coated upon a support which may either consist of glass, in which case *plates* are produced or may be a flexible cellulose compound, in which case the product is termed *film.* After the emulsion is set by chilling and then dried, the material is cut to suitable sizes and packed in light-tight containers. Films are packed as sheet films, for use in holders similar to those used for glass plates, roll films protected mith paper in special cassettes to make them suitable for loading in daylight, film packs and as long rolls for use in taking motion pictures.

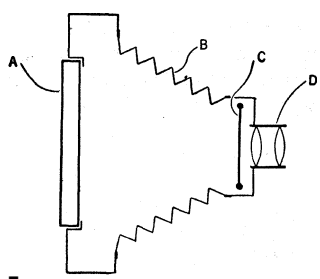

FIG. 2.—DIAGRAM OF A CAMERA

Cameras are of many varieties, the essentials being a *lens* (D) to form the image, a *shutter* (C) to regulate the duration of the exposure, a *material holder* (A) to carry sensitive plates or film and a *connecting shield* (B) to protect the sensitive material from light other than that which comes through the lens. This is generally extensible and then takes the form of a *bellows. (See* fig. 2.)

The cameras used for various purposes are discussed under the section *Apparatus.*

Positive matevials may be used for transparencies, in which case they are *lantern slides* on glass or *positive films* (especially for motion-picture photography). They are prepared in the same way as negative materials, the emulsion being modified to give the results desired. Usually, however, negatives are printed upon sensitized *paper.* Printing papers are generally coated with a sensitive emulsion prepared either with silver bromide, *bromide papers,* with silver chloride, giving *chloride papers,* or with a mixture of chloride and bromide to give *chlorobromide* papers.

Previously, most types of paper were prepared with an emulsion containing free soluble silver compounds and were printed under the negative in strong light until the image was visible—printing-*out papers.* No development was required with these papers, which are, however, almost obsolete now except for the preparation of *proofs* submitted by professional photographers to customers.

Many other varieties of printing processes are known and some are used to a large extent in the reproduction of drawings, *e.g.,* the blueprint, diazotype and Vandyke processes. Others use specially sensitized gelatin or other colloid layers containing pigments, *e.g.,* the carbon and Carbro processes, or to which pigments may be applied, *e.g.,* bromoil.

HISTORY

Photography was discovered by no one man. It was the outcome of the early observations of the alchemists and chemists on the action of light, a subject that belongs strictly to the domain of photochemistry (*q.v.*). Although the blackening of silver salts was known in 1565, it was not until 1727, when J. H. Schulze used a mixture of silver nitrate and chalk under stencilled letters, that it was definitely recognized that this darkening action was caused by light and not by heat. The experiments were also done by W. Lewis in 1763. These experiments were important in that, in conjunction with those of K. W. Scheele, 1777, they led to the experiments of T. Wedgwood with silver nitrate on paper and leather in 1802. It was also suggested that silver chloride was more sensitive These were practically failures because of the very long exposures required, and no means were kno n of removing the unaffected material and thus stabilizing or "fixing" the image against light.

Camera.—Leaving for the time being the question of the sensitive salts, we may turn to the evolution of the camera. This was the outcome of the old camera obscura, the invention of which is usually ascribed to Giovanni Battista della Porta. 1553, though its principle had been indefinitely described by Xlhazen, 1100, Roger Bacon. 1267, and others. Leonardo da Vinci, who died in 1519, described and pictured a camera obscura in an unpublished manuscript. In 1 jjo J. Cardan suggested the use of a speculum or concave mirror in front of the instrument, and D. Barbaro, 1568, proposed convex lenses and the use of a diaphragm to secure greater sharpness of the images. E. Danti, 1573, corrected the reversed image by means of a mirror behind the lens, a device still in use. F. Risner, who died in 1580, described in his works published in 1606 the methods of enlarging and reducing, and a portable box in lieu of the cumbrous fixed hut in use until then. Porta in his second edition, 1589, of which an English translation was published in 1658, was the first to introduce the use of the convex lens in the camera. Johann Kepler in his work on optical astronomy, 1604–11, described the use of a concave lens behind the convex to obtain larger images, and thus anticipated the telephoto lenses of the present day. In J. Zahn's book, 1665, there was described a portable camera obscura with two or three lenses, to secure greater brilliancy of the image, and side wings to shield it from extraneous light. At the beginning of the 18th century the portable camera obscura had become a regular article of commerce and was used to obtain sketches from nature. It was encouraged by the growth of amateur artists.

The Beginnings of Photography.—Toward the end of the 18th century there grew a demand for pictures. Wood engraving was revived and lithography was invented. A simple way of producing pictures was the silhouette, made by tracing the outline of a projected image of the face and filling it in with black. In 1786 G. L. Chrétien invented the physionotrace in which the projected image of a head was traced by a stylus, and by a pantograph arrangement an engraving tool cut a copper plate which could be inked and printed. A. Senefelder discovered lithography in 1796; but, though it was introduced in Paris in 1802, it was not until 1813 that it became a success and a fashionable hobby. From that date until 1817 J. Nicéphore Niepce was engaged in an examination of natural stones to find one suitable for the process. Since he was unable to draw, his son Isidore, undertook this work. and when the latter was called for military service. Niepce was impelled to produce the images automatically In conjunction with his brother Claude. Niepce first tried photography with silver chloride on paper. The light-sensitiveness of iron, manganese, acids and other compounds was tested. stone, metal and paper being used as supports. Finally, guaiacum resin was tried and then asphaltum. or bitumen of Judea, which had been in common use as an etching ground since the days of Rembrandt van Rijn. This, becoming insoluble in its usual solvents by the action of light, gave not only a resist for the etching of metal plates but also transparent images on glass A successful result was obtained in 1822, and thus it may be said that the first permanent photo-

graph was made in that year by Niepce. Prior to this, in 1816, Niepce had obtained a positive on paper, probably in silver chloride, which he could not fix.

Three years were required to perfect the process of heliography, as it was called, and in 1836 an etched metal plate was sent to G. Lemaître, of Paris, to be printed. In order that the pictures should be more distinct, they were exposed to the vapours of iodine. The high lights of the plates consisted of hardened bitumen; the shadows, of the bare metal; thus, the contrasts were very poor, which led to the use of tin instead of copper. Lemaître suggested silvering copper plates.

Daguerreotype. — In 1826 L. J. M. Daguerre, a painter who had experimented with silver salts, heard of Niepce's work and approached him to form a partnership. This was consummated in 1829. The work which Daguerre had done with Niepce had drawn their attention to the light-sensitiveness of silver iodide, and Daguerre discovered accidentally that the effect produced by exposing an iodized silver plate in a camera would result in an image if the plate were fumed with mercury vapour. The inventions of Niepce and of Daguerre were published to the world simultaneously by the French home minister in a bill presented to the house of deputies proposing a national reward to the inventors. A full description of their methods was presented by François Arago on Aug. 19, 1839, at a meeting of the Academy of Sciences.

The daguerreotype process was a complete success. In its operation, a silvered copper plate was buffed and burnished to a high polish. It was then iodized by fuming with iodine, and later (1840) resensitized with bromine and then exposed in a camera. At first, exposures of minutes in bright sunlight were necessary; but later, exposures were secured in a few seconds under favourable conditions. The development was effected by placing the exposed plate over a cup of mercury heated to about 75° C. The image was then fixed with a solution of thiosulphate of soda and toned by treatment with gold chloride. The results obtained were excellent when all the operations had been carried out correctly; and the process flourished, especially for portraiture, until it was superseded by the wet collodion process in 1851.

Calotype.—A preliminary notice of Daguerre's success was made by Arago on Jan. 7, 1839. This caused Fox Talbot, an Englishman, to claim priority in obtaining a picture in the camera, and rendering it permanent. Talbot began his experiments in 1834, using the camera obscura with silver chloride and common salt or potassium iodide as fixing agents. A communication was made to the Royal society on Jan. 31, 1839. But not until a month later did he disclose his working method, which then involved silver iodide with excess of the nitrate, and fixation with sodium thiosulphate. The solvent action of this for silver salts had been discovered by Sir J. W. F. Herschel in 1819. Talbot's process was called "calotype," and the image was developed with gallic acid, the action of which seems to have been discovered independently by the Rev. J. B. Reade.

The developed image on calotype paper was the exact reverse, as far as light and shade were concerned, of the original image. Such a picture was termed by Herschel in 1841 a "negative." The transparency of paper can be increased by waxing or oiling, and so Talbot was able to obtain true copies or positives of any negative by simple contact printing upon another piece of sensitized paper. Talbot's process is the first stage in the real line of photographic development, the inventions of Daguerre and Niepce being bypaths whose chief importance was the stimulus they gave to photographic evolution. The disadvantages of calotype were the somewhat long time required for printing and the structure of the paper.

Herschel suggested the use of glass plates and the deposition of silver chloride thereon. In 1848 Niepce de Saint-Victor suggested albumen as the vehicle for silver iodide. This process, called "Niepceotype," held its own until 1851, when Scott Archer, an English architect, published his wet collodion process.

Collodion Process. — To a solution of pyroxylin in ether and alcohol, Archer added a soluble iodide, usually with the addition of a little bromide, and coated a clean glass plate with it. In the darkroom, the iodized colodion was sensitized by immersion in a bath of silver nitrate and formed silver iodide with excess of silver nitrate. The plate was exposed wet in the camera, developed by pouring on a solution of pyrogallol containing acetic acid, and fixed with a strong solution of thiosulphate of soda for which cyanide of potassium was later substituted. Archer's collodion process was not patented, and in three or four years it displaced both calotype and daguerreotype.

The necessity for preparing the plates immediately before exposure and developing them immediately after considerably limited the practice of photography. J. Spiller and W. Crookes suggested bathing the prepared plates in a solution of a hygroscopic salt, so that they could be kept some time both before and after exposure. This was followed by the use of hygroscopic substances of all kinds.

Collodion Emulsion. — In 1864 B. J. Sayce and W. B. Bolton described the preparation of an emulsion of silver bromide in collodion. In 1874 Bolton washed the emulsion in bulk to remove the soluble salts formed in precipitating the silver bromide, and his methods are still followed.

Collodion emulsion was a practical advance on wet collodion, but it was no more sensitive. A considerable increase of sensitiveness was obtained when C. Russell introduced alkaline development in 1862, but the full fruit of this was reaped only with the introduction of gelatino-silver bromide dry plates.

Gelatin Emulsion. — In 1871 R. L. Maddox made an emulsion of silver bromide in essentially the same manner as that used for making collodion emulsions but he replaced collodion by gelatin. The matter was followed up by other experimenters, among whom may be mentioned J. Burgess and J. Kennett. Kennett placed on the market a dry, washed emulsion which photographers could dissolve in warm water and use as a coating on glass and thus produce their own plates.

A great amount of experimental work was at once commenced on gelatin emulsions, the records of which filled the photographic journals between 1873 and 1885. The by-product salts were removed by washing. Sir William Abney recommended the use of iodide in small quantity with the bromide and found that this made it possible to obtain faster emulsions with less fog. Digestion, or "ripening," as it was called, came into use — long digestion at low temperatures being suggested by C. Bennett — in 1878, and digestion with ammonia was used in 1876 by J. Johnson and in 1879 by D. B. van Monckhoven, who employed precipitation in ammoniacal solution as the basis of a process of manufacturing dry plates.

In 1877 the commercial plates of the Liverpool Dry Plate company, Wratten and Wainwright and B. J. Edwards were introduced; and by 1879 comparatively rapid dry plates were available on the market similar in type to the slower varieties of plates used today.

After this period, amateurs gradually ceased their researches, and mass manufacture became general. Considerable increases in sensitiveness were made between 1890 and 1900, and after 1930 improved emulsion-making techniques resulted in further advance in sensitivity without the undesirable qualities which previously accompanied attempts to increase speed.

It is interesting at this point to record the advance made in photography in terms of the relative sensitivity of the process.

Progress in Speed Represented by the Exposure Required to Give a Good Negative at f/11 in Sunlight	
Original daguerreotype, 1839	4,000 sec.
Bromized daguerreotype, 1840	80 "
Wet plates, 1864	8 "
Early dry plates, 1880	1/2 "
Dry plates of 1885	1/10 "
Dry plates of 1900	1/50 "
Dry plates of 1931	1/100 "
Modern fast film	1/500 "

Colour Sensitivity. — The silver halides are sensitive chiefly to the blue, violet and ultra-violet rays; hence, all other colours are reproduced as dark grays or blacks. In 1873 H. W. Vogel discov-

ered that the addition of certain dyes to the emulsion, or immersion of the coated plates in a solution of dye, increased the sensitiveness to the less refrangible colours.

Following this, J. Waterhouse found that eosin sensitized collodion emulsion, and shortly afterward J. Clayton and P. A. Tailfer found that eosin would sensitize gelatin emulsions. They obtained a patent for its use in England and France, and their plates were placed on the market under the name of "isochromatic" plates. In **1884** eosin was replaced by erythrosine, which was found by Joseph M. Eder to be a better sensitizer, and for 50 years erythrosine was used almost exclusively for the use of the so-called "isochromatic" or "orthochromatic" materials. In 1902 A. Miethe and A. Traube found that ethyl red, an isocyanine dye, gave strong colour sensitiveness as far as the orange of the spectrum, and in 1905 B. Homolka discovered Pinacyanol, a dye of structure somewhat similar to ethyl red but which sensitizes very powerfully throughout the red.

It was now possible to make "panchromatic" plates, which would photograph the entire spectrum without difficulty, and such plates were placed on the market in 1906.

The early dyes were largely of the cyanine and isocyanine types. In **1920** W. H. Mills and F. M. Hamer found Pinacyanol to be a carbocyanine dye. After that time there was great activity in the study of sensitizing dyes, resulting in the present great variety which permit high sensitivity in all parts of the visible spectrum and out into the infra-red. Most of the new dyes were found after 1929 in England, Germany and the United States, and the most important types are modifications of the carbocyanines and the merocyanines.

The first panchromatic film was made by the Eastman Kodak company in **1914,** but it was not generally used for motion-picture work until 1925. In 1931 a new super-sensitive type of panchromatic film was introduced. The progress in sensitizing dyes made possible the great advance in colour photography since about 1930 and the introduction of plates and films of high speed and low graininess.

Film.—The weight and fragility of the glass support led to attempts to replace it by lighter and flexible substitutes. In **1884** the roll film system of photography was developed by George Eastman and W. H. Walker, the emulsion being coated on paper, and a machine for continuously coating photographic paper in long rolls was patented by them in **1884.** The sensitized paper was loaded into a roll holder which could be attached to the back of a camera in the same position as a plateholder. At first, the paper was greased to reduce the printing time, but later a stripping film was used, this consisting of a temporary paper base coated with soluble gelatin, which in turn was coated with a gelatin emulsion.

This stripping film was used in the first portable roll film camera, the No. 1 Kodak, marketed in **1888.** The pictures were circular, about two and one-half inches in diameter. When the film was used up, the camera was returned to the manufacturing company, which developed and printed the pictures and reloaded the camera. This was the origin of modern photofinishing.

Eastman made experiments to produce a flexible film from collodion, but the ether-alcohol solutions would give only films which were too thin to be of practical use. Finally, the use of wood alcohol as a solvent for nitrocellulose was discovered, and a flexible film was marketed in rolls in **1889.** In the same year J. Carbutt introduced emulsion coated on sheets of plastic nitrocellulose cut from blocks. The new flexible Eastman film was applied at once by Thomas A. Edison to making motion pictures.

In **1891** daylight loading film was made. The film was wound on a wooden core inside a light-tight box and black cloth leaders were attached to the ends of the film. Later, the film was wound inside a protective sheet of black paper leaving sufficient overlength to permit loading of the camera without fogging the sensitive film. This was further modified in 1903, when a noncurling film was produced by coating the back of the film with plain gelatin.

In **1895** positive film was introduced for printing motion pictures, the film used previously being of the negative variety. In 1909 slow burning motion-picture film was first made by the substitution of cellulose acetate for cellulose nitrate as the plastic used in the preparation of the base.

A method of packing films, invented in 1903, was introduced on the market under the name of "film packs." These are now used mostly in cameras of the type originally designed for dry plates. They have the advantage of not requiring a special roll film back. Flat sheet films have taken the place of plates to a considerable extent, especially in professional photography.

In 1917 X-ray films coated on both sides with emulsion were introduced. Because of the transparency of the material to the X-rays, this enables double the density to be obtained.

In 1923 motion-picture film **16** mm. wide on cellulose acetate base was introduced packed in such a manner that it could be loaded into small motion-picture cameras without the use of a darkroom. This film was designed for finishing by a reversal process, in which the first negative is removed by a bleaching bath and a positive is then developed in the remaining silver bromide. In 1932 a similar film **8** mm. wide was introduced.

The use of these films led to a great advance in amateur cinematography.

Developing Agents.—In the calotype process gallic acid was used as the developer, but in 1851 H. V. Regnault of Paris and Justus Liebig simultaneously discovered the more energetic pyrogallol, which actually allowed shorter exposures to be given. This was used also at first for wet collodion, though it was later replaced by an iron salt, and for dry collodion plates. Until **1861** free silver nitrate was an important ingredient of developers; but in that year G. Wardley proved that pyrogallol alone could be used. C. Russell and J. Leahy independently announced alkaline pyrogallol development, the former suggesting also an alkaline bromide as restrainer. Even after the introduction of the gelatin plate, pyro-ammonia was the only developer used until **1884,** when the alkaline carbonates became general. In 1880 Abney discovered the developing properties of hydroquinone. C. Egli and Arnold Spiller recommended the use of hydroxylamine in 1884. In **1888** M. Andresen of Berlin patented the use of paraphenylene diamine, paratoluidine diamine and xylidene diamine as developers. In **1891** he patented the use of paraminophenol and its derivatives, especially monomethyl-paraminophenol, known under the trade name of metol.

Printing Processes.—The first printing process was with silver chloride and excess of silver nitrate on plain paper, which gave prints with a rather sunken appearance, the image being more or less buried in the fibres of the paper, and daylight was essential for printing. Louis-Désiré Blanquart-Evrard, in **1847,** suggested the use of albumen to keep the sensitive salt more on the surface. In the same year Romieu proposed salting with a mixture of alkaline bromides and chlorides containing gelatin and subsequent floating on silver nitrate solution. A few years later the first coat of albumen was coagulated and a second applied, which gave a more brilliant glossy surface. The colour of prints obtained on these papers was foxy, and to darken this an acid was added to the fixing bath, causing sulphur toning. G. Le Gray, in **1850,** proposed the use of a gold salt to improve the colour, and an alkaline gold bath was recommended by Waterhouse in 1858. E. De Caranza, 1856, recommended the use of platinum in lieu of gold. Albumenized paper made in this way and toned with gold remained the standard photographic printing medium until 1890.

A. Gaudin had suggested an emulsion of silver chloride in collodion for printing-out. This was revived by Wharton Simpson in **1865.** Paper thus prepared was introduced commercially by J. B. Obernetter three years later. Humbert de Molard, 185**j,** proposed to precipitate silver chloride, wash and suspend it in solution of starch or gelatin and paint the mixture onto paper. The same process was revived by W. H. Smith and J. E. Palmer in **1865** and by Abney in **1882.** From that date gelatinochloride or printing-out paper came into general use and eventually completely displaced albumen. Printing-out papers are little used now except for proofs.

Silver bromide with excess silver nitrate was used by Fox Talbot, and J. W. Swan in **1879** patented the use of paper coated with silver bromide emulsion not containing excess silver for

development. It did not, however, come into general use until marketed by Eastman and by E. Just in *1883.* J. M. Eder and G. Pizzighelli published, *1881,* an exhaustive paper on gelatinochloride of silver with development, and the former, two years later, described a chlorobromide emulsion. Chloride developing paper was introduced by A. Marion in England under the name of Alpha in 1889, and by Leo Baekeland in America as Velox. Since then the use of this paper has increased, special types, including a great variety of surfaces, being used for amateur and professional work. Modern papers are of the chloride type for contact printing, and of the bromide and chlorobromide types mainly for enlargements.

Nonsilver Printing Processes. — Robert Hunt was the first to utilize the light-sensitiveness of ferric oxalate in combination with a platinum salt in the hopes of obtaining images in that metal. But the process was a failure because he did not recognize that the ferrous salt, formed by the action of light, must form a complex salt in order to reduce the platinum salt to the metallic state. W. Willis in *1878* introduced the first workable platinum process. The advantage of this process is that the pictures are permanent. The high cost of platinum and the ease with which development papers are worked has resulted in disuse of the process.

Louis Vauquelin in *1798* had discovered the light-sensitiveness of silver chromate; G. I. Suckow in *1832* observed that the bichromates were reduced by light in the presence of organic matter. Mungo Ponton, *1839,* used paper treated with potassium bichromate. Edmond Becquerel, *1840,* and R. Hunt, *1843,* made improvements; but Fox Talbot first pointed out, 1852, that bichromated gelatin became insoluble in light, and this was patented as a resist for photogravure, for which it is still used.

P. Pretsch, Alphonse Poitevin, Testud de Beauregard, H. Garnier and A. Salmon and John Pouncy, *1859,* devised carbon processes, in which carbon itself in a finely divided state was used as the pigment in bichromated gelatin. But they failed to recognize the important point that, as the light acted first on the outer surface of the gelatin, those parts underlying the half tones and high lights would still be soluble; hence, on developing with warm water, they would have no anchorage to the support and would be washed away. J. W. Swan in *1864* patented the production of carbon or pigment prints by transfer of the exposed pigmented tissue to a temporary support, on which it was developed from the back. His process is in use today, and its long scale of gradation, the possibility of using pigments of any colour and the stability of the pictures are much in its favour, though the necessity of day- or arc-light for printing is against it.

T. Manly, 1905, patented a pigment process in which a developed silver print was squeegeed into contact with pigmented tissue saturated with potassium ferricyanide and bichromate. These salts migrated to the silver image, bleached it, and the reduction products wandered back to the tissue, rendering it insoluble in ratio to the amount of silver in the picture, as though the tissue had been exposed to light under the negative. A modification of this, known as Carbro, was introduced later.

In 1905 G. E. Rawlins reverted to an old process suggested by E. Mariot in *1866.* Gelatinized paper is sensitized with bichromate. dried, exposed under a negative, freed from excess salt and inked up with a greasy ink, which adheres only to the light-affected parts. Somewhat similar is the bromoil process first suggested in 1907 by E. J. Wall and worked out by Welborne Piper. This utilizes the principle stated by Howard Farmer in *1889* that finely divided silver imbedded in gelatin reacts with bichromates and renders the contiguous colloid insoluble. A bromide print is treated with a hardening and bleaching solution, fixed, washed and dried, then soaked in water and inked up with a greasy ink, which takes only on those parts where there was silver.

A number of printing processes have depended upon the light sensitivity of salts of iron. The most used is the blueprint process for copying drawings, introduced by Herschel in *1842.* Paper is sensitized with a mixture of potassium ferricyanide and ferric ammonium citrate. On exposure to light the latter is changed to the ferrous compound which, on wetting the paper, combines with the ferricyanide to form Prussian Blue. In the ferrogallic process the exposed iron salts are developed in gallic acid to give a positive image in dark ink. The ferrous salts formed by exposure to light of ferric compounds can reduce other metal salts to the metal. Platinotype depends essentially on this reaction, but in the argentotype (Herschel, *1842)* and kallitype *(1889)* and the more recent Vandyke processes, a silver image is formed by reduction of silver nitrate by the ferrous salt. In the ferrogelatin process (A. Tellkampf and *A.* Traube, 1905; also known as fotol, Ordoverax, fulgar) an unwashed blueprint is squeegeed in contact with a moist gelatin surface, then removed and the surface rolled up with greasy ink which gives a positive image which can be transferred to paper.

Light-sensitive organic compounds have formed the basis of many printing processes, the most used being the diazotype process for copying drawings (G. Kogel, 1917, *1920).* In it, paper is coated with diazo compounds which are destroyed on exposure to light, development being with a "coupler" which combines with the diazo compound not exposed to form a dye.

(C. E. K. M.: W. Cк.)

THE BRANCHES OF PHOTOGRAPHY

Amateur Photography. — In the 19th century, amateur photographers were responsible for many of the major advances, particularly in the days when the photographer had to make his own materials. Nowadays, however, the making of photographic materials is in the hands of manufacturers who can supply ready-to-use products in large quantities and of uniform quality. The amateur is now essentially a user and his opportunities for making basic advances are limited. He can and does, however, contribute much to advance practical techniques and pictorial qualities. The amateurs range from the millions who want personal photographic records with the minimum of effort, skill and expense, to the group to whom photography is an extremely serious matter, and who will spare no pains to achieve the technical quality and aesthetic effect they personally desire. (See *Pictorial Photography.)*

In general, however, photography did not become a popular amateur interest until the roll film camera was introduced in *1888.* It then became the means by which uninstructed amateurs could record scenes from their o n experience easily and faithfully. The first such cameras, to which George Eastman gave the name of Kodak, were preloaded at the factory with a roll of film sufficient for 100 pictures, each of which was round in shape and about 24 in. in diameter. After the roll was exposed. the loaded camera was returned to the factory, where the film was developed. With contact prints from all printable negatives and with a fresh loading of film, the camera was then returned to its owner.

The mass production of negatives and prints which this procedure involved constituted the beginning of the business of photofinishing, which was later developed by independent concerns all over the world. Some of the largest of these do immense volumes of work on a mail-order basis.

Almost from the start, amateur photography became extremely popular. Picturemaking came within the grasp and capacity of practically everyone. The necessary financial outlay was small, and the production of satisfactory pictures of personal interest required neither great skill nor intensive training. Before long, of course, strata developed within the great mass of camera users. Because of personal aptitude, perception and persistence, some individuals and groups took up photography in a serious way. They preferred to control the processes of development and printing; thus was formed the beginnings of the great body of advanced amateurs to whom photography is a consuming interest and an intense avocation.

Cameras and general photographic equipment for the amateur have evolved rapidly since the turn of the century. The simple, fixed-focus, fixed-exposure, roll film camera of the "box" type appeared in 1900. Thereafter, the box camera maintained its great popularity and has changed very little. It is basic; any attempt to equip it with faster shutters, faster lenses or adjustments of any complexity whatever have tended to cancel its fundamental usefulness and appeal. Various box-camera formats

have appeared, but the most popular is that which permits eight $2\frac{1}{4}$x$3\frac{1}{4}$-in. images per roll of film. Box cameras are made in metal, fibreboard and plastics. The lenses, of simple meniscus formulae, are generally about *f*/13 in relative aperture.

While the box camera remains an amateur photographic staple instrument, many other types of cameras have developed out of it. There are folding or snap-out cameras which afford box-camera simplicity of operation, yet attain greater compactness when not in use. Folding cameras are available in many varieties, some of which incorporate wide-aperture anastigmat lenses, shutters which can be adjusted for exposure ranging from "Time" to 1/500 sec. plus means for synchronization with flash lighting, accurate range finders and focusing adjustments and a host of small features of greater or lesser importance to suit the interests of the individual amateurs.

In the 1920s, the miniature camera appeared. Originally designed as a means of testing 35-mm. film made for professional motion-picture photography. the miniature camera soon assumed importance as a means of making small but excellent "still" negatives. Considerable precision was necessary to produce a clean, sharp, enlargeable image on an area about 1x1½ in. in size; this precision was implicit in the lens, in the adjustments for focusing, for exposure and for film movement. Lenses for the miniature camera were, as a rule, considerably faster than lenses for larger cameras; lens ratings of *f*/1.9, *f*/2 and *f*/3.5 are common among miniature cameras, whereas larger cameras are seldom equipped with lenses rated at faster than *f*/4.5.

Its fast lenses, highly sensitive films and inconspicuous size threatened, for a time, to characterize the miniature as primarily a candid camera, but it survived this threat as serious-minded amateurs appreciated the wide capability of miniature equipment. These amateurs soon constituted a large and influential group. They organized themselves, forming enthusiastic and articulate units. They required, and ultimately received, improved equipment of all kinds—finer cameras, specialized lenses and films, processing tanks and enlargers capable of producing clear and crisp enlargements of 10 or 20 diameter magnification.

In the late 1930s, reversal colour film became available. Again, as at the start of amateur photography, the processing was done by the film manufacturer, and without added cost. The colour transparencies thus made were mounted as 2x2-in. slides for projection, and many optical projectors were made available for use with them. They were also used for making several varieties of colour prints, some of which could be produced by the amateurs themselves.

Techniques developed for the miniature enthusiasts were ultimately reflected in refinements of equipment and processes for conventional-format photography. Mechanical and optical precision of high degree became characteristic of larger as well as smaller cameras. Films that once were primarily for the miniature cameras were made available in larger sizes; and fine-grain developers, often necessary in miniature work, came into general use.

Essential to the maintenance of photography as a popular amateur activity is the easy availability of film, and amateur roll film in standard sizes can be found in thousands of general merchandise shops as well as in those primarily concerned with photographic and optical goods.

Film for the box camera usually permits 8 or 12 exposures and is provided in a variety of types. For general outdoor pictures there is orthochromatic film; for work by artificial or low-level light there are fast panchromatic films; for pictures destined for considerable enlargement there are fine-grain films and there are negative and reversal colour films from which colour prints can be obtained.

While roll film is by far the most commonly used sensitive material among amateurs, many serious workers prefer sheet film (for which special film holders must be used) or film packs. Most of the types of film which are put up in rolls are also provided in sheets or packs, with a number of special types available in sheet film for the specialized requirements of many amateurs as well as professionals. Colour films are made in sheet and roll form.

The great majority of amateurs have their finishing (developing and printing) done for them by commercial photofinishers. Prints by contact are made on the so-called contact printing papers on special printers, while enlargements are made on bromide paper, in a variety of equipment.

For the amateurs who do their o n developing and printing, there is a wide range of simple and inexpensive apparatus; and chemicals are put up in packaged form to eliminate the need for measuring out quantities. Papers are provided in a great variety of surface and contrast either for enlarging or contact printing.

With the introduction of the sensitive panchromatic films, especially following 1931, it became possible for the amateur to take photographs indoors with simple artificial lighting equipment. This was aided considerably by the introduction of the overvolted Photoflood types of lamps and simple stands and reflectors, and later by the flash bulbs and synchronizers which could be attached to amateur cameras. Nowadays many amateur cameras are provided with flash attachments or at least with special shutters having electrical contacts which permit their use with flash bulbs. Colour films are made to give good quality photographs with artificial lighting. (See *Apparatus.*)

Estimates of the number of amateur cameras in more or less active use at any given time cannot be accurate; obviously they run into many millions.

However, the steady increase in the number of camera clubs and public participation in them, colour transparency clubs, exhibitions and salons is ample evidence of a great and increasing interest in photography as a hobby, as an avocation and as a means of recording individual and family histories.

Professional Photography. — From the era of the daguerreotypes—the 1840s and early 1850s—down through the collodion and dry plate eras to the first or second decade of the 20th century, the professional photographer mas almost invariably a portrait photographer. Indeed, photography was popularly accepted as primarily a means to personal portraits.

This was, in part, because of the rise of the bourgeoisie and the eager assumption—on a cheapened or mechanized basis—of those things which had formerly been limited to the aristocracy. Before photography, few but the wealthy could afford to have a good portrait made.

The photographic portrait establishments attempted to maintain something of the grand style. Furnishings and decoration were lavish, and the backgrounds against which patrons were posed were elaborate counterfeits of grandeur.

Because the common use of electricity came only in the 20th century, most early portrait studios used daylight, provided by large banks of windows facing north, or away from direct rays of the sun. By the ingenious use of reflectors, diffuse light was used with considerable effect, but the intensity was relatively low. This fact, coupled with the slowness of the photographic plates then available, necessitated long exposures. To assure the rigidity of the sitter during exposure a head clamp was commonly used; such a device tended inevitably also to induce rigid facial expressions. However, because naturalness and informality were almost foreign to the manners of the late 19th century, portrait photographers flourished and few respectable homes were without their albums in which portraits of the caste de *visite* size (2x3 in.) were elaborately presented, along with some of the larger "Cabinet" size (about 3x5 in.). By the 1860s, portrait photography had become so popular that cameras taking several portraits on one plate were used in order to speed up taking and developing.

In the United States particularly, the vogue of portrait photography was immense. "Artists of the lens" were established in every town, and itinerant portrait photographers toured the fringes of the frontier. The camera was invariably a bulky mechanism mounted on a heavy stand which was sometimes carved to comply with the standards of contemporary elegance. From beneath a black focusing cloth, at the back of the camera, the photographer watched the ground glass image of his sitter, suggesting, cajoling, pleading for a pleasant expression.

Early in the 20th century, public taste turned from the formality and the artificiality of conventional portraiture. Thanks to

the constant improvement in plates and to the growing use of artificial light. it became possible to make studio portraits with the sitter far more nearly at ease. Exposures were shortened. the head clamp disappeared and the rococo motif in furnishings and backgrounds gave way to simplicity, with all the interest falling on the sitter.

Modern professional portraiture is done almost exclusively on sheet film of the orthochromatic or panchromatic variety, one or the other being used according to the nature of the sitter. The negative sizes tend to be smaller than in earlier years, and modern types of long focus lens and modern shutters are used. The lighting is almost exclusively artificial, largely by tungsten filament electric lamps in special reflectors or as spotlights. Some fluorescent lighting is used for general lighting, and there is a growing use of the flash bulb.

Proofs of portraits are usually provided the sitter, and they are made on print-out paper or special slow types of enlarging paper. Contact and enlarging papers are made for portraits, frequently giving somewhat warmer tones.

Mass production methods have been introduced into portraiture, especially in automatic or semiautomatic "studios," and in coin-operated machines. The best portrait quality is, however, attained by the photographers who undertake each appointment seriously and carefully apply their time and skill to making good studies of the subjects. In recent years, colour photography has been introduced into portraiture.

Commercial Photography. — Photography is used very widely for commercial illustration and advertising, for technical illustration and for a wide variety of special purposes. When the photographs are made by professional photographers on a commercial basis, the subject is called commercial photography and it is a very important branch of photography. The photographers are usually highly skilled in the art of lighting and the use of special techniques, particularly as advertising agencies demand much in the way of unusual subjects and dramatic effects. There is some tendency to specialization in commercial photography, one man doing primarily fashion photography with live models, another still photography of food subjects, another sporting events and so on.

The apparatus of the commercial photographer is varied and flexible, to suit the wide range of subject matter. The studios are arranged so that all kinds of sets can be constructed, and many of the photographers are equipped with portable lighting equipment, even portable generators, so that they can make photographs on location.

Sheet film is generally used, but some photographers use roll film in miniature or twin lens reflex cameras. The prints are generally of such a quality that they can be used for reproduction by the graphic arts processes.

Colour photography is much used by commercial photographers. For still subjects, colour separation negatives may be made in succession through three separate filters, or in three-colour, one-exposure cameras, where the three negatives are exposed simultaneously. Living subjects are also photographed in these cameras. The integral tripack or monopack sheet colour films came rapidly into use for all work. (See *Colour Photography.*)

(W. B. BT.)

Press Photography. — Wood engravings were the earliest practical means of disseminating picture news. Economical to produce in comparison with engravings on copper, steel etchings, etc., the wood engraving could also be printed with type matter—a decided advantage. They are found in the ancient ballad sheets and broadsides, which, like the modern newspaper, had their origins in "tragedy and violence." National calamities, floods, storms and significant battles brought forth illustrated tracts and, with the beginning of regular newspapers, crude wood engravings for the press.

The modern illustrated press can trace its origin to the year 1842 and the founding of the *Illustrated London News*. The Mexican, Civil and border wars stimulated magazine and newspaper illustration in the United States. F. Gleason's *Pictorial Drawing-Room Companion,* patterned after the *Illustrated London News,* was established in Boston, Mass., in 1851, and lasted until 1859. P. T. Barnum and H. D. Beach started the *New York Illustrated News* Jan. 1, 1853, and sold it to Gleason a year later. Some of the most notable work produced in the United States during that period is to be found in *Frank Leslie's Illustrated Newspaper* and in *Harper's Weekly*. Leslie's publication began Dec. 1 j, 1855, and *Harper's Weekly* Jan. *3,* 1857.

Although the camera came into commercial use on both sides of the Atlantic about 1840, it received little recognition by the press until a number of years later. In spite of his great photographic coverage of the American Civil War, Mathew Brady was credited with but few of the pictures which appeared in the illustrated publications of his day, although his photographs must have served as "copy" for many illustrations. *Harper's, Leslie's* and the *Southern Illustrated* (published in Richmond, Va.) all had their sketch artists, among them Al Waud and Winslow Homer. Sketches drawn in the field were redrawn on wood blocks and carved by hand. Even with the advent of "photography on wood," which preserved the original work of the artist, the process was slow when judged by later standards. Line cuts, zincographs and chalk plates had been used before 1900, but few halftones — which would reproduce the tonal range of a photograph — had appeared.

The first halftone direct from nature, the now famous "Shantytown" reproduction credited to Stephen H. Horgan, appeared March 4, 1880, in the *New York Daily Graphic.* The halftone screen consisted of a set of parallel lines, rather than the cross-screen developed later by Frederic Eugene Ives and others and perfected by the Levy brothers.

The halftone process, although not in universal use at the time, did help to give visual reportage to the Spanish-American War. Jimmy Hare, for *Colliers Weekly,* and J. C. Hemment, for William Randolph Hearst, were among the combat photographers in 1898.

Sketch artists (among them Frederic Remington) also served in Cuba.

Although photo reportage was greatly stimulated by the Spanish-American War, it unfortunately was typed as a tool of the "yellow press." Conservative publishers looked upon it as an interloper —a sensational device used by Joseph Pulitzer and Hearst in their circulation war.

The reputation of press photography was further damaged in the 1920s when the *Daily Graphic, Daily Mirror* and *Daily News* staged a three-way battle for readership in New York. playing up the Hall-Mills and Snyder-Gray murder cases, the "Daddy" Browning-"Peaches" episode. etc. It brought forth use of the "composograph," a form of photographic fakery.

Another, but less violent, period came in the 1930s with the advent in the United States of the miniature camera and the candid camera craze. In the hands of such men as Eric Salomon, the miniature was a sensitive and valuable instrument. Many, however, imbued with the new power which the fast lens imparted, went beyond good taste in the snatching of unposed and unflattering pictures.

World War I was a stimulant to the illustrated press. With an increased interest in foreign lands, the reading public wanted to see pictures of the battlefields and armies in action. Thanks to more versatile and less cumbersome photographic equipment, improved lenses and sensitive material, the best photo documentation to date was possible. Visual education — movies and pictures as a training device for soldiers — and photographic propaganda for soldier and civilian consumption came into prominence. The work of the combat photographer became more involved, however, as war techniques increased in complexity. Not able to operate without restrictions as he had done in the Spanish-American War and the Russo-Japanese conflict, the aging Jimmy Hare gave way to younger men.

Photo Syndicates. — With the realization that pictures are news came a general demand for news-picture syndicates. Bain's and the American Press had made previous attempts at syndicated picture coverage and were followed in the 1920s by the *New York Times* Wide World, Hearst's International News Photos and Scripps Howard's Ne spaper Enterprise association (later Acme;

Acme Newspictures was sold Jan. 1, 1952, to the United Press), the Pacific and Atlantic (P and A), owned by the *Chicago Tribune* and the *New York Daily News*.

The Associated Press began its picture service in 1926. On Jan. 1, 1935, the Associated Press Wirephoto 10,000-mi. network was inaugurated. All major syndicates acquired photo networks.

The syndicates, in addition to radio and mire transmission, dispatch photographic prints and mats made from master engravings to publications not equipped to handle telephoto, wirephoto, etc. Larger papers utilize the mat services, too, for feature pictures and "time" copy, keeping the faster wire network for more urgent news breaks.

Pictures naturally fall into various classifications: spot news, feature, sports, picture stories (picture sets and picture sequences) and colour. Newspaper staff photographers provide the greatest number, with syndicates coming second.

Free-lance workers, or "stringers," also shoot a considerable number. on assignment and on speculation.

Other sources of pictures in the news include studios, amateurs and publicity bureaus. Local and national government bureaus and industrial organizations spend huge sums each year for pictures nhich are sent gratuitously to publishers.

Magazines in the decade 1920–30 greatly influenced newspaper illustrative trends. In Europe, and especially in Germany, a new publishing technique—the picture weekly with fast miniature camera illustrations—had come into being.

The picture publications, offspring of the new streamlined journalism which followed World War I and advancements in photography, were popular from the start.

Later, with the rise of Adolf Hitler, many German picture specialists went to England and the United States, where their influence was profound. *Picture Post*, London, one of the most successful of British picture magazines, was a result of this exodus. Among those from Europe who exerted a great influence in photojournalism in the United States were Kurt Safranski, Eric Salomon, Alfred Eisenstaedt, Eric Schaal and others.

Significant developments in U.S. photojournalism were: sale of the first flash bulb in the U.S. (1930); invention of the electronic light (1931); establishment of the AP Wirephoto network (1935); establishment of *Life* magazine (1936) and *Look* magazine (1937). Even before *Life*, the Cowles brothers had carried on extensive surveys in picture usage. The *Des Moines Register-Tribune* and other Cowles publications were pioneers in photojournalism. Many examples of photojournalism had appeared before *Life*—*the New York Times Mid-Week Pictorial, Roto, Panorama* and others—but it was not until *Life* appeared that a U.S. magazine based on photo reportage became entirely successful. *Look*, in Jan. 1937, and a host of others such as *Click, Pic, Focus*, etc. quickly followed.

The *New York Times* established the first Sunday rotogravure supplement in the U.S. in 1914. By 1930 the number had reached 80, but it dropped to 65 in 1940. Only ten newspapers produced their own supplements. The others had the work done by commercial gravure plants.

The earlier rotogravure sections were poorly designed and from many points of view inadequate. Profiting from the picture magazines, rotogravure supplements eventually became functional, enlightening and inviting. With a balanced offering of black-and-white and colour reproductions the roto sections became in effect small picture magazines tuned to local and world happenings.

Many editors considered the large picture magazines their strongest competition. This belief undoubtedly influenced the great circulation of such "inserts" as *Parade* and *This Week*.

Opposition to the newspicture weeklies helped bring about formation of the Metropolitan Group, the National Newspaper Network, an alliance of rotogravure papers throughout the nation. One of the purposes was to permit the group to bid on a more even footing for the services of top-flight free-lance cameramen—something they could not justifiably do as individual publications.

Sociological Aspects.—Photojournalists learned that pictures can document and report the happenings of the day. They also can and do editorialize.

"The backbone of photo-journalism," said Frank Luther Mott, "is 'the recording of fires, wrecks, tragedies." Yet, he adds: "The camera has a devastating effectiveness in portraying evils. It is the best crusader of our times. Think of any abuse—social, economic, political—and sound and honest pictures which will bring the evils to our eyes suggest themselves immediately."

Among the first to use pictures as an editorial influence was Jacob Riis, a great police reporter, who in 1888 used his camera to help bring about social reform in New York slum areas. Line drawings from his famous photographs appeared in newspapers, magazines and books *(How the Other Half Lives*, etc.). Lewis Hine's pictures of the Pennsylvania coal miners in the early 1900s, and his work which graphically portrayed the evils of child labour, became classics of their kind.

A later example was the work emanating from the Farm Security administration under the direction of Roy E. Stryker in the 1930s. Stryker's photographers—Walker Evans, Arnold Rothstein. Dorothy Lange, Russell W. Lee, Edward Rosskam and others (nucleus for the so-called documentary school)—photographed depression bread lines and the dust bowl with all their qualms and heartbreaks. Several FSA photographers as free-lancers or regular staff members were employed by the newly born photo publications. Their keen perception and austere style greatly influenced photojournalism.

Still other examples of "camera crusades" were those for slum clearance by the *St. Louis Post-Dispatch* (Mo.) and the campaigns against "Skid Row" in Detroit, Mich., and Chicago, Ill., by the Knight newspapers.

Press photography was advanced in the United States by the formation of two important organizations—the National Press Photographers association, founded at Atlantic City, N.J., in 1946, and the American Society of Magazine Photographers. Another factor contributing to the advancement of U.S. photojournalism was recognition by universities and accredited journalism schools, which introduced courses of training in the field. Regional short courses throughout the nation, such as those sponsored by the National Press Photographers association and the *Encyclopædia Britannica*, and the annual Photo Workshop conducted by the University of Missouri school of journalism also aided. Yearly photo competitions were also credited with furthering the cause of photojournalism.

World War II and After.—Wars and rumours of wars had long acted as stimulants to the publishing industry. Between World Wars I and II, photojournalism had gained in favour, and many significant developments had been made. The photo news magazines were accepted, flash bulbs and electronic tubes were invented. colour work had improved, wire and radio transmission of photographs became commonplace.

The reading public had learned to rely to a great extent upon visual presentation of the news. It was during this period that the picture magazines attained huge circulation figures, and the *Daily News*, "New York's Picture Newspaper," founded in 1919, became the largest daily in the country.

When World War II broke out, the stage was set for the greatest use of photojournalism the world had known. Press syndicates, newsreel companies, magazines and newspapers promised a coverage which would have been impossible at any previous date.

To assure an equitable photographic coverage of the far-flung battle fronts of World War II the U.S. photographic pool was organized in 1942. Principal participants in this enterprise were the Associated Press, Acme Newspictures, International News Photos, *Life* and the U.S. army and navy.

The combat photographer, whether a member of the pool or of the Allied services, served with distinction. Longer focal length lenses, high-speed equipment, sequence cameras and many other developments made it possible to photograph the war in all its phases.

At the war's end, many publications which had ceased to exist because of the manpower and material shortage were reactivated. During the postwar period a number of small daily and weekly publications installed photographic and photoengraving equipment. Some turned to the photoelectric engraver, while still

others installed photo-offset (lithography). (C. C. E.)

SCIENTIFIC AND APPLIED PHOTOGRAPHY

The advantages of photography for scientific and technical recording are that it can record visible images in black-and-white or colour; it can record radiations which are of wave length invisible to the eye; it can integrate faint radiation and build up a record which can be seen, whereas the eye does not possess this property; it can be used to measure the intensity of radiation and it can give glimpses of actions which are too fast to be studied in detail by the eye. Moreover, it gives a reasonably permanent record which can be studied at leisure, or filed for future reference.

Photomicrography. — Photography through the microscope is very important in biology, metallography and petrography. Apparatus for photomicrography consists essentially of a camera arranged at the eyepiece end of the microscope so that the image is focused on a film or plate. Photomicrographs are made by transmitted or reflected light. Low-power photomicrographs can be made with single short-focus lenses, while for the highest magnifications high-aperture objectives and high-magnification eyepieces are employed. Special supports are used for the apparatus, to ensure freedom from vibration and ease of centring the optical system.

In the case of stained specimens, such as biological sections or bacteria, maximum contrast is obtained in the photograph by using light filters which transmit light of the colour complimentary to that of the stain. If maximum detail rendering is required, the filter is selected to transmit light of the colour of the stain. The resolving power of a lens is higher, the shorter the wave length; and, therefore, the ultra-violet is frequently used to give the maximum rendering of detail. The infra-red is sometimes used because certain materials which are dense or opaque to visible light are transparent to the infra-red. Polarized light is frequently used in the photomicrography of rock sections and etched metal specimens. Colour photography is also important, especially when used in metallography, polarized light photomicrography and photography of stained sections. Many high-magnification motion pictures have been made by using a motion-picture camera in conjunction with the microscope.

Spectrography.—The bulk of spectroscopic observation is done by attaching a camera to the spectroscope and photographing the spectrum. The visual spectrum can be photographed on panchromatic materials. and the near ultra-violet on ordinary blue sensitive plates or films. For wave lengths shorter than 2,800A the absorption by the gelatin of the emulsion is too strong to permit photographs to be made, and in this region spectrography is done by coating the normal plate with a thin layer of material which fluoresces in the short wave length ultra-violet, the fluorescent light being used to make the photograph. In the Schumann method the emulsion has practically all of its gelatin removed. For the infra-red, emulsions containing special infra-red sensitizing dyes are used and photographic records have been obtained to beyond 12,000A. Plates are available having especially high sensitivity in rather narrow wave-length bands spaced all through the visible and near infra-red.

In spectrographic analysis, photographs of spectra are used to detect the presence of elements and to obtain an estimate of the proportions in which they are present. The analyses, qualitative and quantitative, are based upon measurements of the positions and relative intensities of the spectral lines. The method is particularly useful for identifying materials and for determining very small percentages which might be missed entirely or measured inaccurately by the normal chemical methods.

The spectrograph has been particularly useful in astronomy since it provides the only means of determining the composition of the celestial bodies. (See *Astronomical Photography*, below.)

Infra-Red Photography. — Films and plates can be sensitized to the invisible near infra-red to permit photography in that region. The optical properties of many materials in the infra-red are quite different from those in the visible region of the spectrum. Atmospheric haze is more readily penetrated by the infra-red than visible light, which tends to be scattered, and infra-red photography thus permits haze penetration over long distances and from high altitudes. Chlorophyll is transparent to infra-red and foliage appears white in infra-red photographs. Many green paints which match foliage in colour absorb the infra-red strongly, and infra-red photography can therefore be used in camouflage detection. The skin is somewhat transparent to infra-red and infra-red photography is sometimes of value in medicine in showing the appearance of veins just beneath the skin. It is also of use in dermatology, ophthalmology and the photography of gross specimens and biological sections. Other applications include photography in total darkness, determination of temperature distribution at the surface of heated bodies, deciphering of altered documents, study of falsified or deteriorated works of art and of textiles, particularly where dark dyes interfere with visual examination, and many applications in botany, palaeontology, the graphic arts field and technology.

Ultra-Violet Photography. — Ultra-violet photography is used in the examination of altered documents, restorations of works of art, detection of invisible writing and fingerprints and other instances where advantage can be taken of the fluorescence of materials. There are two different methods of ultra-violet photography: (1) The reflected ultra-violet method which is analogous to ordinary photography except that a filter is used allowing only ultra-violet to reach the film; (2) the fluorescence method in which the subject is illuminated by ultra-violet and the camera is provided with a filter which absorbs ultra-violet and allows only the visible fluorescent light to reach the film.

High-Speed Photography. — Photographs made at high speed are very important in science and technology, because they record a phase of a fast event, or photograph a rapid sequence of events which can be slowed down for study. It is necessary to use a very bright light and very short exposure times so that sharp records can be obtained.

The first high-speed photograph was taken by Fox Talbot, using a spark from a Leyden jar. In 1882 and following years, Eadweard Muybridge published photographs of moving animals, successive exposures of short duration being obtained in 24 cameras. E. J. Marey, in 1882, perfected a "photographic rifle" in which 12 photographs were taken in 1 sec. on a revolving plate. This was called chronophotography, and in 1890 he devised the photochronograph, using film. Similar experiments were made by O. Anschiitz in the 1880s.

The earliest photographs of projectiles in flight were attempted about the middle of the 19th century at Woolwich arsenal in England, by Marey in Paris and by Anschiitz in Germany. A cannonball in flight was photographed at Woolwich in 1866, but the best ballistic pictures were obtained after 1884, when E. Mach, in Prague, introduced the electric spark as light source. The spark was released by allowing the projectile to cut a wire. L. Bull, Marey's successor in Paris, applied Mach's principle in such a way that he obtained a rate of 2,000 pictures per second. In 1909 C. Cranz made a ballistic cinematograph giving exposures at time intervals of one five-thousandth of a second, for a total time of one-tenth of a second.

Among the early studies of extremely high-speed photography are the photographs of ripples by J. H. Vincent, of splashes by A. M. Worthington, the shadow photography of bullets in flight by C. V. Boys, the analysis of the propagation of flame by Mallard and Henry le Châtelier and T. E. Stanton's studies of the pressure of gases ejected from nozzles. P. P. Quayle later made improved studies of the flight of projectiles and R. W. Wood of sound waves, outlines of which had accompanied the ballistic pictures of Boys. With a high-speed camera devised by W. Heape and H. B. Grylls, and taking 10,000 pictures a second, studies were made of the penetration of shells into hardened steel targets. Other cameras designed by C. F. Jenkins and Baron Shiba, and the Eastman Kodak and the Bell Telephone laboratories, have yielded results of much value in the study of high-speed phenomena. During World War II, high-speed photography was very much developed and applied to a wide range of studies of military interest.

The modern methods of high-speed photography may be

broadly classed as follows:

A. Single, Instantaneous *Photographs.*—(1) Steady illumination and short shutter exposure: the best mechanical shutter will not permit of shorter exposures than about one-thousandth of a second.

(2) Light flash of short duration, (a) shadow or silhouette, (b) reflected light, (c) stroboscopic.

(a) In shadow photography, used for objects moving as fast as bullets, the shadow of the object may be cast directly on the film or plate. An electric spark is generally the source, since it is bright, of short duration and small, so permitting sharp shadows on a film at a fair distance from the spark, if the subject is near the film. Exposures of the order of one-millionth of a second may be obtained. Alternatively, a condenser may be used between the spark and the object, the photograph being made in a camera with a lens. A development of this is the Schlieren method, originally by Jean Foucault and applied by August Toepler, which depends on slight differences of refractive index in the air, or inhomogeneities in glass and other transparent solids. It will show sound waves accompanying the flight of projectiles, convection streams from heated bodies, vortex rings formed in warm air or vapours of different densities.

(b) In the reflected light method, the source is a spark or preferably a lamp of the type of the Edgerton gaseous discharge lamp, the latter with its large area source being preferred from the point of illumination. A camera is used, as in normal photography. This method requires more energy and longer exposure time than the shadow method, but exposures as short as 1/50,000 sec. can be attained, which is satisfactory for practically everything other than ballistics photography (See BALLISTICS).

(c) In the stroboscope, a series of light flashes is made to agree with the speed of rotation of a steadily rotating object, so producing a stationary appearance of the object. This can be photographed in an ordinary still camera with long exposures if necessary to record the aspect of the object at any part of its cycle.

B. Series *Photographs.*—(1) Motion pictures: The normal slow-motion camera takes photographs at 64 frames per second, and some at 128 frames per second. These cameras have intermittent motion of the film. For higher speeds, up to 5,000 or more per second, the film moves continuously and there is compensation for image movement by some optical device, such as a rotating plane parallel glass block, or rings of lenses or prisms. If films made in this way are projected at normal speed, the movement is slowed down to the extent of the ratio of the taking to the projection speeds. The Eastman Type III High Speed camera and the Bell laboratories Fastex are examples.

(2) Series of photographs can be made of short duration and at closely successive intervals. In one method, developed particularly by Gjon Mili, successive photographs are made on one sheet of film by using a rapid series of flashes from a gaseous condenser discharge lamp, or from a series of flash bulbs. In the early studies of animal locomotion by Muybridge, 24 separate cameras, operated in rapid succession, were used.

(3) A special high-speed camera was developed by the Bell laboratories as the ribbon-frame camera, primarily to study the behaviour of rockets in the early part of their flight. The shutter consists of two concentric drums, the outer of which has five slots and the inner four. Both are rotated in the same direction, but the outer at 24 and the inner at 30 r.p.s. Glass plates are used to compensate for image movement, and the photograph appears as a series of narrow adjacent strips across the film.

(4) In some cases, as in explosions, the subject is self-luminous, moving fast and of short duration, and a rapid sequence of photographs of it permits a study of its development. Two methods were in use in 1947 for the study of flame in explosions. In one, short snapshots are made through a rapidly rotating shutter onto a stationary film or plate. If the flame is moving along a transparent tube, a series of such photographs in rapid succession shows the consecutive phases of its propagation. In the second method, the film or plate is moved. If the explosion occurs in a horizontal glass tube, and it is photographed by a lens on a plate falling vertically, or on a film wrapped about a rotating drum, an envelope showing the changing shape of the flame will be obtained, and its velocity can be calculated. In some cameras, rapidly rotating mirrors are used in the moving film camera to give what amounts to a series of separate snapshots, or the film is held still and a single rotating mirror is used. Exposures shorter than 1/50,000 sec. can be obtained in this way. Continuous trace photographs on continuously moving film were used in the study of the initial stages of the explosion of the atomic bombs.

Astronomical **Photography.**—(*See* PHOTOGRAPHY, CELESTIAL; SPECTROSCOPY, ASTRONOMICAL.) Visual observation in astronomy has been replaced almost entirely by photography through the telescope, because it has many advantages. By giving long exposures, stars may be photographed which are much fainter than those which can be seen. Many stars may be photographed simultaneously, so providing a record of relative positions which may be compared with records made later. Wave lengths not visible to the eye may be used in photography, and careful choice of wave-length band may reduce the limitations imposed on penetration into space by the luminosity of the earth's atmosphere. In order to photograph extended areas of the sky, lenses of the type used in normal photography are employed, or Schmidt lenses. In these, high apertures and short focal lengths are obtained by using a correcting plate in conjunction with a spherical mirror. The small-scale photographs so obtained are valuable for position measurements and surveys, and if the aperture is high enough, faint nebulae, the Milky Way and meteors may be recorded.

For photographing positions more precisely, or for separating close stars, objectives of longer focal length are used. They are either refractors or reflectors. Refractors suffer from chromatic aberration and are corrected to give their best focus in the green, and the best photographic focus is therefore obtained by using orthochromatic plates and yellow filters. Reflectors do not have this disadvantage. The fastest available photographic plates are used, and the lower definition given by plates of highest speed is not serious, since "seeing" limits the sharpness of image the telescope will give. The plates are made to have the minimum reciprocity failure for long exposure times.

In addition to direct photography, the other great branch of astronomical photography is spectrography. The chemical and physical constitution of the stars may be determined by the light they emit. Spectra may be recorded, simultaneously, of many stars by placing a prism or grating over the camera objective. Spectral types of many stars may thus be determined in a short time. For more detailed study, the image of the star produced by the telescope is directed to the slit of a spectrograph, and long exposures may be given.

The nearer planets are bright and exposures are relatively short, although really fixed by the short time of good seeing. Short focal-length telescopes give small bright images, and slow plates may be used. In long-focus telescopes the image is larger but less bright and fast plates must be used. Information about the atmospheres of the planets has been obtained by using plates of different colour sensitivities, relying on the different opacities of the atmospheres to different wave lengths.

Detail of the surface of the sun, the nearest star, is much studied. Direct photography records the positions and areas of sunspots, and the prominences and the corona during eclipses. In times when there is no eclipse, the corona can be photographed by means of the coronagraph. Much information about the sun is obtained from instruments which enable phptographs to be made with narrow wave-length bands, in particular the spectroheliograph (*q.v.*), which uses the red light of the Ha line of hydrogen, or the blue light of the H and K lines of calcium. Birefringent filters transmitting extremely narrow bands of radiation were in 1947 being developed for the same purpose. Motion pictures, speeding up motion, have been made of the moon and the planets, and are regularly made of the sun.

Great advances in astronomy are attributable to improvements in speed and colour sensitizing of photographic plates, and the improvement in fine grain, resolution and reciprocity failure characteristics.

Criminology.— Photography plays an important part in identification records, fingerprint photography, photographs in crimes of violence, automobile accidents, arson cases, burglaries and forgeries; ultra-violet and infra-red photography aid in detecting stains, invisible writing and alterations on documents; spectrographic analysis of traces of evidence, radiographic analysis and cinematography in recording criminal operations. Comparison photomicrographs are important in the examination of bullets.

Photoelastic Analysis.— A study may be made of the stresses in structures by making models of them in transparent plastics which are isotropic and have large optical stress coefficients. If a stressed model is photographed in polarized monochromatic light, a pattern of light and dark bands results, and from these the distribution of stress may be calculated. The method has been sucressfully applied to such things as test bars, hooks and chain links, structural foundations, bridge trusses, expansion joints, machine details and the action of cutting tools. (See **LIGHT**: Polarization and Electromagnetic Theory.)

Recording in Physical Measuring Instruments can be done by photography where an external spot of light is deflected, for instance, by a galvanometer mirror and falls on a dropping photographic plate or on a moving band of paper or film and records a trace of its path. There are many such devices, *e.g.*, oscillographs, electrocardiographs, seismographs, magnetometers, optical gas-engine indicators and other devices recording variations in pressure, electrical characteristics, optical transmission and reflectance, thickness variations and so forth. The most-used photographic recording of this type is sound recording, by variable density or variable width trace, on motion-picture film. A somewhat more difficult type of recording is photography of the trace on a cathode ray tube, particularly if it is in the form of a rapid transient which does not repeat, or if the image does not persist. Fast materials specially sensitized to the green or inherently fast to blue light are needed for this. During World War II, a special adaptation of this was to photograph the images on the tubes of radar equipment.

Photo-Layout. — Special photographic methods are available for transferring drawings to metal or other sheets for making templates, precision dials, scales and wiring diagrams, and for laying out designs on metal for the engineering, aircraft and shipbuilding industries. Bichromated colloids may be coated on the sheet and developed in the manner used in photomechanical reproduction, and the final lines darkened by ink or dye. A later variation of this, called Transfax, uses a sensitive colloid containing the pigment, but gives a direct positive image from a positive. In the strictly photographic method, the sheet on which the drawing is to be printed is sensitized by a silver halide emulsion applied by spraying, or by a stripping layer transferred from a temporary support. The drawings from which copies are made on the sensitized metal by contact printing can be prepared on sheet material coated with a white layer which fluoresces or phosphoresces in ultra-violet or under influence of X-rays. The glowing sheet on which the glow is obscured where there are opaque lines drawn, is used to print on the sensitized sheet. Alternately, the fluorescent layer may be overcoated by a photographically opaque layer through which the drawing is scribed, exposing the lines in white fluorescent pigment which can be excited and printed. Copies can also be made by reflex copying to give negatives for contact printing, or in a camera to give reduced negatives which can be printed by enlargement onto the sensitized sheet.

Underwater Photography. — Photographs can be taken of underwater objects such as swimmers and divers, fish, the bottom of the sea, ship's bottoms and the corrosion of structures. Water absorbs red and blue light strongly, and the dominant colour is blue-green. At depths to 15–20 ft., pictures can be taken with reasonable exposures, using the light penetrating from outside. At greater depths, special lighting equipment has to be lowered into the water. Strong lights are required, particularly for study of the behaviour of fast missiles dropped into water, or launched under it. Special cameras in water- and pressure-proof cases have been designed for still and motion-picture photography, with flat glass pressure plates in front of the lens. Some attempts have been made to design lenses which can be used with the front surface in contact with the water. There are few special problems involved in photographing underwater from outside through windows, provided the water is clear, the light intensity is adequate and proper account is taken of reflections and refractions. Surface reflections must be avoided by shielding. Colour photographs will tend to appear blue-green, but compensation at moderate depths may be achieved with daylight-type film with the appropriate colour-correcting filter. During World War II, black-and-white and colour photographs were obtained from aircraft to permit depth of water determinations off enemy coast lines.

Medical Photography. — Among the most important applications of photography in medicine are radiography and photomicrography, ahich are dealt with as special subdivisions of photography. There are many other uses. It has largely replaced drawings and diagrams in publications and lectures. In the form of the motion picture it is important in surgery for recording and teaching. In still photography its scope has three main aspects, *i.e.*, photography of the living person, photography of surgical operations or methods of treatment and photography of pathological specimens. Special lighting techniques may be necessary in some cases, but in general the technique is that which would be used in good ordinary photography, but under the supervision of the medical expert. Colour photography is of increasing value. Special techniques used include infra-red and ultra-violet photography, use of special equipment for photographing the eye and studying body cavities by endoscopic photography in which pictures can be made of the interior of the stomach, larynx, bladder, thorax and nearly all other body cavities.

Some special instruments, such as the electrocardiograph, which record minute electrical charges generated in the body, use rolls of photographic paper or film for recording the galvanometer traces.

Photography of Documents. — The copying of documents by photography has assumed great importance. There are two main aspects. In one, copies of printed material and notes for research, musical scores and parts, drawings, letters, business records, insurance policies and such are made on paper at the same size as the original, or only slightly reduced. They may appear as positives, dark on a light ground, or as negatives, in light copy on a dark ground. In the other group, copies of the documents are made on film, usually of 16-mm. or 35-mm. motion-picture type. They are stored in this form to save storage space by substituting films for paper, to safeguard valuable records by having a copy of them stored away from the original, to record transient documents which might be destroyed and of which a record might be required, to facilitate shipment of copies of documents to other places and to provide duplicates of files and indexes for libraries. They can be preserved as negatives or positives, and prints on paper can be prepared from them if required.

Copies of the first type can be made by contact printing through onto sensitized photographic paper, if the original is printed only on one side, to give a negative from which further prints can be made, or if a single print is required, a negative in which the type is not reversed, by putting the support of the material to be copied in contact with the emulsion. In the case of double-sided or opaque originals, reflex copy negatives can be made and prints obtained from them. If large production is involved, or if the copy is to be reduced in size, special cameras for photographing onto paper are used, the best known being the Photostat, Rectigraph and Rutherstat. Alternatively, the documents may be made on film to reduced size in Microfile and similar cameras and the negatives enlarged to give paper prints.

An important microfilming procedure was introduced in England in 1941 as Airgraph and later in the United States as V-mail, and was used for distributing mail to and from the armed services overseas. Letters were written on special forms, copied onto 16-mm. film which was flown to centres abroad where enlargements on paper were made and distributed to the addressee.

In the drawing office, copies of tracings are made by blueprint, iron-silver and diazo processes and by special types of papers which give normal silver images, but which can be handled in ordinary room light.

Recording Cameras. — Among the uses of cameras for special recording purposes may be mentioned: gun cameras, used for training in aerial gunnery and for recording the effectiveness of gunfire in combat; phototheodolites for survey from the ground, and for plotting the position of shell-bursts; submarine periscope cameras for photographing through the periscope the results of torpedo fire, and enemy coast lines; cameras provided with enclosed lights for photographing fingerprints and instrument panels; special cameras frequently using invisible rays for photographing aircraft instrument panels; cameras for photographing inside tubular cavities such as gun barrels and oil well bore holes.

Photographic Photometry. — The intensity of radiation can be measured by photography. The radiation whose intensity is to be measured is compared with that from a standard source by matching the densities of photographic images produced by both. A number of conditions have to be met, and they are described

in the publications on the subject, especially by G. R. Harrison and L. A. Jones.

Phototopography.—(*See* SURVEYING; PHOTOGRAMMETRY; also Aerial Photography.) Col. Aimé Laussedat of the French army pioneered the application of photography to surveying, especially in the Alpine regions, and it was applied extensively in Canada, especially by E. Deville. Practically all photographic survey by the 1940s was done from the air. In ground phototopography, special cameras (phototheodolites) are used after the manner of theodolites, and photographs are taken in pairs from the ends of measured base lines, in such a way that the same object can be identified in both photographs. The cameras have means for orienting them precisely in relation to the subject, levels for setting them true to the perpendicular and means for properly orienting the image inside the camera. Plates are usually used rather than film, unless easy portability is important; and exposures may be long, so the plates may be relatively slow and of high resolving power. Special phototheodolites have been used for determining the position of anti-aircraft shell bursts and similar inaccessible objects.

Aerial Photography.— The first aerial photographs were made from captive balloons (Nadar, 1858, S. A. King and J. W. Black, 1860) using wet collodion plates. The principal early development of aerial photography came after the advent of the aeroplane, and particularly during World War I, when thousands of photographs were taken each day for military intelligence purposes. During World War II, millions of photographs were made from the air and more than 80% of knowledge of the enemy was derived from them; the same mas true during the Korean war.

The chief uses of aerial photography are: in military intelligence, for recording troop movements, positions, defenses, supply facilities, bridges, railways, docks, industrial establishments, shipping, etc., orientation of bombers and bomb damage assessment; in mapping, military and civilian, to provide the basis for making new maps and filling in detail or revising existing maps; for mosaics, which are composite aerial photographs made by joining together a number of separate photographs of the ground; making survey photographs for purposes of forestry, oil. geology, crops, soil erosion, archaeology, traffic distribution, real estate, exploration and such studies.

Aerial photographs are made in cameras specially mounted in aeroplanes to minimize vibration, and are called vertical or oblique according to the orientation of the camera to the ground. Early aerial cameras were modifications of existing plate cameras, but provided with magazines permitting exposure of a number of plates in rapid succession. With the exception of a few special survey cameras which still use plates, aerial cameras use long rolls of film which can be moved intermittently by hand or by an electric motor controlled by an intervalometer, in order to make series of photographs of the ground along the line of flight. These photographs are usually arranged to overlap about 60% so that they can be viewed stereoscopically when maps are being plotted from them, or when it is desired to study ground detail.

Film for general aerial photography is of the high-speed panchromatic type, with extra red sensitivity to permit short exposures through filters. Infra-red film is used for long distance and high altitude photography, for camouflage detection and for forestry survey. Colour film was first used extensively in aerial photography in World War II. The colour contrasts aid identification of objects, show up underwater features, and permit night photography of coloured flares. Aerial films range in width up to 20 in. and up to 400 ft. in length

The film support for aerial photography is mainly of the topographic variety, which undergoes little dimensional change in processing or with change in humidity, and so reduces the errors which must be corrected in plotting maps from the photographs.

A wide variety of lenses is used, ranging in focal length from about 3 in. to 100 in., and in apertures from f/8 to f/1.5. (See Photographic Lenses.)

In aerial photography the camera is moving in relation to the subject photographed, and exposure times must be very short or the picture will be blurred. High-speed shutters are therefore used. They are of the focal plane, louvre and between-the-lens types, the first two being favoured by the British and the last by the Americans. For night photography using flash bombs, special shutters were developed to be operated by a photocell circuit activated by the light of the flash.

Instead of, or in addition to, using high-speed shutters, compensation for movement of the image can be effected by moving the lens during exposure, moving the film continuously through its magazine at the same rate that the image moves, the exposure being made continuously through a narrow slit in the focal plane, or moving the film in its magazine but exposing the full picture area intermittently as in normal operation.

In order to photograph large areas of ground at one time, wide-angle and short-focus lenses, or multiple-lens cameras, or groups of separate cameras may be used. Multiple-lens cameras having three, four, five and nine lenses have been developed, the most popular being that with five lenses. In the Tri-Metrogon system developed for rapid survey during World War II, three cameras are used, one vertically and two obliquely, one on each side of it, the photographs being made to overlap somewhat to cover the entire ground from horizon to horizon on each side.

Atmospheric haze presents a serious problem for aerial photography since it tends to lower the contrast of or obscure ground detail. Haze scatters blue light preferentially and transmits the longer wave lengths. Its effects can, therefore, be largely eliminated by using panchromatic film and filters which absorb blue light. The commonly used filters are yellow, but for better haze penetration it is sometimes necessary to use red filters, or in extreme cases to use infra-red-sensitive film and a deep red filter. Special filters are used for particular purposes, for instance, green filters for distinguishing certain kinds of vegetation.

Film for aerial photography is developed in the roll on special machines in which it moves continuously through a series of tanks, or back and forth from one reel to another in single tanks, or on spiral reels or racks which can be immersed in the solutions for the desired times.

Special instruments and techniques are used for plotting maps from aerial photographs. (See SURVEYING; PHOTOGRAMMETRY.)

Radiography.— (See RADIOLOGY; X-RAYS, NATURE OF.) In this branch of photography, photographs are produced on film by the passage of X-rays or gamma-rays through an object. There are several aspects: medical and *dental* radiography which is by far the widest used; industrial *radiography* for examination of the interior condition of solid objects, especially castings, welds and structures, usually of metal; gamma radiography, for examination of the interior state of solid objects, but using the gamma-rays from radium; X-ray *diffraction* for the analysis of the atomic and molecular structure of materials.

Radiographs, other than diffraction photographs, are shadow photographs obtained by passing a beam of the rays directly through the object, which absorbs them to an extent depending on its nature (especially the atomic number of its elements) and thickness. Photographic films are sensitive to X-rays and gamma-rays, as they are to light, and when the exposed film is developed, the image varies in density according to the extent to which the rays were absorbed. The invisible internal structure is thus revealed.

The earliest radiographs were made in 1896, the year in which Wilhelm Rontgen discovered X-rays, and the glass plates then available were used. Modern radiography is done on film coated with a special emulsion, and usually on both sides to give maximum speed and contrast. Only a very small percentage of the X-ray beam is absorbed by the emulsion, and in order to increase the effectiveness of the exposure, therefore, the film is usually put between two "intensifying screens" which are coated with a layer of material such as calcium tungstate which fluoresces under the action of the X-rays and the fluorescent light augments the exposure caused by the X-rays. For some classes of industrial radiography, thin lead foil screens are used to improve the contrast and clarity of the photograph. For dental radiography and some industrial work, no intensifying screens are used.

The penetrating power of X-rays depends on the voltage between the filament and target in the X-ray tube; the higher this voltage, the "harder" or more penetrating are the rays. For general medical radiography 40–80 kv. may be used, the higher values being for the thicker body parts. For industrial radiography, voltages ranging up to several million may be employed. X-rays generated at high voltage for radiography of metals are so penetrating that materials such as cloth, paper and leather appear quite transparent to them, and low voltages of 4–20 kv. must be used with them.

When X-rays strike an object, a considerable percentage of them is scattered, in much the same way light is scattered by fog. The scattered rays tend to cause a veil over the radiograph and so reduce contrast and detail. This effect can be offset by using a Potter-Bucky diaphragm, which consists of a grid of alternate strips of lead and wood which is moved between the object and the film during the exposure. The direct X-rays pass through the wooden strips, while the lead strips absorb those scattered sideways. The grid is moved to prevent its casting a shadow, but sometimes a stationary Lysholm grid of thin, closely spaced lead strips is used.

Medical uses of radiography include location of foreign bodies and cavities, fractures, diagnosis of tuberculosis and abnormal conditions of the digestive and urinary tracts, the heart, the spinal column and the sinuses; and in the case of dental radiography, cavities, abscesses, unerupted teeth, pyorrhea and many other conditions.

The widest use of industrial radiography is in examination of interior structures for hidden faults, without involving damage to the object, for instance, in castings and welds, assembled mechanisms, moulded plastics, munitions and a vast range of manufactured products.

Among special radiographic techniques may be mentioned: *body-section radiography,* in which only one plane of the body gives a distinct image, nearer and farther parts being blurred, the result being obtained by moving film and X-ray tube in opposite directions about a pivot point in the plane which is to appear sharp; *roentgenkymography,* used for study of moving parts, such as the heart, by moving between the patient and the film during exposure a lead plate with a series of horizontal slits; *microradiography,* usually for thin specimens of low X-ray absorption, with very fine detail, in which the radiograph is made on fine-grain film and subsequently enlarged; *high-speed radiographs* have been made in one-millionth of a second for ballistic and other high-speed studies.

There developed, particularly during World War II, a need for radiography on a grand scale, particularly for making X-ray photographs of the chests of people being examined for induction in the armies. *Mass miniature radiography* was introduced. In Europe, photographs of the fluorescent screen image were made on 35-mm. film, using lenses of very high aperture. In the United States, the preferred size was 4 x 5 in., stereo pairs being made on film 4 x 10 in. in size. In motion-picture- or *cineradiography,* motion pictures are made of the image on the fluorescent screen, or, less frequently, series of natural-size radiographs are made in quick succession. Usually one cycle of movement of a part is photographed, and in projection it is viewed in repeated succession. The chief limitation in this work is that extremely high aperture lenses are required in order to keep the X-ray dosage to the patient at the minimum. In *gamma radiography,* the gamma-rays from radium are used. They are of shorter wave length than X-rays and thus have greater penetrating power. They are specially used in the radiography of thick metal specimens.

Radiographs are usually examined as the negatives, and in order to give the impression of depth they are frequently made in pairs, using two positions of the X-ray tube, and viewed in the stereoscope. In *X-ray diffraction* methods, the internal structure of crystals may he determined by the diffraction pattern photographed on passing a beam of X-rays through a single crystal or a sample of the material in powder form. Autoradiography is a procedure that originated with the ready availability of radioactive isotopes. It is known that when isotopes are introduced into an organism, they localize in certain tissues and, in some cases, in specific portions of the living cell. These concentrations of the radioactive substances can be detected by placing thin sections of the tissues in close contact with special photographic plates. Upon development of the plate, black specks identify the location of the concentrations of the radioactive materials. By using fine-grain materials and magnifying the resultant image microstudies are possible. (*See* CRYSTALLOGRAPHY: *Diffraction of Crystals;* X-RAYS.)

COLOUR PHOTOGRAPHY

In 1810 J. T. Seebeck, in 1840 Sir J. Herschel and later E Becquerel and Claude Niepce de Saint-Victor, observed that silver chloride darkened by exposure can record the spectrum of the sun by its direct action, in colours similar to those of the spectrum itself. The colours can not be fixed and the method has no practical value.

The first fixed colour photographs from nature were made by G Lippmann in 1891, using the interference principle, the possibility of which had been pointed out by W. Zenker (1868), Lord Rayleigh (1887) and O. Wiener (1890). In the method, a transparent grainless panchromatic emulsion is coated on glass and exposed with the emulsion in contact with a reflecting surface, usually of mercury. The reflected light gives an interference effect, setting up standing waves in the emulsion. The exposed and developed silver is thus arranged in laminae half a wave length apart, and reflects light of double the separation, giving bright colours. Beautiful colour reproductions can be obtained, but the plates are insensitive and the viewing is not convenient.

The basic principles of modern colour photography are derived from an experiment made in 1861 by James Clerk Maxwell in a study of the theory of colour vision. He photographed coloured ribbons through red, green and blue filters, from the negatives made three positive black-and-white transparencies and projected these in register onto a screen using three lanterns, each transparency being projected by light of the colour by which its negative was taken. The image on the screen was a colour reproduction of the ribbons.

In 1869 Ducos du Hauron published a book in which he laid down the principles which provide the basis for all modern processes of three-colour photography. At about the same time C. Cros published an article with much the same conclusions. Du Hauron's book gives a clear account of the two fundamental processes of colour photography, the *addztive* and the *subtractzve,* with suggestions for carrying them out. The practical development of the processes was delayed for many years until panchromatic plates became available through the introduction of colour sensitizing by Vogel in 1873 and the introduction of isocyanine and carbocyanine sensitizers early in the 20th century.

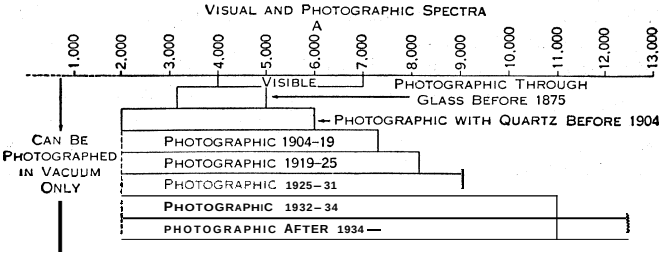

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FIG. 3.— PROGRESS IN COLOUR SENSITIZING PHOTOGRAPHIC MATERIAL

Modern colour processes are divided into the additive process, which is used only for transparencies for projection and direct viewing, and the subtractive processes which can be used for transparencies and also for paper prints to be viewed by reflected light. In both cases the first step is to make three separation negatives of the subject by the red, green and blue light from it. It is also possible to make colour photographs by the two-colour process, in which the separation negatives are made by half the spectrum, blue-green and orange, but the best colour rendering is obtained by the three-colour process.

Additive Processes.—In the additive processes, the colours are produced by adding together varying amounts of red, green and blue light. There are three main processes of additive colour photography: *triple projection, screen unit* and *lenticular film.*

In the *triple projection* process, black-and-white positives made from negatives exposed through red, green and blue filters are projected through similar filters in register on a screen. This was

the original Maxwell experiment. Special equipment for making the three separation negatives in succession or simultaneously were put on the market, together with triple lanterns for projection. Du Hauron, Cros and F. E. Ives invented devices for viewing the three pictures directly rather than by projection. In the photography of stationary objects, the three negatives can be exposed in succession. In the case of moving objects, however, the three negatives must be made simultaneously, otherwise colour fringing will occur. For simultaneous exposure of the three negatives, groups of lenses have been used, as in the Gaumont motion-picture camera of 1912, or beam splitters consisting of a group of mirrors or prisms. Another system of making these three negatives, originally invented by Du Hauron, is the so-called tri-pack in which three separate films are arranged behind each other, with filters to ensure that the red, blue and green records are obtained separately, one on each film.

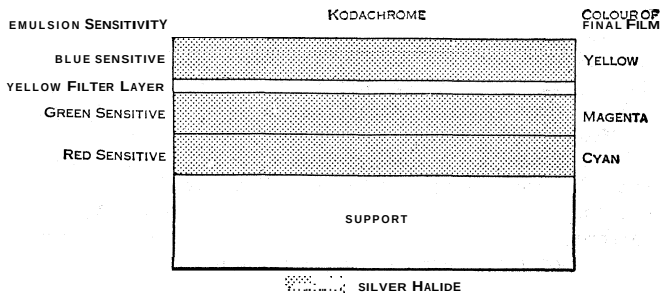

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FIG. 4.—CROSS SECTION OF INTEGRAL TRIPACK FILM

In the triple projection process extremely good colour quality can be obtained, but the system is complicated and up to 1947 had never been a commercial success.

The Screen Unit Process.—The first commercially successful colour process, the Lumière Autochrome, brought out in 1907, utilized the screen unit process. This was a modification of one form of additive process first suggested by Ducos du Hauron. Instead of making three separate negatives through filters, a single plate was covered with minute blue, green and red filter elements. A panchromatic emulsion was coated over this layer. The exposure was made through the filter layer so that the image obtained was broken up into tiny units representing blue, red and green components of the colours of the subject. The emulsion was developed by the *reversal process* (originally by *R.* Namias) to give a direct positive in black-and-white, which, on direct viewing or projection through the layer of minute filters, gives a reproduction of the subject in colour. Alternatively, if the filter elements are uniformly arranged, the plate or film can be developed to a negative and printed to give a positive transparency which can be registered in contact with a plate carrying minute filter elements to give a positive colour transparency.

The first successful use of the screen unit process was made by J. Joly and by J. W. MacDonough in 1892, the filter elements being on a separate plate from the negative. This arrangement was later employed in the Finlay plate, which was used commercially for many years. In the Lumière Autochrome process, the filter layer consisted of dyed starch grains with the spaces between filled with carbon black. The plates gave good colour quality, and were on the market as plates and later as films for 30 years. Other screen unit processes were later introduced, in particular, the Finlay process mentioned above, in which the screen was printed in bichromated colloids, the Agfacolor plates and film in which the filter layer consisted of dyed resin particles rolled flat and the Dufaycolor process, in which the emulsion was coated on a regular dyed screen pattern prepared on the film support. The Agfacolor and Dufaycolor materials were developed by reversal, and were sold as roll, sheet and motion-picture film.

The screen unit process gave transparencies of good colour quality, but the plates and films were difficult and costly to manufacture. They were dense, so that it was difficult to get enough light in projection, and the screen pattern was frequently very evident.

The Lenticular Film Process.—This was invented by R. Berthon in 1908 and developed by A. Keller-Dorian and particularly by J. G. Capstaff and the Eastman Kodak company, who made it commercially available in 1928 as the Kodacolor process for amateur motion-picture photography in colour. In this process, the film support is embossed mith minute cylindrical lenses on the side opposite the emulsion. A three-colour banded filter is used over the lens; and in taking, the embossed side of the film faces the lens. Somewhat as in the screen unit process, the lens forms a full image of the subject on the film, but it is broken up into minute elements which are images of the banded filter formed by the embossed lenses on the film. The film is developed by the reversal method and projected through a three-colour banded filter.

The quality of the results given by the lenticular film was excellent, but disadvantages were encountered in projection. which involved a great loss of light because of the filters, so requiring special projection optical systems, and the lenticular pattern was often very much in evidence.

Subtractive Processes.—The subtractive processes are the most important of the practical processes of colour photography. They were first described by Ducos du Hauron, and are now practically exclusively used for colour prints on paper and transparencies for still and motion-picture projection. In the subtractive process, three separation negatives are first made by red, green and blue light. From these, positives are made in colours which are complementary to those by which the negatives were made, and the three are superimposed in register, on white paper to give a colour print, or on film to give a transparency.

The negative made by red light is printed to give a cyan (blue-green) picture; that made by blue light is used to give a yellow picture, while that exposed by green light is printed in magenta. When these partial images are superimposed, a good colour reproduction can result.

The three separation negatives can be made: (a) separately by successive exposures through the three filters on three plates or films; (b) simultaneously on three plates or films using a one-exposure (one-shot) three-colour camera provided mith a beam-splitter of partially reflecting prisms or thin pellicles or split lenses; (c) simultaneously on a tripack of three films or plates superimposed and so sensitized and provided with filter layers that each records only one of the primary colours; (d) simultaneously on an integral tripack or monopack.

In the first three cases the three negatives are generally used to print three positives which can be superimposed on paper or film. Various processes have been used, in particular carbon, Ozobrome or Carbro, bromoil and dye-mordant methods and differential tanning of a gelatin layer. There are two principal forms of the last-named—the Pinatype process in which dye is taken up in an amount dependent on the softness of the gelatin, and allowed to stay in the layer if a transparency is required, or transferred to gelatin-coated paper by imbibition if paper prints are required; and the wash-off relief or dye transfer process in which the soft parts of the differentially hardened gelatin layer are washed out leaving a relief image in hard gelatin which can be dyed and the dyes transferred to paper or film by imbibition.

The Technicolor motion-picture films are made by dye transfer from three gelatin relief films to a final gelatin-coated film.

Monopack or Integral **Tripacks.**—It is evident that better results would be obtained if the three layers were coated over each other on a single film support. This proposal was suggested in the early history of colour photography with the idea that the layers should be separated for development and printing, but the manipulation proved to be too difficult for practical handling.

It was next suggested, first by K. Schinzel in 1905, that the three superimposed layers should each be arranged to respond to a single primary colour, that the layers should be inseparable and that a coloured image should be developed in each. In Schinzel's proposal, dyes of colour complementary to the spectral region of sensitivity were incorporated in the layers, which were to be developed and then treated in such a way that the dyes were bleached by oxidation to an extent proportional to the amount of silver developed. C. Christensen in 1918 proposed a similar arrangement, in which the dyes in the layers mere destroyed by reduction

by hydrosulphite in the presence of the silver image. The silver-dye bleach method was applied commercially by B. Gaspar, in whose process the dyes were catalytically bleached in the presence of the silver.

Instead of bleaching the dyes in the layers to an extent depending on the silver developed, it is possible to form dyes in the layers to a degree depending on the amount of action of light and consequent development of silver. Processes based on this formation of dyes form the greater part of modern colour photographic processes. They depend on the discovery made by Homolka and worked out by R. Fischer that when a developer reacts with silver bromide to reduce it to silver, the oxidized developer resulting can react with certain compounds to form dyes. This is generally known as coupler development. The developers which are used are of the kind known as the diamines. The couplers are distinguished chemically by possessing a reactive group, usually methylene. The couplers which form cyan dyes are usually phenols; those giving magenta dyes are often nitriles or pyrazolones; those which form yellow dyes are typified by esters, ketones or amides. Substituents may be introduced into the developer or coupler to modify the colour.

In 1912 Fischer proposed a colour process which used a film with three layers of emulsion coated over each other, each layer containing couplers so that during development appropriate colours would be developed in them. Fischer was not able to make his process work, because he could not ensure that the dye couplers and the sensitizers would not wander from the layers to which they applied.

The first commercially successful colour process using coupler development was worked out by L. D. Mannes and L. Godowsky and the Eastman Kodak company and marketed in 1935 as the Kodachrome process. The image-forming dyes were introduced in processing, the couplers being in the developers rather than in the emulsions. About 1931 nonwandering sensitizing dyes had been developed. In Kodachrome, the film was coated with three emulsion layers, which would respond respectively to red, green and blue light, that responding to red being nearest the support. Below the blue-sensitive top layer was a yellow filter layer to prevent blue light's reaching the two lower layers. The process was designed to give direct positive pictures by reversal. After exposure, the film mas developed to give a negative in all three layers. This was then bleached out, the film exposed to light and then coupler-developed to give a cyan dye image in all three layers. By means of a bleach the penetration of which was controlled, the dye was removed from the top two layers, and the silver bromide regenerated in them. They were then developed in a coupler developer to give magenta images in them. The top layer was then bleached by controlled diffusion of a bleach, and developed in a developer containing a coupler which gave a yellow image. The silver resulting from the development of all layers was then bleached out, leaving the dyes alone to form the colour transparency *(see* fig. 4).

The processing of Kodachrome by controlled diffusion was clumsy, but commercially successful for three years. Toward the end of 1938, it was replaced by a selective method, in which the assigning of the dyes to their proper layers was determined by the sensitivity of the layers. In this, the film is first developed to give a negative in all three emulsion layers. It is then exposed through the base to red light, which affects the undeveloped parts of the bottom red-sensitive layer, and is then developed in a developer containing a cyan coupler, so that a positive cyan dye image is formed in the bottom layer. By exposing through the front to blue light, an image in yellow dye can be developed in the top layer, and the middle layer can then be made developable and give a magenta image. If the silver in all three layers is bleached out, the dyes alone remain to give the colour picture. The success of the Kodachrome processing depends largely upon using sensitizing dyes which will not wander from their appro. priate layers, and which will withstand processing solutions.

The Kodachrome types of coating applied to white cellulose acetate sheet instead of clear film permitted prints to be made from Kodachrome transparencies. They were first known as Minicolor and Kotavachrome prints, but later simply as Kodachrome prints.

The type of process suggested by Fischer, in which the couplers were incorporated in the emulsion layers, was introduced by Agfa in Germany, and later by Ansco in the United States. The couplers were associated with heavy molecules so that their tendency to wander from one layer to another was reduced. Films giving positive colour transparencies were introduced as Agfacolor-neu and later Anscocolor. Negative films, giving complementary colours, were also made available by Agfa and Ansco.

In 1940 the Eastman Kodak company made a colour film, Kodacolor Aero Reversal film, for aerial photography for the U.S. army air forces, which could be developed in the field to give direct positives by reversal. The film was of the integral tripack type, and the dye-forming couplers were incorporated in the emulsion layers, dissolved in minute droplets of insoluble organic compound dispersed in the emulsions. On development of the film, the oxidation products of the developer enter the nearest dispersed solvent-coupler droplets, and react with the coupler to form a dye. On bleaching, the silver is removed, leaving dye images in their appropriate layers. This process is known as a protected coupler process.

In 1942 a new Kodacolor film was made available. It used the protected coupler process to give negative colour pictures. Red, green and blue sensitive layers were coated on the film as in Kodachrome film, but each layer contained dispersed particles containing couplers. After exposure, the film is processed with a developer the oxidation products of which react with the couplers to give silver plus dye images in each layer. The silver is removed and a colour negative results, in which the image is not only negative in the normal photographic sense, but all the colours are complementary to those in the subject photographed. These negatives are printed onto paper coated with a similar set of emulsions, and processed in the same way, and paper prints are obtained in which the colours of the subject are reproduced. Soon after the introduction of this film, an extra layer was incorporated in it in which a black-and-white negative could also be developed to act as a mask to give improved colour quality in the print.

In 1946 a form of Kodacolor designed to give direct positive transparencies by reversal, similar to the earlier Kodacolor Aero Reversal film but of lower contrast and longer scale, was introduced by Eastman Kodak as Ektachrome, in sheet-film form. It was designed to be processed by the photographer, and an important aspect of it was that for the first time, coupler developers were used which produced no more effect on the skin of the user than the customary black-and-white developers. All the diamine developers previously used could give bad dermatitis.

Late in 1946 the important invention of coloured couplers was disclosed by Eastman Kodak. They were intended for use in the integral tripack negative process to correct for the unwanted blue and green absorption of the cyan dye and the unwanted blue absorption of the magenta dye, so giving improved colour quality in printing. Couplers are used which are actually red and yellow in colour, but the colours are destroyed where the dyes are developed. The final negative consists of the negative dye images combined with positive images in red and yellow, caused by the residual coloured couplers.

Colour-printing Processes. — Prints on paper have been made by the screen unit process, but they are unsatisfactory because of the high density of gray with which they must be associated. All satisfactory colour prints are made by subtractive processes, in which positive images in yellow, magenta and cyan pigment or dye are combined in register. The chief methods of obtaining the coloured pbsitives are: Chemical *toning,* in which the black-and-white silver images are converted into coloured compounds, for instance, lead chromate for yellow, nickel dimethyl-glyoxime for the magenta and an iron blue for the cyan (Chromatone of Defender Co., Snyder and Rimbach); *dye mordanting,* in which the silver images are converted into compounds known as mordants which have an affinity for basic dyes, among the best known being silver iodide (Traube's Diachrome), copper ferro-

cyanide (Traube's Uvachrome) and copper thiocyanate (Christensen); imbibition or transfer processes, in which differentially hardened gelatin layers are formed by tanning development or tanning bleach in the pattern of the positive image of the subject, and dyed directly to give a picture in which the dye is taken up to an extent depending on the hardness of the gelatin (Pinatype), or washed out with hot water to give a gelatin relief image, which can be dyed. In either case the dyes can be transferred to gelatin-coated paper to give a print on paper, and if the three-colour images are so transferred, a colour print results (Eastman Rash-off Relief and Dye Transfer processes).

Pigment Processes.—In the pigment processes, the gelatin contains pigments and can be differentially hardened by the direct action of light if bichromated, or indirectly by a tanning developer, or by indirect action from a bromide print and a special bleach, to give positives which can be washed out with hot water to give pigment-gelatin images. In the carbon process, originally devised in a practical form by Sir Joseph Swan in 1864, the gelatin containing the pigment is bichromated and exposed and developed in hot water, leaving an image of hardened gelatin containing pigment. In Carbro, which was developed from processes devised by A. Marion (1873) and T. Manly (1898), a bromide print treated with a special bleach is placed in contact with a pigmented gelatin and differential hardening of the gelatin occurs. The soft gelatin can be washed out in hot water, and three positives so prepared can be transferred to a common support to give a colour picture.

In the Duxachrome process, silver bromide emulsions containing pigments were coated on supports from which the images could later be stripped. The exposed layers were developed in tanning developers and washed out in hot water, the silver was bleached out and the remaining pigment images transferred in register to a final support.

In the dye-coupling printing processes, there are the equivalents of Kodachrome, Kodacolor and Agfacolor on white support. The printing processes are known as Minicolor, Kotavachrome, Kodacolor prints, Kodachrome prints and Printon.

The dye-destruction printing processes are typified by the Gasparcolor prints, in which the three superimposed layers of emulsion contain the subtractive pigments. On exposure and development a special solution is used to bleach the pigment image to a degree depending on the amount of silver developed.

The dye-bleaching processes were not yet of practical importance in 1947; but the Utocolor paper of J. H. Smith (1910), relying on direct bleaching of the dyes by light, was produced commercially. The sensitivity of the dyes to bleaching was enhanced by thiosinamine, and the stability of the image was determined mainly by rendering the sensitizer ineffective.

Colour Motion Pictures.—The earliest colour motion pictures were by the additive processes: Kinemacolor, a two-colour additive process using successive projection of the separate positives and a rotating pair of filters; the Friese-Green process of successive projection through filters, or with the frames on the film themselves dyed; the Gaumont process of simultaneous additive projection using three lenses in taking and projection. Variants of these are proposed periodically. Later, the Dufaycolor screen-unit process was used for motion pictures, and methods of printing the film for theatre release were worked out. The lenticular process, of which 16-mm. Kodacolor was commercially developed, was worked out, but not used to any extent in the theatres. The additive processes, although giving unsurpassed colour quality, give low screen brightness and difficulty of registration, or undesirable patterns, and are surpassed by the subtractive processes, from the practical point of view.

The earliest subtractive processes used chemical toning, dye toning or dye mordant methods, especially as two-colour processes, printing the separate colour positives on the opposite sides of a single support. The earliest Technicolor process was a two-colour relief process, but about 1928 it was changed to a two-colour, and later to a three-colour, imbibition process. For the three-colour process a special camera was used in which separation negatives were made on a single film and a bipack, using a special type of beam splitter. The three negatives were printed onto special films to give matrices from which prints were made by imbibition. Later, integral tripack or monopack films were used in the cameras, and separation negatives were made from them for printing by the normal imbibition process.

Particularly in Germany, some motion-picture films were made by the Agfacolor process using the Fischer type of film by the negative-positive, or the reversal methods. A great deal of experimental work has also been done with the Gaspar dye-bleaching process for motion-picture colour photography.

THEORY OF PHOTOGRAPHY

The Sensitive Material.—Under the high-power microscope, the image on a photographic negative is seen to be not continuous but to consist of large numbers of small, dark grains of silver. They are derived from the structure of the original emulsion, which consists of crystals of silver bromide distributed in the gelatin. These crystals are usually flat, triangular or hexagonal in shape, with an occasional rod shape, but there are emulsions in which they do not exhibit a crystalline appearance. They are of various sizes, ranging up to about 1/10,000 in. across, depending on the type of emulsion. In a normal film, there are several thousand million in a square inch. Examination by X-rays shows that the silver halide is all in the crystalline form, even though the separate particles may have a lumpy appearance.

If solutions of silver nitrate and potassium bromide in water are mixed, the silver bromide formed settles out in flocks; but if gelatin is present, the silver bromide remains suspended in a much finer form. Gelatin is present in emulsion making, so keeping the silver bromide suspended as fine crystals. In the ripening stage of emulsion making, the crystals grow in size, but they are of low sensitivity. After the addition of the bulk of the gelatin, washing and digestion, there is little increase in crystal size, but there is a growth of sensitivity to light, to an extent which depends largely on the kind of gelatin.

The sizes and distribution of sizes of the crystals or grains in the emulsion are determined by the way in which the emulsion was precipitated, and the sizes are related to the photographic properties of the emulsion. If they cover a wide range of sizes the emulsion usually has high speed and low contrast and is used for making negatives. If they are small and uniform, the emulsion has low speed and high contrast, and might be used for motion-picture printing film, or lantern slides.

When an emulsion is exposed to light an invisible change known as the latent image is produced in it, and the effect of the exposure is not apparent until the emulsion is developed by treating it in a chemical reducing solution, the properties of which will be discussed later. On development, the emulsion blackens to a degree which depends on the extent of development and on the exposure. In the case of a film exposed in a camera, a negative is produced, in which the brighter parts of the subject are reproduced as dark, and the darker parts as light. The degree of blackening of the film is called density (see Sensitometry). When a print is made from a negative, the light parts again appear dark and vice versa, so that in the print the tones are in the same order as in the subject.

The density in the negative is caused by the presence of the developed silver grains—the more silver in a particular area, the higher is the density. The silver grains have their origin in the silver halide crystals originally present, so that higher density means that a higher percentage of these crystals was made developable by exposure. On the average, the larger crystals in an emulsion are more sensitive to light than the smaller crystals. This is not only because they are bigger and therefore contribute more silver than a small grain, for it is possible by chemical treatment to make a fast emulsion practically insensitive without changing the size of grain,

When an exposed grain starts to develop, it does so at a limited number of isolated points on its surface. These points are distributed according to the laws of chance, and it appears that they coincide with points on the crystals which were preferentially affected by light, *i.e.*, the latent image is concentrated at certain

centres. This indicates that the crystals had extra high sensitivity at these centres; in other words, there are sensitivity centres on the original emulsion grains. Evidence indicates that they are specks of silver sulphide in the crystal surface. The most important support for this view comes from the study by S. E. Sheppard of the function of gelatin in determining emulsion sensitivity. He isolated the sensitivity-promoting substance from gelatin and found it to consist of sulphur compounds. especially allyl isothiocyanate. This material forms allyl thiocarbamide in presence of alkali, and this can form a complex compound with silver bromide. In presence of alkali, the complex can give rise to silver sulphide, and apparently this is the sequence of reactions occurring in the manufacture of a high-speed emulsion. In addition to the sensitizing material, gelatin can also contain desensitizing materials, and the net sensitivity will be the result of a balance of properties.

There have been mady theories as to how the sensitizing specks act during exposure to give rise to the latent image. After Sheppard found the specks to be silver sulphide, he and A. P. H. Trivelli and R. P. Loveland propounded the "concentration speck" theory. According to this, the silver-sulphide speck was able to cause the light energy absorbed by the crystal to be concentrated about a speck, and there to liberate silver by decomposition of the silver bromide. There is plenty of evidence that the latent image consists mainly of metallic silver. It is accumulated about the silver-sulphide specks. A silver speck can initiate development when it has grown to a certain size.

The concentration speck theory still forms the basis of latent image theory, but the mechanism by which the concentration is effected is now explained on the basis of atomic physics. Although it cannot be assumed that the whole mechanism of latent image formation is understood, the modern theory based on photoconductivity and electrolytic conductivity can correlate much existing data and predict new effects. When light is absorbed by silver bromide, the ability of the material to conduct electricity is much increased by certain electrons becoming available. J. H. Webb suggested that these electrons could move through the crystal freely, but that they would become trapped at the sensitivity specks of silver sulphide. In addition to this conductivity. there is also a small conductivity of silver bromide which is actually caused by the movement of some silver ions within the crystal R. W. Gurney and N. F. Mott visualized a combination of these two conductivity processes in explaining latent image formation as follows:

On exposure to light, the photoconductivity electrons are supposed to move freely in the crystal until they by chance impinge on the silver-sulphide specks where they are trapped and build up a negative charge. This negative charge will attract the positively charged free silver ions which will migrate to the speck where they will be neutralized by the electrons to form neutral silver atoms. The speck will thus grow by accumulation of silver atoms until it is big enough to act as a nucleus in the development process.

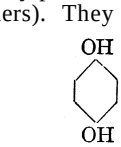
Development. — In development, the emulsion is treated with a solution which converts the exposed silver halide to black silver. The developer must act much more quickly on exposed than on unexposed grains. There are two kinds of development — physical and chemical. A physical developer contains chemical reducing agents and silver compounds in solution which deposit silver on the latent image from the solution. and not by changing the silver halide. It is of great importance for the theory of development, but not of much practical value. A chemical developer does not contain any silver, and is essentially a solution of chemical reducing agents which will distinguish between exposed and unexposed silver halide in an emulsion, and actually convert the exposed silver halide to metallic silver.

When a silver-halide crystal in an emulsion starts to develop, it does so at a limited number of points, from which development spreads outward, until the whole crystal is converted to silver. A giain develops completely or not at all. The development is initiated at the latent image centres where silver was deposited in the exposure, and the development of the silver bromide starts about these silver centres. It was felt by some for a long time that the latent image nuclei played no part in development except to act as a centre on which silver formed by reduction of dissolved silver halide could deposit. It is now clear that such a process does not play a major part in development, The more likely explanations involve a mechanism by which there is direct reduction of the silver halide at the boundary of the silver-sulphide latent-image speck, and that the speck itself in some way accelerates this.

Typical developed silver grains and the silver bromide crystals from which they were produced are shown in Plate V. The actual shape and size of the silver particles varies with the kind of developer and other factors. Studies made in the electron microscope show that the silver does not have a compact cokelike structure, as might appear from examining it in an ordinary microscope, but that it has a fibrillar, seaweedlike structure.

Only a limited number of types of chemical compounds are able to be used as developers. A few inorganic compounds. particularly ferrous oxalate, have been used, but the developers used in normal photographic practice are organic reducing agents of the classes known as phenols or amines. A rule established by A. and L. Lumière and by M. Andresen in 1891 stated that developers must contain at least two hydroxyl groups, or two amino groups or one hydroxyl and one amino group, attached to a benzene nucleus in the ortho- or para-position to each other. Meta compounds do not develop. It has also been pointed out that many developers form quinones or quininoid compounds when they are oxidized. J. D. Kendall formulated a rule which stated that hydroxy- and amino-compounds could be developers if they had the basic structure a-$(C=C)_n$-*b*, where C=C represents two cdrbon atoms joined by a double bond, *n* is zero or an integer and a and *b* are hydroxyl- or amino- or substituted-amino groups. There are, however, some developing agents which do not follow these rules.

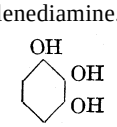
The most common developers are hydroquinone and monomethylparaminophenol (known by trade names Elon, Metol and others). They have the following structure:



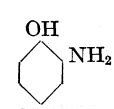
hydroquinone

monomethylparaminophenol (Elon, Metol)

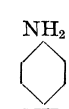
A popular developer in the past, but which is less used now, was pyrogallol. Amidol (2:4-diaminophenol) has been much used as a paper developer, and there is a wide range of developing agents on the market for special purposes, and under trade names. Fine grain and colour developers have been frequently based on paraphenylenediamine.



Pyrogallol (1:2:3-hydroxybenzene)



Amidol (2:4-diaminophenol)



paraphenylenediamine

The essential constituents of most practical developing solutions are: the developing agent; an alkali, sometimes called the accelerator; sodium sulphite, sometimes called the preservative, and potassium bromide, the restrainer.

The cotnmon alkalis are sodium carbonate, sodium hydroxide and some borates, particularly sodium metaborate (Kodalk) and tetraborate (borax). The function of the alkali is to make the developer active, and it does this by adjusting the alkalinity (or pH) to a suitable value and holding it there. This applies to developers containing hydroxyl groups, but the pH also seems to determine the activity of developers which do not contain such groups. Amidol does not require an alkali to make it effective.

Sulphite plays two important parts in a developer mixture. It acts as a preservative by decreasing the tendency of the developer to be oxidized by the oxygen of the air. It also combines with

the oxidation products of the developer which are formed when the developer reduces the silver bromide to silver, so preventing them from interfering with the progress of development, and from staining the photograph, for they may be highly coloured.

Potassium bromide is frequently added to a developer to restrain the growth of fog (*i.e.*, development of unexposed grains) and to control the uniformity of development. It usually slows down the rate of development, and may tend to make the photograph warm in colour. In addition to bromide, other antifoggants used in developers include benzotriazole and 6-nitrobenzimidazole.

Special developers for producing fine grain are either compounded with paraphenylenediamine as the developing agent, or of conventional developers adjusted to be of low activity, and containing a solvent for silver bromide, which may be an increase in the normal sulphite, or a special solvent added, *e.g.*, thiocyanates. Paraphenylenediamine probably acts by virtue of its own solvent action on silver halides.

The modern colour photography processes rely on so-called coupler development, in which the oxidation products of the developer combine with organic compounds known as couplers to form dyes. The couplers may be in the developer or in the emulsion.

Various developing agents differ in their behaviour. For instance in a plain elon developer the development starts much more quickly than in a plain hydroquinone developer. The elon gives detail first and slowly builds up density, while with hydroquinone the detail appears only after much density has been built up. In combination, the elon and hydroquinone form a very satisfactory developer.

The differences in activity are partly described by what is called the reduction potential of the developer. Three ways have been used for determining it: the ability of the developer to overcome the restraining action of bromide on the growth of density; the amount of silver bromide changed to silver by a certain amount of developing agent; measurement of the electrical potentials of the solution. The following table shows values obtained by the first method by A. H. Nietz. and by the third method by R. M. Evans and W. T. Hanson. The second method is little used.

Developing agent	*Reduction potential* Nietz	*Evans and Hanson*
Amidol	30–40	—0.434 *volts*
Bromhydroquinone	21	—0.327 "
Elon *(Metol)*	20	—0.308 "
Pyrogallol	16	—0.388 "
Chlorhydroquinone	7	—0.335 "
Paraminophenol (HCl)	6	—0.291 "
Toluhydroquinone	2.2	—0.390 "
Hydroquinone	1.0	—0.357 "

Practical developers are worked out for various special purposes, and they vary widely in their properties, depending not only on the material they are used to develop, but inherently among themselves. The developing rate increases with temperature but varies markedly with the nature of the developer. It also depends on the concentration of the components, and the effect of alkali in particular varies with the developing agent. Developers also vary in the way in which they keep when they are exposed to the air, in the rate at which they become exhausted in use, in the rate at which they will develop fog and in the effective emulsion speeds they produce,

When an exposed part of a film is developed, there is an initial period in which no visible effect appears, and this is known as the induction period. After this, the density increases, rapidly at first and then more slowly, and eventually further time in the developer produces no more density until fog starts. For the simplest case of a developer and emulsion in which there is no tendency to produce fog on prolonged development, and in absence of much free bromide, the relation between density and development time is

$$D = D_{\infty}(1 - e^{-kt})$$

in which D is the density which has been developed at a time t, Dm is the density ultimately developable and k is a constant—the velocity constant of development.

From this, the law of constant density ratios is deduced: if a film which has had a series of increasing exposures is developed, the ratio of the densities caused by any two exposures is constant and independent of development time. Other aspects of development are dealt with under Sensitometry.

After-Processes. — *Fixing.* — Afterdevelopment, the emulsion is "fixed" by dissolving out the unchanged silver halide. The commonest fixing baths are water solutions of sodium or ammonium thiosulphate (known respectively as hypo and ammonium hypo). Potassium cyanide is used in the wet collodion process in photomechanical reproduction, since it readily dissolves silver iodide, but it is extremely poisonous and is not desirable for bromide emulsions.

When a negative or print is transferred to the fixing bath, it carries some developer with it. This may oxidize and cause stain, which may be prevented by adding sulphite to the fixing bath. The alkali carried over in the developer may cause development to continue in the fixing bath and also tends to assist oxidation of the developer. Acid is therefore added to neutralize the alkali. Thiosulphate, however, is unstable in presence of acids and will deposit sulphur. This can be prevented by presence of sulphite. A simple acid-fixing bath, therefore, contains thiosulphate, sulphite and a weak acid, such as acetic.

In order to prevent softening of the gelatin, hardeners may be added, and the result is an acid-hardening fixing bath. The commonest hardeners are potassium and chrome alums, and their hardening ability is facilitated by the acidity of the bath. When the acidity of a potassium alum fixing bath becomes too low, a sludge of basic aluminum sulphite forms; but this tendency can be diminished by adding boric acid.

Stop baths or rinse baths are sometimes used between development and fixing, in order to neutralize the alkali carried over. A simple water rinse is better than nothing, but a weak acetic acid solution is preferred. Sometimes a hardening bath containing chrome alum is used prior to fixing, especially in hot weather. In order to depress swelling of the gelatin, sodium sulphate is sometimes added to the stop bath. As a special hardener for emulsions after fixing and before special later treatment, a bath containing formalin and carbonate is used.

The rate at which a fixing bath acts depends largely on the concentration of hypo and the temperature. It is most rapid at 20–40% concentration. The optimum temperature lies between 60° and 70° F. Agitation also increases the fixation rate somewhat. A practical rule for fixing is that it should be continued to twice the time taken for the film to clear, and still longer in the case of prints. Use of a second fresh bath is preferred.

Washing. — Negatives and prints are washed after fixing in order to remove products which might affect their appearance or stability, and in particular to eliminate the fixing salts and the compounds they formed in dissolving the silver halides. If the silver compounds are not removed, there will be stain in the highlights and unexposed areas, while if the thiosulphate and its products are not removed, there will be slow sulphurizing of the image on keeping.

In washing, the basic factor is the rate of diffusion of the hypo and other salts out of the film and into the water, provided the water in contact is continuously renewed. The removal is exponential. *i.e.*, the amount of salts remaining in the gelatin is halved for each equal period of' time. Removal of salts is more rapid the higher the temperature. but the temperature is limited by the danger of softening the gelatin, and 60°–70° F. is best. Washing is more rapid if no hardener is used than if a potassium alum hardening fixing bath is used, although chrome alum hardening has little eifect.

Washing of prints is slower than of negatives, because the paper fibres offer much resistance to the removal of the salts. It is very difficult to remove the last traces of hypo from paper by washing, and if in the interest of permanence the last traces must be eliminated, recourse must be had to chemical agents. Alkaline solutions will assist the removal, but it is preferable to use hypo-eliminators which convert the last traces of hypo to sulphate which does not affect the image. An effective solution contains

hydrogen peroxide and ammonia.

Drying.—After washing, negative materials are usually dried in moving, moderately warm air, after removal of surface moisture by blotting, wiping or squeegeeing. Prints on paper can be dried at higher temperatures, and in the case of large-scale photofinishing this is usually done on heated revolving metal drums, which may also give gloss to the prints if they are put emulsion side to the polished metal surface.

Reduction and Intensification.—"Reduction" in photography refers to methods of decreasing the density or contrast of an image by chemical means, while "intensification" involves processes for increasing density or contrast.

Photographic reducers are actually oxidizers in the chemical sense, and convert some of the silver into a soluble compound. They are divided into three classes according to the way in which they affect density and contrast:

(1) *Subtractive* or cutting reducers remove equal amounts of silver from all densities. The proportion of silver removed is thus greater the lower the density, and the effect is that of increasing image contrast. The reducers are used for overexposed negatives and for reducing fog density, and the most-used formulas contain potassium ferricyanide and hypo (Farmer's reducer), or potassium permanganate and sulphuric acid.

(2) Proportional or true-scale reducers remove silver in proportion to the amount present, thus reducing the contrast of the negative. They are used with correctly exposed but overdeveloped negatives, and a typical formula contains potassium permanganate, persulphate and sulphuric acid.

(3) Superproportional reducers remove a greater proportion of silver from the higher densities than from the lower, thus reducing the highlights without affecting the shadow detail. They are used with overdeveloped negatives of contrasty subjects. The formulas contain potassium or ammonium persulphate and sulphuric acid.

Photographic intensifiers increase the density of the image by deposition of some other substance such as chromium, silver or mercury compound on it, or by toning it. They may also be roughly divided into three classes according to the results they give:

(1) Proportional intensifiers are the most common and useful types. Best known are the chromium intensifier, in which the silver image is bleached in a solution of bichromate and hydrochloric acid and redeveloped in elon-hydroquinone, the silver being reinforced by a chromium compound; the silver intensifier, in which silver is deposited directly on the image from a solution containing silver nitrate, sulphite, hypo and elon, and Monckhoven's mercury intensifier in which the image is bleached with mercuric chloride and potassium bromide, and blackened with silver nitrate in cyanide solution.

(2) *Superproportional* intensifiers have a solvent or other inhibiting action which tends to prevent increase in the lower densities. Examples are the Monckhoven intensifier with a slight excess of cyanide in the redeveloper, or a mercury bromide bleach with a sodium sulphite redeveloper.

(3) Subproportional intensifiers do not fully intensify the intermediate and higher densities. Typical are the uranium toner containing uranium nitrate and potassium ferricyanide, and the chromium intensifier in which bleaching or redevelopment is incomplete.

A very effective intensifier which gives the greatest known degree of intensification of very weak images on fast negative films contains quinone and hypo.

Toning.—The colour of the photographic image can be modified by toning. The normal colour is black or gray, but by modifying the size of the silver particles by special development or other treatment, the colour can be changed, usually to brownish, olive-green, blue or purple. If fine-grain silver images tend to have a "warm" tone, it can frequently be made "cold" by adding certain organic chemicals called blue-black addition agents to the developer.

Toning can be effected by a change in the chemical composition of the silver image. In the days of print-out papers, it was customary to replace the silver of the image by gold by using a bath containing gold chloride and thiocyanate, and modern printing papers can be toned to brown by gold solutions.

Brown, purplish and reddish tones may be obtained by converting the silver into silver sulphide, selenide or telluride. sulphide toning may be direct, in which case the photograph is converted by direct bathing in a solution containing colloidal sulphur or polysulphide, or indirectly, in which case it is first bleached to silver chloride or bromide, which is then acted upon by sodium sulphide solution. Selenium or tellurium dissolved in sulphite or sulphide will tone directly, or the indirect method may be used.

Many coloured metallic salts will be precipitated by the silver image and tone it. In conjunction with ferricyanide, copper and uranium salts give red and brown tones, and iron compounds give blue.

Dye images may be obtained by the methods of coupler development used in colour photography, in which an image of silver halide (obtained by bleaching a silver image if necessary) is developed with the special developer in presence of a coupler (see Colour Photography). They may also be formed by the methods of dye toning in which the silver image is converted into a mordant, such as silver iodide, silver ferrocyanide or a mixture of silver and uranium ferrocyanides, to which the dyes attach themselves.

Sensitometry.—Sensitometry strictly refers to the measurement of the sensitivity of photographic materials, but in practice it includes the measurement of all the factors which go to making a photographic image. The first quantitative measurements of the action of light on photographic materials were made by W. de W. Abney in 1874. He measured the transparency of the image and demonstrated that within limits it varied inversely as the logarithm of the exposure.

In 1890 F. Hurter and V. C. Driffield published a paper, "Photo-Chemical Investigations and a New Method of Determination of the Sensitiveness of Photographic Plates," which laid the foundations of modern sensitometry. They studied the relation between exposure, development and the silver deposit resulting and defined density, D, as the logarithm of the opacity, O, which was defined as the reciprocal of the transparency, T. Thus, if a light of intensity I fails on a photographic deposit, and I is transmitted, then

$T=I'/I$; $O=1/T=I/I'$ and density D =log I/I' or $-\log I'/I$.

The following table shows the relation between a few values of transparency, opacity and density:

Transparency	Opacity	Density
1/2		0.301
1/4	4	0.602
1/8	8	0.903
1/10	10	1.0
1/100	100	2.0
1/1,000	1,000	3.0

The density of the silver deposit in many cases is approximately proportional to the amount of silver per unit area. A density of 1.0 is given by about $\frac{1}{10}$ mg. of silver per square centimetre of film area.

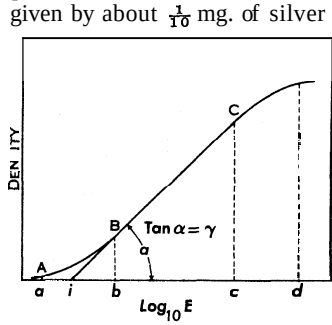


FIG. 5.—CHARACTERISTIC CURVE OF AN EMULSION

The relationship between density and the logarithm of exposure was first shown by Hurter and Driffield in what they called 'the characteristic curve. As light source they adopted first the standard candle and later the pentane lamp. Exposures were made in an increasing series of steps in a sensitometer using a rotating disk in which successively increasing angular apertures had been cut, and the density of the final plates was measured in a visual photometer. This curve is the basis of modern sensitometry. (See fig. 5.)

The characteristic curve has three fairly well-defined portions:

an appreciable part of the curve for most materials is a straight line, B to C, known as the region of correct exposure, because the exposure values rendered on it are directly proportional to the brightness values in the subject; in the lower and upper portions of the curve, this proportionality does not exist, and they are known respectively as the underexposure region or "toe" (A to B), and the overexposure region or "shoulder" (C to D).

The chief use of the characteristic curve is in determining the sensitivity or speed of a film, plate or paper, the contrast, the latitude of exposure and the manner in which tones will be reproduced. The curve must be made under carefully controlled conditions involving. a source of light giving radiation of known intensity and spectral quality; a modulator by which a series of graded exposures of known values are produced; standard development conditions; a means of accurately measuring density; a method of interpreting the results.

Many light sources have been proposed, but that adopted internationally in 1928 was a tungsten filament electric lamp operated at a colour temperature of 2,360° K., and screened with a filter (Davis-Gibson) of specified composition to give light having approximately the spectral quality of mean noon sunlight in Washington (5,400° K.).

The light source and the exposure modulator constitute the sensitometer. Exposures are made on a strip of the material either in a continuously increasing manner, or usually as a series of steps. The change in exposure through the series mag be made by changing the intensity of light or the time of exposure, and sensitometers are therefore either intensity-scale or time-scale instruments. A typical intensity-scale sensitometer is a step tablet or optical wedge consisting of a series of areas having precisely known light transmissions, or a continuously graded transmission. A typical time-scale sensitometer consists of a series of slots of known lengths, cut in a plate which falls past or is rotated in front of the material being exposed.

The exposure may be intermittent, *i.e.*, in a series of short times which add up to the desired total time, or continuous. The early sector wheel sensitometers gave intermittent exposures, for they were rapidly rotated in front of the material. Continuous exposures are to be preferred, however, because the photographic material does not add up the separate short exposures properly for normal frequency of intermittency. This is the so-called intermittency effect.

Since subjects photographed vary in brightness and negatives vary in transmission, and one time of exposure is given in the camera or in printing, the best sensitometers should be of the continuous-exposure intensity-scale type, and the exposure time should be roughly equal to that which would be given the material in use.

Development of the exposed strips is carried out in a standard developer or in the developer recommended for use with the particular material, for the desired time, at a standard temperature, usually 68° F., and under conditions of agitation which will ensure uniformity and reproducibility.

Density is measured in a densitometer, and in accordance with the definition established by Hurter and Driffield. The early densitometers were of the optical bench type using the inverse square law, but in more recent instruments the intensity is controlled by polarizing devices, as in the Martens photonieter, or by variable apertures. Some densitometers are comparators in which the density is compared with one which has already been calibrated on another instrument. Many instruments use photoelectric cells in place of the eye for the measurement.

When light passes through a negative, some of it is scattered or diffused, while some passes straight through and is said to be specular. If all the light, diffused and specular, which passes through is collected and used in the measurement, the density obtained is called the diffuse density. If only the light passing directly through is measured, the density is said to be specular density. The diffuse density is higher and is related to the other by Callier's Q factor, which increases as the density is lower. and also depends on the type of emulsion. The value may range from one to almost two. Most densitometers have a diffusing glass in contact with the negative and the readings are of diffuse density. The most satisfactory and reproducible diffusing medium is an integrating sphere.

Developed materials generally show a very slight density in parts which have not been exposed, and this is known as fog. Some fog is inherent in the emulsion, and some is caused by the development conditions and increases with time in the developer. Any density read also includes that caused by fog. In order to find the density caused by the exposure alone, it is customary to measure the density caused by fog on an unexposed area and subtract it, or make other correction for it.

In the case of prints on paper, the densities must be measured by reflected light, and the definition of reflection density is analogous to that for transmission density. If D_R is the reflection density, and R is the ratio of the light reflected by the paper to the light reflected by the image on it,

$$D_R = \log 1/R.$$

Characteristic curves are drawn by plotting the densities against the logarithms of the exposures which produced them (see fig. 5). If the straight line BC in the figure is produced to meet the exposure axis, it cuts it at a point i, which Hurter and Driffield called the inertia, and at an angle designated as α. This angle is of great importance; and its tangent, that is, the slope of the line BC, was called by Hurter and Driffield gamma (the Greek letter γ). It is frequently used as a means of expressing contrast, but it must be realized that it refers only to the straight-line portion of the curve.

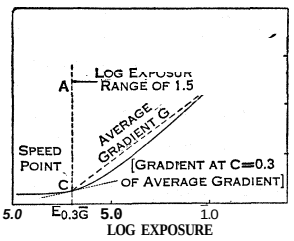
The projection of the straight-line portion of the curve (BC) onto the exposure axis, at the points *b* and c, is called the latitude and is expressed in log E or exposure units. It represents the exposure range over which there is strict proportionality between density and log exposure. The total scale of a negative, on the other hand, represented roughly by the distance a to *d* on the log E axis of fig. j, denotes the whole exposure range within which the material can represent a brightness difference in the subject by a density difference in the negative. In most negative materials the total scale is much larger than the brightness range of most scenes.

As the time of development increases, the slope of the characteristic curve increases. Hurter and Driffield found that with a bromide-free developer, the inertia points for curves for different development times coincided. In other words, inertia was independent of development time and was therefore a very significant constant. Hurter and Driffield, therefore, used the inertia as a basis for a method of expressing speed. So-called "H. and D. speeds" were obtained by dividing the exposure corresponding to the inertia point into 34, a value which was arrived at empirically. Later, other people used other numerators, and the inertia method was used for many years. Unfortunately, it does not hold that with all emulsions and different developers the straight-line parts of the curves will intersect at the inertia, and the inertia method has fallen into disfavour.

Some methods proposed for estimating speeds did not rely on the characteristic curve, but on estimating the exposure which corresponded to a just perceptible density — the threshold density. Such methods included those which used the Eder-Hecht wedge, and the Scheiner method using a rotating sector wheel. A modification of the threshold method was the German DIN system, in which the speed was derived from the exposure required to give a density of 0.1 higher than the fog.

Since the function of the photograph is to reproduce brightness differences in the subject as density differences, it is logical to conclude that speed systems should not be based upon a single density. The idea that they should be based upon a gradient in the underexposure part of the curve, rather than upon a single point or density, was first proposed by R. Luther and later developed by L. A. Jones. It was applied first for Kodak speeds and later adopted by the British and Americans as standard. In the system, it is assumed that negative film speed should be based on the least exposure to give a negative from which prints of excellent quality can be made. On the basis of a statistical

study of print quality, the standard for measuring speeds was selected, based on the exposure, E, in the toe of the characteristic curve where the gradient is 0.3 of the average gradient over a log exposure range of 1.5. (See fig. 6.) Speed= 1/E.

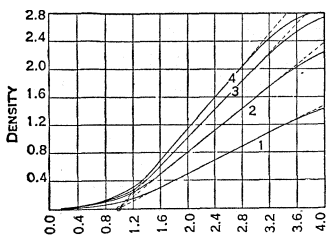


BY COURTESY OF KODAK RESEARCH LABORATORIES

FIG. 6.—ESTIMATION OF SPEED BY FRACTIONAL GRADIENT METHOD

The term speed actually refers to an inherent property of the film itself, whereas in practice the number used should take into account the exposure latitude, the type of exposure meter and the technique by which it is used and so on. Instead of film speeds, therefore exposure indexes based on the speeds have been worked out for practical use. Exposure index

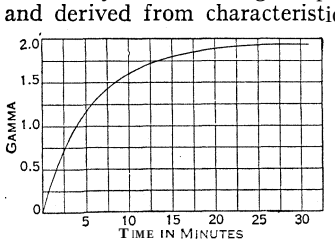
It has already been mentioned that as development time is increased, the slope of the characteristic curve, or the gamma, increases. A typical series of curves is shown in fig. 7. Ultimately, further increase in development time results in no further increase in contrast, and the maximum obtainable is known as gamma infinity (γ_∞). If gamma is plotted against time of development, a rate-of-development curve or a time-gamma curve is obtained, similar to that in fig. 8. The curve describes the rate of change of development with time, showing that it increases rapidly at first and then gets slower until it reaches a limit. The limit reached depends on the developer and on the emulsion, being lowest for the high-speed materials and highest for the very slow materials used for photomechanical reproduction.



BY COURTESY OF KODAK RESEARCH LABORATORIES

FIG. 7.— CHARACTERISTIC CURVES OF FILM FOR FOUR TIMES OF DEVELOPMENT. THE TIMES INCREASE IN THE ORDER 1, 2, 3, 4

The sensitometric characteristics of printing papers can be described by a series of figures parallel to those used for negatives, and derived from characteristic curves obtained by plotting reflection densities against the logarithms of the exposures. The most important constants of a paper are the *exposure scale*, which is determined by limiting exposures in the high and low density regions of the curve, the *density scale*, which is the difference between the densities corresponding to these two limiting exposures, and the *useful maximum density*, which is the density corresponding to the upper limiting exposure. The speed values of photographic papers are based on a gradient, as in the case of negatives, but it is at the limiting exposure in the high density part of the curve.



BY COURTESY OF KODAK RESEARCH LABORATORIES

FIG. 8.—CURVE SHOWING INCREASE OF GAMMA WITH TIME OF DEVELOPMENT

The contrast of a printing paper is a difficult thing to define, since it involves both psychological and physical considerations, but it has been expressed in terms of sensitometric characteristics.

Increasing the development time of papers mainly increases the effective speed in the case of chloride and chlorobromide papers, since gamma infinity is reached very rapidly, but with bromide papers, increased development increases both average gradient and speed.

An important factor is the *failure of the reciprocity law*. The law itself was first enunciated for photochemical reactions, and stated that the result of the action of light depends on the product of the light intensity and the time of action, and not on the individual values of either. W. de W. Abney found that it does not hold in the case of photography that the density resulting from an exposure E is independent of the absolute values of I and t, where $E=It$. Generally, the curve relating density to intensity for constant It has a maximum, as shown in fig. 9. The extent of the failure varies with the emulsion, the sensitizing, the nature and extent of development and other factors. It may have much practical significance in the case of the very long exposures used in astronomy, or the very short bright exposures of some flash tubes. An effect closely associated with the reciprocity law failure is the *intermittency effect*.

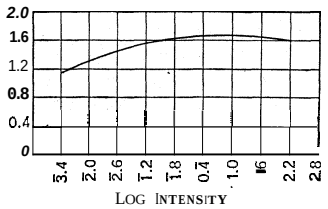


FIG. 9.—GRAPH SHOWING RELATION BETWEEN DENSITY AND INTENSITY " BEING CONSTANT

In addition to their sensitometric characteristics, photographic materials differ in *graininess* and *resolving power*. Graininess refers to the visual appearance of inhomogeneity in a developed photograph. Many methods have been proposed for measuring it, depending largely on visual observation of conditions under which it will just disappear, or comparing it with a set of standards. Measurements have also been made by physical means of *granularity*, which is the objective aspect not involving the psychophysical factors encountered in visually judging graininess. Graininess depends on a variety of factors. It is generally more noticeable in fast emulsions than in slow, it depends on the nature of the developer and it increases with time of development or contrast, and with the density of the image, reaching a maximum at a density of 0.6–0.8. In prints, graininess increases as the density of the negative increases.

Resolving power is defined by its ability to distinguish fine detail in the photograph. It is usually expressed as the number of lines per millimetre which can just be separately distinguished in the photograph. In general, the resolving power increases as the emulsions are of lower speed and higher contrast. The values range from 40–50 lines per millimetre for fast negative emulsions, through 80–100 lines for positive types of film, to several hundred lines for some special, slow, high-contrast materials. The values depend also on the contrast of the image photographed, the spectral quality of the exposing light, the density of the image, the turbidity of the emulsion and other factors. In practical photography, the combined resolving power of a lens and film combination is lower than that of either the lens or the film.

The simplest emulsions respond only to ultra-violet, violet and blue light, but by dye sensitizing they can be made to respond to other wave lengths. In measuring the *spectral sensitivity* of an emulsion it is customary to trace the curve showing its response to different wave lengths of a source of a particular spectral quality, or to an ideal source in which the energy is assumed to be the same at all wave lengths. The response to a particular source, such as a tungsten filament lamp, is frequently measured in a wedge spectrograph, which is a spectrograph in which the sample is exposed, and having an optical wedge over the slit, so that the photograph of the spectrum obtained will vary in height at any wave length according to the response of the material to the light source at that wave length. For equal-energy spectral sensitivity measurements, characteristic curves of the material are made for a series of narrow wave-length bands isolated in a spectroscope, and from the curves the sensitivity values for equal energies at all wave lengths are deduced and plotted against the wave lengths.

Tone Reproduction. — The basic problem of photography is to make a reproduction which will produce in the mind of the observer the same sensations as were produced by viewing the original scene. At least, it is important to represent satisfactorily the brightness aspects of the original on a paper surface. There are two major aspects of the problem. One of these is the objective phase, in which by physical methods it is possible to determine the fidelity with which the brightness and brightness differences in the original subject are rendered in the reproduction. On the other hand, the faithfulness with which the appearance of the original is reproduced involves psychological factors, and this is the subjective phase of the problem.

The quality of the reproduction of tone obtained in a two-stage negative-positive process depends on a variety of factors,

including the intensity of the light from the subject, flare light in the camera, the spectral sensitivity, exposure, development and shape of the characteristic curve of the negative material, the type of printer or enlarger and flare light in the enlarger, the exposure, development, shape of the curve and kind of positive printing material and the method of viewing the final photograph. The tone-reproduction problem has engaged the attention of many photographic workers, and complete studies have been made by L. A. Jones (see C. E. K. Mees, The Theory of *the Photographic Process*).

PHOTOGRAPHIC MANUFACTURE

Before the introduction of the dry plate, photographers made their own materials. In 1873 there appeared in England the first advertisement for a gelatin emulsion ready for use, and the first coated plates were placed on the market in England. In 1880 Eastman marketed plates in America and manufacture began on the continent.

The manufacture of photographic materials is now a large and specialized industry, and the distribution of its products is one of the world's big businesses. Until 1900 small factories under the control of their founders produced most of the sensitive products, but modern manufacture is largely organized in factories operating on a big scale.

The three chief photographic sensitive materials are plates, films and papers, and in each case three main manufacturing operations are involved — preparation of the base or support, manufacture of the sensitive emulsion and coating of the emulsion on the support. In addition, there is the cutting to shape and the packing.

Preparation of the Support. — Glass Plates. — The support of plates is glass sheets which are chosen from the higher grades of sheet glass made for various purposes. It is selected for reasonable optical flatness and freedom from blemishes. It is cleaned by brushing in alkaline solutions in special machines, and is then coated with a substratum, *e.g.*, of a weak solution of gelatin containing chrome alum, which will cause the gelatin emulsion to adhere to the glass. It is then dried, examined to reject defective sheets and passed to the coating room. The thickness of glass for plates increases with the size, and ranges from about 0.05 in. to 0.125 in.

Film Support. — Film support or base consists of a transparent, thin layer of cellulose nitrate, acetate or mixed esters, free from cloudiness or other optical defects. In general, it ranges in thickness from $3\frac{1}{4}$ thousandths of an inch for roll film, through $5\frac{1}{2}$ thousandths for motion-picture film, to $\frac{7}{8}$ thousandths for sheet and X-ray film. It is coated as a layer of viscous liquid called dope on a continuously moving smooth surface on which it sets and from which it is stripped and dried.

Cotton in the form of linters, which are the short fibres remaining on the cotton seed hull after the long fibres have been removed, is the source of cellulose for film base. It is first mechanically cleaned to free it from dust, mechanical particles, etc., and then degreased by heating under pressure with dilute alkali. It is then washed and bleached, treated with dilute acid to remove the last traces of bleaching solution and iron and washed again. The water is centrifuged off, and the cotton is conditioned to a low moisture content.

To form nitrocellulose with the correct properties, the cotton is nitrated with extreme care in a centrifuge, in a mixture of sulphuric acid, nitric acid and water, to give a product with about 12% nitrogen. It is then centrifuged thoroughly, washed extremely carefully and treated with dilute alkali to remove last traces of acid, bleached, washed again and dehydrated with alcohol.

To form cellulose acetate, the cotton is treated with acetic anhydride and acetic acid in the presence of a catalyst, usually sulphuric acid. The product is cellulose triacetate which can be precipitated out with water, and has an acetic acid content slightly under the theoretical value of 62.5%. To produce the variety for common safety film base with a lower acetic acid content, the product is hydrolyzed with water, sulphuric acid and other reagents. The acetate is thrown out of the solution by adding water, centrifuged, washed and dried. Nitroacetate, which has been used for film manufacture, is made by acetylating cellulose nitrate.

In order to convert the cellulose nitrate or acetate into film base, it is dissolved in suitable solvents. In the case of the nitrate, typical solvents may be methyl or ethyl alcohol and ether, or methyl alcohol and acetone, with a third material, such as amyl alcohol, to reduce the rate of evaporation of the solvent on drying. The solvents for cellulose acetate vary according to the method of preparation, but among those used are methyl acetate, methyl formate, methyl ethyl ketone, chlorohydrocarbons, amyl acetate and others. It is also common to add a nonsolvent for cellulose acetate, such as alcohol and water, to control evaporation of the solvent.

In addition to the solvents, softeners or plasticizers are added to give flexibility to the final film. For nitrate base, the softener is largely camphor, and for acetate base there is a large variety, *e.g.*, esters of phthalic acid, mono-, di- and triacetin, sulphones and sulphonic esters. The solutions are prepared in proportions suitable for coating, filtered and bubbles of air are removed. They have the appearance of clear honey and are called dope.

To form the film base, the dope is spread out into a thin layer by coating it onto a smooth travelling surface. In the United States, it is usually done on big wheels, approaching 20 ft. in diameter, with optically finished rims 4–6 ft. wide on which the dope is spread as the wheel rotates, and in Europe the coating is mostly made on endless metal bands about 26 in. wide and 40 ft. or more long, and sometimes coated with gelatin. After the band or drum has made almost one complete revolution, the film has set to such an extent that it can be continuously peeled off and passed over a series of heated drums until it is finally wound up in rolls of about 2,000 ft. The coating machines are completely enclosed so that the evaporated solvents may be drawn off and recovered. Special coatings or treatments may be applied to the film base, for instance, to modify its tendency to curl, to reduce the formation of electrical charges on handling, to change the colour, etc., and particularly to enable the emulsion to stick.

Cellulose acetate film is called safety film, since it is slow burning, presenting about the same fire hazard as common newspaper. It is used exclusively for amateur and educational motion-picture film, X-ray and portrait films and is coming into use for films for other purposes. Cellulose nitrate film is highly inflammable, but, at least until recently, it possessed a number of advantages over acetate film and was used where proper precautions against fire could be relied upon.

Paper Base. — Photographic paper base is generally made in mills which specialize in its manufacture. It is generally made from rag stock or specially prepared wood pulp. The methods of manufacture are similar in general to those used for other papers, but extreme care is taken to exclude traces of impurities, and especially of metals such as copper and iron from the paper stock. The composition of the paper and its treatment varies according to the purpose for which it is to be used. It is appropriately sized, and it must have high wet strength, for it has to undergo much handling while soaked with water and alkaline and acid solutions. It is generally made about 41 in. wide and 500–1,000 yd. long. It is calendered to give a closer texture or smoother surface or to give a special surface finish.

Before it is coated with the emulsion, photographic paper is usually baryta-coated, *i.e.*, a suspension of baryta (barium sulphate) in gelatin is coated over the surface; and if a high gloss is needed, the paper may be calendered after coating with baryta.

Emulsions. — Emulsions are of two main types, used for negative materials and for positive materials, generally printing papers. Negative emulsions consist of suspensions in gelatin of silver bromide containing a small amount of silver iodide, and the soluble salts which result from the precipitation of the silver halides are removed by washing. The emulsions for paper may also consist of silver bromide in gelatin and be washed, but usually printing paper emulsions consist of silver chloride or a chloride and bromide mixture in gelatin and not washed.

In making negative emulsions, silver nitrate is run into a solu-

tion of potassium bromide containing a small percentage of potassium iodide, and a low percentage of gelatin. The temperature, rate of addition and stirring are controlled, and the mixture is ripened in the presence of excess bromide at an elevated temperature, or of ammonia at a lower temperature, until the silver halide crystals have attained the required size and size distribution. More gelatin is then added, the emulsion is set to a jelly by cooling, cut into shreds and the shreds washed in cold water. The washed emulsion is then melted again, more gelatin added if necessary and the whole is digested by maintaining it at a moderate temperature during which period contrast and speed build up. Sensitizing dyes are added if required, and finally special additions to preserve the emulsion, to keep down fog and to aid in coating are included.

In making paper emulsions, chloride or a mixture of chloride and bromide are most used, most of the gelatin is added before precipitation and the emulsion is unwashed. Some of the high-sensitivity bromide papers used for enlarging are made with washed emulsions similar to those made for slow negatives or for motion-picture positive film or lantern slides.

There is one type of paper, which is now used only for making proofs by directly printing-out the image in sunlight or mercury light, which is also unwashed, and in which the silver salts are a mixture of chloride and citrate.

Coating.—Plates are coated with emulsion by passing the cleaned and prepared glass sheets, on a horizontally moving belt, under a device which permits the melted emulsion to spread out in a uniform layer on the glass. The coated plates pass to a cold moving belt or set of rollers where the emulsion sets, and at the end of the machine they are placed on racks and dried slowly and evenly in cabinets. When dry, they are cut to the required sizes by machines provided with diamonds, and packed with specially prepared interleaving paper in boxes for the market. Sometimes a special antihalation coating is applied to the back of the glass.

A great variety of plates in a wide range of sizes is made. For much photography there has been a tendency for sheet film to replace glass plates, but plates are much used in the graphic arts, commercial photography, for colour separation negatives, lantern slides, photomicrography, and in a great range of speeds, contrasts and spectral sensitivities for astronomy and spectroscopy.

Film and paper may be coated on the same type of machine. The roll of support, usually 42 in. wide and about 2,000 ft. long, is led over a series of rollers which keep it taut, into a coating trough or other device where a layer of emulsion is applied to it, the thickness depending an the temperature, viscosity and rate of travel. The coated base passes into a vertical run-up, where the emulsion coating evens itself out, or over a chill roll and then into a cold chamber where the emulsion is thoroughly set. The film or paper is then automatically looped into festoons varying from 5 to 20 ft. in length, and travels slowly through drying tunnels supplied with cleaned air of properly adjusted temperature and relative humidity. The dried film or paper is continuously reeled up into rolls of appropriate length and is then sent to the finishing departments.

In the case of many films, the back is coated with a layer containing dyes, which are destroyed or removed in processing, to prevent halation and sometimes to prevent curl. Special coatings may be applied over the emulsion in films and papers to prevent abrasion marks. Some motion-picture films are coated on a support carrying a nonremovable dye to reduce halation.

In modern films for colour photography, many separate coatings may have to be applied, for instance, there may be three emulsions responding to blue, green and red. with separating or filter coatings between them, and in addition antihalation coatings on the back.

Motion-picture film is slit from the roll in 35-mm. or 16-mm. width and is perforated for camera or projector use with standard perforations. It is edge printed with the maker's name and other marks in such a way that they become visible on development, and footage numbers are printed in the case of 35-mm. negative film, to aid in editing. Professional motion-picture film is packed in a variety of lengths, but mostly in 100-, 200-, 400- and 1,000-ft. lengths. The 16-mm. film is generally wound on metal spools in 100- or 50-ft. lengths and provided with leader for daylight loading, or in special magazines. Thirty-five-mm. film for miniature cameras is spooled in special cassettes in lengths for 18-, 20- or 36-exposures.

Roll films are slit from the full coated rolls in the required widths and lengths, usually for six or eight exposures, and wound on metal spools with light-impermeable backing paper so that they may be handled in daylight. Sheet films are cut in sizes comparable with plates and packed in a similar manner. In the case of film packs, the sheets are attached to black paper sheets carrying numbered tabs and inserted in groups of 12 in metal holders. For X-ray photography, film is usually coated on both sides with emulsion, and individual sheets are put into special light-tight envelopes.

Photographic paper is cut from the roll into sheets which are stacked and cut to the desired sizes by a guillotine, wrapped in black paper and boxed.

All plates, films and papers are carefully inspected at various stages during manufacture to ensure the minimum of defects, and all wrapping and packaging materials are carefully selected so that they will not have any adverse effect on the emulsion. For the tropics, special packaging methods are used which will not permit moisture to enter the containers.

APPARATUS

The most important piece of photographic apparatus is the camera, in which the photograph is made. Next is the equipment for printing and enlarging. The other important items are the apparatus for lighting the subject and that for handling the material in processing. There are large numbers of accessory apparatus. Of these may be mentioned the supports for the camera, filters, range finders, exposure meters, the special equipment for darkrooms and the devices for storing and viewing photographs. Lenses are dealt with later in this article. For detailed discussion of the historical development of photographic equipment, the reader should refer to some of the works listed in the bibliography of this article, particularly those by C. Fabre, J. M. Eder and K. Pritschow.

Cameras.—A camera consists of an image-forming device, which may be a pinhole but in practice is a lens; a shutter which permits light to enter the camera for a desired time; a holder for the sensitive material on which the photograph is to be made; a light-tight enclosure which carries the lens and material holder in their proper positions and prevents light not passing through the lens from falling on the material and a finder to show what is being photographed.

The camera is a direct descendant of the camera obscura, the principle of which was known to Aristotle, and was described by Leonardo da Vinci before 1519, and by Giovanni Battista della Porta in 1553. These were pinhole models, and the first description of the lens in the camera obscura must be accredited to Daniello Barbaro, in 1568. The early cameras were actually rooms, but later portable models were made and used for entertainment and as an aid to drawing. In 1826 Niepce made a photograph with a camera obscura equipped with a lens, and Fox Talbot and Daguerre established its use. The first commercially available cameras for photography were made by A. Giroux in Paris for Daguerre in 1839. They consisted of two wooden boxes sliding one in the other for focusing, a Chevalier simple achromatic lens, a pivoted metal cover to act as shutter, a ground glass back for focusing and a holder for the plates. Other models of cameras were quickly introduced, and the tripod was used in 1839 by Baron P. A. Séguier, who also introduced the collapsible bellows to make the camera more portable. To the same end, Peter Voigtlander made the camera conical in shape. The first panoramic camera was invented by F. von Martens in 1845.

Fox Talbot used simple cameras with telescopic boxes in his photography, and the construction was not much changed in the '50s when the wet collodion process was introduced, except that special holders were used for wet plates and the bellows was in common use. Wet plate cameras ranged in size from miniatures

taking plates about one inch square, to those taking very large plates of glass.

With the advent of the dry plates there was a demand for more portable cameras, because photography became easier for the general public. Plates for these were loaded into special single or double holders for use in the backs of the cameras. Sometimes 12 plates could be loaded in the back, a special device being provided for dropping them in the bottom of the camera after exposure, or magazines containing a number of plates could be used in the position of a single plateholder.

When paper roll film was introduced by Eastman in 1885, it was loaded into roll-holders which fitted on camera backs in place of the plateholders. In 1888 the Eastman company introduced the Kodak which was a simple box camera containing a roo-exposure roll of stripping film. This marked the introduction of modern amateur photography with roll film and the small hand camera. In 1889 the first transparent flexible roll film was marketed and many light-weight box and folding cameras were introduced for use with this type of film. In 1894 the roll film was packed with a roll of black paper to permit loading and unloading in daylight, and small cameras in box and folding form became popular. The first pocket Kodak was introduced in 1895 and the first of the collapsible cameras, the folding pocket Kodak, in 1898. The small cheap Brownie camera, originally intended for children, appeared in 1900. Later, sheet film instead of plates began to be popular in certain cameras of the plate type and the film pack was also introduced to provide a convenient magazine of sheet films for this type of apparatus.

Large studio portrait cameras were introduced in the wet collodion days. They had long focus lenses and from them were derived the later studio cameras taking dry plates and sheet film. Sturdy stands were used, adjustable for height and inclination and on casters to permit moving them easily. The cameras were generally of the square bellows type, with means for rapidly focusing by rack and pinion movements and with rising and falling fronts designed to carry heavy lenses.

The so-called field cameras were mainly intended for use outdoors on a tripod, for large groups, genre studies, landscape photographs and so on. The cameras were rigidly constructed, and had long bellows, rising and falling fronts and swing backs. Some had parallel instead of conical bellows, and they are still used in studios for copying.

With improvement in plates and films and facilities for enlargement, the use of large cameras tended to decrease. The small-sized pocket cameras increased in popularity, but there was developed an important group known as hand-or-stand or view cameras. They used relatively small plates, sheet films or film packs, had ground-glass focusing as well as focusing scales, long-extension bellows, rising, cross and swing movement for the front, swing, reversible and revolving backs and drop or swinging beds. They were the basic small cameras of great flexibility.

Small cameras were developed in the second half of the 19th century as instantaneous-hand-cameras or detective cameras, and in general they used lenses of short focal length with good depth of focus. Even in the wet collodion days, some were small enough to fall into the class now known as miniature cameras. Some of them were of the secret type, which could be concealed from the subject, *e.g.*, in the hat, vest or necktie, or had the form of some familiar object such as a book, satchel or pair of binoculars. Some cameras took the form of pistols or revolvers and used very small plates. The Skaife pistolgraph of 1360 was only $3\times1\frac{1}{2}$ in. in size over-all. These were the forerunners of the modern miniature cameras,

Early in the 20th century very small roll-film cameras, such as the Vest Pocket Kodak, were introduced and in 1914 there were brought out the first still cameras using 35-mm. motion-picture film. The new vogue in miniature photography did not develop until the '20s, however, being given a great boost by the introduction of the Leica in 1924. This camera had been designed by O. Barnack for testing motion-picture film. A wide variety of such cameras followed, and in general they used 3j-mm. film with pictures twice the normal motion-picture frame size, *i.e.*, 24×36 mm. in 18-, 20- or 36-exposure cassettes. The cameras were characterized by compactness. They had high aperture lenses of short focal length. and some had focal plane shutters and provision for interchanging lenses and coupled range finders. Special processing, printing and viewing equipment was made, films of fine grain permitted high enlargement of the small negatives and special colour films and projectors were made for use with the cameras.

Special cameras are used for press photography, many of them being based on the German Goerz-Anschiitz and the English Panros, which were introduced at the start of the 20th century. The most popular type in the United States in 1947 was the Speed Graphic. These cameras were designed for rapid use at eye level, and generally have focal plane shutters, large finders for rapidly viewing and composing the subject, means for rapidly opening and focusing them and, in modern models, range finders and flash lamp attachments.

In reflex cameras, it is possible to compose and focus the image to be photographed up to the moment of exposure. There are two forms. In that first developed (Sutton, 1860; Marco, 1883), a mirror inside the camera reflects the image to a ground glass on top, which is viewed through a collapsible vertical hood. The mirror is pivoted; and when the lever is pressed to make the exposure, the mirror is first urged out of the light path. The cameras usually have focal plane shutters, and folding types have been made. In the second type, called the twin-lens reflex camera, two similar cameras are in effect used, one above the other. The upper camera serves as the finder, while the lower carries the taking lens, shutter and film. In older forms of twin-lens camera the ground-glass focusing screen of the finder was in the rear, but in modern forms a reflex finder is used, a mirror reflecting the image to a focusing screen on top.

For panoramic photography, special cameras are used to cover the wide angles of view frequently involved. Panoramic photographs may be made with an ordinary camera by taking a series of pictures which slightly overlap, swinging the camera about the nodal point of the lens. In single cameras, the lens may be rotated about its optical centre while a curved film is scanned by a slit (Martens, 1845, Kodak), or the camera may be rotated about the centre point of the lens, the film being moved to compensate for the image movement. Such cameras are sometimes used for photographing large groups of people, or for wide landscape views.

Special cameras or attachments are used for stereoscopic photography. In principle, two photographs must be made from positions corresponding to the positions of the two eyes of an observer, and the prints must be viewed in such a manner that each eye sees only its appropriate view. Two successive views may be made from two camera positions, using a single-lens camera, but the most-used cameras are made with two lenses to make two photographs simultaneously. Alternatively, a single-lens camera may be provided with a beam splitter having two reflectors spaced at about the interocular distance apart, and giving two adjacent photographs on the normal picture area.

Shutters and Diaphragms. — The exposure in a camera is made by a shutter which is opened and closed to permit light to pass through the lens. The earliest shutters were hinged or pivoted metal plates by which the front of the lens could be uncovered and covered by hand. These, and the removable lens cap, could be used only where the exposures were rather long. With faster plates and shorter exposure times quicker-acting shutters were needed. The simplest was the guillotine or drop shutter which consisted of a wooden or metal plate with a hole in it, allowed to drop freely, or urged by a spring or rubber band, across the lens. In modifications of this, a second plate is provided to prevent light passing through the lens while the shutter is being set, or two plates with holes move in opposite directions, or the plates rotate rather than slide in a straight path. Modifications of some of these are still used on some cheap cameras. Varieties of flap shutter consisted of one or two hinged flaps opening outward. The roller-blind shutter has a blind with a fixed slit aperture, mounted in a frame and used behind or before the lens. The blind can be wound so that when it is released the slit passes rapidly across the lens, the speed being varied by changing the tension.

Two types of shutter were in common use in 1947: focal plane and diaphragm or between-lens shutters. In the focal plane type, a roller blind is used, having a single adjustable slit or a series of slits of different widths, one of which travels across the film to expose it. The tension on the blind and the setting of the slit are operated from outside the camera. The shutter operates just in front of the film—practically in the focal plane—and is capable of exposures as short as $\frac{1}{1,000}$ of a second. The common types of diaphragm or between-lens shutters have their blades arranged near the diaphragm between the lens elements. They usually consist of three or more thin blades which open out from and close into the centre of the lens. They are made to give a range of exposure times, in some cases from 1 sec. to a nominal $\frac{1}{500}$ sec., in addition to "bulb" in which the shutter stays open so long as the release is pressed, and "time" at which the shutter is opened when the release is pressed, and closed at any later time when it is again pressed. A spring provides the motive power to open and close the blades; and the time the shutter remains open is controlled pneumatically, or by gears and escapements.

Diaphragms, or stops, are apertures which control the amount of light admitted through the lens. They are arranged in front of the lens or between the elements, depending on the lens type. There are three main forms: Waterhouse stops, which consist of a metal plate carrying a single hole, and able to be inserted in a slot in the lens barrel; rotating stops, which are circular plates carrying a series of holes of different diameters, any one of which can be brought into position in the lens, and iris diaphragms, which consist of a series of overlapping leaves of metal associated with a rotatable ring to form an approximately circular aperture the size of which can be varied by turning the ring.

Finders.—Finders are important in that they show exactly what will be included in the photograph. In cameras which have a ground-glass focusing screen, the screen can be used to compose the picture as well as to focus it. In single-lens reflex cameras, in which the camera lens is used as the finder, the picture can be exactly composed on the ground glass to which the image is reflected. Most finders, however, are auxiliary to the camera. They are usually arranged on the top or side of the camera body, and view the subject from a slightly different angle from the lens. The errors introduced by this separation are reduced by putting the finder as close to the lens as possible, making the axes of the two intersect at about 15 ft. from the camera, and making the finder field smaller than the camera lens field. The errors will be apparent only in the case of very near subjects.

Finders can be divided into two general classes—reflecting finders and direct-vision finders. The simplest reflecting finder is a small camera with a simple lens, a mirror and a ground glass to which the image is reflected, reversed left to right. In the "brilliant" finders more commonly used the ground glass is replaced by a viewing lens. In twin-lens reflex cameras, the finder is essentially a duplicate of the camera, placed above it, and having a mirror which reflects the image to a ground glass where it can be composed and focused, the focusing mechanism being connected with that of the camera lens so that when the finder is in focus, the camera lens is in focus. Direct-vision finders are used close to the face. The simplest consists of a wire frame of the picture size arranged over the lens, and a peep sight behind in the plane of the film. In a more compact form, the aperture of the front frame is reduced in size and placed nearer the peep sight, the angle included remaining that of the camera lens. Direct-vision optical finders consist essentially of a reversed telescope, with a strong negative lens in front and a weak positive lens at the eye.

Range Finders.—Range finders are used in photography to measure accurately the distance of the subject from the lens. They may be separate from or attached to the camera and are small versions of those designed for military use. They are of the split-field and coincidence types. In coupled range finders, the range finder is mechanically coupled to the camera lens so that when a distance is determined in the range finder, the camera lens is automatically focused on that distance. The field of the range finder sometimes forms part of the full field of the view finder, so that it is only necessary to look through one eye lens to focus and compose.

Focusing Scales.—Cameras which do not rely on ground-glass focusing or coupled range finders are equipped with focusing scales. When the whole front of the camera moves in focusing, the scale is attached to the camera bed. If focusing is by rotating part of the lens, the scale is on the lens mount or shutter face.

Depth-of-Field Indicator.—Many cameras carry a table or circular slide rule which shows the distance range in focus for various distances on which the camera may be focused, and for various lens apertures.

Flash Attachments—In the early days, flash photographs were taken by burning magnesium ribbon, or by exploding a powder containing magnesium and an oxidizing agent, the camera shutter being opened before and closed after the burning time. Modern flash photographs are made by flash bulbs of glass containing wire or foil of magnesium and aluminum in an atmosphere of oxygen, or by condenser discharge lamps. They are fired electrically, and the circuit is closed when the camera shutter is operated. In one form, operating the shutter brings into play a solenoid which at the appropriate moment closes the battery circuit to the flash bulb. In the other form, the shutter itself is provided with a contact which closes the flash-bulb circuit as the shutter operates. Various settings are provided to be used according to the delay in the firing of the flash after the circuit is closed.

Exposure Estimation.—Experience gives photographers confidence in their unaided judgment of exposure, but for many people and in special circumstances, some guide is useful. *Exposure tables* are provided by most film manufacturers. They are reliable if carefully compiled. They usually give exposure times and lens apertures for the time of day, latitude, weather conditions, degree of light and shade and for various types of subjects. *Exposure calculators* are forms of slide rule in which the exposure can be calculated from the type of data given in exposure tables, the first important calculator being the Hurter and Driffield Xctinograph of 1888. A calculator was usually combined with the older chemical type of meter and is alnays included in the modern devices. *Chemical exposure nzeters or actinometers* depend on measuring the light value by a photochemical change, usually the time taken for a silver-chloride paper to darken to a standard tint, *e.g.*, in the Watkins and the Wynne meters, but the Hurter and Driffield Actinometer nas a form of differential thermometer which was used to provide the light values for the Actinograph. *Visual, optical* and *extinction exposure meters* are photometers in which (a) the brightness of a scene is compared with a calibrated lamp, the light from nhich can be modulated in a known way; (b) the scene is viewed through the instrument and a neutral density wedge is adjusted until shadow detail disappears or (c) a numbered or lettered step wedge is moved across the integrated light from the scene and the dimmest number or letter is taken as the basis for calculating the exposure. *Photoelectric exposure meters* measure the light by a barrier-layer type of photocell and a sensitive direct current meter. The meter readings are translated into exposures by using a calculator. These meters are used as illumination meters, which measure the light falling on the subject, and more generally as brightness meters, which measure the integrated light reflected by the scene, or the brightness of a particular part of it, the angle of view or acceptance angle being chosen to approximate that of the average camera lens. They are also used for determining exposures in contact printing and enlarging.

Light Filters.—(See also FILTERS, LIGHT). Filters are sheets of dyed gelatin or other plastic, coloured glass or other medium, specially designed to transmit particular regions of the spectrum and absorb others, or to absorb uniformly through the visible spectrum. There are many forms used in photography:

Correction (orthochromatic) filters are designed for use with panchromatic materials to ensure that the film-filter combination gives a photograph in which the tone values agree as closely as possible with those perceived by the eye. *Contrast filters* are used to enhance or subdue contrast in the reproduction of the subject, the principle being that to render a colour light in the print, a

filter is used which transmits that colour, and to render a colour dark in the print, a filter is used which absorbs that colour. *Colour compensating filters* are used with colour films to correct for variations in the colour of the light source or the colour response of tht film, to ensure good colour balance in the photograph. *Separation filters* are intended for use in two- and three-colour photography and in photomechanical reproduction in order to make the separation negatives for the printing process. *Monochromatic filters* transmit a narrow spectral band and are usually used in conjunction with a gaseous discharge light source. *Safelights* are filters designed for use with a specified lamp, to provide just enough light to see in handling plates, films and papers without fogging them. *Haze filters* decrease or eliminate the flattening influence of atmospheric haze. *Graduated filters* are made in such a way that the transmission varies over the area of the filter, the most used being the sky filter, which is yellow in the top part and graduates into clear in the lower part, and the neutral wedges or tablets, in which the light transmission varies along the length of the filter either stepwise or gradually. *Neutral density filters* reduce the photographic effectiveness equally at all wave lengths in the visible spectrum. *Special filters, e.g.,* for infra-red and ultra-violet photography. In addition to the normal types of filters there are special polarizing sheet materials (Pola-screens) which are used for subduing reflections and for special sky and other effects. Such filters are also made in combination with coloured filters.

Filters having the most precise spectral transmission and the best reproducibility are made from dyed gelatin sheet which may be used alone, coated with a transparent lacquer or cemented between glass or plastic sheets. Filters are also made of coloured glass, but they are not easily reproducible.

Most filters absorb some light, and in making photographs through them it is therefore necessary to increase the exposure by an amount which is known as the filter factor. In addition, filters can be made from coloured liquids or gases in special glass cells, but they are used only for special purposes.

Supports and Tripods.--When it is necessary to compose a photograph carefully, or when exposures longer than about $\frac{1}{25}$ sec. are to be given, it is necessary to use the camera on a rigid support. For commercial photography these supports may be of complex mechanical construction, permitting the camera to be used from near floor level to a great height above it, and to be tilted to any angle, and yet be quite steady. Portrait studio cameras are of sturdy pillar construction with means for rapidly raising and lowering the table on which the camera rests, and for moving rapidly about the studio floor. For general photography the tripod forms of stand are most used. They are made of wood, or preferably metal, and frequently have adjustable legs to permit folding or telescoping to increase portability and to allow them to be suited to uneven ground. The tripod top, or head, is generally flat and provided with a screw which attaches the camera by a special socket in its body: In flexible models, a second raised head can be used to give extra height, and there are means for rotating and tilting the head.

Auxiliary Camera Equipment.— Lens shades are used on the front of the lens to prevent as much light as possible not coming from the subject from reaching the front of the lens. Shutter operators with a pneumatic bulb or Bowden cable are used to operate the shutter at a distance. Changing bags are used to load plate- or film holders (or developing tanks) in daylight when a darkroom is not available.

Dark slides, or plate- and sheet-film holders, are used to carry plates or sheet films and to position them in the plane occupied by the focusing screen. They are provided with a draw-slide which makes them light-tight, but which can be withdrawn in the camera before the exposure is made. They take one or two plates or films, in the latter case back to back with a metal partition between. Film packs are used in special adapters which fit in the place otherwise used by dark slides, and are provided with draw slides. Roll-film adapters make it possible to use roll films in cameras made for plates and sheet film, and alternatively some roll-film cameras have plate or sheet-film adapters. Plate or sheet-film magazines contain 12 or 18 thin metal septums, each carrying a plate or sheet of film. After the front one has been exposed, it is transferred to the back of the group so revealing the next for exposure, the whole being done in the light-tight magazine.

Special Cameras.— Special cameras are designed for many of the particular applications of photography. They can not all be described here, but the following are a few of the important ones.

For photomicrography the cameras are of the conventional type using plates or sheet film, but they are arranged on special vertical stands or horizontal optical benches in conjunction with the microscope, filters, light source and a variety of attachments and adjustments for ensuring alignment.

For colour photography special cameras were devised to permit making three-colour separation negatives through three primary filters (see *Colour Photography).* In the simplest form, the negatives can be made by three successive exposures, changing the plateholder and filter three times. In repeating backs, the three filters mere placed in a row in front of a long plate or three separate plates in one holder which was moved through the camera back in three steps, one for each exposure. These are now obsolete and have given way to one-exposure three-colour cameras in which an arrangement of reflectors permits the three exposures to be made simultaneously. These cameras are used primarily for commercial colour photography but are being partly eliminated by the integral tripack films.

Cameras for copying in photomechanical reproduction may be large and complex. They may have to handle dry plates and film and wet collodion plates; provision is made for photographing through half-tone screens with means for varying the distance of the screen from the plate; precision lenses of long focal length are used and arrangements are made for changing filters. Some cameras have vacuum backs in which film is held flat by sucking it against a back-plate. Provision is made for accurately arranging parallelism of the plate or film and the copy, and special supports are used to eliminate effects of vibration. In copying cameras used for mapping, provision may also be made for correcting distortions by tilting the plate- or film-holder or the copy. Photocomposing cameras are available in which, through the operation of a keyboard, negatives of type face can be photographed on a roll of film in rapid succession, the material thus being actually composed photographically to give a negative from which a printing plate can be made directly. Composing backs are made in which a series of photographs of a number of pieces of copy can be made on one film or plate, properly arranged in relation to each other, thus composing a page of a variety of subject matter.

A wide range of cameras was made by 1947 for copying documents by microphotography on film. In the simple forms, negatives are made on 3j-mm. film in miniature cameras, but for work where large numbers of negatives of all kinds and sizes of subject matter are required, special cameras, with film and paper-feeding devices, special framing means and other refinements, are used. One of the most important developments in this field was the Recordak, originally brought out for the use of banks in copying checks on 16-mm. film, but later applied in both 16- and 35-mm. size to copying commercial documents, newspapers, drawings, large bound volumes and so on.

In cameras for photocopying, documents are photographed directly onto rolls of paper without using an intermediate negative, as in the Rectigraph and Photostat machines introduced in the first decade of the 20th century. Various scales of enlargement and reduction can be used, the lens carries a prism to invert the image and the photograph is white on a black ground. Automatic machines of this type are made in which the processing of the paper is also carried out. Automatic coin-operated portrait cameras are made, in which the subject is photographed on paper which is processed in the machine to give a direct positive picture.

Studio Arrangements and Lighting.— Photographic studios are provided with backgrounds, seats and properties to be selected according to the whim of the photographer and the nature of the subject. The most important studio materials, however, are those concerned with lighting the subject. In the earlier

days, daylight was used, controlled by drapes and reflectors. Mercury vapour lamps and carbon arcs were later employed; but since the introduction of fast panchromatic films, incandescent tungsten filament lamps are used in the main. Some carbon arcs are employed. and some fluorescent lamps for broad lighting, but the greatest flexibility is obtained with tungsten lamps. The lamps are used in special lamphouses or reflectors, which vary in the extent to which they concentrate the beam of light. Although good pictures may be made with one lamp, for flexibility several are needed. The number and arrangement of lights depends on the subject and the desired effect, but a typical arrangement for portraits consists of a key-light from the front, or partial front, a fill-light to illuminate the shadows, a backlight for use behind the subject and a background light to illuminate the background. Overvoltaged lamps of the Photoflood type came to be much used, especially by amateurs; for colour photography. lamps operating at a colour temperature of 3,200° K. are employed, and for general studio use high efficiency lamps of up to 5,000 watts are employed. The choice of reflector is very important.

For flash photography. flash bulbs are used in arrangements similar to the normal studio lights, although they are also much used at the camera position and on extensions from the camera synchronizer to other positions. Gaseous condenser discharge lamps, introduced by H. E. Edgerton, can be used in the same manner as flash bulbs. All have a shorter flash duration, and some have a much greater light output.

Printing and Enlarging.— Prints are made from negatives by contact, in which case they are the same size as the negative, or by enlargement or projection printing, to produce bigger pictures. Contact prints are made in (a) printing frames, which press the negative and paper in close contact against a sheet of glass through which exposure can be made to a lamp, and (b) printing boxes or machines, which contain the printing lamps as well as the means for holding negative and paper in contact. The simplest printers contain one lamp and are made for small negatives. The professional printers are designed for larger negatives. frequently have many lamps and means for dodging, or controlling the exposure of different parts of a negative. Printers for photofinishing are designed to permit a large number of prints to be made from single negatives or rolls of negatives in the minimum of time. In some the exposing platen is operated by a foot treadle to leave both hands free for manipulating the negative and paper, and there are means for stamping identification numbers on the prints. In the more advanced types, the printing time for the negative may be measured photoelectrically and the appropriate exposure given automatically.

A projection printer or enlarger has a means for illuminating a negative, and a lens for projecting an image of it onto a sheet of photographic paper on a board or easel. It resembles a lantern-slide projector, or a camera in which the negative is the subject and the paper corresponds to the film. The best enlarger lenses are designed to operate at magnifications of a few times, and are generally more satisfactory than camera lenses for enlargement.

Projection printers are distinguished mainly by the means by which the negative is illuminated, and are of three main types: (a) diffusion enlargers, in which there is a lamphouse or reflector containing a lamp, and in front of this, a sheet of ground or opal glass in front of which the negative is placed; (b) condenser enlargers, which contain a small light source, and a condensing lens behind the negative; (c) the modern type of condenser enlarger, in which a lamp with a diffusing bulb or having a large area, such as a fluorescent lamp, is frequently used to lessen the degree to which grain and dirt on the negative are shown sharply in the print. Condenser enlargers give prints of higher contrast than diffusion enlargers.

Enlargers are arranged horizontally or usually vertically. In the simplest forms, focusing is achieved by watching the projected image on a sheet of white paper which temporarily takes the place of the printing paper, and adjusting the lens until the image is sharp. Some enlargers. however, focus automatically, the image remaining in focus on the paper over a wide range of magnifica-

Darkrooms and Processing.— Rooms for handling films, plates and papers must be dark, or illuminated only by light to which the materials do not respond appreciably in a reasonable time. They are provided with running water, large sinks and benches on which operations can be carried out. Small darkrooms are used for loading, unloading and developing negatives and for printing and developing prints. In larger installations the negative and printing rooms are separate. Negative rooms for handling panchromatic materials are completely dark or illuminated by safelights green in colour, since the eye has its maximum sensitivity in the green, and a very low level of illumination may thus be used. For orthochromatic films, deep red safelights are used, while for slow noncolour-sensitized materials, such as positive or process films, orange or even deep yellow safelights can be used. In printing rooms, the lighting is yellow, orange or yellow-green, since most papers are not sensitive to red light.

Developing, fixing and washing are done in trays, tanks or special equipment; and all require sinks and plenty of water. Roll films are frequently developed in tanks on spiral reels on which they are wound, or hung vertically in tanks, and sheet films and plates are used in special frames or hangers, so that many can be handled together. Paper prints are developed in trays. Washing of negatives and prints must be done in such a way that there is frequent change of' water over the entire surface of all, and special washers are made for use where large quantities of films or prints are handled. Drying of negatives can be in the open air, or preferably in special drying cabinets through which warm air is blown. Prints can be dried flat in the open, on racks covered with muslin or between blotters or by passing automatically around heated drums which can also be used for glazing thé prints. Prints are commonly glazed by squeegeeing them onto metal plates with a lacquered or chromium-plated surface. Printing rooms contain the contact printers and enlargers.

Clocks are necessary in all darkrooms to time the steps of processing accurately, and thermometers must be used to control processing temperatures. Sections of the rooms are devoted to storage and mixing chemicals, and storing sensitive materials to be readily available for use. Adequate ventilation is important.

Special equipment is used in photofinishing establishments, especially for the automatic processing of large numbers of roll films. They are hung vertically on special hangers, and pass continuously into a deep tank of developer and then into each successive solution and washing tank and finally through a drying cabinet. In smaller installations, the film hangers are used in deep tanks but are transferred manually.

Similarly, special apparatus is made for large-scale printing operations, in which the exposed papers pass with the minimum of attention through the solutions, and are then dried, and glazed if necessary, on continuously rotating drum driers.

Finished prints are frequently mounted on cards. A number of adhesives may be used, the most satisfactory being dry mounting tissue, which is a sheet of tissue impregnated with shellac or other fusible plastic. If this is placed between the print and the mount and the whole is heated in a press, the shellac melts and sticks the print to the mount. (W. Ck.; X.)

PHOTOGRAPHIC LENSES

A photographic lens must give crisp definition over a relatively wide flat field, and in this respect it differs from all other types of lens. Moreover, for instantaneous photography the image must be bright, which implies a high relative aperture.

LENS TYPES

The Landscape Lens.—The first deliberately designed photographic objective was made in 1812, about 20 years prior to the introduction of photography. It was the simple meniscus landscape lens (see fig. 10a) proposed by the English physicist William Wollaston for use in the camera obscura. At first, a simple equiconvex lens was used, but it was found that the image was sharp in the middle and became blurred in the outer parts of the field. Wollaston's invention consisted in the use of a meniscus-shaped lens with a small stop on the front (concave) side, as in

fig. 10b, the mirror being mounted between the stop and the lens.

The effect of this change on the image quality is profound. In fig. 11 are shown a biconvex lens and a meniscus lens of the same focal length, each traversed by a number of light rays at an obliquity of 90° which may be supposed to emanate from an infinitely distant object point. In the upper figure, the oblique rays meet nicely almost at a point, but the point is not at all on the desired flat field. In the second case, the oblique rays through the whole lens do not meet at a point, but suffer from all the properties of spherical aberration. By placing a small stop (about f/11) at B we isolate a beam of light which comes to a focus exactly above the focus of the axial beam. We have thus produced a flat field by isolating only those rays which cross where we wish them to cross.

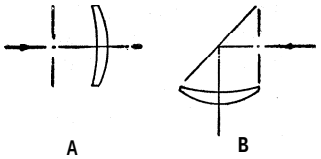


FIG. 10.—THE WOLLASTON LANDSCAPE LENS. A, IN A CAMERA, B, IN A CAMERA OBSCURA

Having introduced this type of lens, Wollaston also applied it to the small box type of camera obscura used by artists as an aid in drawing. This instrument was actually the original photographic camera, for the photographer merely had to replace the ground glass by a sheet of photosensitive material to make a record of a scene, the mirror being necessary to rectify the image. Landscape lenses of this simple type are still manufactured in large quantities for use in box cameras and in the cheaper types of folding cameras. At f/11 or f/16 they give satisfactory pictures over a half-field angle of 20° to 25°.

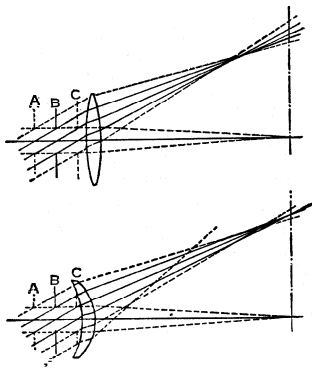


FIG. 11.—PATHS OF LIGHT RAYS THROUGH BICONVEX AND MENISCUS

The Defects of the Landscape Lens.—The Wollaston landscape lens suffers from many defects. These are:

(1.) The presence of chemical focus, which is a difference in image position between visual light and the photographically active rays. This was early regarded as very serious, especially as the necessary correction varies with the distance of the object, and thus can not be compensated in the construction of the camera.

(2.) The aperture is limited to f/11 or less, because of bad spherical aberration.

(3.) It possesses much lateral chromatic aberration, causing coloured fringes around images in the outer parts of the field. On black-and-white emulsions, these fringes appear as a blurring of the definition.

(4.) Beyond a semifield of about 20°, the astigmatism becomes bad. This implies that the image of a point object is no longer a point, but consists of a radial focal line, separated by a finite longitudinal distance from a similar tangential focal line.

(5.) It has bad distortion. When this aberration is present, a square object becomes imaged either as a pincushion-shaped or a barrel-shaped figure.

When photography appeared in 1839, with the daguerreotype and the calotype processes, the need arose to correct these defects and especially to increase the speed of the lens for portraiture. Historically, however, the problem of the chemical focus and lateral colour was solved first by achromatizing the lens. C. Chevalier in 1821 had combined a positive lens of crown glass (low refractive index and low dispersion) with a negative lens of flint glass (high index and high dispersion) as shown in fig. 12. This served to correct both of the chromatic aberrations perfectly, but the dispersive (or divergent) cemented face in the lens led to a backward curving field with much astigmatism in the outer parts. Also, the maximum speed remained around f / 15, so the new lens had limited application.

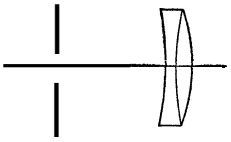


FIG. 12.—THE CHEVALIER ACHROMATIC LENS

The Petzval Portrait Lens.—Finding that the customary speed of landscape lenses (f/11) was slow for portraiture, J. Petzval of Vienna undertook the designing of a rapid lens. In 1841 he produced his famous Portrait lens, fig. 13, which had the remarkable speed of f/3.6 and covered a half-field of 10° to 12° in extent. Beyond that angle, the astigmatism and field curvature became so great as to soften the definition to a serious extent, but on the lens axis the definition was exceedingly sharp and clear-cut. The Petzval lens consists essentially of two modified telescope objectives spaced apart, each being achromatic and substantially spherically corrected. The lack of sharp definition in the outer parts of the field is not serious in portraiture; in fact, it is actually desirable to have the background somewhat out of focus.

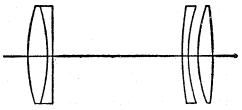


FIG. 13.—THE ORIGINAL PETZVAL PORTRAIT LENS (1841)

Because of its high relative aperture and excellent central definition, this type of construction, suitably modified, has been used extensively for motion-picture photography and projection. The definition is very sharp to about 5° from the axis even at apertures as high as f/1.6, after which it begins to fall off abruptly. The semi-field of projection lenses is often extended to 10° by means of a field flattener, a thin negative element close to the image plane which tends to overcorrect the astigmatism and thus flatten the field. This method of field flattening was first suggested by C. Piazzi Smythe, in 1863, who used it to make excellent miniature photographs in Egypt on one-inch square wet collodion plates.

Distortionless Landscape Lenses.—The landscape and the portrait lenses served photographers well for many years, but the distortion of the landscape lens became increasingly objectionable, especially after the introduction of the wet collodion process in 1850. The increased sensitivity of the collodion layer permitted photography indoors, and the distortion of the lens became evident on the vertical lines.

After 1850, therefore, opticians made great efforts to remove this distortion by variations in lens design. Early pioneers were J. T. Goddard and T. Sutton in England, who modified the arrangement of the Petzval portrait lens to widen the field at a much reduced aperture, the distortion being removed by arranging two positive components about a central negative component.

In 1860 a notable contribution was made by C. C. Harrison and J. Schnitzer of New York city in their Globe lens, so-called because the two outer faces formed parts of the same sphere (U.S. Patent 35,605). This lens was distortionless and covered a half-field of 30°, but only at an aperture of about 1/36. It was achromatic, but not spherically corrected. The same lens was made by T. Ross in England. A similar design was the Pantoskop, designed by E. Busch in 1865.

The Symmetrical Principle.—From these early attempts to correct the distortion of landscape lenses, it soon appeared that a lens which is symmetrical about the stop is automatically free not only from distortion, but also from lateral colour and coma. This is not entirely correct except at unit magnification, but the improvement in these three aberrations resulting from the symmetrical construction is so marked that symmetry in lenses became almost a universal rule from 1865 to about 1910.

The first to appreciate the advantage of the automatic coma-correction associated with symmetry were A. Steinheil in Munich and J. H. Dallmeyer in London about 1866. Prior to this time, landscape lenses had possessed spherical aberration; and, consequently, it was possible to choose a stop position which would simultaneously correct the coma and make the field as backward curving as possible. Dallmeyer and Steinheil realized that with the coma automatically eliminated by symmetry, it was no longer necessary to have a considerable residual of spherical aberration in the separate components. They, therefore, chose a symmetrical construction as indicated in fig. 14, in which the divergent cemented surfaces were used to correct the spherical aberration, and the outer shape of the lens was chosen so as to flatten the field. The coma of each component was bad, but it disappeared as a result of the

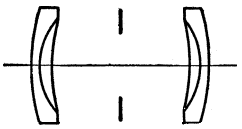


FIG. 14.—STEINHEIL'S APLANAT

symmetry. By this means, a simple, substantially distortionless lens could be constructed at an aperture of f/7 or f/8 with a flat field out to 25° half angle. There was some residual astigmatism at that obliquity, but the depth of focus at f/8 or f/11 covered it up to a considerable extent. This was fundamentally the construction of the Steinheil Aplanat and the Dallmeyer Rapid Rectilinear lens. This type immediately became popular, and it was imitated by almost every manufacturer for nearly 50 years. A number of variants of these designs mere tried, some of which were good, but no real progress was made until the introduction of barium glass in 1886, which brought about a revolution in the art of lens designing and ushered in a new era.

Barium Glasses, and the Anastigmat Lens.—In all the types so far discussed, the negative elements were of flint glass with a high refractive index and high dispersive power, while the positive elements were of crown glass with a low index and low dispersion. Thus, the cemented surfaces were generally divergent in action, and tended to overcorrect the spherical aberration and the astigmatism.

By 1880 E. Abbe and O. Schott in Jena were making experiments to try to develop a crown glass having a high refractive index combined with a low dispersion. If such could be found, it would be possible to make achromats in which the cemented surface would be convergent instead of divergent. Thus, it would be possible to stop and even reverse the drastic overcorrection of astigmatism which occurred in the outer parts of the field of all lenses up to that time. Their efforts were rewarded in 1888 when Schott announced the first barium crown glass having the desired properties.

By 1890 Paul Rudolph in the Zeiss company. working, no doubt. under Abbe's inspiration, had entirely redesigned the Rapid Rectilinear type of construction by replacing the divergent cemented surface in the rear component by a convergent surface (fig. 15). The new barium crown glass was used in one element of the rear component, thus rnaking an objective in which one of the cemented surfaces mas divergent and concave to the stop. lending to an increasingly overcorrected astigmatism and spherical aberration, while the other cemented surface was convergent and convex to the stop, leading to an increasingly undercorrected astigmatism. The result was a lens in nhich the astigmatism was everywhere small, and it actually became zero at one obliquity of the field. This lens was announced in 1890 as the Anastiginat, the name being changed to Protar after other firms took up the word Anastigmat to imply any lens having a node of zero astigmatism somewhere in the field. Early designs of this type up to f/9 were produced, and even an f/4.5 lens was made with a cemented triplet in the rear. The Protar was still manufactured in 1947, chiefly as an f/12 or f/18 extreme wide-angle lens.

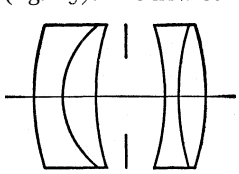


FIG. 15.— THE ZEISS PROTAR

The Dagor Type.——Within two or three years after Rudolph's design of the Protar, both he and Von Hoegh of Goerz announced almost identical designs of a symmetrical lens, each member consisting of a cemented triple lens (fig. 16). Rudolph called his the Triple-Protar, and Von Hoegh called his the Double Anastigmat Goerz, which was later contracted to Dagor by taking the initial letters of the name. In each half of this lens, the refractive indices rise steadily out from the stop, being in that order, 1.52, 1.57 and 1.61. Achromatism is secured as usual by choosing low-dispersion glasses for the convex elements and a higher dispersion for the concave element. Each component, therefore, contains a strong divergent cemented surface and a weaker convergent cemented surface, the convergent surface being convex toward the stop. Thus. the essential properties of the tno components of the original Protar design were combined in each half of the double lens.

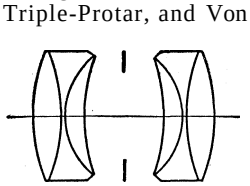


FIG. 16.—THE GOERZ DAGOR

Many variations of this lens were designed during the years 1893 to about 1905, the advantages being a wide field with a high degree of anastigmatic correction, but only at an aperture of f/6.3 or f/8. In 1930 A. W. Tronnier of the Schneider company revived this construction in his wide-angle Angulon, which is an f/6.3 lens covering satisfactorily to about 40° from the axis.

Convertible Lenses.—Most of the triple-cemented double lenses that have been designed are complete lenses corrected as a whole, but the two separate halves have too much coma to be used independently and the symmetry takes care of coma correction. However, the advantages of being able to double the focal length by removing the front component were so evident that Rudolph in 1894 designed his Double Protar or Quadruple Protar, which comprised both parts of the original Protar directly cemented together in each component (see fig. 17). The additional degrees of freedom made available to the designer by this construction enabled him to correct the coma of each half separately. The lens thus became convertible. *i.e.*, each component could be used separately, or two similar components of different focal lengths could be combined together to make a satisfactory double objective. Thus, a pair of components having focal length of 8 and 10 in., could be used either separately or together to form a lens of about 5-in. focus. These convertible sets of lenses were quite popular early in the 20th century, but their use died out nhen large view cameras became replaced by small roll-film hand cameras without focusing screen.

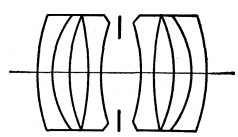


FIG. 17.—THE ZEISS CONVERTIBLE PROTAR

Double Objectives with Air Gaps.—The chief reason why lenses of the Dagor type are so limited in aperture is the need for having an increasing refractive index in the successive elements counting outward from the stop. The index difference available at each cemented face is, therefore, rather small, necessitating quite strong surfaces.

It became apparent early that by introducing an air gap (usually at the dispersive surface), the refractive index of the separated element could be varied independently. leaving a wider range of indices for the cemented elements. This type of construction was first suggested by Von Hoegh in 1899, and was used later in such lenses as the Euryplan, the Plasmat, the Orthometar and the Wide-Angle Xpres. The two latter lenses are unsymmetrical and highly corrected for distortion to render them suitable for aerial surveying over a semifield of 35°, at a speed of f/4.5.

The Airspaced Four-Element Lens.—In 1898 Von Hoegh designed the Celor, an entirely new type of lens shonn diagrammatically in fig. 1S, which as first constructed covered a 28° half field at f/8. The design may be regarded as a direct descendent from the Dagor. In each half of the Dagor lens, there are two outer surfaces. both concave to the stop, an internal divergent cemented surface and an internal convergent cemented face convex to the stop. Von Hoegh argued that the airspaced construction shown in fig. 18 is essentially equivalent to the Dagor, since each half contains two outer surfaces concave to the stop, an internal divergent surface and an internal convergent surface convex to the stop. The airspaced construction has the advantage over the cemented construction that each surface separates glass from air, with a large index difference, and, thus, the internal surfaces in this lens become much weaker than the corresponding surfaces in the Dagor. Little difficulty was found in extending the new design to f/3.5 covering 21°, an achievement quite impossible with the cemented type. The field is, however, not so wide as in the Dagor type.

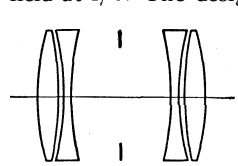


FIG. 18.—THE GOERZ CELOR

This airspaced four-element design was used by the Goerz company in the Dogmar series, and was later adopted by A. Warmisham in the Aviar lens (1915). R Steinheil used a similar design in his Unofocal of 1901, and a great many similar designs have appeared. All the Kodak anastigmats prior to about 1928 were of this type, and a number were still manufactured in 1947.

The **Tessar.**—In the preceding paragraph the evolution was

traced of the Von Hoegh quadruplet from the Dagor. At about the same time, Rudolph was following a parallel path. Whereas Von Hoegh replaced the divergent and convergent cemented surfaces in his Dagor design by glass-air surfaces, Rudolph returned to his original Protar of 1890 and replaced the cemented surface in the front component by an air lens, remembering that a convex-shaped air lens has a diverging action. In this way he designed the famous Tessar lens in 1902, shown in fig. 19. It was a successful lens, mainly as an f/4.5 universal objective covering a semifield of about 26°. By 1910, some f/3.5 designs had appeared, and in recent years, the type has been practically universal for both f/4.5 and f/3.5 lenses of the better grade. Even f/2.7 Tessars have been produced, but this high aperture requires a more complicated type of construction. In long focal lengths, f/6.3 and f/8 has been a popular speed, the angular field being then increased somewhat. A line of Apo-Tessars has been designed for process work, and a wide-angle f/8 Tessar has been used on the Zeiss Contax cameras.

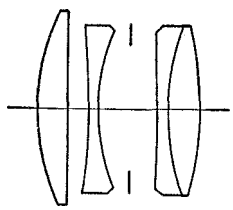


FIG. 19.—THE ZEISS TESSAR

The Gauss-Lens and Its **Application to** Photographic **Objectives.**—In 1817 the mathematician C. F. Gauss discovered that a meniscus-shaped airspaced telescope objective could be designed in such a way that the spherical aberration curve is practically the same for all wave lengths. Such a lens is said to be free from sphero-chromatism. However, because of its high manufacturing cost, it never became popular as an astronomical objective.

In 1889 the American telescope-maker Alvan Clark took out a patent (C.S. 399,499) on the use of two Gauss objectives mounted together in a single tube, concave sides adjacent, as a photographic lens. He stated that the field curvature could be varied by adjusting the airspaces in the lens. The same idea occurred independently to Rudolph, who attempted to design a properly corrected symmetrical photographic lens using meniscus-shaped elements according to this plan. He was, however. unable to achromatize the lens and decided to use buried surfaces[1] in the negative lenses to increase the dispersive effect of those elements. In this way, he produced the Planar lens, first announced as a symmetrical f/4.5 lens for process work in 1895 (fig. 20).

In 1902 K. Martin of the Busch company succeeded in achromatizing a lens of this type without the use of either barium crown glasses or buried surfaces; and announced it as the Omnar. At about the same time appeared the similar Meyer Aristostigmat and Ross Homocentric lenses, also of this so-called Gauss type. In recent years, the type has been revived in lenses of about f/6.3 aperture covering very wide angular fields, culminating in the Zeiss Topogon (see below).

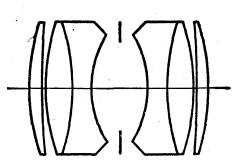


FIG. 20.—THE PLANAR

All interest in this type of construction apparently disappeared from 1902 until 1920, when H. W. Lee of the Taylor, Taylor and Hobson company in England revived it. He went back to the original Planar design and decided to see how far he could increase the aperture. He realized that Rudolph had wasted many possible degrees of freedom by insisting on a symmetrical construction and burying the cemented surfaces of the negative elements so that they were optically nonexistent so far as the monochromatic aberrations were concerned. Lee departed from these two artificial limitations and succeeded in designing an f/2 lens covering a semifield of almost 25°. This was marketed as the Cooke Opic lens, in several sizes up to five-and-one-half inches focal length. Such a huge aperture was entirely revolutionary for photographic lenses covering a 24° semifield. Higher apertures can be reached by the Petzval type of construction, for a 5° or 7° field, but this was the first lens to combine high aperture and field successfully. The Opic lens ushered in a period of 20 years of strenuous effort on the part of many manufacturers to outdo everyone else in the matter of high-aperture lenses. Notable achievements were the Zeiss Biotar of 1927, covering a 14° half field at f/1.4 for 16-mm. motion-picture cameras, the Leitz Summar f/., having a 20" half angle, the Kodak f/-. Ektar covering 26° for the Bantam Special camera and the Cooke Speed Panchro f/2 lens for 3j-mm. motion-picture cameras. Other manufacturers have used the same general type of construction for lenses of about f/2 aperture, but it does not appear to be very satisfactory for apertures higher than f/2 because of the enormous oblique spherical overcorrection which appears in the outer parts of the field, leading to marked haze and low contrast.

The **Topogon** Lens.—In 1933 R. Richter of Zeiss sought to extend the field of the Gauss type of objective as widely as possible, and finally adopted the construction shown in fig. 21, representing an f/6.3 lens capable of covering a half field of 45°. This lens may be regarded as being derived from the Harrison and Schnitzer Globe lens by separating the cemented elements, and bending the flint to a more extreme form. In World War II it was made in the U.S. by Bausch and Lomb as the Metrogon lens.

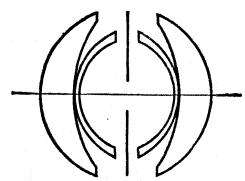


FIG. PI.—THE RICHTER TOPOGON WIDE-ANGLE LENS

The angular field covered by this lens is astonishing. For example, a 6-in. Topogon will cover satisfactorily to the corners of a 9x9-in. plate. Of course, the illumination at the corners is perhaps only 10% of that at the centre of the field, but in spite of this, the lens is much used in aerial photography.

The Cooke Triplet Lens.—In 1893 H. Dennis Taylor decided to cut aside all historical precedent and proceed to design the simplest possible photographic lens. To do this. he argued that a separated pair of approximately equal positive and negative elements will automatically satisfy the Petzval condition for a flat field and will also have some positive power by virtue of the finite separation. However, such a system will be badly unsymmetrical and will exhibit considerable distortion and lateral colour. He therefore divided the positive element into two parts and set the negative element between them. Thus, he had five degrees of freedom (three powers and two airspaces) wherewith to secure the desired over-all power, the desired Petzval sum, to achromatize and to correct the distortion and lateral colour. In addition, he could bend or alter the shape of each of the three elements to eliminate spherical aberration, coma and astigmatism. In this way, Dennis Taylor produced the first modern triplet known as the Cooke lens (fig. 22). It was made in several series, including a narrow-angle f/4.5 design for portraiture, a wide-angle f/6.3 for landscapes, etc. Originally, no barium crown was employed, but its use greatly facilitates the design and shortens the over-all length of the lens, thus improving the corner illumination.

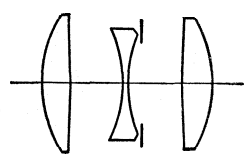


FIG. 22.—THE COOKE LENS

Since 1893 this type of lens has been made by millions, in apertures up to as high as f/2.7 in short focal lengths, but mostly as a low-priced f/4.5 or f/6.3 anastigmat for ordinary folding cameras. Within its limitations, it is an excellent lens, although of course it can be improved by making it more elaborate.

Modifications of the Triplet Lens.—From some standpoints, the Tessar (fig. 19) may be regarded as a modified triplet in which the rear element has been replaced by a cemented doublet. In 1902 H. Harting, of Voigtlander, felt that if a convergent cemented face in the rear component is an improvement. then the insertion of a similar surface in the front component should be a still greater improvement! and in this way he developed the Heliar lens. This form has not been commonly adopted, in spite of its merits, typical

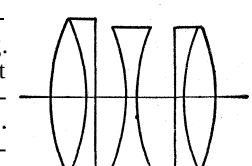


FIG. 23.—THE DALLMEYER PENTAC. DESIGNED BY L. B. BOOTH

[1] A buried surface is a cemented surface separating two glasses of the same index but difierent dispersion. Surh a surface is, of course, nonexistent so far as the monochromatic aberrations are concerned, its sole purpose being to correct the chromatic aberrations.

modern examples being the Dallmeyer f/2.9 Pentac (fig. 23) covering to 22°, and the recent Kodak f/3.5 Ektar covering to 26°.

In 1924 H. W. Lee of Taylor, Taylor and Hobson, and at the same time W. Bielicke of Astro, attempted to raise the aperture of the Cooke lens to f/2.5 by dividing the rear positive element into two closely spaced positive elements.

Although this device succeeded in reducing the zonal spherical aberration of the f/2.5 lens to an acceptable extent, the astigmatism in the field remained rather serious, and as a result this type of construction has not been much used.

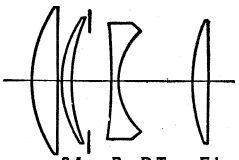


FIG. 24.—BERTELE'S TRIPLET WITH ADDITIONAL MENISCUS LENS IN THE FRONT AIRSPACE

The Sonnar Lens.—A much more profitable modification of the triplet was that originally suggested by C. C. Minor in 1916 and developed by L. Bertele of the Ernemann company during the early '20s. In fig. 24, it will be evident that in its essence. Bertele's lens may be regarded as a triplet in which a strongly bent meniscus-shaped positive lens has been inserted in the front airspace. This additional lens is shaped so that it contributes practically nothing to the spherical aberration, yet it does introduce some positive power. The power of the front and rear lenses can then be reduced by this amount, resulting in a net reduction of the spherical undercorrection contributed by them.

Lenses of this type can be designed to have an aperture as high as f/1.5, using only four single elements. The field is usually small (15°), and if attempts are made to increase it, the result is a rather large amount of astigmatism at the zones of the field intermediate between centre and edge. At f/1.9, a number of excellent lenses have been designed of this type, covering 14° half angle, mainly for cinematograph purposes.

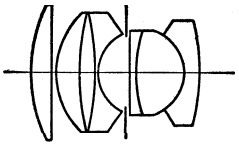


FIG. 25.—THE ZEISS SONNAR F/1.5

Many attempts have been made to improve the field coverage by adding other elements to this basic four-lens type. Notable attempts were the f/1.9 Ernostar of 1924, and the f/1.5 Sonnar of 1932 (fig. 25), both designed by Bertele. In these lenses, the second and third elements of fig. 24 were combined together with a low-index element instead of air between them. By this means, a well-corrected high aperture lens can be made, covering up to 22° from the lens axis. This general type of construction has appeared very frequently in lens patents since 1930.

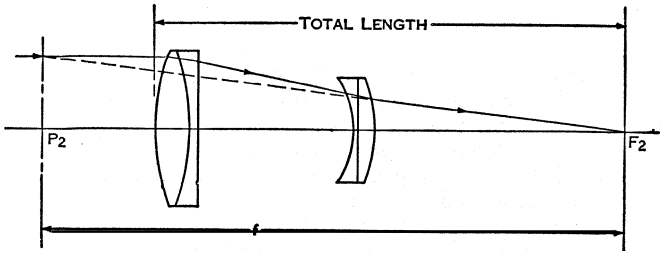


FIG. 26.— THE TELEPHOTO PRINCIPLE

The Telephoto Lens.—This type of lens was first introduced into regular use about 1891, its particular property being a shortening of the total length of the lens from the front vertex to the focal plane. Indeed, in some telephotos the total length is as little as 60% of the focal length, in contrast to the Tessar or Cooke Triplet type in which the total length may be about 115%, or the Petzval Portrait lens which may reach 140%.

The telephoto type of construction consists essentially of a positive front member separated widely from a negative rear member. the action of this combination being to move the rear principal point forward (fig. 26). Originally, a complete normal camera lens was used for the positive component, the rear membrr being a thin achromatic negative lens, the separation between the positive and negative systems being adjustable to give any desired magnification. These designs were unsatisfactory optically, had bad pincushion distortion and worked at very low apertures.

In 1905 the modern era of telephoto lenses was initiated by the Busch Bistelar, a fixed self-contained telephoto lens of f/8 aperture covering a half field of about 15°. The two components were nothing but cemented doublets, yet because the designer was released from the necessity of separately correcting the front component, the final result was superior to all previous telephoto lenses and was comparable in performance to the normal f/8 lenses of the day. However, when larger relative apertures were attempted, many difficulties were encountered, and it was not until the introduction of the Cooke and Dallmeyer f/5.6 anastigmatic telephoto lenses in 1919 and 1920 that this type could begin to compete with modern anastigmats. Nevertheless. in spite of all the efforts of lens designers, the aperture of an 80% telephoto lens had not by 1947 been raised much above f/3.5, nor the semifield much above 12° to 15°. Recent attempts to remove distortion have led to the use of either a strongly convergent cemented surface in the rear member, as in the Kodak f/3.8 Telephoto, or a definite separation of the rear component into two meniscus elements separated by an airspace shaped like a negative lens, as in the Cooke Distortionless Telephoto f/5.0 (fig. 27). During World War II, many large telephoto lenses of focal lengths ranging from 24 in. to 60 in. were manufactured for use in aerial reconnaissance cameras. The aperture was usually f/5.6 to f/8, and the angular semifield rarely more than 12°.

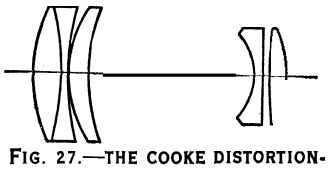


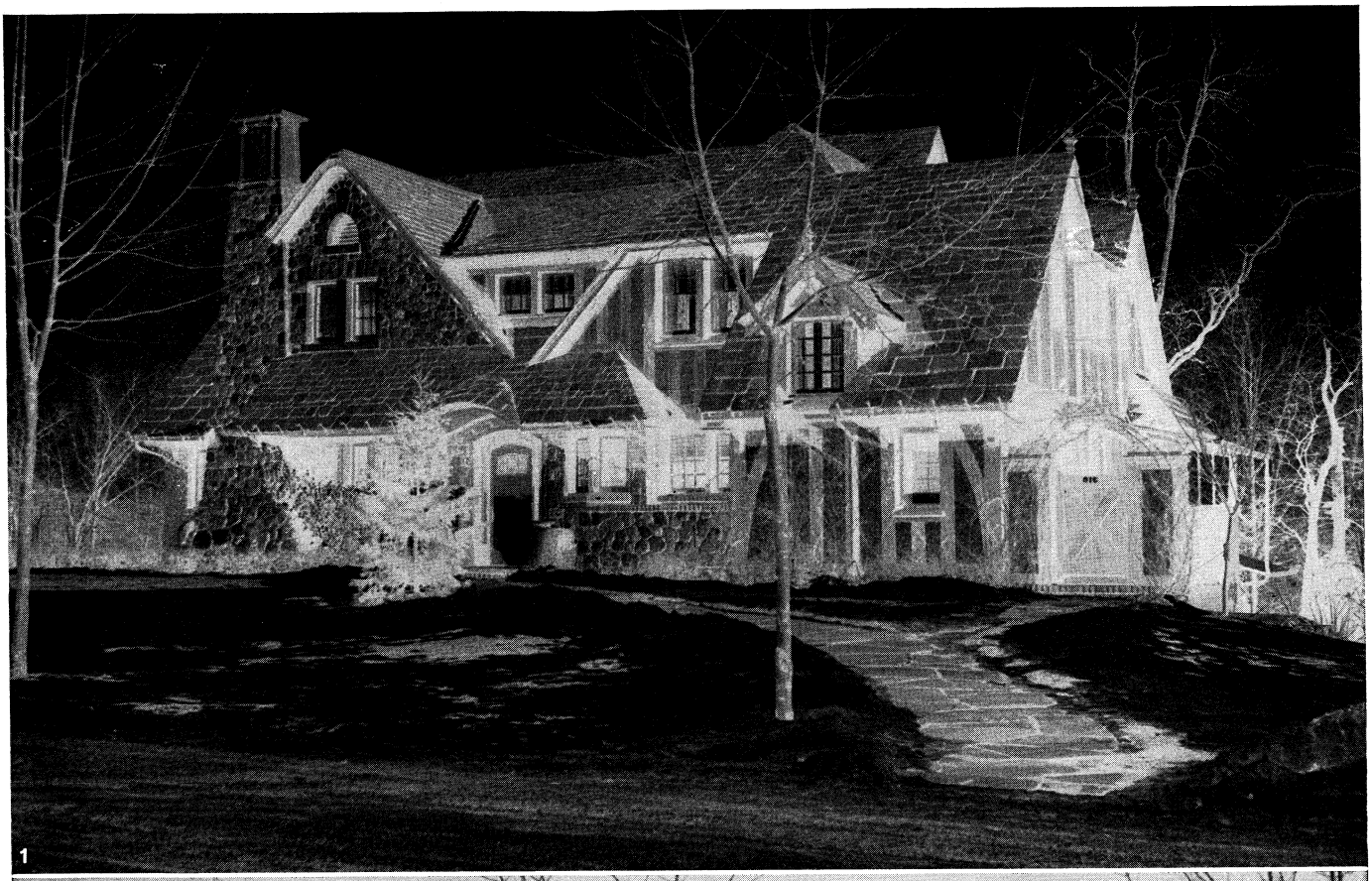
FIG. 27.—THE COOKE DISTORTIONLESS TELEPHOTO

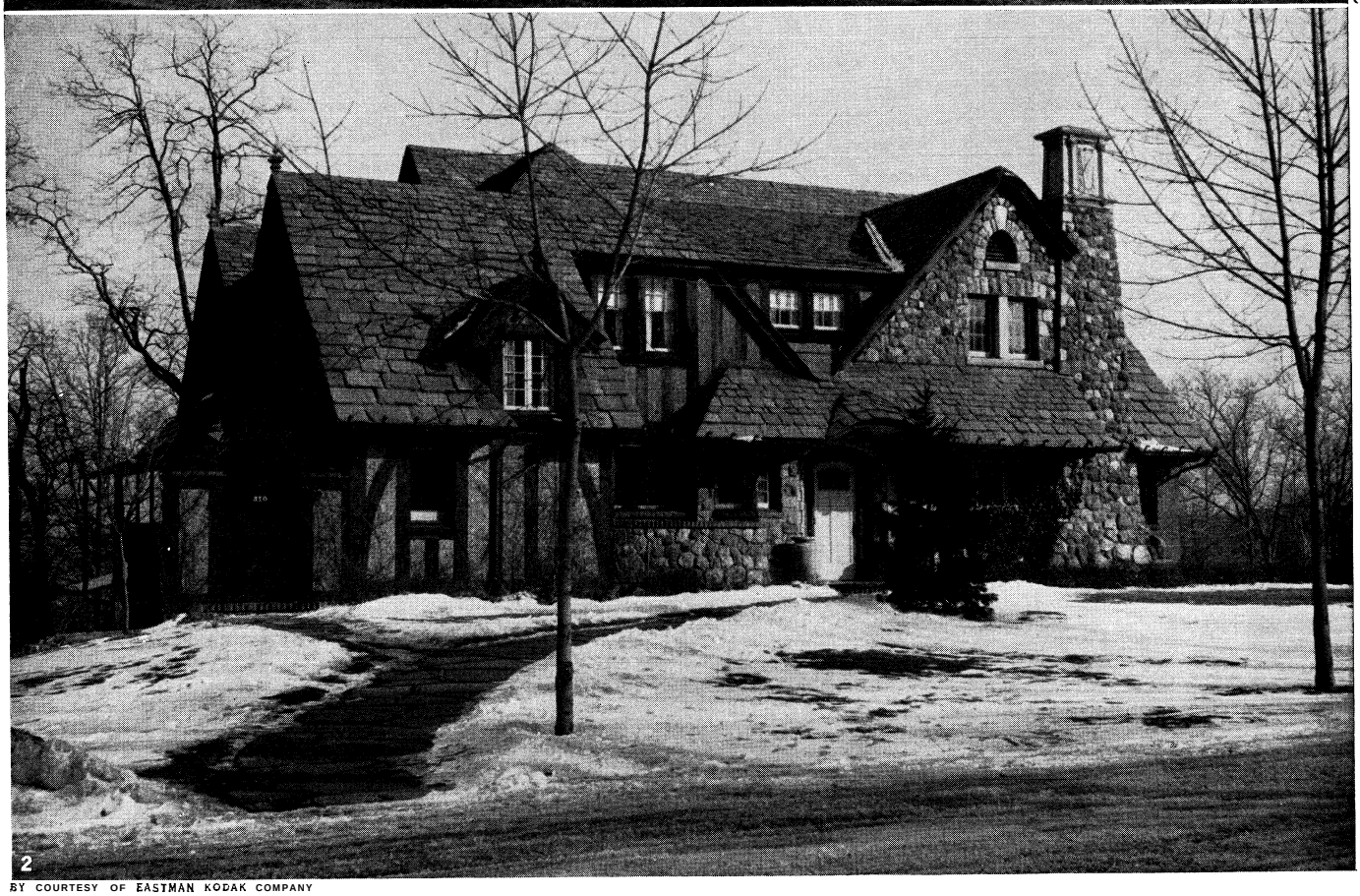
The Reversed Telephoto Lens.—By turning a telephoto lens end-for-end, it is possible to design a wide-angle system having an exceptionally long back-focus clearance. This has been used in cases where a beam-splitting prism or other device must be inserted between the lens and the film, such as in Technicolor cameras. An extreme example of this construction is found in the Hill Sky lens (British Patent 225,398) which will compress the entire hemisphere onto a flat plate, with drastic distortion as a necessary consequence.

Apochromatic Process Lenses.—In photomechanical reproduction, it is frequently necessary to make colour-separation negatives of coloured original drawings or photographs, and the lenses used must be colour-corrected to a degree entirely beyond anything necessary in ordinary lenses. By the use of special types of glass and restricting the aperture to about f/10 or f/16, it has been found possible to design lenses, generally of a symmetrical type, in which all the colours of the spectrum are brought accurately to a common focus. It is furthermore necessary in these lenses that all the coloured images shall be of precisely the same size. Such lenses are called apochromatic process lenses to distinguish them from the ordinary achromatic lenses in common use.

Enlarging Lenses.—Enlarging lenses differ from ordinary camera lenses in that they are intended to be used at much lower magnification ratios, the field must be flat and the colour correction must be such that the best focus in visual light coincides exactly with the best focus for the extreme blue end of the spectrum for which bromide paper has its maximum sensitivity. In many cases, ordinary camera lenses make satisfactory enlarging lenses, but this is likely to be not the case if the lens is of very high aperture or if it is of a markedly unsymmetrical type of construction.

Lens Attachments.—The familiar portrait attachment for fixed-focus cameras consists of a weak meniscus-shaped positive lens having a focal length approximately equal to the distance of the subject (four feet). Stronger positive lenses are sometimes used to photograph small objects, when the focusing scale of the camera will not go down to a sufficiently close distance. Negative lens attachments are also occasionally employed to lengthen the focus of a camera objective to give a magnified picture, but their use requires a considerable bellows extension. Small Galilean telescopes have been used as lens attdchments to enlarge or



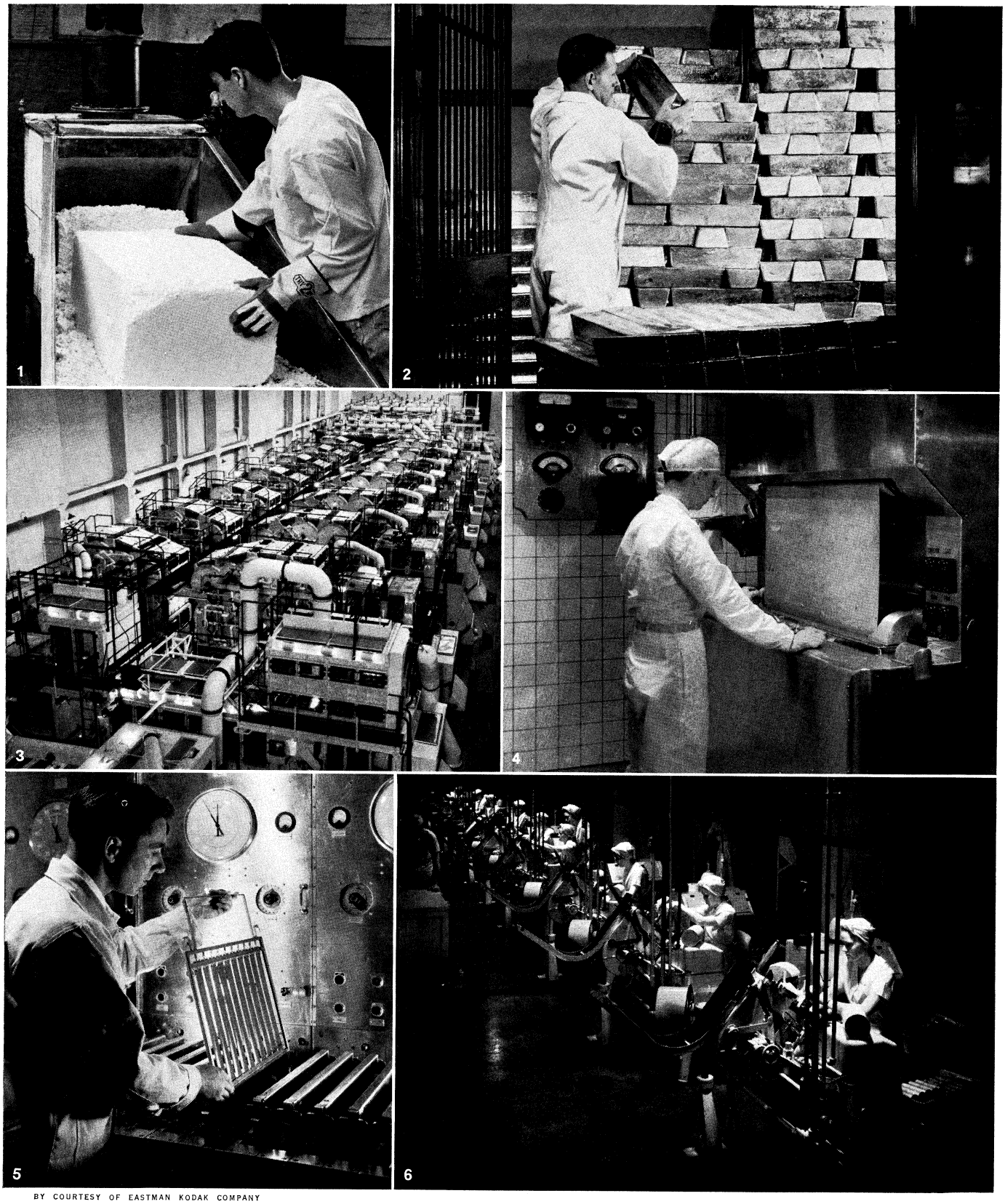


BY COURTESY OF EASTMAN KODAK COMPANY

EXAMPLES OF NEGATIVE AND POSITIVE PHOTOGRAPHIC PRINTS

1. Photographic negative, after development. Light areas appear dark and vice versa; right side of picture appears left in the camera
2. Positive photographic print, made from negative in fig. 1

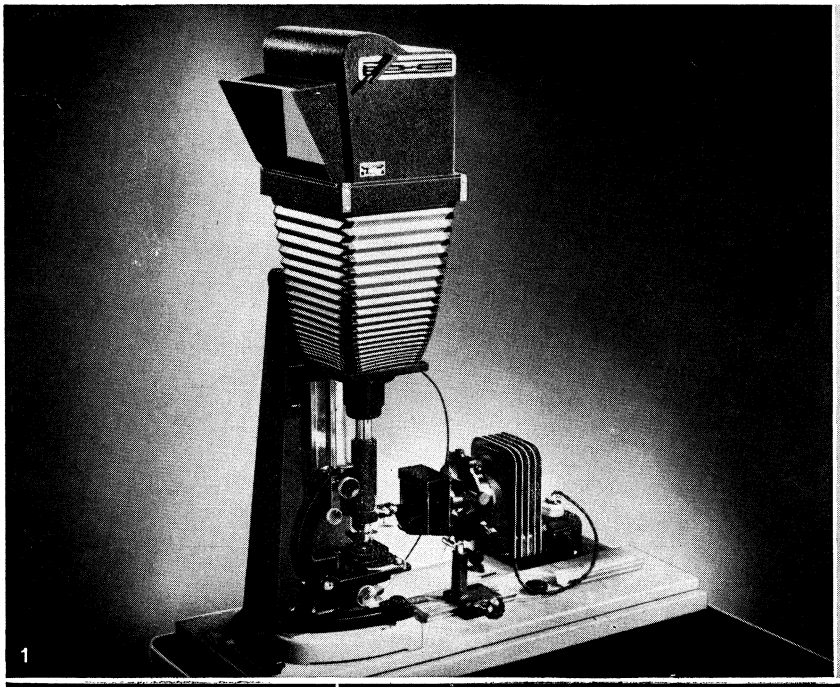
PHOTOGRAPHY

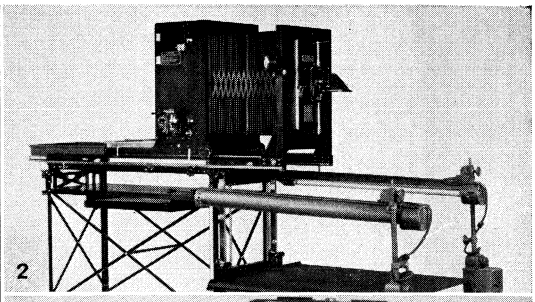


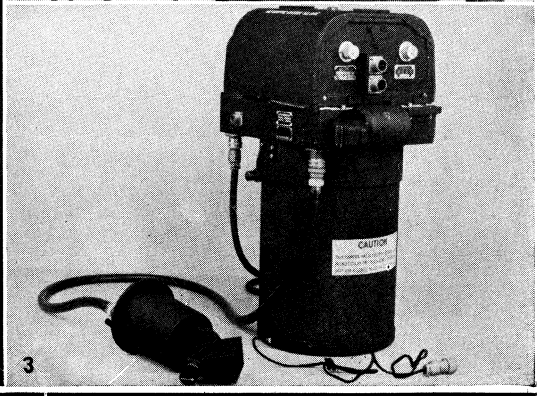
BY COURTESY OF EASTMAN KODAK COMPANY

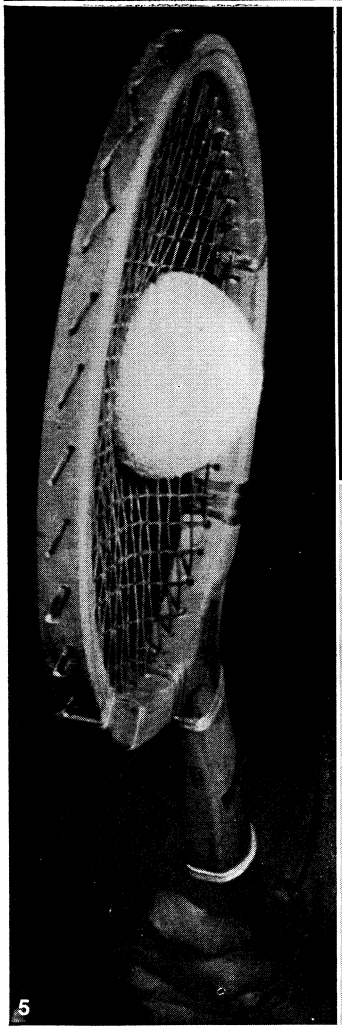
MACHINERY AND SUPPLIES USED IN THE MANUFACTURE OF FILM

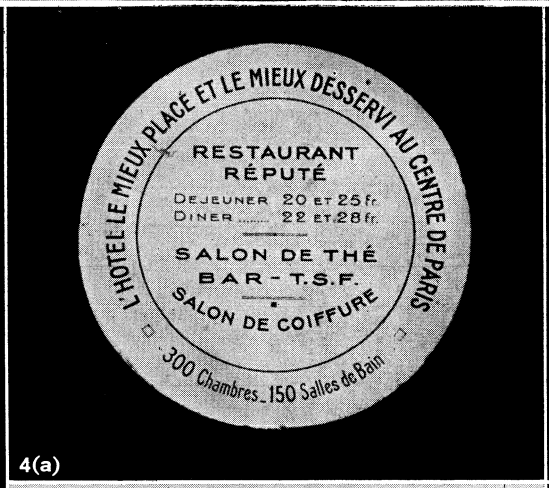
1. Bale of cellulose acetate being broken up and added to solution containing solvents for use in making film support
2. Silver ingots used in making light-sensitive emulsion for photographic film
3. Machines used in the manufacture of film support
4. Film emulsion coating machine
5. Developing test samples for control of film quality
6. Infra-red photograph of actual operation of spooling film

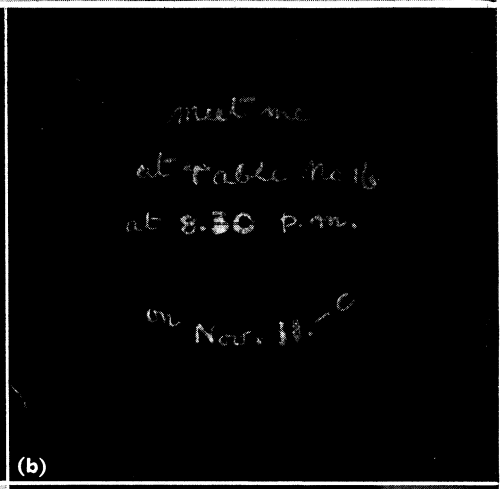


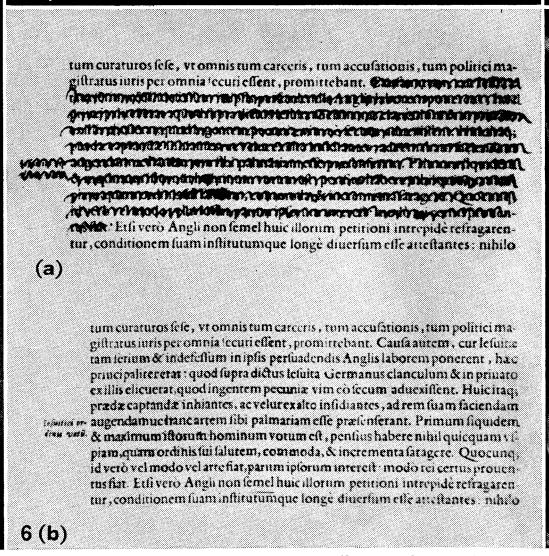


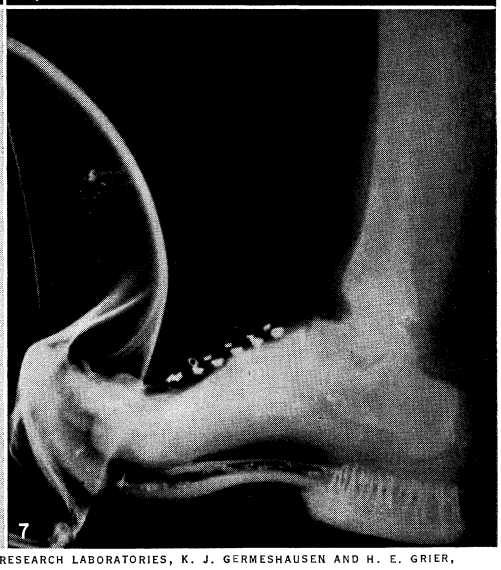












BY COURTESY OF (1) BAUSCH & LOMB OPTICAL CO., (2) PHOTOSTAT CORP., (3) U.S. ARMY AIR FORCES, (4) KODAK RESEARCH LABORATORIES, K. J. GERMESHAUSEN AND H. E. GRIER, (5) H. E. EDGERTON, (6) L. BENDIKSON, (7) C. M SLACK AND WESTINGHOUSE ELECTRIC CORP.

APPLICATION OF PHOTOGRAPHY AND SPECIAL TECHNICAL EQUIPMENT

1. Photomicrographic apparatus showing camera, microscope and arc lamp
2. Photostat@ photographic copying apparatus
3. Camera used for aerial photography at night with photoelectric cell attachment operated by light from flashbomb
4. Ultra-violet photography revealing hidden message by fluorescence
5. High-speed photograph showing tennis ball flattened on hitting racket
6. infra-red photography, (a) Normal photograph of censored document, (b) infra-red photograph showing penetration of ink
7. High-speed X-ray photograph made in one-millionth second

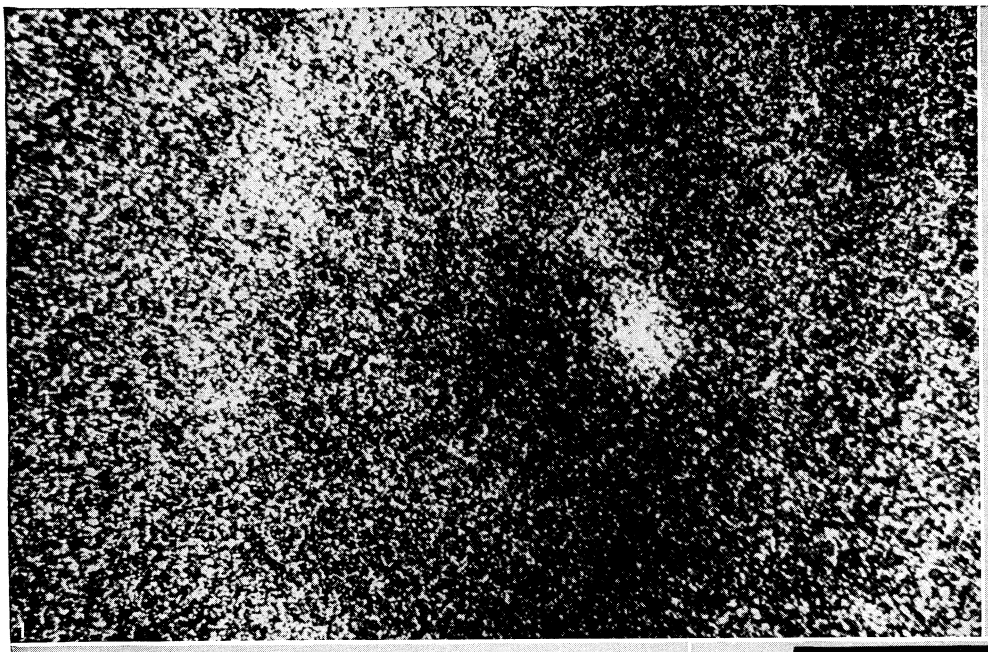
PHOTOGRAPHY

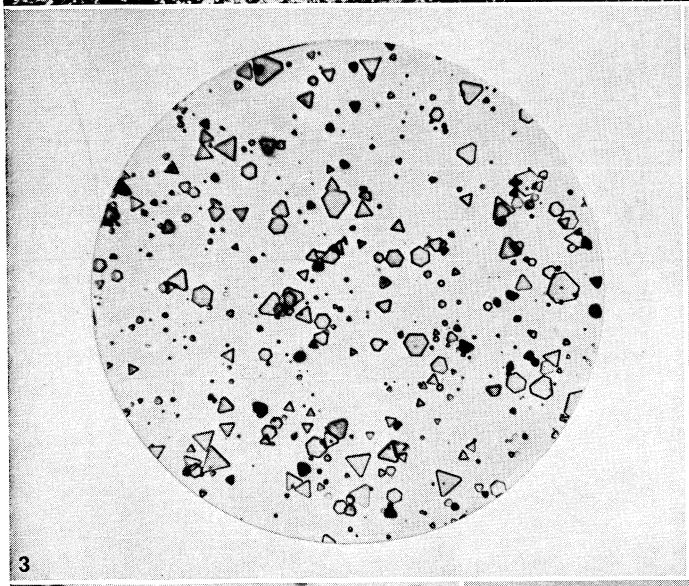
2

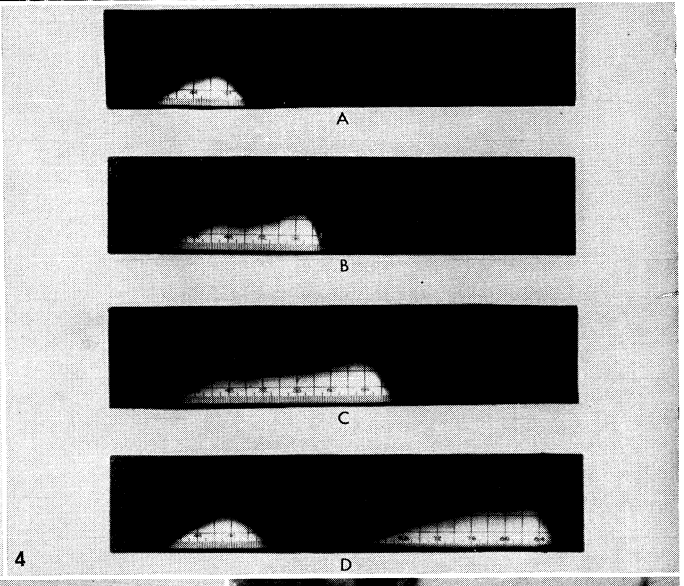
BY COURTESY OF U.S. ARMY AIR FORCES

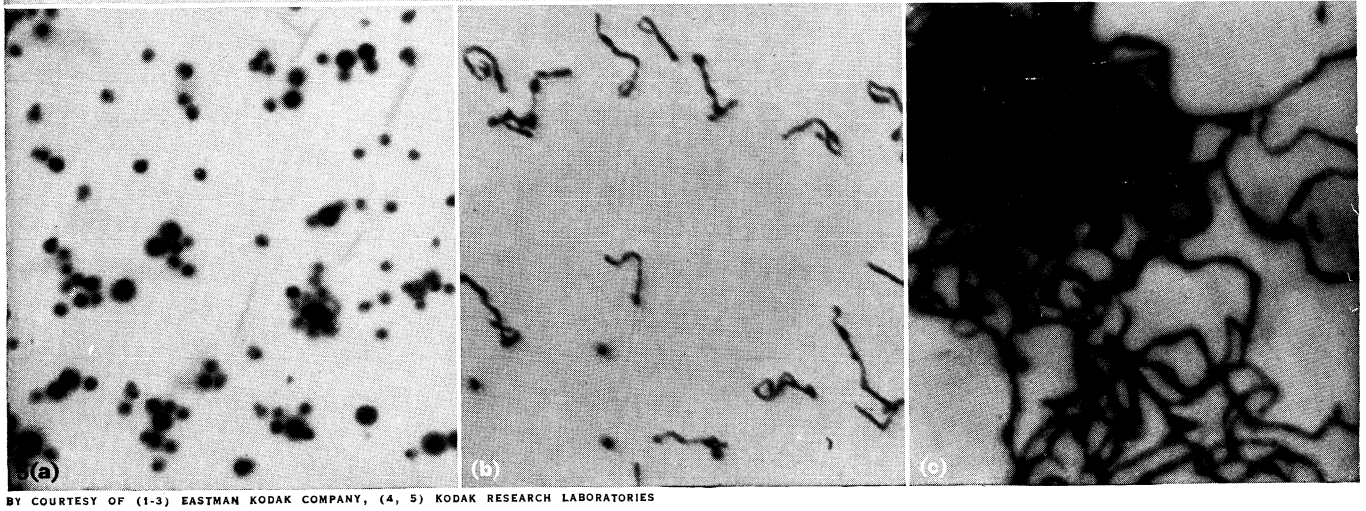
OBLIQUE AND VERTICAL AERIAL PHOTOGRAPHS OF THE SAME AREA

1. Oblique aerial photograph
2. Vertical photograph showing, enclosed between white lines, same area as fig. 1







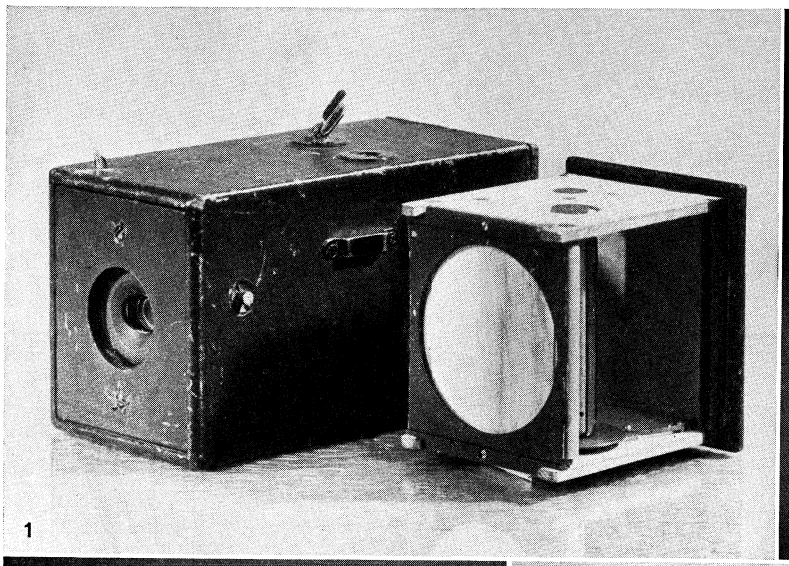


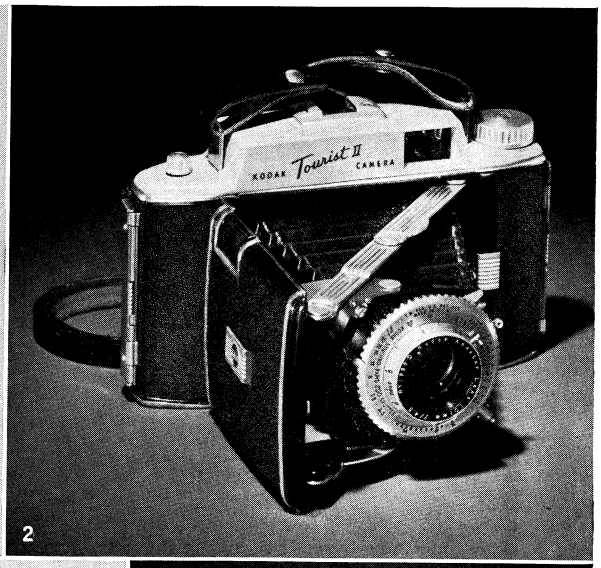
BY COURTESY OF (1-3) EASTMAN KODAK COMPANY, (4, 5) KODAK RESEARCH LABORATORIES

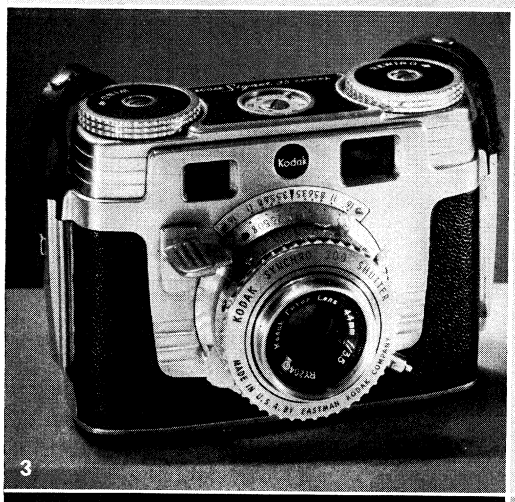
STRUCTURE AND PROPERTIES OF PHOTOGRAPHIC MATERIALS

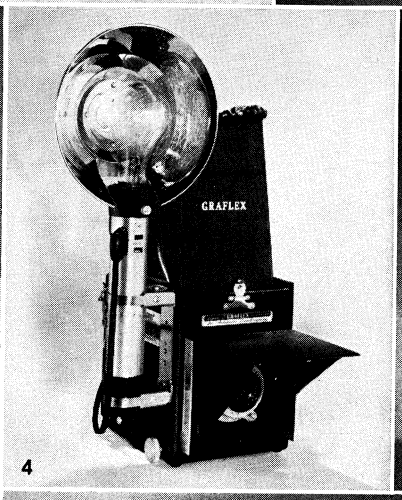
1. Grain structure of an image
2. Silver-bromide grains, before and after development
3. Crystalline grains of silver bromide in an emulsion
4. Wedge spectrograms showing spectral sensitivity of: (A) ordinary. (B) orthochromatic, (C) panchromatic, (D) infra-red plates and films
5. Photographs made in electron microscope of: (a) grains of "grainless" Lippmann plate; (b) the same developed; (c) developed grain of high-speed film

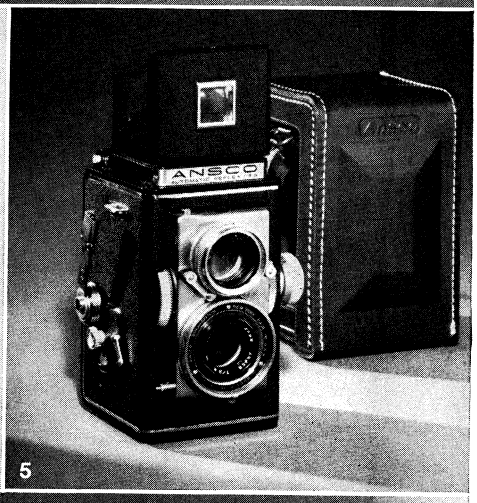
PHOTOGRAPHY

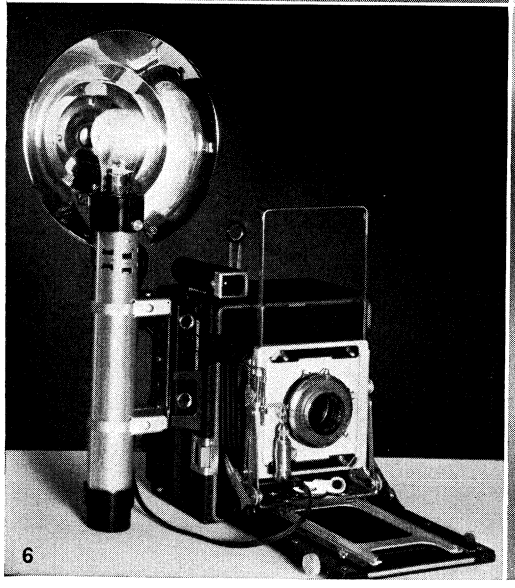


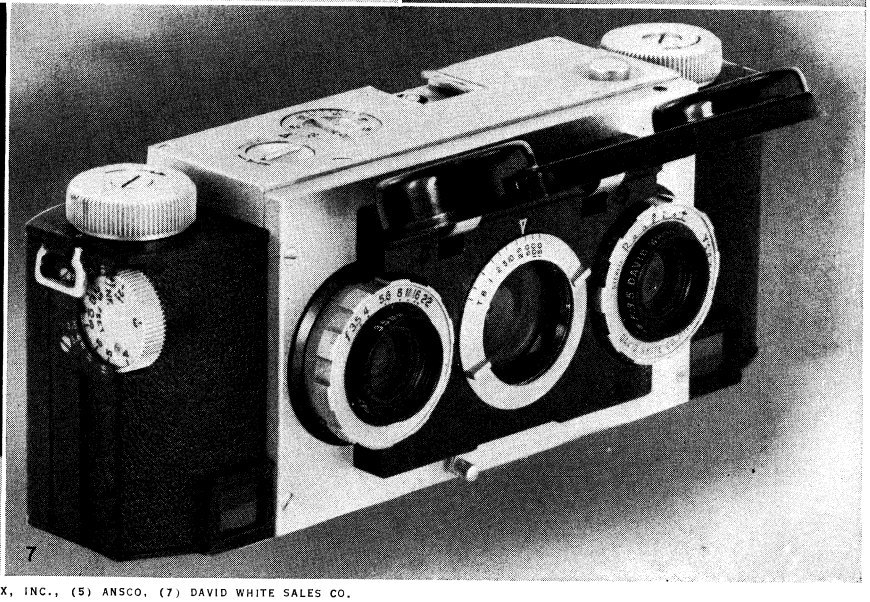












BY COURTESY OF (1, 2, 3) EASTMAN KODAK CO., (4, 6) GRAFLEX, INC., (5) ANSCO, (7) DAVID WHITE SALES CO.

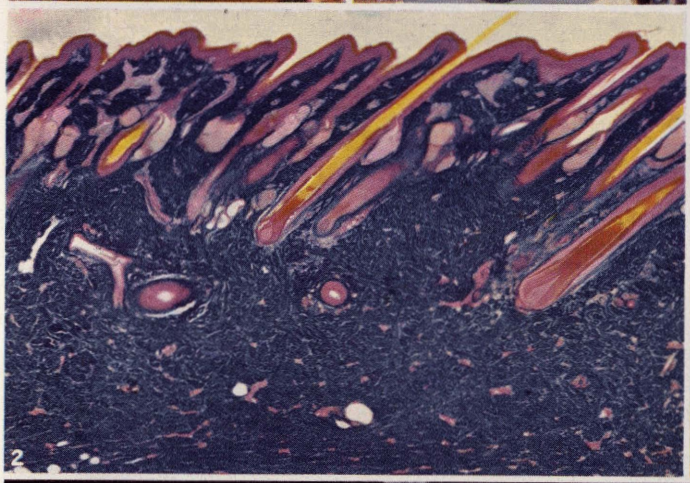
CAMERAS

1. The original No. 1 Kodak, 1888
2. Modern amateur roll-film camera
3. Modern amateur miniature camera using 35-mm. film
4. Reflex camera. Super D Graflex with automatic diaphragm and flash attachment
5. Two lens automatic Reflex *f*/3.5 camera
6. Speed Graphic camera with flash attacnment for press photography
7. Stereo Realist camera

BY COURTESY OF BRADFORD WASHBURN

AN EXPLORATION PHOTOGRAPH—MT. BERTHA IN THE ICY BAY DISTRICT OF ALASKA

PHOTOGRAPHY



BY COURTESY OF EASTMAN KODAK CO.

1. A colour negative and positive
2. Scientific photography — a section of calfskin, in Kodachrome photomicrography
3. An example of outdoor professional photography. An Ektachrome
4. This example of indoor portraiture was made on Ektachrome by tungsten lights

minify the picture sizes without the necessity of a change in focus or f-number, especially on motion-picture cameras.

By use of suitable prisms, or of systems of cylindrical lenses, it is possible to broaden a picture in one direction only without affecting the sharpness of focus. Such systems are called anamorphotes and find occasional application in advertising and commercial art photography.

A diffusion disk is another type of attachment which has some considerable degree of application, to soften the hard lines in a portrait or to give atmosphere to a pictorial scene. To be effective, a diffusion disk must let about 70% of the light beam enter the lens unchanged and slightly scatter or disperse the remaining 30% of the light. This is accomplished either by shallow grooves polished in the surface of the disk, or by streaks of glass of different refractive index fused into the interior of the glass disk itself. (R. KE.)

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PHOTOGRAPHY, CELESTIAL. Celestial photography is the application of photography to objects in the sky and, in particular, to astronomical objects such as the sun, moon, planets, satellites, comets, stars and nebulae. Although pictures of clouds are not generally considered to be examples of celestial photography, pictures of meteors and of aurorae, which are also atmospheric phenomena, are considered within this subject. This article is divided into the following sections and subsections:

I. The Application of Photography to Astronomy
II. Photographic Telescopes
  1. Photographic Efficiency
  2. Limiting Magnitude
  3. Field
  4. Schmidt Telescope
  5. Other Modern Telescopes
  6. Photographic Plates and Films
III. Celestial Photographs
  1. Sun
  2. Moon and Planets
  3. Artificial Satellites
  4. Meteors
  5. Aurorae
  6. Charts of the Heavens

I. THE APPLICATION OF PHOTOGRAPHY TO ASTRONOMY

The invention of photography by Louis Daguerre in 1839 led to a great step in astronomical progress. The first application of the daguerreotype to astronomy was made by John William Draper of New York city, who photographed the moon on March 23. 1840, the exposure being 20 min. Experiments in the new method were made under the direction of W. C. and George P. Bond at the Harvard College observatory, with the assistance of John A. Whipple and his colleague Black, photographers of Boston, as operators; the first photograph of the moon was taken there on Dec. 18. 1849, with the 15-in. object glass. A daguerreotype picture of the moon shown in London by George Bond at the Great Exhibition of 1851 attracted much attention.

Having seen the Harvard pictures in England. Warren De la Rue took up the subject and presented to the Royal Astronomical society, in 1857, positive copies from a negative picture of the moon made by a collodion process that he had found practicable five years earlier. In 1864 Lewis M. Rutherfurd of New York city made a telescope with object glass of 11¼-in. aperture so corrected as to bring the photographic rays to focus. About the same time Henry Draper surpassed his father's efforts by taking photographs of the moon with a 15-in. reflector.

Probably the first photograph of a star was a daguerreotype of Vega taken at Harvard observatory on July 17. 1850, but want of sensitiveness made this process rather impracticable, and there was little success in stellar photography until the invention of the collodion plate that was used in America and England in

1852. In Nov. 1857 a photograph taken at Harvard of ζ Ursae Majoris (one of the stars of the Ursa Major cluster) with its companion Alcor was sent for exhibition at the Royal Astronomical society by W. C. Bond; an exposure of 80 sec. had been given to photograph the 6th-magnitude star with the 15-in. refractor. De la Rue at that time was making experiments on the actinic power of Jupiter and Saturn compared with that of the moon, but his photographs did not show any details of the planetary surfaces. Under De la Rue's direction, and to his design, a photoheliograph was made and set up at Kew observatory, Surrey, Eng., for the Royal society, and the work of taking daily photographs of the sun, that was later carried on successfully at Greenwich and elsewhere, began at Kew in March 1858. De la Rue did not succeed in his attempt to photograph Donati's comet of that year, but Usherwood of Walton Common, Surrey, Eng., photographed the comet in 7 sec. with a portrait lens of short focus.

Daguerreotypes of the sun taken by J. B. L. Foucault and Armand Fizeau in 1845 and photographs of the solar eclipses of 1851 and 1854 were interesting experiments, but the photographs taken by De la Rue and by Pietro Secchi of the total solar eclipse in 1860 were the first of their kind to have real scientific importance, since they established beyond doubt that the solar protuberances were really appendages of the sun and not of the moon. Ten years later, at the eclipse of Dec. 12, 1870, excellent photographs taken by A. Brothers at Syracuse, N.Y., supplied evidence that the corona was also of solar origin; from that time a photographic picture of the sun's surroundings remained an integral item in the program of eclipse observation.

In the years after 1870 many people were engaged in research and experiment in photography generally. Of particular relevance to astronomy were the studies of W. de W. Abney. It was decided, mainly at the instigation of De la Rue, that photography (in addition to visual observation) should be used by the British expeditions that were to study the transit of Venus in 1874, and the work, so far as the process was concerned, was put in Abney's charge. He realized that the circumstances of the occasion would make a wet-plate process inapplicable and, after experiments conducted at Chatham, Kent, Eng., recommended the adoption of an albumin dry process, using a highly bromized collodion and strong alkaline development.

The titles of two of Abney's papers—"On Dry Plate Processes for Solar Photography" and "On the Photographic Method of Mapping the Least Refrangible End of the Solar Spectrum"—indicate their bearing on astronomy. These papers represent a remarkable achievement in that Abney succeeded in producing a special photographic emulsion, sensitive to red light, which he used to map the solar spectrum far into the infrared.

It was pointed out by George Bond that photography might be successfully used to measure the relative positions of stars, of a group or of double stars; and in a letter to William Mitchell on July 6, 1857, he predicted, in effect, the application of photography to stellar astronomy on the magnificent scale that actually exists today. In 1864 Rutherfurd began a long series of photographs of star clusters and of the bright double stars; but apparently these measures mere never completed. In 1870–84 B. A. Gould, in an expedition to the southern hemisphere, accumulated negatives of the principal double stars and clusters. Because the wet-plate process was used in making these photographs it was not possible to give an exposure long enough for faint stars to imprint themselves. With the invention of the gelatin dry plate, which had been used by William Huggins for spectrum photography in 1876 and which came into general use about 1880, this difficulty was removed and modern astronomical photography became possible. Circumstances connected with the comet of 1882, which was especially magnificent as seen from the southern hemisphere, led to new applications of celestial photography. A photograph, taken with a camera strapped, for the purpose, to the great equatorial of the Royal observatory of the Cape of Good Hope, showed not only the comet but great numbers of faint stars around it; this at once suggested to David Gill the possibility of making star charts by photography. Effects of various kinds followed upon Gill's idea. At Paris the brothers Paul and Prosper Henry of the National observatory were engaged in the laborious task of plotting the positions of stars found by eye observation in order to make charts of the stars near the ecliptic; but they abandoned this work and devoted their efforts to making a telescopic object glass suitable for photography.

In England. Ainslie Common turned to the art and, with a three-foot silver-on-glass mirror, took a photograph of the Orion nebula on Jan. 30, 1883, with an exposure of 37 min. He earned the gold medal of the Royal Astronomical society in 1884 for this feat, which Abney called "epoch-marking" when presenting the medal to another nonprofessional astronomer for similar work 11 years later. An earlier photograph of this nebula, taken by Henry Draper of New York city on Sept. 30, 1880, is said to be the first obtained but it is agreed that this was not a satisfactory representation. The later recipient of the medal mentioned above was Isaac Roberts. In 1885 he had made a 20-in. silver-on-glass reflector of nearly 100-in. focal length for the purpose of making star charts by photography, but altered his plans and devoted the instrument to photographing star clusters and nebulae. The excellent pictures produced at his observatory at Crowborough, Sussex, are collected in two volumes published during his lifetime, supplemented by a third prepared and issued by his widow in 1928.

Common's photograph of the Orion nebula led. through Edward Holden, to the acquisition of a three-foot reflector in 1895 by the Lick observatory, Mt. Hamilton. Calif. Two mirrors made by Calver and formerly owned by Common, were presented to that institution by Edward Crossley of Halifax, Eng., and one of these, refigured by Sir Howard Grubb, forms the essential part of the instrument known by his name. In James Keeler's hands it yielded a superb series of photographs of nebulae which for the first time demonstrated the great advantages of the reflecting telescope for certain classes of astronomical photography and led to the construction of the great modern reflectors.

(H. P. H.; F. H. S.; D. E. O.)

II. PHOTOGRAPHIC TELESCOPES

The instruments used for celestial photography are telescopes of one or another kind, but without an eyepiece. Instead the light is brought to a focus at the photographic plate, as in a simple camera. Astronomical telescopes may be grouped into three classifications: (1) refractors, (2) reflectors and (3) catadioptric or composite systems (see TELESCOPE). In a refractor a lens collects and brings light to a focus; in a reflector a concave mirror, usually of glass aluminized on the curved surface; serves the same purpose; in a catadioptric system a light-transmitting plate and a mirror in combination have the same function. In addition refractors may be subdivided into two kinds: those designed for visual. observations, and those for photographic purposes. Since the development of celestial photography and its almost universal application occurred after many of the larger refractors had been constructed, a number of observatories were in the position of having to use for photography instruments originally intended for visual work. In these cases the adaptation from visual to photographic use was accomplished in a variety of ways: by adding another lens to the objective; by reversing one of the elements in the objective; by placing a small correcting lens a few feet in front of the focus; or by using a yellow colour filter and an emulsion sensitive to visual light. The last two methods, because of their simplicity, are those in commonest use respectively for photography of spectra and of star fields by the largest refractors, such as the 40-in. telescope at Yerkes observatory, Williams Bay, Wis., and the 36-in. Lick telescope. In the case of reflectors, since their mirrors bring light of all colours to the same focus, photography over a wide spectral range is possible without focal compensation.

1. Photographic Efficiency.—The aperture, focal length and focal ratio of a telescope are usually chosen to make it as efficient as possible for a particular type of problem. The larger the focal length, the larger the scale or magnification of the image. For a particular focal length, the larger the aperture, the greater the

North America nebula in Cygnus photographed in 1909 by E. E. Barnard, Yerkes observatory, using a 10-in. lens and a blue-sensitive photographic plate

North America nebula in Cygnus photographed in 1949 by the National Geographic society-Palomar observatory sky survey observers using the 48-in. Schmidt camera and a red-sensitive photographic plate

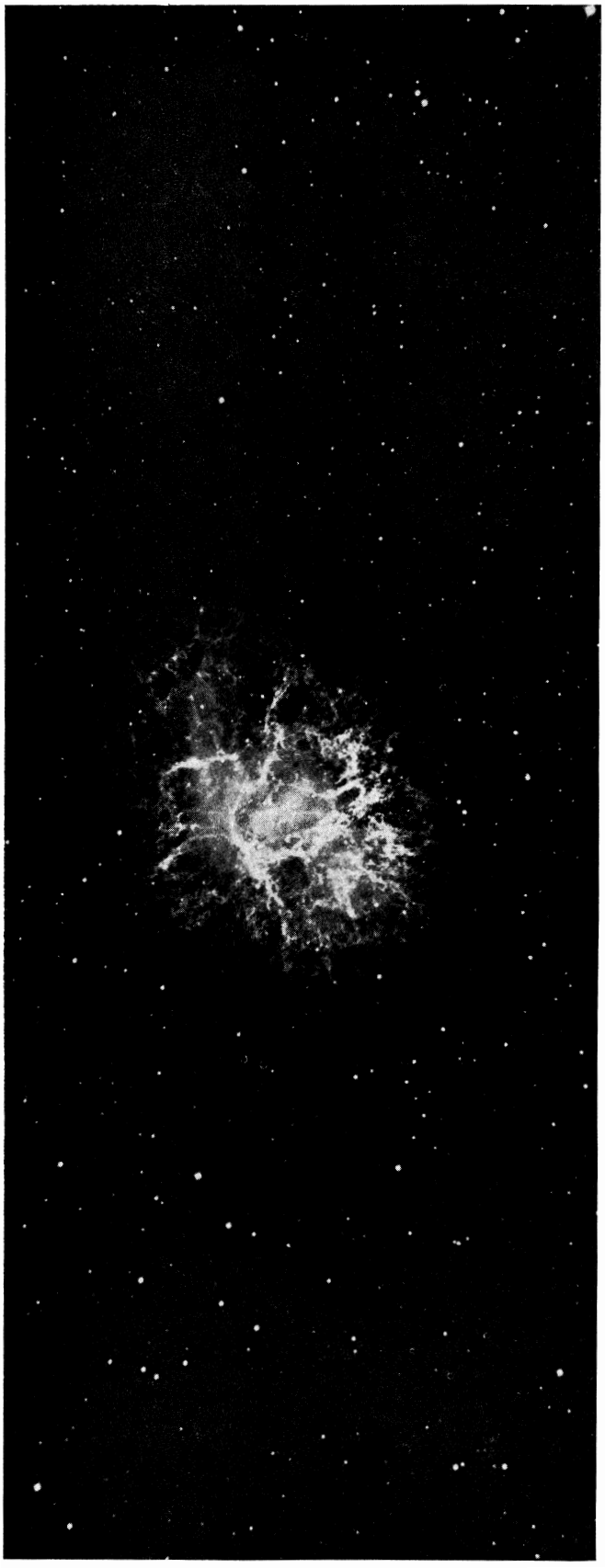
Horsehead nebula in Orion photographed with an 18-in. Schmidt camera, showing a large field, about 5° in diameter, at a relatively small scale. Horsehead is the small feature near middle of picture

Horsehead nebula in Orion photographed with the 200-in. telescope, showing a small field (Horsehead is only about 5 minutes of arc long) at a very large scale

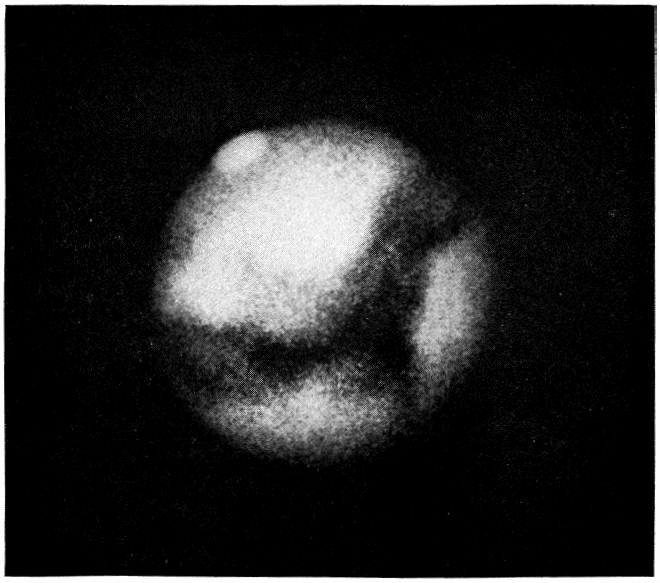
PHOTOGRAPHS OF NEBULAE IN CYGNUS AND ORION

BY COURTESY OF (TOP LEFT) YERKES OBSERVATORY, (BOTTOM) MT. WILSON AND PALOMAR OBSERVATORIES: PHOTOGRAPH, (TOP RIGHT) COPYRIGHT NATIONAL GEOGRAPHIC SOCIETY-PALOMAR OBSERVATOPY SKY SURVEY

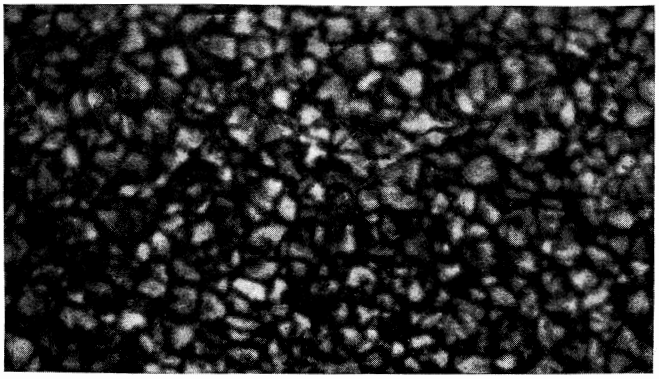
PHOTOGRAPHY, CELESTIAL



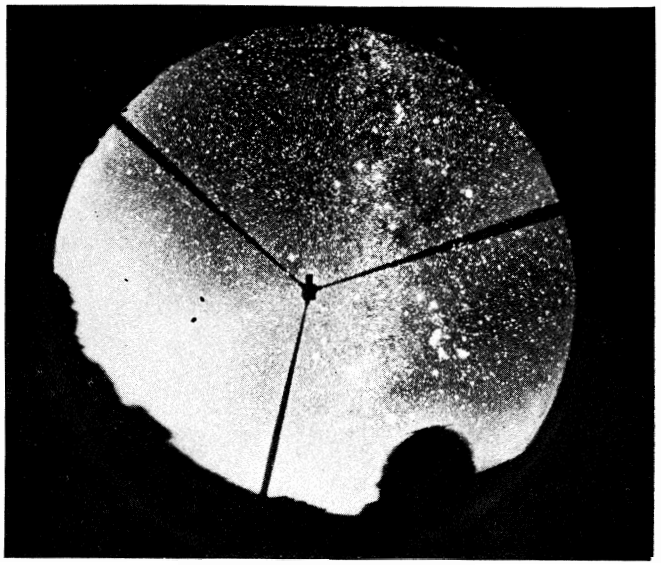
Crab nebula in Taurus photographed in red light, showing filamentary structure of expanding gaseous matter ejected by supernova of A.D. 1054



Mars photographed with the 40-in. refractor, Yerkes observatory, 1909



Solar granulation photographed with a 12-in. reflector from a balloon. Smallest detail has a size of about 0.3 seconds of arc



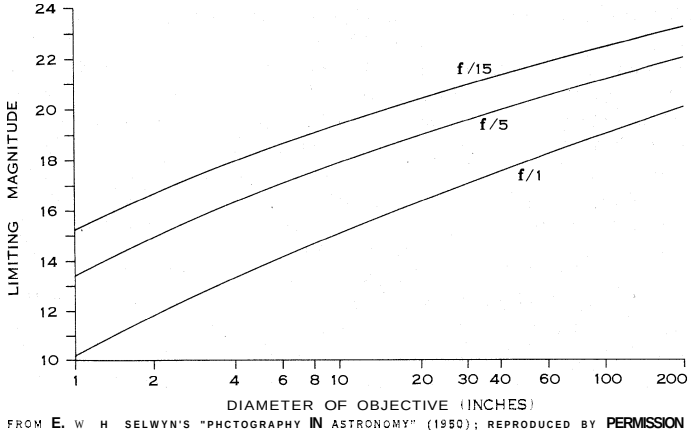
Milky Way, zodiacal light and stars photographed with the Greenstein-Henyey wide-angle camera. Diameter of picture is 1400, only a little less than whole hemisphere. Faintest stars on picture are also faintest stars that can be seen with naked eye, so picture reproduces sky as the eye sees it

ADDITIONAL EXAMPLES OF CELESTIAL PHOTOGRAPHY

BY COURTESY OF (LEFT) THE MOUNT WILSON OBSERVATORY AND W. BAADE, (TOP RIGHT, BOTTOM RIGHT) YERKES OBSERVATORY; PHOTOGRAPH, (CENTRE RIGHT: PROJECT STRATOSCOPE OF PRINCETON UNIVERSITY, SPONSORED BY THE U.S. OFFICE OF NAVAL RESEARCH AND THE U.S. NATIONAL SCIENCE FOUNDATION

amount of light collected and hence the brighter the image. For objects having extended surfaces like the sun, moon, planets and nebulae, the situation is similar to ordinary terrestrial photography. The photographic efficiency for surfaces is inversely proportional to the square of the focal ratio and is independent of the aperture; for a particular focal ratio the advantage of a large aperture is its great magnification and hence its ability to resolve small details.

For stars the situation is somewhat different. According to geometrical optics, star images are points; if diffraction is taken



FROM E. W. H. SELWYN'S "PHOTOGRAPHY IN ASTRONOMY" (1950); REPRODUCED BY PERMISSION OF EASTMAN KODAK COMPANY

PHOTOGRAPHY OF FAINT STARS

For a given focal ratio, the larger the telescope aperture the fainter the stars that can be photographed. For a given aperture, a larger focal ratio permits fainter stars to be recorded

into account. they are small disks whose linear size is proportional to the focal ratio. One might expect that the photographic efficiency would be proportional to the square of the aperture of the telescope. However. for telescopes with apertures larger than a few inches, the actual image size is determined by aberrations and imperfections in the optical elements and by the effects of disturbances in the earth's atmosphere (called "twinkling" or "seeing"). In larger telescopes, therefore, the star images are larger and the photographic efficiency does not increase as rapidly as the square of the aperture.

2. Limiting Magnitude. — For a given telescope it is impossible to photograph fainter and fainter stars merely by prolonging the exposure time. In order to record a percepttble image of a star there is required a certain minimum difference between the brightness of the stellar image and the sky background. The effect of sky illumination, the light of nhich is a faint and variable auroral glow produced in the earth's atmosphere by solar radiation, is determined by the focal ratio. For a given focal ratio. therefore. increase in linear dimensions does not affect the sky brightness in the focal plane of the telescope. From experience it is found that nhen the surface brightness of an object falls below one-sixth the sky illumination it becomes difficult to recognize the object on the emulsion. When this condition is approached the magnitude of the faintest star discernible on the photograph is termed the limiting magnitude. Because of its great practical importance. the limiting magnitude attainable nith a given telescope has been the subject of a number of studies. The results of these studies are collected in the figure. compiled by E. W. H. Selwyn, nhich shons the limiting magnitude as a function of aperture and focal ratio of the telescope.

To record a perceptible image of a nebula also there is required a minimum difference between its brightness and the general sky brightness. This contrast can be increased by taking the photograph with light of such wave length that the nebula is relatively bright and the sky is relatively faint. Because much of the nebular light is therefore rejected. this procedure requires long exposure time or particular photographic skill.

3. Field. — For most of the large refractors. nhich generally have focal ratios in the range f/15 to f/20, the field of critical definition amounts to 1° to 2° in diameter. In order to cover larger areas lenses of shorter focal length and of focal ratio f/7 to fi4.5 usually are employed. However! simple doublets of this focal ratio have only a small field of good definition and in order to photograph a larger field it is necessary to use a more complicated multielement lens. Among the most useful of these wide-field lenses are a series of four-element objectives, f/7, designed by F. E. Ross, which have a field of several degrees.

The field of good definition of a reflecting telescope also decreases with decreasing aperture and with increasing focal length, and is only a few minutes of arc for the 100-in. reflector at Mt. Wilson observatory, near Pasadena. Calif., and the 200-in. reflector at Palomar observatory, Palomar mountain, Calif. In 1929 Ross designed a lens that. when placed a short distance in front of the focus, extended the useful field to an area nearly 1° in diameter. Since lenses of this type changed the focal length very little they were called zero correctors. By the early 1960s nearly all of the large, modern reflectors were provided with auxiliary lenses of this character.

4. Schmidt Telescope. — In 1931 Bernhard Schmidt of the Hamburg observatory, Bergedorf, Ger., designed and constructed a new type of telescope that represented an ideal composite system. The Schmidt telescope consists of a figured correcting plate, which the light passes through, and a spherical reflecting mirror, which then brings the light to a focus on a spherical surface with a radius half that of the mirror. It is therefore necessary to bend the photographic film or plate to fit this curved focal surface. Since the Schmidt telescope has a much larger field of good definition than either a reflector or refractor of the same focal ratio, it is superior whenever coverage of a large area on a single exposure is required. By the 1960s many 24-in. (aperture) Schmidt cameras were in operation; the largest was the 48-in. camera of the Mt. Wilson and Palomar observatories.

5. Other Modern Telescopes. — During the early 1940s A. Bouwers in the Netherlands and D. D. Maksutov in the U.S.S.R. independently discovered a composite system somewhat similar to the Schmidt telescope. In the Bouwers-Maksutov telescope the light passes through a weak spherical lens and is focused by a spherical mirror onto a curved film. The advantage of this system is that its lens involves only spherical surfaces and for this reason it is easier to construct than a Schmidt corrector plate. Furthermore the over-all length of the telescope is shorter than that of a Schmidt telescope of the same aperture and focal length. The disadvantage of the Bouwers-Maksutov telescope is that its definition. while superior to that of an ordinary refractor or reflector over a wide field; is not as good as that of a Schmidt telescope. By the 1960s the largest two Bouwers-Maksutov telescopes in operation were the 20-in. (aperture) at Alma-Xta and the 18-in. at Simeis, both in the U.S.S.R.

With Schmidt or Bouwers-Maksutov telescopes it is possible to photograph with good definition a field of from 5° to 15° in diameter, depending on the size of the instrument. (Although this is much smaller than the field of an ordinary hand camera, it must be remembered that astronomical requirements of definition and of scale are much greater than those that can be met by hand cameras.) Various modifications of these telescopes make it possible to extend the usable field to as much as 50° but for still larger fields a different type of instrument is necessary (see *Celestial Photographs: Meteors; Artificial Satellites,* below). A very wide-field system invented by J. L. Greenstein and L. G. Henyey in the 1940s uses a spherical mirror that focuses the light on a spherical focal surface. There is, however, no film at this focal sphere; instead there is a complicated lens system some distance above it which refocuses the light onto a flat plate. In this way a different section of the mirror is used for photographing each part of the sky and the field of good definition is quite large. The largest Greenstein-Henyey camera! owned by the Yerkes observatory, has a mirror 12 in. in diameter, but the effective aperture is only 0.2 in. and the effective focal length 0.4 in. This instrument photographs a field of 140° at one time, only a little less than the whole hemisphere of 180°.

6. Photographic Plates and Films. — The photographic materials used in astronomy are ordinarily coated on glass plates

because of the relative freedom from stretching achieved in this way. Film is used only if it has some special advantage, as in some Schmidt cameras because it can be bent easily, or in solar or planetary photography because large numbers of exposures are taken in rapid succession. Ordinary photographic emulsion is sensitive only to the wave-length region 3,000 Å to 5.000 Å. (An angstrom unit, written Å, is $\frac{1}{100,000,000}$, or 10^{-8}, centimetre. The limits of human vision extend from about 4.000 Å, violet, to 7,000 A, red. while 5.000 Å is green.) After the discovery of sensitizing dyes by Hermann Vogel in 1873 the short wave-length region that can be photographed was extended to 3,000 A; more recent inventions pushed the long wave-length limit to 13,000 Å.

Astronomical plates and films are considerably more sensitive than commercially available materials but on the other hand they become fogged more easily and must be kept under refrigeration until shortly before use. There is a range of speeds of astronomical plates available: generally the more sensitive a plate is to light, the grainier its structure is when developed and the poorer its resolution is. Thus one must always compromise between speed and resolving power.

III. CELESTIAL PHOTOGRAPHS

1. Sun.—The sun is extremely bright, brighter than almost any other source, and therefore can be photographed with very long focal-length instruments and on large scale. Furthermore fine-grain (and therefore relatively slow) plates can be used for the maximum resolution of fine detail on the sun's surface. Cnder these conditions the resolution is limited chiefly by the unsteadiness of the earth's atmosphere and by the deformation of the optics of the telescope caused by solar heating. In the early 1900s George Ellery Hale discovered that a considerable part of the daytime unsteadiness occurs near the ground as a consequence of convection of heated air. Therefore he arranged for the construction of the 60-ft. and 150-ft. solar towers at Mt. Wilson, each of which has an objective lens of 12-in. aperture at the quoted distance above the focal plane. The solar towers are fixed refracting telescopes with vertical axes, equipped with coelostats, or systems of fiat mirrors driven to follow the sun's apparent daily motion, that direct the sunlight down into them. Each of the towers is actually composed of two completely independent structures, one inside the other. The outer tower serves as a screen to prevent the inner tower, which bears the optical equipment, from being set into vibration by the wind. The combination of great height above the ground and shielding from wind proved quite successful in limiting the effects of atmospheric unsteadiness and improving the image quality. Subsequently several other tower telescopes were built, including those at Potsdam, Ger., at Arcetri, Italy, and at the McMath-Hulbert observatory near Pontiac. Mich. The last observatory in particular pioneered in making motion pictures of rapidly changing solar phenomena. Solar telescopes are often used in conjunction with a spectroheliograph (*q.v.*) to record a photograph of the sun in the light of a single wave length, *i.e.,* in the light of a single element, such as hydrogen or calcium.

In an attempt to obtain solar photographs of even better resolution two groups of astronomers were led in 1956–57 to use balloons to take their telescopes to heights above nearly all the atmospheric unsteadiness. A. Dollfus of the Paris observatory and D. E. Blackwell and D. W. Dewhirst of Cambridge observatory took an 11-in. refracting telescope of 180 ft. effective focal length to a height of 20.000 ft. in a manned balloon, while M. Schwarzschild and J. R. Rogerson of Princeton University observatory and J. W. Evans of Sacramento Peak observatory, Sunspot, N.Mex., sent an automatically operated 12-in. reflector of 200-ft. effective focal length to a height of 84,000 ft. in an unmanned balloon. Both telescopes mere composite systems consisting of an objective together with an enlarging lens, so that the over-all tube length was considerably smaller than the effective iocal length, and both took many exposures on continuous rolls of film. The definition of both sets of photographs was very good, those taken from the unmanned balloon being the finest solar pictures ever taken.

The solar corona is the very faint outer envelope of the sun, only about $\frac{1}{1,000,000}$ as bright as the sun. It can be phorographed easily at eclipses—when the bright solar disk is hidden —but at other times sunlight scattered by particles in the earth's atmosphere and by imperfections in the optical parts of a telescope ordinarily completely masks the faint coronal light. In 1931, however, Bernard Lyot of the Paris observatory succeeded in photographing for the first time the solar corona outside eclipse. By using an ingenious telescope of his own design termed the coronagraph, and by working on the Pic du Midi (elevation 9,400 ft.) in the Pyrenees, Lyot was able by 1936 to photograph the inner corona out to 7′ of arc from the sun's limb. With still further instrumental refinements, and with the use of a polarizing monochromatic filter (see LIGHT: Polarization and *Electromagnetic* Theory) that transmitted a band of radiation only 1.5 Å wide, Lyot by 1941 not only obtained pictures of the corona but also made direct photographs of the chromosphere, prominences and sunspots that rivaled in quality those given by the spectroheliograph. Two more coronagraph observatories were constructed: the Zurich observatory station at Arosa, Switz. (elevation 6,600 ft.), and the Harvard station at Climax, Colo. (11,500 ft.).

2. Moon and Planets.—The moon and the planets near the earth, though fainter than the sun, are relatively bright objects, comparable with brightly illuminated outdoor scenes on the earth. Thus it is possible to use long focal ratios and short exposure times in photographing these objects. In many cases it is advantageous to use an enlarging lens to increase the effective focal length of the telescope and consequently the scale of the image on the plate. Because the main effect that limits the definition is theunsteadiness of the image caused by turbulence in the earth's atmosphere, it is customary to take large numbers of exposures in the hope that some mill be taken during short moments of "good seeing." After the films have been developed the best images are selected for further study; it is even possible to make a composite print from several different negatives of the same planet to average out the fictitious details caused on a single picture by the earth's atmosphere and by flaws in the film. Experience has shown that, except on a very few superbly steady nights. a telescope of 20- to 40-in. aperture is the best for this type of photography. A larger telescope looks through a greater volume of the earth's atmosphere and is therefore more likely to be affected by unsteadiness of the air.

Photography has made it possible to map the moon in detail and to study, particularly by comparing photographs taken in light of different colours, the surfaces and atmospheres of the planets (see VENUS; MARS; JUPITER).

3. Artificial Satellites.—In Oct. 1957 the U.S.S.R. launched the first artificial earth satellite, and a new subject for celestial photography was created. The first Russian sputniks were large and bright enough for many amateur astronomers and photographers to obtain pictures of their paths across the sky with simple terrestrial cameras. Many scientific problems can be solved by obtaining precise positions of artificial satellites. The United States put into operation a network of 12 cameras specially designed for tracking satellites. These Baker-Nunn cameras are modifications of the Schmidt camera. equipped with a complicated three-component corrector lens and a spherical mirror. The cameras have a focal length of 20 in., work at a focal ratio of f/1 and have a field of good definition 30" in diameter. They use roll film, and a single exposure photographs an area 5° wide and 30° long; inside the telescope is an illuminated precision clock, which gives the exact time of the observation. The telescopes have specially designed mountings that make it possible for them to track alternately on the orbital motion of the satellite and on the diurnal motion of the stars. In this way the image of even a faint satellite can be recorded during one phase of the exposure, and the images of faint stars near it in the sky during the other phase. By measurements of the developed film accurate positions of the satellite can be obtained. A precision of about one second of arc has been obtained with these cameras, the limiting factor being the difficulty of determining the precise time (an accuracy of bet-

ter than 0.001 sec. is required) at remote points on the earth.

4. Meteors. — Meteors or "shooting stars" are solid bodies, ranging in size from small grains to rocks as big as a house, which are heated to incandescence as they plunge through the earth's atmosphere. There is no way of predicting when or where they will appear and they burn out so quickly that once seen it is too late to turn a camera to them. Therefore it is only by accident that a telescope being used for another purpose will occasionally record a meteor trail. For serious scientific work on these objects it is necessary to patrol continuously a large area of sky nith very efficient cameras in order to record the meteors down to as faint a limit as possible. The most effective cameras employed to this end are the so-called "Super-Schmidts," designed by James G. Baker for the Harvard observatory. Each of these cameras has a four-element corrector together with a spherical mirror and may be described as a complicated combination of a Bouwers-Maksutov and an achromatized Schmidt camera. Four of these cameras were constructed, each with an aperture of 12 in. and a focal ratio f/0.67 and each nith a field of good definition 52° in diameter. The focal surface is curved too steeply for ordinary film to be bent to fit it, so the cameras use special hemispherically molded films. After development these curved films are copied photographically onto flat glass plates for measurement and storage. The Super-Schmidt cameras contain electrically driven rotating shutters, which interrupt a meteor trail at accurately known time intervals, and thus make possible a measurement of a meteor's angular speed through the sky. The cameras are operated in pairs, separated by distances of 50 to 100 mi. so that the height and space velocity of any meteor photographed from both stations can be determined by measuring its apparent shift with respect to the background stars.

5. Aurorae. — The aurora borealis, or northern lights. is one of the most impressive sights offered by the night sky Although many successful pictures of individual parts of an auroral display have been taken with hand cameras, the whole phenomenon is so vast that a camera covering nearly the whole sky is needed for a complete photograph. The Greenstein-Henyey camera. which photographs a field 140" in diameter on one exposure, has proved ideal for this work. One of these cameras fitted with a motion-picture attachment was used by A. B. Meinel and his co-norkers at the Yerkes observatory to photograph the changes in form and structure of typical aurorae. (D. E. O.)

6. Charts of the Heavens. — The advantage that photographs of clusters and nebulae have over visual observation is obvious. A glance at a photograph shons the whole of the object in all its beauty. The field of view of a telescope is small and a complete conception of the nebula has to be built up from successive elements. It has always been mentioned that Gill foresaw the possibility of recording the positions of stars from a single plate; the next step was to connect individual plates to make a complete survey of the heavens, as had been — and is — the final aim and purpose of transit observing. The first effort in this direction was made by Gill, who (1885–89), took photographs covering the sky from the south pole to declination 18° S. nhich, measured by Jacobus C. Kapteyn of Groningen. gave approximate co-ordinates and magnitudes of nearly 500.000 stars that form the *Cape Photographic Durchmusterung.* In a more ambitious scheme initiated in 1887 by Amédée Mouchez. director of the Paris observatory, 18 observatories of the world combined to make the *Astrographic Chart,* or a picture of the whole sky which should show all stars down to the 14th magnitude, to nhich was added later a catalogue of all stars to the 11th magnitude By 1958 the catalogue was substantially complete but the chart covered only approximately 50% of the sky. In this connection mention should be made of a series of plates that came later, taken by Franklin Adams in 1903–04 at the Cape of Good Hope and in 1909–10 at Godalming, Surrey, Eng.. with a photovisual objective of 10-in. diameter. Two hundred and six of these plates, each covering an area of 15° X 15°, chart the whole sky to the 16th magnitude.

The extreme delicacy of the gelatin film, especially during development and fixation, led in the beginning to a certain distrust of measurements made on photographic plates. Experience showed these fears to be groundless and photographic methods to be well suited to measurements of the most exacting kind. With properly designed instruments the economic factors are also favourable. An undertaking which effectively utilized these advantages was the reobservation by photography of the zones of the great Astronomische Gesellschaft (A.G.) catalogue, in which the positions of stars to the 9th magnitude were originally measured with meridian circles at many different observatories. In 1913 Frank Schlesinger initiated at the Allegheny observatory, Pittsburgh, Pa., a program of observations with a wide-angle lens which proved to yield accurate star places over a plate 5 square degrees (sq.deg.). Although successful results were obtained with the 25-sq.deg. field, the frequent difficulty of not having enough bright reference stars for plate reductions led Schlesinger at the Yale University observatory in 1927–28 to employ a specially designed 5-in., f/14 Ross lens that covered a field of 140 sq.deg. Other workers soon adopted the photographic method and by 1938 the northern A.G. zones had been completely reobserved by Yale and a number of European observatories.

The most ambitious project of charting the sky was the National Geographic society-Palomar observatory sky survey, made with the 48-in. Schmidt telescope during the years 1949–1956. The whole sky north of declination 27° S. was divided into fields approximately 40 sq.deg., and two photographs of each field mere taken, one in blue light and one in red, for a total of almost 1,800 photographs. These photographs show stars as faint as the 20th magnitude and permit estimates of the stars' brightness and colour to be made. The band of wave lengths used for the red exposures was so selected that the diffuse nebulae had several emission lines, and therefore appeared very bright. The sky survey provided an unusually complete record of stars and nebulae, which proved invaluable in many statistical and research programs.

The proper motions of stars can be measured by wholesale photographic methods, the most direct method being to photograph a star field at two different times, separated by several years, with the same telescope. Then if the two photographs are compared, the fastest moving stars can be identified as those whose two images are displaced by the greatest amount, while the majority of stars that move more slowly have nearly coincident images. This method of finding stars with large proper motions was pioneered by Max Wolf in Germany and by F. E. Ross in the United States. Furthermore the proper motion of every star on the pair of photographs can be measured in this way if there are some reference objects on it with known motions. Such a proper-motion survey was undertaken at the Lick observatory with a specially designed 20-in. refractor. The extragalactic nebulae, which are so far away that their apparent motions are very small, served as the reference objects. The whole northern sky was photographed for the purposes of this survey during the period 1948–56; a second series were to be taken about 25 years later.

As an early example of astronomical work made practicable by the measurement of photographs, mention may be made of the determination of stellar parallaxes by Charles Pritchard at the Oxford Cniversity observatory in the year 1887. 'lost researches that depend on the measurement of small distances are now made by means of the photographic plate, though close double-star measurement is an exception. E. Hertzsprung devised methods involving the use of a grating and colour filters to ensure freedom from error in finding the distance between the components of double stars and their position angles, but it is considered that the photographic method is unsuited for pairs whose separation is less than about a second of arc.

In addition to the advantages already mentioned, others that pertain to the sensitive plate are that its receptivity is cumulative; by continued application it can see where the eye is blind. The impressions are permanent and constitute a record that can be measured and consulted at will. Faint comets. for example, are discovered by photographing the region in which the object is believed to lie and searching the developed plate. In this manner 6 of the 11 satellites of Jupiter and 1 of the 9 satellites of Saturn were discovered; satellites X and XI of Jupiter are so small that they were found only with the 100-in. Mt Wilson reflector by S. B. Nicholson in 1938. A similar method for finding minor

planets has been very fruitful, and examination of the series of celestial photographs of the Harvard College observatory has brought to light many novae that have appeared in past years but which were not detected visually at the time of their appearance. This great collection of photographs that was accumulated systematically over many years constitutes a record of the state of the sky at approximately regular intervals. It was especially fruitful for the discovery of variable stars and for the determination of their light curves. See also Index references under "Photography, Celestial" in vol. 24.

See E. W. H. Selwyn, *Photography* in *Astronomy* (1950); G. Z. Dimitroff and J. G. Baker, *Telescopes* and *Accessories* (1945).

(N. U. M.; D. E. O.)

PHOTOGRAPHY, SPARK, a technique that derives its name from the type of illumination employed for the photograph, utilizes the light produced by a small electric spark of extremely short duration and great intensity. This technique should not be confused with the electronic flash ordinarily used for photography.

The spark method finds many applications in the photography of rapidly moving objects; for example, the earliest known spark photograph was an ordinary snapshot of a newspaper clipping fastened to the surface of a rapidly spinning disk. The size of the spark is so small that it can be used to project a silhouette directly on the photographic film, and, in ordinary practice, the conventional camera with its lens is not required.

The spark itself is generated by the discharge of a high-voltage capacitor across a gap between two electrodes. The circuit consists of the condenser, the main gap, and a trigger gap formed by a third electrode placed between the two main electrodes. Electrical energy is slowly stored in the condenser over a relatively long period of time, since the spacing of the electrodes is wide enough to hold the voltage. and is discharged with sudden violence through the main gap at the instant the circuit is effectively completed by sparking the trigger gap.

The gap and condenser are designed to produce the most brilliant flash of light possible in the shortest time. By grouping the elements of the condenser in a ring around the gap so that the discharge of electricity takes place in a concentric path, the duration of the spark can be shortened to 10^{-7} seconds and good exposure obtained at spark to photographic plate distances of 4 to 10 ft. with an operating capacitance of 0.1 microfarad and voltage of 7,000 volts.

Fortunately, the light from the spark is rich in ultraviolet radiation and its photographic effectiveness is thereby increased in taking direct spark shadowgraphs. More brilliant sparks can be obtained for other applications by increasing the capacity and voltage, but the duration of the light is also increased, approaching several microseconds in extreme cases.

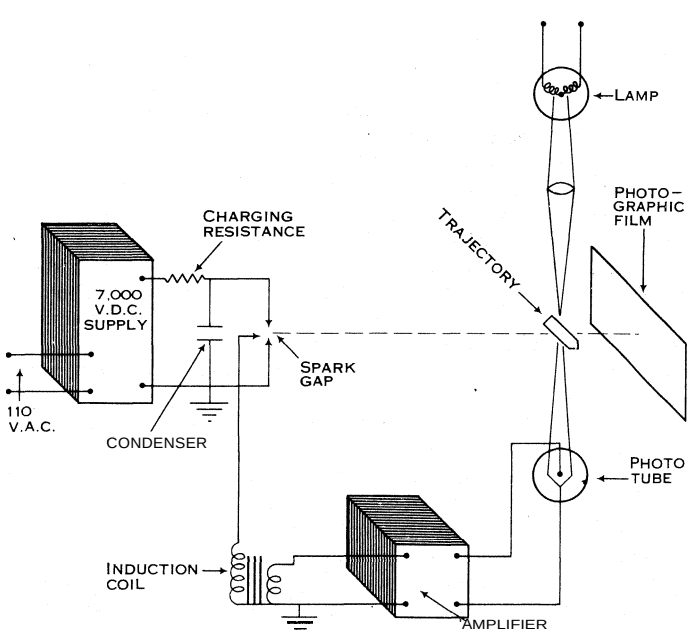


FIG. 1.—SCHEMATIC WIRING DIAGRAM OF SPARK PHOTOGRAPHY APPARATUS

Firing the spark at the desired time during the brief period the moving object is in front of the plate is usually the most difficult feature of this photographic system. and many ingenious methods of triggering have been developed. This operation must be extremely precise; a tolerance of 10^{-5} seconds is common, and fast electronic circuits are required. The particular method chosen depends on the application, but ordinarily some property of the object itself starts the trigger operation. The simplest of all methods is the make-or-break contact. If the object is made of steel, a magnetic trigger can be used; if it can be charged to a high potential, an electrostatic trigger is suitable; if the geometry of its motion can be arranged so that it cuts the path of a beam of light, a photoelectric trigger gives good results; or, if the object is traveling faster than the speed of sound, a sonic trigger will work.

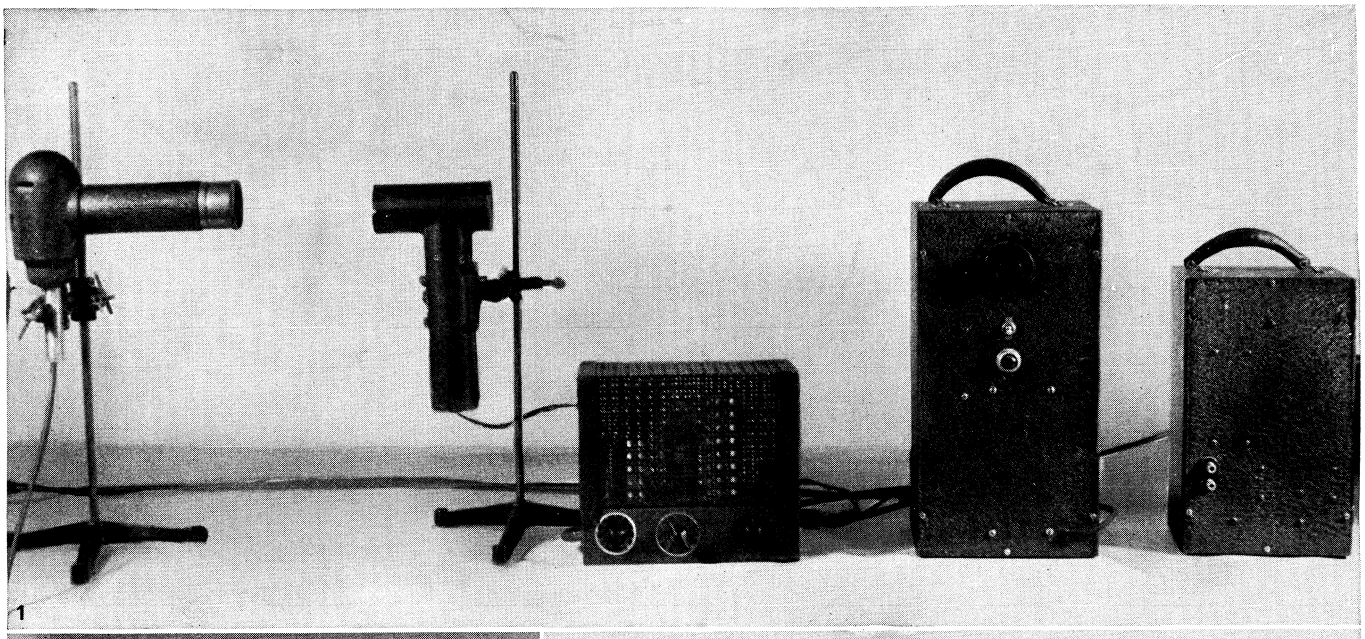
The over-all operation is conveniently illustrated by tracing through the sequence of events involved in taking the spark photograph of a bullet in flight using the apparatus shown in the fig. 1. The room is darkened. the photographic plate put in position, and the gun is fired. Since a photoelectric trigger is used, the gun is aimed so that the trajectory intersects the beam of light from the lamp to the phototube. As the bullet interrupts this beam, it changes the amount of light falling on the phototube and thereby generates a voltage pulse in the electronic circuit. This pulse is amplified and used to fire a gas discharge tube in the output of the amplifier. The discharge tube in turn sends a surge of current through the primary of an induction coil, and the high voltage surge resulting in the secondary is applied to the electrode of the trigger gap producing a weak spark across this gap. The trigger spark ionizes the air in the main gap, causing it to break down, the condenser discharges through the main gap, and the spark photograph is taken. The duration of the light is sufficiently short to arrest the motion of even the highest velocity projectiles.

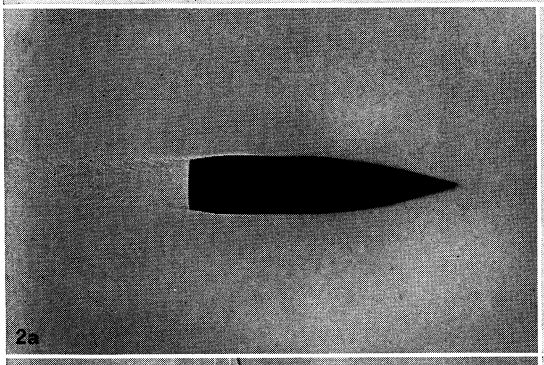
Applications to Ballistics.—Spark photography is of great value to the ballistics engineer, enabling him to answer many questions on the flight of bullets and the flow of the air about them. Such problems as that of determining the distance from the muzzle at which the velocity of the erupting gas becomes less than that of the bullet are readily solved. It is of particular interest in the case of shot shells where the disposition of the shot and wads may be easily observed. Work of this nature led to the commercial development of shot shells without the top card wad over the shot, for it was observed by spark photography that this wad interfered with the proper flight of the shot.

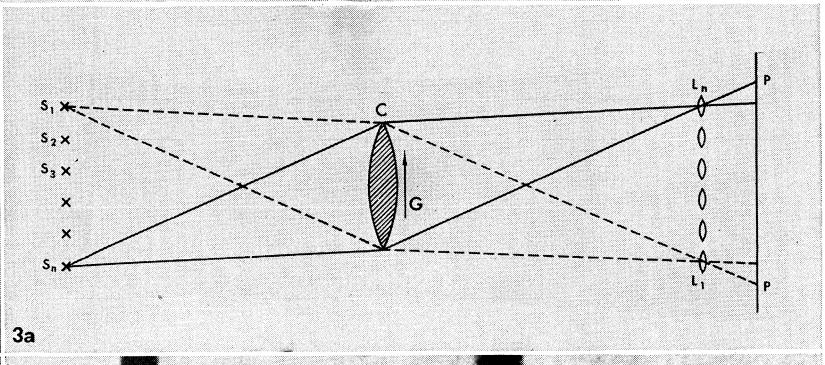
Aerodynamics Range.—As the projectile flies from gun to target, it experiences violent resistive forces because of its high-velocity motion through the air, and if the flight path is to be computed, these forces must be measured. Here spark photography gives the ballistician a tool of great precision in the so-called "aerodynamics range." The projectile is fired into a long, enclosed gallery containing from 10 to 25 spark-photography stations spaced at intervals along its length. As the projectile passes each station in turn. two spark pictures are taken in perpendicular planes (one horizontal, say, and the other vertical) and the time of the event is recorded on a high-speed chronograph.

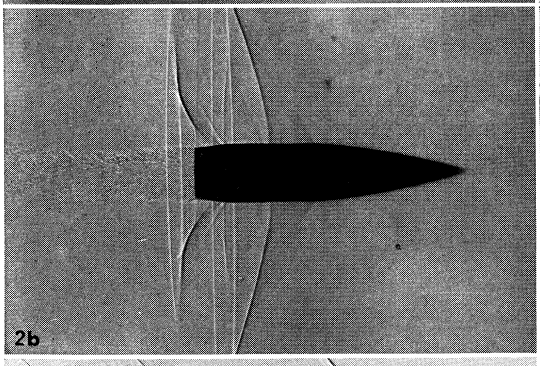
Thus, each pair of spark photographs records the position of the projectile at a measured time, and all of the records can be combined to determine the retardation of the projectile's motion and the aerodynamic drag. The inclination of the projectile's axis to its direction of motion can also be measured from each pair of pictures, and from these measurements the projectile's stability can be computed.

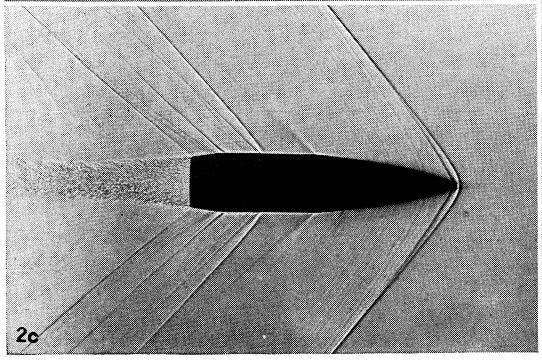
Applications to **Physics.**—Many processes of physics not only take place with extreme rapidity, such as the flight of bullets, but also require special optical apparatus in order to be recorded in a useful manner. For example, the flow of air over an airplane in a supersonic wind tunnel is quite invisible to the naked eye but can be seen clearly if viewed through the particular combination of light sources, mirrors and lenses known as a Schlieren

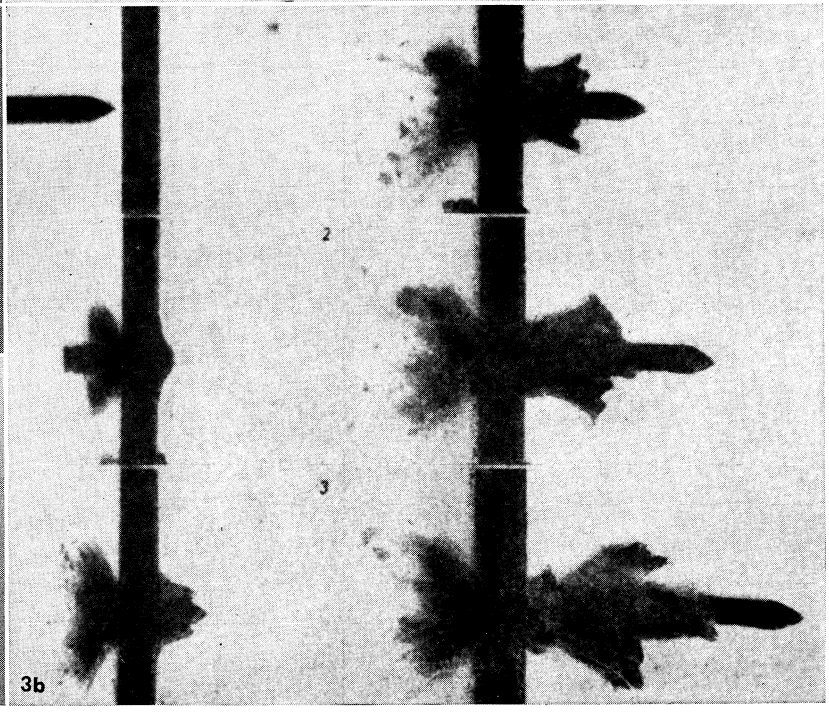












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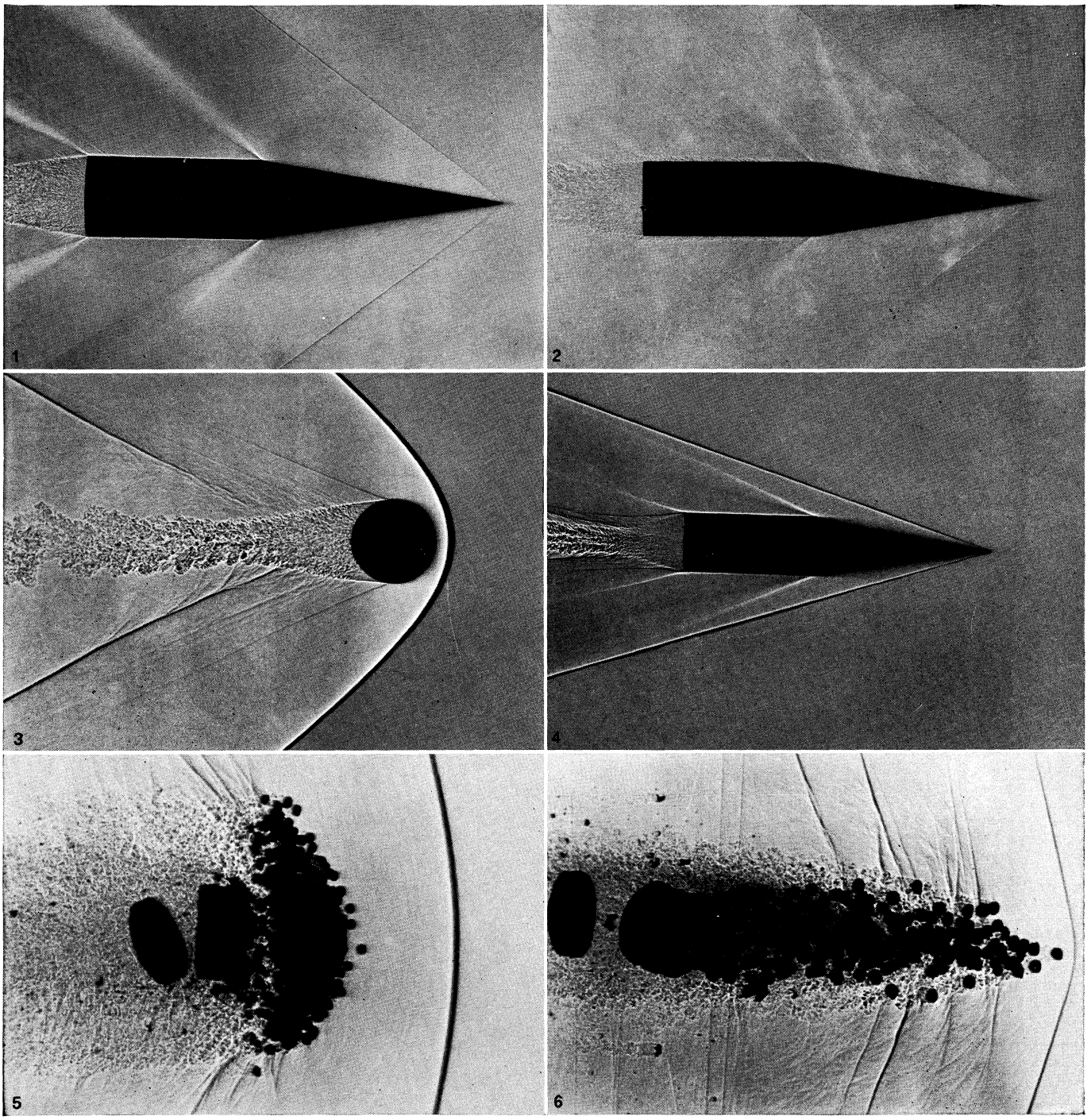
APPARATUS AND EXAMPLES OF SPARK PHOTOGRAPHY

1. Complete spark photography equipment. Left to right: phototube lamp, phototube, amplifier, power supply and spark source
2. Spark photographs of a ½-in.-diameter model of a 155-mm. HE projectile travelling (a) far below, (b) near and (c) well above the velocity of sound

3a. Diagram of optical system for multiple-spark apparatus; 3b. Penetration of armour plate by 13-mm. projectile

PHOTOGRAPHY, SPARK



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SPARK PHOTOGRAPHY OF BULLETS IN FLIGHT

1. Smooth cone-cylinder projectile (20 mm.) at 1,850 ft. per second
2. Rough cone-cylinder projectile (20 mm.) at 1,530 ft. per second
3. A 9116-in.-diameter sphere (cannonball) at 2,050 ft. per second
4. Smooth cone-cylinder projectile (½-in. diameter) at 4,046 ft. per second
5. A 12-gauge shot charge from cylinder-bored gun, photographed three feet from muzzle
6. A 12-gauge shot charge fired from choke-bored gun, three feet from muzzle

system. Near the speed of sound the flow over the airplane becomes unsteady and changes violently from one instant to the next. Waves sweep back and forth over the wings at high speed, and the exposure must be as brief as in ballistic photography if the details of the flow processes are to be recorded clearly.

Spark photography furnishes the key to the instrumentation by providing a light source having both a short duration and the very small size required by optical systems. Its use in a Schlieren system is shown in the accompanying diagram. 411 of the light from the spark is brought to a focus at the knife edge, and the lateral dimension of the spark must be limited to a small value, ranging from 0.01 in. in small Schlieren systems to 0.1 in. in large. If a limited number of photographs are to be taken in rapid succession. several sparks placed side by side may be used in a Schlieren system with small orifices replacing the knife edges, each orifice being located at the conjugate focus of one of the sparks. Rates of up to 1,000,000 pictures per second have been obtained.

Other processes in physics require the photography of high-speed objects which are brightly luminous themselves, such as a rocket with a burning jet of exhaust gases or a very high-speed missile that glows like a meteor as it streaks through the air. The light from these objects would fog the film of a direct shadowgraph or obscure the image of a microflash photograph. Again, a spark light source can be combined with an optical system to provide a suitable means of photography. In one system, the spark casts a shadow of the object on a motion-picture screen rather than on a photographic film directly. The screen is photographed by a camera placed adjacent to the spark but to one side so that the images of the object itself and its shadow on the screen are displaced from one another on the camera's plate. In this way. the light from the object is separated from the shadow on the movie screen and does not impair the silhouette of the object seen in the spark photograph.

Shock Wave Phenomena. — One of the most spectacular examples of spark photography is the shadows produced by compression waves in the air. These waves are seen as lines. usually curved, with a dark front edge and a light rear edge. Strong compression waves, known as shock waves. have fronts that amount to surfaces of very small thickness through nhich the pressure, density. temperature, and, consequently, index of refraction change violently. They are roughly similar to the fronts of naves rolling up a shallow beach. The rays of light from the spark passing tangent to these wave surfaces are refracted to form lines of alternate dark and light representing the projection of the wave surfaces on the photograph. The technique is very sensitive and wave patterns are recorded in fine detail.

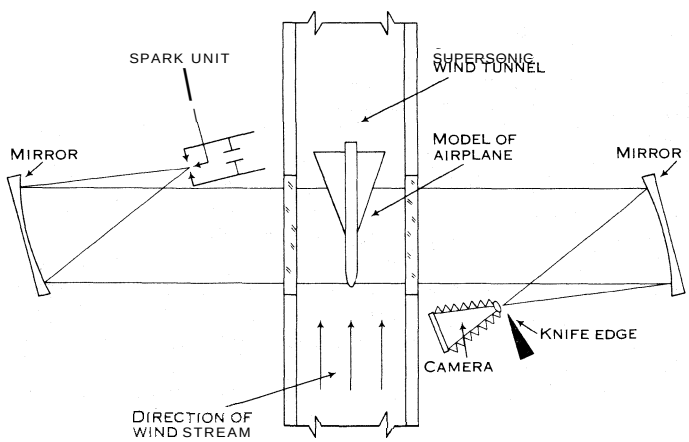

FIG. 2.—SCHEMATIC DIAGRAM OF SCHLIEREN OPTICAL SYSTEM FOR PHOTOGRAPHING FLOW OVER MODEL OF AIRPLANE IN SUPERSONIC WIND TUNNEL

Shock waves are produced in air by any disturbance that is sufficiently strong and abrupt. Electric sparks. explosives, projectiles and aircraft traveling at speeds close to or greater than the speed of sound all generate shock waves. An example of pure wave photography is found in the study of the reflection of shock waves from solid surfaces. The wave patterns surrounding bodies at transonic and supersonic velocities are of particular interest since they tell much about the nature of the air flow over the body. Even the turbulent layer of air next to the projectile's surface and the wake following it are visible. (R. E. E.; A. C. Cs.)

PHOTOGRAPHY, STROBOSCOPIC. The term stroboscopic photography should apply strictly to the use of multiflash techniques. However, it has become commonly used to describe single-flash photography and the contraction "strobe" is often heard when referring to single-flash electronic equipment and photographs taken with it.

Nearly all electronic photography systems of short flash duration rely upon the electrical capacitor to supply the high peak power needed to flash the lamp. The instantaneous power must be about 100,000 watts even for a small, portable flash lamp. The important criterion for exposure is the quantity of light produced, beam-candle-power-seconds (b.c.p.s.), which depends upon the efficiency of conversion of electrical energy to useful light and the storage capacity of the capacitor.

The capacitor is the most important component in a flash unit, other than the flash lamp itself, accounting for most of the weight, volume and cost of the equipment. The capacitor has the ability to accumulate energy at a slow rate and discharge it suddenly into the lamp at a high rate for a short time. Many oi the advances in modern electronic flash-equipment design have been concerned with improved capacitors, such as the electrolytic type.

Electronic-flash tubes are made in many sizes and forms, such as the straight, U-shaped and spiral, as required for different applications. The gas in the tube, usually xenon at a pressure of 0.1 atmosphere, and the electrode spacing are arranged so that the lamp will not flash by itself in most applications. The flash is initiated when a pulse is applied to an external starting wire, causing internal ionization; the tube flashes when the capacitor discharges. Flash duration for a specific flash tube and circuit can be portrayed as a curve showing the initial delay, the rise, the peak and the decay of the light intensity. From a practical standpoint the entire duration of the flash is a negligible amount of time if the motion of the subject is effectively stopped. The duration is defined as the time between instants when the light is at one-third of its peak.

The output oi a flash tube is rated as the integral of light as a function of time. An approximate value can be obtained by taking the product of the flash duration and the peak light, the latter being measured in candle-power-seconds. Special exposure meters are available which integrate the light during the flash and present a meter reading of the integral of the light as a function oi time, Some of these meters have phototubes in probes that are used to read the light at the film position in the camera.

The electronic flash tube has an unusual volt-ampere characteristic. At the start of the discharge the resistance is infinite since no current is flowing. Then as current starts to flow the resistance drops rapidly, reaching a value of a few ohms during the main portion of the discharge. Finally the current again becomes zero and the resistance, infinite. During most of the flash, however, the volt-ampere characteristic is similar to that of a resistor, and the circuit transients can be calculated approximately by considering the flash lamp to be a fixed resistor. For example, the resistance of the FX-1 flash tube manufactured by Edgerton, Germeshausen and Gricr, Inc., is about 2 ohms. This lamp has an effective length of 6 in. and an inside diameter of 4mm. Extrapolations to other lengths and diameters of flash tubes can be made as though the tube were a resistor of uniform conductivity, especially if the stored energy per unit of lamp volume and the voltage per unit of length (or mean free path) are the same as in the FX-1 flash lamp at rated value (2,000 volts and 200 watt-seconds). The flash duration equals $\frac{1}{2}RC$ seconds, where C is the value of the capacitance in farads and R is the flash-lamp resistance as defined by

$$R = \frac{\text{initial capacitor voltage}}{\text{peak current}}$$

where the energy density is more than about 40 watt-seconds per cubic centimetre in the lamp.

There is a large variety of electronic flash tubes available for the equipment designer to consider and newer ones appear frequently. Some of the factors to be considered in designing a flash tube for any specific purpose are shape, efficiency, flash duration, voltage and spectral output.

In considering shape, a concentrated lamp is more effective in a reflector when control of the light is required, but some light may thus be lost by self-absorption,

Each lamp has its maximum efficiency for a particular output. The designer should attempt to use the lamp at or near this maximum (about five candle power per matt) although he usually cannot for such reasons as heating or life of the rube.

If a specific duration is required, the design voltage is usually fixed

for a specific lamp.

Efficiency needs to be considered in terms of voltage since the efficiency usually drops when the tube is used at low voltage.

The xenon flash lamp has a spectral output very similar to that of daylight except for an excess in the blue and near ultra\-iolet. It is known that a flash lamp with a large voltage per mean free path and high energy per unit volume will have a greater excess in the blue compared to the output of a lamp operating at small values. The differences, however, are small and difficult to detect, even with colour film. A long flash lamp operated at low voltage has a large relative proportion of infrared output.

There are many instances in which the most eificient flash tube cannot be used because of heat storage and conductivity problems. This is the usual case with stroboscopic sources, and particularly with those lamps that operate at high frequency and high power for extended periods of time.

Multiple-Flash Photography. — The first multiexposure photographs were made with a slotted disk as a shutter, or with a series of cameras. Electronically produced flashes of light at accurately controlled intervals of time are an excellent method of producing stroboscopic photographs. Two practical problems arise, however, when an electronic flash tube is required to run as a stroboscopic source. First, the flash tube may become so hot that it does not function properly and may misfire due to improper starting. Second, the flash tube may fail to deionize, thus preventing the capacitor from building up a charge for the subseauent flash. The Dower unit then supplies continuous current to the lamp in a condition known as holdover.

A hot lamp may fail for several reasons, such as electrical puncture of the glass by the external sparking circuit, short circuiting of the triggering spark by the conduction of the hot glass or actual collapse of the glass mall of the tube. Failure of a tube to deionize, in addition to the holdover condition, may result in self-flashing due to the lowering of the holdoff voltage by residual ionization, high temperature or overheated electrodes. Tubes of quartz are much more capable of operation at high-power rates since the quartz has a higher melting temperature than glass. Several special circuits have been used to operate flash tubes at high flash rates per second. Examples are the series mercury-arc rectifier of the pool type and the hydrogen thyratron, of the type used in radar modulators.

The stroboscopic light can be synchronized mith the motion of the film to produce framed pictures for projection. This is commonly done mith the 16-mm. high-speed rotating prism camera. Magnetic pickups can be used to trigger the flash lamp at the correct instants of time so that the flashes are synchronized with the film position. There is another general type of multiflash equipment that is capable of great speed and flexibility and which is useful when a limited number of photographs are needed. Each flash ior this method is powered by a separate capacitor, connected either to separate lamps or to a common lamp. Such circuits become bulky when a large number of flashes are desired since each flash requires a separate storage system, as contrasted to a single-storage capacitor. (H. E. ED.)

PHOTOGRAVURE: see GRAVURE.

PHOTO-LITHOGRAPHY: see LITHOGRAPHY.

PHOTOMETRY deals with the calculation and measurement of light. Here the word "light" may be restricted to electromagnetic radiations of those wave lengths that are capable of' affecting the eye. In modern photometry, however, the same physical methods of measurement can often be employed also in the nearby ultra-violet and infra-red regions. Thus in many cases, photometry has come to mean the measurement of electromagnetic radiation over a somewhat wider range of wave length than is included in the strictly visible region.

Photometry may be divided into theoretical photometry or photometrics, and experimental photometry:

1. Theoretical photometry
   a. Physical photometrics
   b. Geometrical photometrics
2. Experimental photometry.

Photometrics includes the establishment of the various concepts and units needed in the quantitative specification of light. It also deals with methods of calculating any one of these quantities in terms of the others. Theoretical photometry may be divided into two parts, analogous to the division of optics into physical optics and geometrical optics. Physical photometrics is the part of the subject that deals with the spectral distribution of radiant energy and its evaluation with respect to the receptor. Geometrical photometrics considers the space distribution of radiant energy. Experimental photometry treats of the apparatus and experimental methods that are used in the measurement of light.

The literature of photometry includes the classic treatises of François Marie (1700), Pierre Bouguer (1729), Johann Heinrich Lambert (1760) and August Beer (1854) and the more recent books by John William Tudor Walsh, Charles Fabry, A. A. Gershun and others. The subject is still in the process of rapid growth, as attested by the large numbers of original researches described in the journals of the optical societies and illuminating engineering societies. A few references are given at the end of this section.

Physical **Photometrics.**—The early photometrists (1760) based their work on the idea of light as a separate entity produced by a candle, and these crude ideas persisted even into the 20th century. But today everyone knows that visible light is physically the same as other electromagnetic radiation, the only difference being that visible radiation is of such wave lengths that it affects the eye while other radiations are of longer or shorter wave lengths to which the eye does not respond. Thus the modern approach to lighting is through the physics of radiation.

Electromagnetic radiation includes the wide range of radio (wireless) waves, the infra-red region, the visible region, the ultra-violet, X-rays, etc. All of these radiations are of the same nature and are separated into regions on the basis of wave length. The wave length of electromagnetic radiation is measured in any convenient units of length. For radio broadcasting, wave lengths may be expressed in metres (1 m. = 39.37 in.). For visible radiation, the metre is too big a unit so the millionth part of a metre is ordinarily employed. This unit is called the micron. Two other units of wave length are sometimes used:

1 micron (μ)	$=10^{-6}$ metre
1 millimicron ($m\mu$)	$=10^{-9}$ metre
1 Angstrom (Å)	$=10^{-10}$ metre.

The approximate limits of the visible region are 0.4μ and 0.7μ, or $400m\mu$ and $700m\mu$, or 4000 Å and 7000 Å. Radiation at 0.4μ gives the sensation of violet. As the wave length is increased beyond 0.4μ, the colour sensation changes through blue, green, yellow, orange and red. Radiation at 0.7μ appears as a deep red, while radiation much beyond 0.7μ is invisible. This is the infra-red region. If radiation is much shorter than 0.4μ, it is likewise incapable of affecting the eye, and the radiation is said to be in the ultra-violet region.

When radiation occurs in a very narrow band of wave lengths, it is said to be homogeneous radiation. The yellow light produced by heating common salt in a Bunsen flame is practically homogeneous, as is the radiation from the sodium-vapour lamp used in highway lighting.

Some electric discharge lamps, such as mercury-vapour lamps and neon lamps, produce line spectra. That is, homogeneous radiation is emitted simultaneously at several distinct wave lengths. The set of wave lengths at which energy is emitted is a characteristic of the gas or vapour in which the discharge takes place. A lorn-pressure mercury-vapour lamp, for example, produces four strong radiations in the visible region. It radiates at 0.406μ (violet), 0.435μ (blue), 0.546μ (green) and 0.578μ (yellow). There are additional lines in the ultra-violet and infra-red. An incandescent lamp, on the other hand, radiates at every wave length in a wide band, producing a continuous spectrum. Sunlight is also essentially continuous. In fact, continuous spectra are produced by all sources that radiate because of their temperature.

The physicist and the engineer must know not only the wave length but also the amount of radiation. The sole way in which this amount can be measured is to transform some of the radiant energy into another form, such as thermal energy, and measure the result. A blackened surface can be placed where the radiation is to be measured. Most of the radiant energy incident on the surface is converted into heat and causes a temperature rise of the blackened surface. This temperature rise is measured and constitutes a means of determining the radiant power (watts) per unit area, incident on the surface.

Thus the specification of homogeneous radiation incident on a given receiving surface requires a knowledge of two quantities: (a) the wave length, and (b) the radiant power being received

by the surface per unit area (expressed in watts per square metre). The specification of a line spectrum consists in a designation of the wave lengths of the radiations and the radiant power per unit area associated with each wave length. A continuous spectrum is specified by giving the radiant power incident on a given receiving surface, per unit area of surface and per unit wave length band.

An example is shown in fig. 1, which represents measurements made on direct sunlight. The ordinates of the curve are expressed in watts of radiant power incident on a square metre of surface at the earth, per micron band width.

Similar spectroradiometric curves are available for blue sky and cloudy sky, as well as for incandescent lamps and fluorescent lamps.

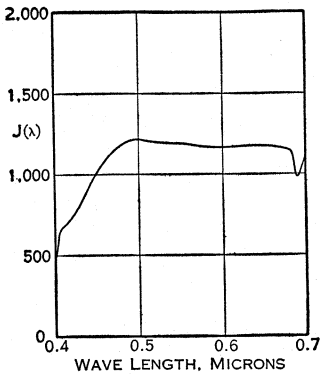

FIG. 1. — SPECTRORADIOMETRIC CURVE FOR DIRECT SUNLIGHT. THE VERTICAL SCALE REPRESENTS WATTS PER SQUARE METRE PER MICRON WAVE LENGTH BAND. THE OBSERVER IS AT SEA LEVEL, THE SUN IS AT 60° FROM THE ZENITH AND THE RECEIVING SURFACE IS TILTED SO THAT IT IS PERPENDICULAR TO THE SUN'S RAYS

From such a curve, the total radiant power per square metre of surface, between any two wave lengths, λ_1 and λ_2, can be obtained by measuring the area under the curve. Expressed mathematically,

$$D_r = \int_{\lambda_1}^{\lambda_2} J(\lambda)\, d\lambda \qquad (1)$$

where D_r = radiant power per unit area (watt m.$^{-2}$), $J(\lambda)$ = ordinate of spectroradiometric curve (watt m.$^{-2}$ micron^{-1}), λ = wave length (micron). D_r and $J(\lambda)$ refer to a particular receiving surface, such as the surface of the earth or a surface set up at a known distance from a lamp. D_r and $J(\lambda)$ may be employed also in specifying the radiation emitted by a given surface.

The evaluation of equation (1) with $\lambda_1 = 0.40\mu$ and $\lambda_2 = 0.70\mu$ gives the total radiant power per unit area for the visible spectrum. The mere specification of radiant power in the visible region, however, is not the best criterion of the visual effectiveness of this radiation. A blue lamp, for instance, may radiate the same number of watts in the visible region as a green lamp, but the latter will appear to be much brighter because the eye is more sensitive to green light than to blue light. Experiments show that under daylight conditions the human eye is most sensitive to yellow-green light ($\lambda = 0.554\mu$) and is progressively less sensitive as the ends of the visible spectrum are approached. Also, there are, strictly speaking, no "ends" of the visible spectrum; radiation somewhat shorter than 0.4μ or longer than 0.7μ can be detected if the radiation is strong enough.

This experimentally determined property of the eye is shown graphically in fig. 2. The ordinate $\bar{y}(\lambda)$ indicates the relative visual effectiveness of homogeneous radiation of wave length λ. Such a curve can be obtained by comparing a yellow-green of wave length 0.554μ with homogeneous radiation of any wave length λ. The observer arranges two contiguous white surfaces in such a way that one is illuminated by each of these sources. If the variable radiation is also at $\lambda = 0.554\mu$, the observer finds that the two surfaces appear equally bright only when he adjusts the lamps so that the same number of watts per square metre are incident on each half of the comparison screen. Thus $\bar{y}(0.554) = 1.00$. But if λ is any other wave length, less radiant power is needed in the 0.554μ comparison radiation than in the radiation of wave length λ to obtain a brightness match. For instance, if an average observer compares a red light of $\lambda = 0.650\mu$ with the standard radiation, he finds that to balance 1 watt/m.^{2} at 0.650μ he requires only about 1/10 watt/m.^{2} of the yellow-green radiation. Thus at 0.650μ, $\bar{y} = 0.10$.

The curve of fig. 2 may be called the lamprosity curve (Gr. $\lambda\alpha\mu\pi\rho\acute{o}s$, luminosity). Other names for it are luminosity curve and visibility curve. These older names are more familiar but they have been used with such a variety of meanings that it seems advantageous to employ a new word to designate this specialized curve. "Visibility" and "luminosity," besides their popular meaning, have other specialized scientific meanings and their use for $\bar{y}$ tends to cause confusion.

The experimental data for fig. 2 were obtained by several methods, all of which are basically equivalent to that described in the preceding paragraph. There is considerable variation in the data resulting from different experimental methods and obtained by different observers. As the result of experiments made with a large number of observers, however, K. S. Gibson and E. P. T. Tyndall of the national bureau of standards recommended the numerical values that are plotted in fig. 2, and these values were adopted by international agreement in 1924.

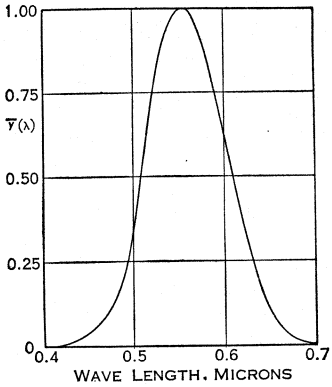

FIG. 2.—STANDARD LAMPROSITY FUNCTION $\bar{y}$ (λ) ("LUMINOSITY," "VISIBILITY") FOR THE EYE. INTERNATIONAL STANDARD CURVE FOR DAYLIGHT VISION, SHOWING HOW THE EYE RESPONDS TO RADIATION OF DIFFERENT WAVE LENGTHS

The existence of these standard values of $\bar{y}(\lambda)$ allows us to weight each small wave length band of a given radiation in accordance with its ability to excite the eye. Instead of taking the entire radiant power in the visible region as in equation (1), we weight each wave length with respect to its lamprosity and write

$$D_l = 647.8 \int_0^{\infty} \bar{y}(\lambda)\, J(\lambda)\, d\lambda. \qquad (2)$$

D_l is a new quantity which is defined by equation (2). It is called luminous flux density or luminous pharosage. It cannot be expressed in watts per square metre but requires a new unit, the lumen per square metre. The conversion factor 647.8 happens to appear because of the way in which the lumen was originally defined in terms of the standard candle instead of by the modern method of equation (2).

Fig. 3 shows how any spectroradiometric curve can be evaluated with respect to the eye. Curve (A) represents sunlight (fig. 1), curve (B) is the lamprosity function for the eye (fig. 2), while curve (C) is obtained by multiplying the ordinates of (A) and (B) at each wave length. In other words the ordinates of the radiation curve (A) have been weighted with respect to $\bar{y}(\lambda)$. The area under curve (A) represents the integral of equation (1) and is expressed in watts per square metre. Measurement with a planimeter shows that in this particular example 328 watts per square metre are being received from sunlight. Similarly, the area under curve (C) represents the integral, equation (2), and is expressed in lumens per square metre. Measurement of this area shows that the visually weighted sunlight is specified as 82,700 lumens per square metre.

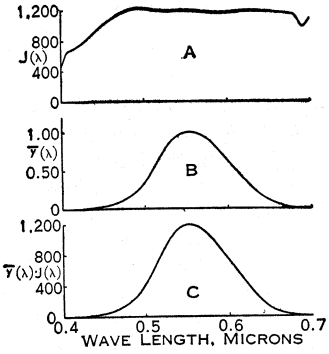

FIG. 3.—METHOD OF CALCULATING PHAROSAGE (LUMEN M.$^{-2}$) BY MEANS OF THE STANDARD LAMPROSITY CURVE

Geometrical Photometrics.—The foregoing section on physical photometrics has shown how photometric magnitudes are based on physical measurements of radiant power per unit area, weighted by means of standard data on vision. Besides the quantity D_l, it is convenient to have a number of related photometric magnitudes. These additional quantities are associated with D_l in a simple geometric manner, and the relationships

among the quantities are covered in the subject of geometrical photometrics.

Luminous flux or pharos F_l is obtained by integrating:

$$F_l = \int D_l dS \tag{2a}$$

where dS is the element of area. In many cases D_l is essentially constant over the area, and luminous flux is obtained by multiplying D_l by area. For instance, if the sunlight of fig. 3 falls on an opening having an area of $\frac{1}{2}$ m.^{2} perpendicular to the sun's rays, the number of lumens through the opening is

$$F_l = D_l S = 82{,}700 \times \tfrac{1}{2} = 41{,}350 \text{ lumens.}$$

In fig. 3, the data are given for a surface that is normal to the sun's rays. Evidently if the surface is tilted from this optimum position, a gix-en amount of radiant power will be spread over a greater area and the amount per unit area will be reduced. This fact is expressed by the cosine relation:

$$D = D_m \cos \psi \tag{3}$$

where D=pharosage (flux density) on tilted surface, D_m=pharosage (flux density) on surface that is normal to the incident rays, +=angle between the direction of the rays and the inward-drawn normal to the surface. This equation applies to radiant pharosage D_r (watt m.$^{-2}$) and also to luminous pharosage D_l (lumen m.$^{-2}$).

Another important equation is the inverse-square relation, which applies if the dimensions of the light source are small compared to the distance from the source to the receiving surface. The inverse-square relation states that if the receiving surface is moved along a line that passes through the centre of the light source, then D varies inversely as the square of the distance between surface and source. In combination with equation (3),

$$D_2 = D_m \left(\frac{l_1}{l_2}\right)^2 \cos \psi \tag{4}$$

where D_2=pharosage (flux density) on tilted surface at distance l_2 from source, D_m=pharosage (flux density) on a surface that is normal to light rays and at a distance l_1 from source, ψ=angle of incidence.

This relation applies either to radiometric quantities (watt m.$^{-2}$) or to photometric quantities (lumen m.$^{-2}$). A knowledge of pharosage D_m at a known distance l_1 allows the calculation of pharosage D_2 at any distance l_2 and at any angle. In the older literature, equation (4) is written

$$\mathrm{D} = \frac{I}{l^2} \cos \psi \tag{4a}$$

where I=intensity of the source (candles) $= D_m l_1^2$.

The concept of intensity or candlepower is rapidly becoming obsolete. In the older days, when candles and oil lamps were still employed, the dimensions of the source were so small that the inverse-square relation was applicable in almost all cases. With modern lamps, such as fluorescent lamps, the dimensions are often so large that equation (4a) does not apply and thus the concept of candlepower is essentially useless.

Caution in the application of equations (4) and (4a) should be emphasized. The inverse-square relation is significant only at distances that are large compared with the dimensions of the source. Experience shows that in general the distances l_1 and l_2 must be at least five times the greatest dimension of the source if equations (4) and (4a) are to give results that are correct to within 1%.

For instance, with an incandescent lamp having a clear bulb and a filament 3 cm. in greatest dimension, the inverse-square relation should not be used at distances less than 15 cm. from the centre of the filament. For a fluorescent lamp 1.22 m. long, the inverse-square relation is invalid at distances less than approximately 6 m. Before the more general method of calculation can be treated, one more photometric concept must be introduced.

This concept is helios, which is associated with the popular idea of brightness. The helios produced by a large, uniform source is defined as π times the incident pharosage per unit solid angle, or

$$H = \pi \frac{D_m}{\omega} \tag{5}$$

where H=helios (blondel), D_m=pharosage incident on the cell (lumen m.$^{-2}$), w=solid angle (steradian) subtended at the cell by the opening in the shield.

To measure the helios of a uniform sky, for instance, one can take an ordinary photographic exposure meter of the photoelectric type and point it at the sky. The photocell produces a current that depends on the lumens per square metre incident on the cell from the sky, and the microammeter in the instrument can be calibrated to read directly in any units desired. The cell is shielded so that it receives light only from the sky.

But ordinarily the helios of the sky is not uniform. To obtain the value in a particular direction, one must change the shield on the photocell so that it cuts out all the light except that from a small part of the sky. This condition is expressed mathematically by specifying that the solid angle w shall be small, or

$$\mathrm{H} = \pi \lim_{\omega \to 0} \frac{D_m}{\omega} \tag{5a}$$

Naturally, helios is not limited to the sky of the foregoing example. The light through the solid angle may come from the sky or from a lamp or may be reflected from a surface. Equation (5a) gives the helios at any point in space and in any direction. Helios is a generalized and extended concept which includes as a special case the older idea of brightness of a surface. In fact, if the source is a surface and the medium between it and the observer is nonabsorbing and nonscattering, then brightness and helios are identical. Ordinarily a surface will be found to have a different helios when viewed from different directions. Matte surfaces, however, are found to have essentially the same helios, no matter how they are viewed. A piece of white blotting paper, for example, seems equally bright in all directions. This characteristic is idealized in the perfectly diffusing surface, which is defined as a surface whose helios is independent of viewing angle. It can be proved that a perfectly diffusing surface having a helios of one blondel emits one lumen per square metre, or

$$H = D_0 \tag{6}$$

where D_0 is the pharosage (lumen m.$^{-2}$) from the surface. Equation (6) applies to perfectly diffusing surfaces only.

The definition of helios allows us to present a general method of calculating pharosage. Unlike the inverse-square relation, this method applies to sources of any size and shape. From equation (5a),

$$D = D_m \cos \psi = \frac{1}{\pi} \int H \cos \psi \, d\omega$$

where the integral is taken over the entire lightcone determined by the source. If H is a constant, equation (7) assumes the simple form,

$$D = \frac{H}{\pi} \sigma''. \tag{8}$$

D is the pharosage (lumen m.$^{-2}$) on any surface. The area a'' is obtained by projecting onto the illuminated plane the portion of a unit sphere which is cut out by the convergent lightcone.

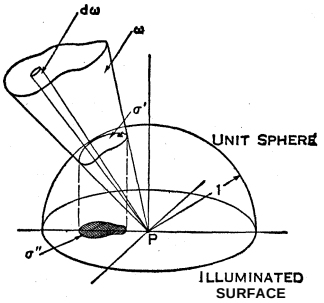

FIG. 4.—THE UNIT-SPHERE METHOD OF CALCULATING PHAROSAGE FROM LARGE SOURCES. THE LUMENS /M.^{2} INCIDENT ON THE HORIZONTAL SURFACE AT P ARE TO BE CALCULATED. THE LIGHT SOURCE WHICH FILLS THE LIGHTCONE OF SOLID ANGLE ω IS NOT SHOWN.

Fig. 4 shows the lightcone and the unit sphere. The light source itself is not shown. It may be any surface or volume source whose boundary determines the lightcone w. The pharosage (flux density) is to be calculated at the point P. The convergent lightcone determined by the source cuts the unit sphere in some kind of an irregular contour. This area a' on the unit sphere is

projected onto the illuminated surface to give the area σ''. The unit-sphere method is a very powerful one and allows the calculation of pharosage (lumen m.$^{-2}$) from sources of any shape.

Besides the photometric concepts considered in the foregoing paragraphs, the concepts of reflectance and transmittance are often useful. The luminous reflectance of a surface is equal to the lumens reflected from the surface, divided by the lumens incident on the surface, or

$$\rho_l = F_{lo}/F_{li} = D_{lo}/D_{li}. \qquad (9)$$

Similarly, the luminous transmittance is defined as the ratio of transmitted lumens to incident lumens.

$$\tau_l = F_{lo}/F_{li} = D_{lo}/D_{li}. \qquad (10)$$

For example, what is the helios of a perfectly diffusing surface having a reflectance of 0.60 when this surface is illuminated normally by direct sunlight (fig. 1)? According to fig. 3, the incident luminous pharosage is D_{li}=82,700 lumens per square metre. From equation (9), the reflected pharosage is $D_{lo}=\rho_l D_{li}$=49,600 lumens per square metre, and by equation (6) the helios (brightness) of the surface is H=49,600 blondels.

The principal concepts of radiometry and photometry are summarized in Table I. The two columns on the right give the names of photometric concepts and units. The columns on the left refer to the corresponding radiometric concepts. The same symbols are employed in both systems, a subscript r or l being used when necessary to distinguish the radiometric from the photometric. The two systems differ only in that the radiometric quantities are true physical magnitudes, while the photometric quantities are these physical magnitudes evaluated with respect to the eye. This evaluation is done by means of the $\bar{y}(\lambda)$ curve shown in fig. 2. Thus $\bar{y}(\lambda)$ is not in either system but effects a liaison between them. Another quantity of similar character is the total lamprosity $\bar{y}_t$ which expresses the total lumens per watt for an entire spectrum. It is evaluated by means of the expression,

$$\bar{y}_t = \frac{\int_0^\infty \bar{y}(\lambda)\, J(\lambda)\, d\lambda}{\int_0^\infty J(\lambda)\, d\lambda} \qquad (11)$$

and is useful in expressing the photometric effectiveness of a given radiation.

TABLE I.—Concepts and Units

Symbol	Radiometric System Name	Radiometric System Unit	Photometric System Name	Photometric System Unit
F	radiant pharos (radiant poner, radiant flux)	watt	luminous pharos (luminous flux)	lumen
D	radiant pharosage (radiant flux density)	watt m.$^{-2}$	luminous pharosage (luminous flux density, illumination, luminosity)	lumen m.$^{-2}$
$J(\lambda)$	phengosage	watt m.$^{-2}$ micron^{-1}	.....	
H			helios (brightness)	blondel
ρ			luminous reflectance (reflection factor)	numeric
τ			luminous transmittance (transmission factor)	numeric
$\bar{y}(\lambda)$	spectral lamprosity (luminosity, visibility), lumen/watt			
$\bar{y}_t$	total lamprosity (luminous efficacy, luminous "efficiency"), lumen/watt			

Note: The word pharos is pronounced far'os (far'os in phonetic symbols). Pharosage is accented on the final syllable, far o sazh' (far o saz'). Helios is pronounced hail' ee os (hel' i os). See J. Opt. *Soc. Am.* 32:348 (1942).

The concepts, names and units of phorometry have never been thoroughly standardized, so the reader will find considerable variation of nomenclature as he reads the literature. Table I is an attempt to present the simplest possible system of photometric concepts. Besides these quantities, there is the concept of intensity or candlepower, which was mentioned previously. There is also phos (quantity of light) in lumen-seconds and phosage in lumen-seconds per unit area. In place of the single concept of pharosage or flux density, some writers prefer to use the two ideas of illumination (lumens per unit area incident on a surface) and luminosity (lumens per unit area emitted by a surface).

Moreover, numerous units are employed in practice. In most countries the unit of illumination is the lumen per square metre, called by various names:

1 lumen per sq.m. ≡ 1 lux ≡ 1 metre-candle.

In Great Britain and the United States however, commercial practice still favours the lumen per square foot:

1 lumen per sq.ft. ≡ 1 foot-candle.

Brightness units are even more numerous and confusing. The simplest way is to ignore these units, to do all one's thinking in a single system and to convert quantities to that system when necessary by use of the conversion factors of Table II.

TABLE 11.—Conversion Factors

Multiply	By	To obtain
Illumination		Pharosage
Foot-candles	10.764	Lumens per sq.m.
Metre-candles (lux)	1	Lumens per sq.m.
Lumens per sq.cm.	10,000	Lumens per sq.m.
Pharosage		Illumination
Lumens per sq.m.	0.0929	Foot-candles
Lumens per sq.m.	1	Metre-candles (lux)
Lumens per sq.m.	10^{-4}	Lumens per sq.cm.
Brightness		Helios
Lamberts	10,000	Blondels
Millilamberts	10	Blondels
Foot-lamberts.	10.764	Blondels
Stilbs	3.14×10^4	Blondels
Apostilbs	1	Blondels
Candles per sq.in.	4,869	Blondels
Candles per sq.ft.	33.82	Blondels
Candles per sq.cm.	3.14×10^4	Blondels
Candles per sq.m.	3.14	Blondels
Equivalent ft.-candles	10.764	Blondels
Helios		Brightness
Blondels	0.10	Millilamberts
Blondels	0.0929	Foot-lamberts
Blondels	2.054×10^{-4}	Candles per sq.in.
Blondels	2.957×10^{-2}	Candles per sq.ft.
Blondels	0.3183	Candles per sq.m.

Experimental Photometry. — As suggested in the foregoing paragraphs, the fundamental measurement in photometry may be considered as the determination of spectroradiometric curves such as fig. 1. The spectrum is obtained by means of a prism or a diffraction grating, and the radiant power is measured at various wave lengths. Such a spectral distribution gives complete information, for from it can be calculated (fig. 3) the radiant pharosage (watt m.$^{-2}$), the luminous pharosage (lumen m.$^{-2}$), and the colour.

Unfortunately, however, a good spectroradiometer is a large and expensive piece of equipment, and the most painstaking care is required in its use. Thus there is need for simpler methods of measuring the various photometric quantities (Table I). In direct photometric methods, it is convenient to have a physical standard against which the photometers can be calibrated. Theoretically, a photometric standard is a redundancy, since everything can be referred to the watt and the standard lamprosity function. But in practice a photometric standard is useful. The early standards were actual candles, but they were replaced by carefully specified lamps such as the Harcourt pentane lamp and the Hefner amyl-acetate lamp. Such lamps could be set up in any laboratory throughout the world and would give fairly reproducible results. In 1909, these lamps were abandoned in Great Britain, France and the United States and the standard was based on calibrated carbon-filament electric lamps. In 1931 the national bureau of standards (U.S.) developed the platinum black body standard. A small tube of fused thoria acts as a black body radiator (see HEAT, Radiation) and is held at constant temperature by being

immersed in pure platinum at the melting point of that material. The helios of this radiator is defined as 1.885×10^6 blondels (brightness = 60.0 candles per sq.cm.).

Naturally, such standards are used only by the basic standardizing laboratories such as the national physical laboratory (Great Britain) or the national bureau of standards (U.S.). Other photometric laboratories employ tungsten-filament incandescent lamps which have been standardized.

Next consider the receptors which are sensitive to radiation in the visible region and which therefore can serve in various types of photometers. Receptors may be listed as follows: (a) thermocouples and bolometers, (b) vacuum and gas-filled photocells, (c) barrier-layer photocells, and (d) the eye.

Thermocouples and bolometers depend on the heating effect of the radiation. When radiant energy falls on a blackened body, most of the energy is transformed to the thermal form and raises the temperature. This temperature rise can be measured in various ways and provides a means of determining the amount of radiant energy. Such devices are essentially nonselective; that is, they are equally sensitive to radiation of all wave lengths. By using suitable optical filters, however, it is possible to cut out all wave lengths except those in the visible region and to make the instrument respond to these wave lengths in accordance with the standard curve for the eye. Such instruments have been built for experimental purposes but have not been used commercially because the response is small and thus difficult to measure.

The thermocouple uses the Seebeck effect to measure the temperature rise caused by the absorption of radiant energy. At the junction between two metals (copper and constantan, for instance), a small blackened target is attached. When radiation falls on this target, its temperature rises and an e.m.f. is generated. The resulting electric current is measured by means of a galvanometer, the galvanometer deflection being directly proportional to the incident radiant pharosage. In the bolometer, a wire or thin metal strip is blackened and absorbs radiant energy. The temperature rise of the metal increases its resistance, and the change is determined by use of a Wheatstone-bridge circuit. The bolometer has been employed extensively by the Smithsonian institution for the spectral measurement of sunlight, and it has also been used in stellar photometry.

Much more sensitive than the nonselective receptors are the photoelectric devices. Vacuum photocells using caesium have been employed successfully in many photometers. Unfortunately the response curves for all such cells are very different from the curve for the eye. Photocells are sensitive in the near ultraviolet and some of them also have high response in the infra-red. To evaluate the different wave lengths in the proper manner, therefore, the cell should be fitted with coloured glass or gelatin filters. Photocells are often used with D.C. amplifiers so that a larger current can be obtained. Another method is to flicker the light by means of a motor-driven shutter, which allows the use of a multi-stage A.C. amplifier. A modification of this method is employed in the Hardy photoelectric spectrophotometer.

Another photoelectric device is the barrier-layer cell. This receptor is of the utmost simplicity. It consists of a metal disk coated with selenium, and it requires no battery. Copper-oxide cells are also used. When light falls on the surface, electrons are released and a current flows through a microammeter which can be calibrated to read directly in photometric units. The entire photometer, consisting of barrier-layer cell and microammeter, can be made so compact that it can be carried in the pocket. The response curves for barrier-layer cells are more nearly like the curve for the eye than in the previous cases, and the curve can be corrected rather easily by use of a green filter.

Many photometers of this type are made without correction and are calibrated with light from incandescent lamps. They can then be used in measuring lighting installations that employ tungsten lamps, but large errors may be introduced if they are used with other kinds of light. Fatigue and cosine-law error are other things that must be guarded against.

The eye was for many years the only receptor used in photometry, and even in 1945 visual photometers were still widely used. It should be realized that the eye is not a measuring instrument, though it does provide a delicate means of determining equality. Thus in visual photometers, a standard must be provided and means must be arranged for varying either the standard or the unknown until equality is reached. As might be expected from this cursory description, visual photometry is a tedious and time-consuming process which will probably be entirely superseded by photoelectric methods.

We now consider the application of the foregoing receptors to the measurement of (1) pharosage (luminous flux density), (2) pharos (luminous flux), (3) helios (brightness), and (4) intensity (candlepower).

First consider the measurement of the pharosage (lumen $m.^{-2}$) at a given point on a given surface. One way is to place a barrier-layer cell at the given point and to measure the photoelectric current. The microammeter may be separate, connected to the cell by flexible leads, or cell and current-indicating instrument may be built together to form a self-contained unit. In either case, the scale can be calibrated to read directly in lumens per square meter or in lumens per square foot. The instruments are calibrated by placing a standardized incandescent lamp at known distances and using the inverse-square relation, equation (4).

Meters of this type are available from a number of manufacturers and in various styles and sizes. They are very convenient instruments and are accurate enough for most engineering purposes. For precise work, however, the user should be careful about cell fatigue, spectral-response error, and cosine-law error.

Another type of instrument that is available commercially for measuring pharosage employs a caesium photocell, connected with flexible leads to a box containing amplifier, batteries, and ammeter. Obviously, this is a more complicated arrangement than the barrier-layer cell instrument, though it can be built to measure smaller amounts of light. Thermocouples and bolometers are also possible.

Visual methods of measuring pharosage (flux density) were employed universally until the advent of the photoelectric cell. Perhaps the best-known instrument of this type is the Macbeth illuminometer. A matte white "test plate" is placed on the illuminated surface. The observer looks through the illuminometer at this test plate and compares it with the outer part of a photometric field which is lighted by means of a small incandescent lamp contained in the instrument. The brightness of the outer part of the field may be varied by moving the incandescent lamp, and the position of the lamp is read on a scale which may be calibrated directly in lumens per square metre. The current through the lamp is kept constant by use of a rheostat and an ammeter. To use the Macbeth illuminometer, the observer places the test plate, adjusts the lamp current to the correct value, sights at the test plate, and adjusts the position of the internal lamp until the two parts of the photometer field appear to be of equal brightness. The value of pharosage is then read on the scale attached to the illuminometer lamp.

Another important measurement is the determination of pharos or total luminous flux. The total number of lumens emitted by a lamp can be measured by finding the pharosage (lumen $m.^{-2}$) in all directions at constant distance from the lamp and summing these values after multiplying by proper weighting factors. A much simpler method is to take a single reading with an integrating sphere photometer or Ulbricht sphere. The lamp to be tested is placed in a sphere whose interior is coated with a matte white paint. Theory shows that the pharosage produced by reflected light at any point on the sphere wall is independent of how the light is distributed from the lamp and depends only on the total pharos. Thus if an opening is made in the sphere wall at any place and a barrier-layer cell is inserted, its reading will be directly proportional to the total lumens from the lamp and the instrument can be calibrated to read total lumens.

Integrating spheres are employed extensively by lamp manufacturers in testing their product. Obviously, the barrier-layer cell is not the only possible receptor for the Ulbricht sphere. Caesium photoelectric cells are often employed in integrating

spheres, and many such photometers still use visual methods.

Helios may be obtained by a modification of the barrier-layer pharosage (illumination) meter. Instead of accepting light from all directions, the helios meter (fig. 5) shields its cell and allows light to enter only through a solid angle ω, equation (5). The scale can be calibrated to read blondels or any brightness unit (Table II). The Macbeth illuminometer is used also in measuring helios. The Luckiesh-Taylor brightness meter is another visual instrument. It operates like the Macbeth illuminometer but is more compact.

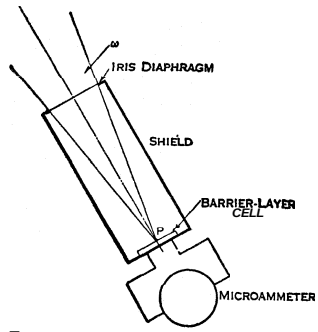

FIG. 5.—A PHOTOELECTRIC HELIOS (BRIGHTNESS) METER

In the older treatises on photometry, attention was given principally to visual methods of comparing intensity (candlepower) of lamps. The standard lamp and the unknown lamp are set on a bar photometer. Between them is a screen, by means of which it is possible to visually compare the separate pharosages produced by the two lamps. The best comparison screen is the Lummer-Brodhun type shown in figure 6.

Distances are varied until the two half-fields appear equally bright, and the intensity of the unknown is then calculated by use of the inverse-square relation, equation (4a).

As mentioned previously, the concept of luminous intensity is an antiquated one, for which there is very little need in modern lighting. When light sources were always of small dimensions (candles. oil lamps, bare incandescent lamps), a knowledge of intensity was convenient in the calculation of illumination by means of equation (4a). But the modern tendency is to use large sources to which equation (4a) does not apply.

Thus the bar photometer and all the paraphernalia of the conventional photometric treatise are rapidly becoming a thing of the past. The only reason that visual methods have persisted in the face of modern photoelectric methods is that the latter are subject to many errors which can be eliminated only by painstaking attention to detail.

In fact, the only reason that visual photometry has survived so long is that the early light sources all produced light of about the same quality. In other words, the problem was one of homochromatic photometry, in which visual matches were comparatively easy to make. With the advent of electric-discharge lamps and fluorescent lamps, heterochromatic photometry became important and visual methods less applicable.

Photometry in 1945 mas in much the same condition that electrical measurements were in about 1880. After that date, however, highly accurate and convenient electrical instruments were developed so that electrical engineering was able to advance safely and rapidly on the basis of precise measurement. A similar development is needed in illuminating engineering, where research is continually frustrated by the lack of accurate measuring instruments. Further research and development in photometry will ultimately yield dividends in the shape of better visual conditions in schools, factories and homes.

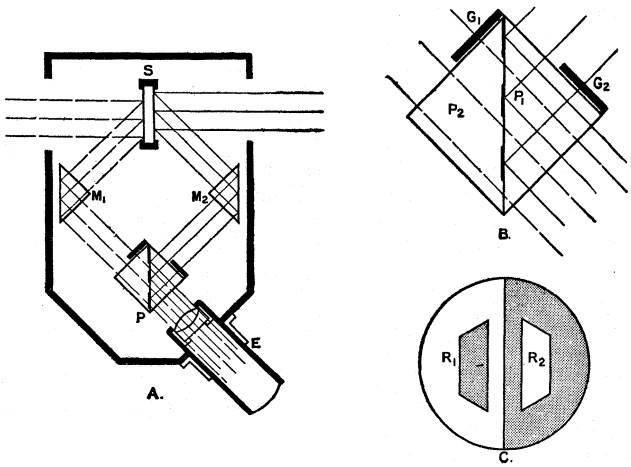

FIG. 6.—THE LUMMER-BRODHUN PHOTOMETER HEAD

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PHOTOMETRY, CELESTIAL. Celestial photometry deals with the measurement and evaluation of light from the stars. This article covers the techniques of visual, photographic and physical photometry, considering in detail photoelectric photometry, a physical technique which had reached great importance by mid-20th century.

Historical Survey.— It requires only an elementary casual observation to realize that the stars are of different brightnesses, and, by a mere inspection of the sky, anyone could for himself arrange the stars in order of brightness. This is exactly what the ancient astronomers did: in Ptolemy's *Almagest* (*c.* A.D. 150) the stars visible to the naked eye are divided into six classes of magnitudes, the brightest stars being designated "first magnitude stars" and those just visible to the naked eye forming the sixth magnitude. Each magnitude class is further divided into three subgroups. When the telescope was invented it was at first used merely as a means of extending to the fainter stars this process of assigning magnitudes by simple eye estimation, a process which culminated in the 19th-century publication of the great visual "Durchmusterungs" or surveys of which the Bonn *Durchmusterung* (B.D.) was the first. It gives magnitude estimates for 324,188 stars, the estimates being made by Friedrich W. A. Argelander and his colleagues. The work was extended to the southern hemisphere by E. Schonfeld who produced the *Südliche Durchmusterung* and by J. M. Thome and C. D. Perrine who were responsible in the 20th century for the *Córdoba Durchmusterung.*

But before the completion of the publication of the Cordoba estimates the *Durchmusterungen* had become out of date, and eye estimation had been replaced by photometric measurement. The magnitude nomenclature was retained but attention had been devoted to giving it a precise quantitative meaning. In 1854 N. Pogson argued in favour of adopting a light ratio of 100 to 1 for a difference of five magnitudes, the difference of magnitude between two stars being then defined as 2.5 times the logarithm (to base 10) of the measured ratio of the amounts of light received from them. This definition (which requires further examination—see below) gives values in rough agreement with the older visual estimates and has been universally adopted; but it still remains to fix some definite magnitude of the scale. It is natural to aim at doing this in such a way as to make measured magnitudes correspond roughly to the *Durchmusterung* values and this has been done in different ways for the different visual catalogues referred to through the bibliography attached to this article. The Harvard system of visual magnitudes (due to Edward Charles Pickering and his collaborators) came to be generally recognized as standard. and the zero point of the Harvard system was, in effect. fixed by making the mean measured magnitude of certain selected stars agree with the mean of the B.D. values for the same stars.

Once the magnitude divisions of the *Durchmusterung* catalogues had a rational basis of measured intensity ratios, the census of

the stars contained in them could be used for statistical studies which sought to determine the distribution of stars in depth and thus to learn the structure and extent of the universe as then known. As astronomy developed in the early years of the 20th century, there were many other lines of investigation in which the magnitudes of the stars. which originally had only a descriptive significance, became increasingly important in gauging their distance and their physical characteristics. These applications of stellar photometry are considered later in the present article; one example would be the powerful method of distance determination based on the periods of Cepheid variables. (See STAR.)

At the turn of the century the photographic plate was rapidly taking over the role of receiving and recording the star images in the focal plane of the telescope. As the human eye was displaced, systems of magnitudes other than visual were developed; the magnitudes based on the blue-sensitive photographic plate were called photographic magnitudes. The labour of extending the census of the stars begun in the *Durchmusterungen* to the faint limits reached with large telescopes was a natural task for photographic methods, because of the great number of star images that could be recorded on a single exposure. This information was needed for the analytical studies of the galactic system being undertaken by statistical astronomers.

By 1920 photoelectric photometry was being used on the brighter stars, particularly for astrophysical problems where high accuracy was required. As the sensitivity gradually improved, photoelectric methods assumed increasing importance. and by mid-century were becoming the standard of reference by which other systems were calibrated.

In all of these nonvisual systems, it was necessary to fis the zero point of the scale by assigning a definite magnitude to a particular star, or to the mean of a selected group of stars. In the case of photographic magnitudes the zero was defined to make the average agree with visual magnitudes between magnitude j.j and 6.5, for stars of spectral type Ao (white stars). This having been done, it is found that for other stars the photographic and visual magnitudes do not agree. Thus for the average of what are known as "main sequence" stars of spectral type Ko (reddish stars) the photographic magnitudes are about 0.8 greater than the visual. The difference is due to the colour of the stars; since the maximum responses of the eye and the photographic plate are to light of different wave lengths, the difference of photographic magnitude between two stars will only be equal to the difference of visual magnitude between the same two stars if the stars involved are of the same spectral energy distribution, that is, of the same colour. The difference between the photographic and visual magnitude of a star is, in fact, a recognized measure of the star's colour. This difference is taken in the sense photographic minus visual. and is known as the star's colour index. The colour index is directly related to the star's surface temperature, being negative for the hottest (bluish white) stars. and positive for the cool (reddish) stars. This relation is an example of the physical information about a star derivable from photometric measurements.

Definition of Magnitude. — The circumstance that the colours of the stars are not all the same requires a more careful examination of the definition of magnitude. Pogson's definition states that two stars differ by one magnitude if the logarithm of the ratio of the quantities of light received is 0.3. that is, if the light ratio is 2.j12 (the antilogarithm of 0.4). But the question arises: what light ratio? If the stars are of the same spectral energy distribution it does not matter; if the light ratio is 2.512 for one wave length. it is 2.512 for every other wave length. But if the two stars are of different spectral energy distribution. then the light ratio can only be 2.512 for one wave length, and the difference of magnitude between them will vary with wave length. How then are we to define magnitude?

The definition has clearly to be related to the physical operation of measurement. The general principle of measurement of the difference of magnitude between two stars is that the light from each is received in some definite apparatus, and the beam from the brighter star is reduced until the response of the apparatus to the two beams is the same. The reduction of the light from the brighter star must be achieved by some definite physical operation. subject to the condition that the reduction factor is the same for all wave lengths, and this reduction factor must be measured by a physical method for each operation. This having been done, the measured reduction factor is the ratio of the brightnesses of the two stars, and the difference of magnitude is then 2.5 times the logarithm of the brightness ratio, that is. 2.5 times the logarithm of the reduction factor. This defines the concepts of "brightness" and "magnitude" with respect to the particular apparatus used. and it is easy to see that, with one exception, this is all that can be done, and that the terms "brightness" and "magnitude" cannot have an absolute meaning but can only be defined with respect to some specified apparatus.

The exception referred to is the case in which the apparatus is sensitive only to a very small range of colour, that is, of wave length, and provided this condition is satisfied the magnitudes obtained will not depend on the particular kind of apparatus used. Such magnitudes are called monochromatic magnitudes, and each system of monochromatic magnitudes refers to a specified wave length. It is now being realized that monochromatic magnitudes are of importance in various astrophysical problems, and more attention is being paid to them (see section on spectrophotometry below). But they suffer from the defect that a severe restriction is imposed on the quantity of light available; and accordingly for the fainter stars it is on the older heterochromatic magnitudes that we have to rely. that is. on magnitude measurements in which the receiving apparatus is operated by light of a considerable range of colour. We have seen above that under these conditions the concept of magnitude can be defined with respect to the particular apparatus used.

It is easy to see that this restriction cannot be removed. Consider the simplest case of heterochromatic photometry, this being the case in which the brightness is the integral or' the quantity of light received at each wave length multiplied by the sensitivity factor of the apparatus at that wave length. the sensitivity factors being regarded as constant for the apparatus used (*i.e.*, not dependent on the light intensity). and the integration being taken over the whole range of colour to which the apparatus is sensitive. Taking. for example, the case of visual photometry, the receiving apparatus is the combination of the human eye and the optical train used, and the sensitivity factors will involve the transmissive properties of the optical train to light of different wave lengths. Consequently: for stars of different colour, the ratios of the integrated brightnesses, and so the differences of magnitude, will depend on the particular photometer and telescope used. The same is true for photographic photometry, in which the receiving apparatus is the combination of plate and optical train, it being understood that some specified process of measurement is applied to the photographed images. In particular. we must expect photographic magnitudes to be different for different types of photographic emulsion. and for different kinds of telescopes. Thus photographic magnitudes determined with refractors, for which most of the ultra-violet light is absorbed by the lenses, will be different from those determined with reflectors, for which a large part of the ultra-violet is reflected by a silvered surface. and still more by an aluminized surface. Further, the earth's atmosphere has to be regarded as part of the optical train. Its effect on the difference of magnitude between tn-o stars can be eliminated if both are observed at equal angular distances above the horizon. But observers who do not use the same equal altitude above the horizon must still expect small differences between their results. And observers at mountain stations have less atmosphere over them than those near sea level. The preferred method is to determine the atmospheric absorption in each photoinetric system by measures of standard stars at varying altitudes above the horizon, and then to compute the magnitude differences that would be observed for all stars outside the atmosphere.

While the effects of the earth's atmosphere can be eliminated by reasonably straightforward procedures. there are more serious complications. In the case of visual photometry the Purkinje effect compels us to regard the sensitivity factors as being dependent on the intensity of the light received, and so, if two stars

of different colour are equal in magnitude when a small telescope is used. the redder of the two will appear the brighter if we employ a larger telescope the transmissive properties of which, with respect to wave length, are similar to those of the smaller one. For this reason alone a system of visual magnitudes must be defined with respect to a definite instrument. There is an analogous effect for emulsions which introduces a further restriction in photographic work. If, using a definite instrument, under definite standard conditions. two stars are found to be of the same magnitude for one duration of exposure (by which is meant that some definite process of measurement applied to the two images gives the same result), they will not necessarily be of the same magnitude for a different duration of exposure. Accordingly, strictly speaking, a system of photographic magnitudes must be defined, not only with respect to a definite instrument: working with a definite type of emulsion, under definite atmospheric conditions and applying a definite process of measurement to the images, but also with respect to a definite duration of exposure.

'These difficulties all disappear in monochromatic photometry, which will be discussed later, but in heterochromatic photometry the magnitude of a star can be defined precisely if, and only if. a definite instrument is specified! working under definite conditions. Systems of magnitude obtained with different instruments working under different conditions will be different, the differences depending on colours. It 'is possible, by careful intercomparison between the different systems of visual or photographic magnitudes. to deduce, in an empirical way, corrections whereby each system can be reduced to some standard system. The corrections will depend on the colours of the stars, which are measured by their colour indices; they can be considerable and may amount to a third of a magnitude in extreme cases. If, however, the wave length range used in a given magnitude system is restricted by carefully specified filters, the transformation equations between observers using different telescopes will have quite small correction terms and simple linear relations will be adequate. It is particularly important to control the ultra-violet radiation which enters into the heterochromatic summation which forms, say, a photographic magnitude, or indeed any magnitude system which is centred on the blue-violet part of the spectrum. By excluding wave lengths shorter than 3.800 Ångström (Å) units several troublesome factors which introduce differences between observers of the same stars with different telescopes are eliminated. These factors include the most variable part of the atmospheric absorption, the unequal ultra-violet absorption of the flint glass in different refracting telescopes, the decreasing ultra-violet reflectivity of silver mirrors as they tarnish, and the varying weight given to the wave lengths shorter than 3,650 Å, where the Balmer discontinuity due to hydrogen absorption causes a precipitous drop in the radiation from stars of early type (see SPECTROSCOPY! ASTRONOMICAL: Continuo *Spectra*).

Nevertheless it is still true that magnitude systems, and the colour indices which are the differences between them, are rarely capable of exact repetition on any telescope other than the one on which they were derived. The numerical results obtained on a specified list of standard stars remain the best definition of a particular system.

The following is a formal definition of magnitude difference: For a definite instrument, working under definite conditions, the difference of magnitude between two stars is 2.5 times the logarithm, to base ten, of the ratio by which the beam from the brighter star has to be reduced so as to make the instrumental respbnse to it the same as the response to the beam from the fainter star, it being stipulated that the two beams are transmitted through the optical train in an identical manner. and that the method of light reduction employed is such that the light for each wave length involved is reduced in the same ratio.

It is important to notice that an implication of this definition is that if two precisely similar stars: both emitting the same total amount of light at any wave length, differ in magnitude by Δm, as measured by any instrument, then, provided there is no obscuring matter in interstellar space. the distance of the fainter star will be $10^{0.2\Delta m}$ times the distance of the brighter. To see this we apply in imagination a method of light reduction which is actually used for photometric work in the laboratory We imagine the distance of the nearer star to be increased until the instrumental response to its beam is the same as that for the more distant star; since the stars are supposed to be precisely similar this means that a e have now placed them at the same distance. If there is no obscuring matter in space the light reduction produced by the change of distance mill be the same for all wave lengths, and so will conform to the condition of the definition above; further, the reduction ratio will be determined by the inverse square law. Hence the difference of magnitude Δm between the stars is 2.j times the logarithm of the ratio of the squares of their distances. and by taking antilogarithms the result follows. Since this result is the basis of modern gaiactic research, it is of high importance that our definition of magnitude should be correctly translated into photometric practice.

It is convenient to remark at this point that the imaginary process, used above, of varying the distance of a star, is employed to define an important conception. The absolute magnitude of a star is defined as being the magnitude that the star would have if moved to a standard distance of ro parsecs (see PARSEC) from the earth. The absolute magnitude of a star is an expression of its intrinsic brightness, not its apparent brightness as seen from the earth; the apparent brightness depends on the distance of the star as well as on its intrinsic brightness. It should be noticed that absolute magnitude has been defined with reference to some specific instrument. since the definition involves the conception of magnitude. For each magnitude system there is thus a different absolute magnitude for the same star. In particular, visual and photographic absolute magnitudes of a star may differ considerably.

In visual photometry the fundamental operation is the measurement of the difference of magnitude between two stars. Visual magnitudes are essentially determined by a series of photometric operations involving pairs of stars. these operations leading to a knonledge of the mutual differences between the magnitudes of the stars over the whole sky. In photographic photometry the mutual differences between the magnitudes of all stars in a field small enough to be photographed on one plate are obtained from a single set of photometric operations, and other photometric operations give magnitude differences between different fields. For both visual and photographic work. and for other measurements in nhich a "physical" receiver takes the place of the eye or photographic plate. the result is the same; photometric methods only measure differences of magnitude, and, indeed. the definition given above is restricted to a definition of magnitude difference. For any particular magnitude system it remains to assign a definite magnitude to some star or to the mean of some group of stars. It has been indicated in the previous section how this has been done for visual and photographic systems.

Modern Astronomical Photometry.— We now turn to a brief survey of the work of the three decades after 191j. It was for the most part photographic, this being due to the circumstances that the problems before astronomers required photometric results for faint stars, and the power of the photographic plate of accumulating the effect of continued exposure to light renders it appiicable to extremely faint sources. The photographic plate also has the great advantage of registering a large number of images at a single exposure, and some modern problems demand results for all stars in various sample areas of the sky, each sample area being small enough to be covered by one plate Naturally enough the work that was carried out was indicated by problems of current interest, and it will be as well to review in brief what some of the main problems are, and to indicate as we go what photometric programs have been carried through to meet their needs.

Our knowledge of the dimensions of the galactic universe.. and of the distances and dimensions of the extragalactic nebulae. is based on photometric observations of Cepheid variables. The median absolute magnitude (*i.e.*, the mean of the absolute magnitudes at maximum and minimum light) of a Cepheid is related to its period by what is known as the period-luminosity relation,

and consequently photometric observations of a Cepheid will lead to a knowledge of its distance. For the photometric observations give both the apparent median magnitude and the period; the latter gives the median absolute magnitude. using the period-luminosity relation, and then the distance can be calculated from the apparent and absolute median magnitudes. It is in this way that the distances of the globular clusters, and of the extragalactic nebulae are ultimately determined, the distances of the former leading us to a knowledge of the dimensions of the galactic system, and those of the latter opening up the way to an extended knowledge of the universe. It is thus important to be able to make photometric measures of Cepheids in any part of the sky, and this can be most conveniently done by establishing a number of what are known as magnitude sequences in various parts of the sky. Each such sequence consists of a series of stars in the same field of view, selected so that their magnitudes form a series with, so far as is possible, roughly equal magnitude intervals between consecutive members, the magnitudes themselves having been measured carefully. Any Cepheid can then be investigated photometrically by a series of comparisons between it and the members of a conveniently near sequence. The sequences are also used for the photometry of other variable stars.

In connection with the study of galactic structure we require to know the numbers of stars, in various parts of the sky, down to various magnitude limits. It mould be quite impracticable to survey the whole sky to faint magnitude limits! but valuable information can be got by confining the measures to sample areas, as has been done in the *Harvard-Gröningen Durchmusterung*, which is a photographic catalogue extending down to the 16th magnitude. Another valuable catalogue of the same kind is the *Mount Wilson Catalogue of Selected Areas,* which gives photographic magnitudes for stars in sample areas extending from the north celestial pole to declination $-1j^{\circ}$, and reaches stars of the 18th magnitude.

Another important development lies in the measurements of the integrated magnitudes of extragalactic nebulae. that is, magnitudes. not of individual stars in the nebulae, but of nebulae as a whole. For the remote nebulae it is impracticable to detect individual stars and measure their magnitudes. and so the Cepheid method of determining distances is not directly available; but measures of the integrated magnitudes lead to a statistical knowledge of the distances; since it may be assumed that on the average the measure of the brightness of a nebula is a measure of its distance. the fainter nebulae being the more distant. From the measures of integrated magnitude a statistical relationship has been discovered between magnitude and displacement of spectral lines to the red. and this has been interpreted as a relation between the distance of a nebula and its velocity of recession. This velocity-distance relation is the observational foundation on which the relativity theory of the expanding universe is based, and the importance of nebular photometry in connection with this theory needs no stressing. An essential hypothesis in the theory is the interpretation of the shifts of the spectral lines as Doppler shifts due to velocity of recession. and it has been pointed out that a possible test would consist of the determination of the total numbers of nebulae down to assigned limits of integrated magnitude, and the comparison of the results with numbers calculated on the assumption that the Doppler interpretation is correct. There is, however, another assumption involved in this calculation, namely, that on the whole the nebulae are evenly distributed in space. *(See* LIGHT: *Waves and Interference.)*

From what has been said it will be apparent that a good deal of modern photometric work aims at the obtaining of data for the whole sky, and so the whole of a program cannot be carried out at a single observatory. This means that the various systems of magnitude involved must be reduced to a common standard. Such a reduction is vital to modern work, and to facilitate it considerable attention has been devoted to the derivation of standard magnitudes for a sequence of stars. known as the north polar sequence. which consists of a set of stars down to the 20th magnitude in the neighbourhood of the north celestial pole. These standard magnitudes were adopted as the result of a careful intercomparison of photographic magnitudes measured at Gottingen, Greenwich, Harvard, Mt. Wilson, Potsdam and Yerkes; and they represent a magnitude system known as the international system. The main object of laying down this standard system was to make it available as a reference system with which any particular system of measured magnitudes can be compared, and since. as we have pointed out, the corrections required to reduce one photometric system to another depend on the colours of the stars. the colours of the standard sequence must be known. The older colour indices were derived by differencing photographic and visual magnitudes. but the measurement of visual magnitudes for the fainter members of the sequence is impracticable, and accordingly visual magnitudes have been replaced for this purpose by what are known as photovisual magnitudes. These are obtained by the methods of photographic photometry, but using plates sensitized to green and yellow light in conjuction with a filter removing the violet end of the spectrum. Photovisual magnitudes have been determined at Mt. Wilson for the stars of the north polar sequence down to the 19th magnitude (photographic). They form a system which is naturally not identical with any of the visual magnitude systems. but they approximate to visual magnitudes, and serve for the purpose of giving, by differencing from the standard photographic magnitudes, the colours of the north polar sequence stars.

If in any program of measures obtained at a northern observatory the precaution is taken of including the stars of the north polar sequence, the material is available for reducing the program measures to the standard international system, provided the program includes measures of the colours of the program stars. For equatorial or southern observatories the north polar sequence is not directly available for observation, and an intermediary sequence has to be employed.

In the following sections some details will be given of the technique of astronomical photometry. These sections will be followed by a section dealing with the new and expanding subject of spectrophotometry, to which only a passing reference has so far been made.

Methods of Light Reduction. — From what has been said above it is obvious that a vital operation in any kind of practical celestial photometry is that of reducing a beam of light from a star and measuring the ratio in which it has been reduced, an essential condition being that the reduction ratio should be independent of wave length. The following are the methods most favoured.

Variable Aperture Methods.—The original beam of light from a star is perfectly uniform in cross section, hence, if the area of the beam utilized is varied. the light will be varied in the same ratio. For this purpose diaphragms. circular- or sector-shaped. or gratings of wires or tapes equally spaced may be used. If the uniform cross section of the original beam is subsequently disturbed, an appropriate correction must be applied—thus care must be exercised in employing these methods when a refractor is used since the lens may absorb differently over different parts of its area. The weak point about variable aperture methods is that the reduced image has a different diffraction pattern from the original.

Polarizing prism arrangements are used in some well-known photometers, including the Zoellner photometer and Pickering's Meridian photometer; but the prisms must be carefully selected by independent tests.

Filter and Wedge Methods.—A neutral-tinted glass may be cut in the form of a plate, or made into a wedge with a wedge of clear glass cemented to it so that the combination is achromatic. The fraction of the light absorbed by the plate or any part of the wedge may be found by laboratory methods, the most accurate being photoelectric methods using a rotating sector. The direct use at the telescope of the rotating sector does not appear to have found favour in celestial photometry. In applying it to photographic photometry there would be the difficulty that Talbot's law is not obeyed unless the sector is run at very high speeds; for speeds of the order of 50,000 r.p.m. for a sector disk with one slot it appears to be obeyed to an approximation of the order

of 1%. *(See* VISION or SIGHT: *Response to Variable and Intermittent Illumination.)* Wire gauze screens are a special case of variable aperture methods, but the absorption of the screen is not readily calculated and must be measured and tested for uniformity in the laboratory. Wire gratings, in addition to their use in variable aperture methods, give diffracted images, and the ratio of the light falling into the diffracted image to that falling into the main image may be computed from a knowledge of the dimensions of the wire and spacing, or may be measured by a separate method. The grating method has been used in photographic photometry and possesses the advantage that images of a known magnitude difference are obtained from the same exposure.

Visual **Photometers.**—We have seen that the essential principle of every photometric measurement is that the light from the brighter oi two stars should be reduced till the response of the receiving apparatus to it is the same as the response to the beam from the fainter star, and that the two beams should be transmitted through the apparatus in an identical manner. This last condition is essential, since, if it were not satisfied, the absorptions of the two beams by the apparatus would not necessarily be the same. But in visual photometry, in which the human eye is involved, the operation becomes one of reducing the intensity of the brighter of two images until the eye judges that it is of the same brightness as the fainter; and this means that the two images must be viewed simultaneously. It is clearly impossible to do this for two stars in different parts of the sky, and at the same time to adhere to the condition that the two beams must be transmitted in an identical manner through the same apparatus. Accordingly each of the two star images is matched successively with an intermediate image; the beams from the two stars are transmitted identically through the same optical train, and the light from the intermediate source can be transmitted through a different optical train. The intermediate source of light may be an artificial star, or it may be a real star in the sky, and visual stellar photometers may be divided into two classes according to which of these alternatives is employed. Examples of the first type are the Zoellner photometer and Pickering's wedge photometer, the latter representing a type of instrument used at the Lick, Yerkes and Leander McCormick observatories for measuring the magnitudes of comparison stars against which the magnitudes of variables are estimated. The Pickering meridian photometer with which the Harvard photometry was performed is an example of instruments using a real star as intermediary, as is also Danjon's "cat's eye" photometer. For details of these and other visual stellar photometers the paper by W. Hassenstein (see *Bibliography)* should be consulted. (W. M. H. **G.** ; E. A. BR.; A. E. W.)

Photographic Photometry.——In photographic photometry the distinctive part of the receiving apparatus is the photographic plate used in conjunction with some definite operation of measurement applied to the developed images. Both the size and density of the image vary with magnitude, the developed image of a star being denser and larger the brighter the star. The operation which gauges the total effect may consist of measuring the size of the image, or of measuring the absorbing power of the image when it intercepts a light beam, or of a combination of the two in the so-called iris photometer. In the latter, the size of the aperture centred on the image, which will permit a given constant amount of light to come through and around the image, is used as a measure of the total effect. These measurements. whatever the method, arrange the stars in a sequence of increasing brightness, but with the true brightness ratio between any unequal pair still unknown. Just as in visual photometry. an intensity reducer of known reduction ratio must be introduced to equalize such pairs of stars, and thus to build up a scale of true relative brightness.

Double exposures are the usual method of introducing the known intensity ratio. The first exposure is taken in the normal yay. Then after a slight shift to avoid superposition, the same field is photographed a second time with the known reduction factor imposed. The reduction may be by means of a gauze screen, or by a calibrated neutral glass filter, or by diaphragming the telescope to make a smaller aperture. As a practical matter only one selected reduction ratio can be applied to all the stars on one plate. The intensity ratio of a nearly equalized pair can be found by interpolation on the numerical scale which gauges the blackness or diameter of all the images. Then by an overlapping process involving many such pairs a graphical relation between photographic effect and true relative brightness or magnitude difference may be built up.

Once a scale of magnitudes has been established for the stars in a standard field. stars in any other area of the sky may be compared with them by exposing the same plate successively to each field, both exposures being of equal length. In less accurate survey work. where an accuracy of o.1 magnitude is adequate, magnitudes are read off by visual estimation of steps between images of calibrated standard stars.

In addition to the standard photographic and photovisual magnitudes which are the basis of the international system, other magnitude systems based on photography are sometimes used. The magnitudes obtained with a panchromatic plate and a red filter are called photored magnitudes. Infra-red-sensitive photographic emulsions and a deep red filter have been used for an effective wave length still farther removed from the normal photographic range. The latter combination strongly favours the coolest stars with large positive colour index. Red and infra-red photographs are better able to show distant stars in directions where there is heavy obscuration because they use light of a wave length which suffers much less attenuation in interstellar dust clouds.

Two defects of photographic photometry must be mentioned. The total range of magnitudes that may be successfully measured on one plate is limited, and the reduction ratio used in the standardization of the intensity must be small enough so that there will be a good number of overlapping steps in that range. In the successive application of this relatively small reduction factor to cover the enormous range between stars which appear bright to the naked eye and the faintest star images registered on plates from the great reflecting telescopes, there is danger of accumulation of error. This accumulation can arise from multiplication of only a small error in the original evaluation, or from the random errors in its repeated use in equalizing ever fainter star images. For this reason the photoelectric method, treated in a later paragraph, has been adopted increasingly as the one to be relied upon in establishing standard magnitudes.

A second defect of photographic photometry is the difficulty, especially with large telescopes, of transferring a magnitude scale from a standard area to a new field by the method of superposition of equal exposures. The procedure assumes identical image quality in the two cases, which, because of unavoidable small differences in guiding, seeing (atmospheric turbulence) and focus is rarely achieved. The difficulty may be circumvented by spreading out the image into a small uniformly blackened area. On some telescopes, extrafocal images may be used for this purpose. The *Schraffierkasette* spreads in-focus images over a small square by giving an oscillatory motion to the plateholder. The latter method has been valuable for comparing the integrated light of diffuse sources such as extragalactic nebulae with stars of known magnitude. The faintest images, however, are lost in the spreading out process, and the practical limit of photometry is at least two magnitudes brighter than the in-focus limit of the telescope.

The modern technique to avoid difficulty in transfer of standards involves establishing a few photoelectric standards in the field in question. Then interpolation by the photographic method can give magnitudes of hundreds of stars on a single plate with an accuracy only slightly below what would be obtained by laborious photoelectric measurement of each in succession. Prior to improvements in photoelectric methods made between 194j and 19j5, however, this was not possible. Photographic magnitudes were the almost universal standard of photometric comparison for the 30 years between 191j and 1945 because only by photography could the measurements be extended to the extremely faint objects at the limit of large reflecting telescopes. And it was just in the range near the limit that some of the important advances were made. The knowledge of the distances and dimensions of extragalactic nebulae that followed E. P. Hubble's identification of

Cepheid variables in the nearer external systems is an example of the advances that were made entirely within the domain of photographic photometry.

Physical Photometers. — The auxiliary instrument, often called a microphotometer, which evaluates the absorbing power of a star image on a photograph gives an impersonal numerical result in the form of a scale reading. Photographic photometry of stars is thus "objective" in that the human eye is not called upon to make a judgment of equality, as it is in visual photometry. The distinguishing characteristic of physical photometers is the use of a detector of radiation which converts the starlight directly into an impersonal "pointer reading." In one form the absorbed radiation is converted into heat. A classic illustration of this type of instrument is afforded by Sir William Herschel's exploration of the solar spectrum with a blackened thermometer bulb — the motion of the mercury thread constituting the pointer reading. In a second type the radiation releases electric charges — internally as in a selenium or lead sulphide film to produce increased electrical conductivity, or externally as from the cathode of a photoelectric cell. The latter phenomenon is the basis of astronomical photoelectric photometry, a technique which had assumed so important a place by the 1950s that extended treatment is reserved for a later section. In both types of physical photometer it is usually true that the pointer reading is directly proportional to the quantity of incident radiation. The calibration or equalization procedures that form so large a part of photographic photometry are thus eliminated. This simplification is a contributing factor to the higher precision that is regularly obtained with physical photometers.

The photometers which depend on heating effect are in general nonselective; they measure the incident radiant energy irrespective of its wave length or spectral distribution. C. G. Abbot's water-flow pyrheliometer for measuring total solar radiation is an example of such an instrument. It was based on the simple and fundamental principle of registering the temperature rise in a stream of water flowing around the absorption vessel. S. P. Langley's bolometer, developed in 1880 for measuring the energy in the various parts of the solar spectrum, was much more sensitive. It depended on the increase in electrical resistance of a thin blackened platinum strip warmed by the absorbed radiation.

Photometry of stars with a heat-sensitive detector has been done principally with the radiation thermocouple. This instrument consists of a tiny disk of blackened metal foil attached to the junction of two dissimilar metals; bismuth and antimony are a favourable combination. The warming of the junction by the heat of the star absorbed on the metal foil generates a thermoelectric voltage which is read on a sensitive galvanometer. Sir William Huggins obtained a barely measurable indication from several bright stars with such an arrangement in 1868. Improvements in the construction of the instrument led to considerably increased sensitivity, and in 1914 W. W. Coblentz was able to measure more than 100 stars with a 36-in. reflector. The work was extended by E. Petit and S. B. Nicholson with the 100-in. reflector of the Mt. Wilson observatory (Pasadena, Calif.). The magnitude thus obtained mas called a radiometric magnitude. The scale was made to agree with the visual scale for Ao stars, as had previously been done for the photographic magnitude scale. One value of this magnitude scale is its close approach to the hypothetical concept of bolometric magnitude, defined as a measure of the total radiation from a star, over the entire range of its spectrum, as received at the top of the earth's atmosphere. This concept, introduced by A. S. Eddington, is useful in studies of the internal constitution of stars.

Radiometric magnitudes of stars are heavily influenced by the radiation coming in the unseen infra-red portion of the spectrum. and the cool red stars show the greatest difference (called the heat index) from visual magnitudes. Long-period variables, such as Mira (Omicron Ceti), have a heat index as high as 8 magnitudes at minimum and are among the radiometrically bright stars at all phases of their cycle. But for most stellar types. measurements with the 100-in. telescope were limited to objects visible to the naked eye.

The thermocouple technique thus fails by several orders of magnitude of serving as the basis of a generally useful magnitude scale. It is, however, the only technique that can detect the infrared thermal radiation from relatively cool bodies such as the moon and the planets. Direct indication of the surface temperature of these bodies was first obtained from thermocouple measurements made by Coblentz at Lowell observatory (Flagstaff, Ariz.) in 1922.

PHOTOELECTRIC PHOTOMETRY

In principle photoelectric photometry consists of measuring the electrical current flowing in the external circuit of a photoelectric cell when the various quantities of luminous flux to be compared are allowed to fall successively on the cathode. (See PHOTOMETRY; PHOTOELECTRICITY.) The extension of this principle to astronomical sources requires electrical instruments capable of measuring very small currents, since the amount of light available, even with a large telescope, is so much smaller than that commonly encountered in illuminating engineering. The low intensity makes cathode fatigue unimportant, and strict proportionality between quantity of light and current holds over an extremely wide range of intensities. Modern developments in photoelectric technique have improved the sensitivity to the point where the whole range of astronomical intensities may be covered. Any object that can be photographed can, with sufficient pains. be measured photoelectrically. The photoelectric cathode is, however. a selective detector of radiation; like the photographic plate or the human eye, it responds unequally to different wave lengths. By the choice of cathode material and the addition of suitable filters. the range of wave lengths used in photometry can be varied over wide limits.

Historical Development. — The first practical photoelectric cells were made by J. Elster and H. Geitel in 1890, only two years after W. Hallwachs established the existence of the photoelectric effect. The first astronomical use of the photoelectric cell was the measurement of ultra-violet light from the sun by Elster and Geitel in 1892. The step from this observation to the measurement of starlight was a considerable one, and did not come until 1913. P. Guthnick in Berlin, H. Rosenberg in Tubingen and J. Kunz and J Stebbins at the University of Illinois (Crbana) made successful observations in that year, all independently and all with similar apparatus. The photoelectric cells were of the Elster and Geitel type, aith hydrogen-sensitized potassium cathodes. An electrometer was used to measure the current, since even the bright stars produced an effect too small for a galvanometer. The practical working limit for the Illinois apparatus was a current of 10^{-14} amp., corresponding to seventh magnitude with a 12-in. telescope. Great care was necessary to avoid spurious effects from leakage currents over the surface of the photoelectric cell, or over other insulators in the system.

The improvements in sensitivity that came in the succeeding decades consisted partly of refinements in the method of measuring the current from the cathode, and partly in improvements in the yield from the cathode itself. Sinclair Smith showed in 1932 that a stable electrometer at the fixed Coudé focus of a reflecting telescope (*q.v.*) could give considerably higher sensitivity than the type customarily used at the end of a moving telescope. The development of electronic tubes with extremely high input resistance (the so-called electrometer tubes) enabled A. E. Whitford to develop an amplifier that could be moved about at the end of a telescope; this type of current measuring apparatus was carried to its ultimate limit by G. E Kron. In order to avoid fluctuations caused by cosmic ray ionization, it is advantageous to put the amplifier tube and photocell in an evacuated container. In this type of amplification, it is necessary to use a high resistance in series with the photocell in order to obtain a voltage to apply to the input grid of the amplifier tube. The "resistance noise" generated by this high resistance adds to the unavoidable "shot noise" fluctuations in the cathode current caused by the random spacing of the photoelectrons released by the incident light. When the over-all accuracy is determined by cathode shot noise alone, then the equipment is doing as well as it can with the particular cathode being used.

With the introduction of secondary emission multiplication as an amplifying principle in the years 1936–39, the offending load resistor could be removed and a close approach to the ultimate shot-noise limit became possible. In the practical form of the multiplier phototube there are 9 to 12 multiplying surfaces in cascade. Each photoelectron impinging on the first multiplying surface releases three to four secondary electrons, which are multiplied in turn at the second multiplying surface and so on. A total amplification of the cathode current by a factor of a million or more is common. a value more than adequate to insure that any further amplification by traditional vacuum tubes will not add to the over-all noise level. In the decade after 1946, the multiplier phototube became the almost universal tool in astronomical photoelectric photometry.

The potassium-hydride cathode used in the first successful photoelectric measurements of stars in 1913 remained the principal type in use until about 1940. It is sensitive to a relatively narrow band of wave lengths in the blue-violet. The much greater spectral range of the cesium oxide cathode. with its peak response in the near infra-red, was first used for astronomical photometry by John S. Hall at the Yale observatory. The thermionic emission from this cathode at room temperature is larger than the photoemission produced by most stars, and had to be reduced by refrigeration with solid carbon dioxide. A major improvement in cathode efficiency was realized from the cesium-antimony surface developed by P. Görlich in 1938. It is sensitive from the ultraviolet through the yellow with a maximum response in the blue-violet. One electron is emitted for something like eight incident quanta. a ratio so markedly superior to that for other cathode surfaces that its use has become standard.

Modern Techniques of Observation. — The photoelectric photometer at the end of a telescope may be considered to begin with a small diaphragm in the focal plane. Csually a series of diaphragms of graduated diameters is provided, so that nebulae as well as stars may be measured. and so that the smallest practical diaphragm may be chosen in cases where it is necessary to exclude the light of the sky. or stars adjacent to the one being measured. There is provision for sliding filter glasses into the beam, often in front of the diaphragm. A total reflecting prism slides in just back of the diaphragm to provide visual inspection of what is in the diaphragm area. If faint stars are to be measured, the multiplier phototube is mounted in a thermally insulated box with provision for surrounding it with solid carbon dioxide for refrigeration. This is necessary because all sensitive cathodes have a thermionic emission level higher than the response caused by a faint star. After the millionfold amplification on the secondary emission surfaces. the output current will generally be in the range 10^{-6} to 10^{-11} amp. Further amplification will be needed. Usually this is arranged so that the final output is recorded on a moving paper chart. Assuming that 1 milliampere will be required to operate the recording meter. the over-all amplification may be as high as 10^{14}. The wide range of currents that must be measured is covered by gain controls in the amplifier. These ratios can be made to be simply the ratio of certain fixed resistances.

With bright stars, the light of the night sky is unimportant, and a moderately large diaphragm can be used. The recording meter operates similar to a laboratory voltmeter and little time need be spent on each star. On telescopes smaller than 24 in.. scintillation of the star may be the main source of noise. This effect averages out on telescopes of larger aperture. As fainter stars are attempted, however, more care must be exercised. The smallest diaphragm that will safely contain the atmospheric tremor disk of the star is chosen, in order to reduce the contribution from the light of the night sky. An auxiliary guiding eyepiece working on a second star around the edge of the field is advisable in order to insure that the star being measured stays on centre. The faintest objects cannot be seen with the eye, and must be centred in the diaphragm by an offset procedure. using a co-ordinate system based on a photograph of the region made nith the same telescope. The offset proceeds from a star near the object in question which is sufficiently bright to be centred in the diaphragm by visual means.

On the faintest objects the light of the night sky becomes the major fraction of the light coming through the diaphragm, and the measurement consists of determining as accurately as possible the relatively small difference between the diaphragm area containing the object in question and an equivalent blank sky area adjacent to it. The cathode shot noise, generated mainly by the unavoidable light of the night sky, may have an amplitude larger than the star signal. Considerable averaging is necessary to obtain a reliable measurement, and a program of alternate exposures to sky and star lasting an hour or more may be needed to build up sufficient accuracy. In this range, integration of the charge coming from the multiplier offers some advantage; the longer the exposure time the greater the accumulated difference between sky and sky plus star. Electronic schemes involving the storing of the charge on a condenser have been developed by H. L. Johnson and others. An alternative approach uses counting methods to perform the integration. Each photoelectron released at the cathode becomes a burst of a million electrons at the output of the multiplier phototube, a signal easily registered on electronic counting devices. This technique was used by W. A. Baum to push the photoelectric technique to the very limits of the faintest photographic images detectable with the zoo-in. telescope of the Palomar observatory (Calif.). The limit reached was photographic magnitude 23.8.

Special Applications of Photoelectric Methods. — The higher photometric accuracy obtainable by photoelectric methods was applied very early to observations of the light curves of eclipsing binaries. A single observation gave an accuracy of the order of 0.01 magnitude, as opposed to .05 to .08 magnitude by visual photometry, and an intermediate accuracy by photographic methods. By combining observations extending over many cycles, Kron was able to achieve a final curve with a probable error of only 0.001 magnitude, corresponding to a relative error of 0.1%. With this increased precision the full power of the methods that had been norked out for deriving the physical properties of stars from analysis of the light curve and the radial velocity curve could be realized. Shallow eclipses that had previously been missed were found at their predicted times. Not only was the list of stars with well-determined diameters and densities considerably lengthened, but secondary features such as the reduced brightness of a star at the outer edge (darkening at the limb) could be derived with real confidence. The latter effect. directly observable only on the sun, gives information on the atmospheric structure of a star.

The simplicity of colour measurements by the photoelectric method led to its early use in that field. The ratio of response through two chosen filter glasses gives a colour index directly, without establishment of two separate magnitude scales. The method is thus suited to colour surreys of widely scattered objects. From such a survey of B-stars. Stebbins and his collaborators found that almost all of the more distant ones in the plane of the Milky Way had been reddened by interstellar dust clouds. The normal or intrinsic colours, as tested on the nearer stars, had the expected correlation with spectral type. The difference between observed colour and normal colour, called the colour excess, is a measure of the reddening and also of total absorption of light suffered as a result of scattering by interstellar dust clouds.

Distances calculated from the spectroscopically determined luminosity of giant or supergiant stars, or from the period-luminosity relation of Cepheids, had previously assumed that space was transparent; for reddened stars the inferred distances were therefore too great. Correction for absorption losses by means of the measured colour excess has become one of the essential steps in establishing distances by the photometric method. and photoelectric colour measurements are usually used in determining the excess.

Photoelectric methods are well adapted to measurement of small differences because the linear response lends itself so directly to simple subtraction of a large background. The detection of very faint stars against the light of the night sky has already been mentioned. The photometry of extragalactic nebulae, where the

tenuous outer portions have a surface brightness only a few per cent of that of the sky. is a similar case. Another example is the demonstration by Hall and by W. **A.** Hiltner that starlight which has passed through interstellar clouds is slightly polarized. This observation has been interpreted as evidence for a weak magnetic field in the Milky Way which aligns interstellar dust particles. In a differential measurement between two planes of polarization on the same star, Hiltner was able to maintain an internal probable error of only 0.016%, or one part in 6,000.

Photoelectric observations have not produced any general catalogues of stellar magnitudes comparable with the *Durchmusterungen* of the visual era, or the *Mt. Wilson Catalogue of Photographic Magnitudes in Selected Areas.* The more limited programs for establishing standard photoelectric magnitudes have in general used yellow and blue filters which give a close approximation to the International system of photographic and photovisual magnitudes. At the Cape of Good Hope observatory a systematic program to cover 4,000 southern stars brighter than magnitude 6.5 was partially complete by 1957. Other published lists, such as O. J. Eggen's and Johnson and W. W. Morgan's, were selected to include representative stars of the various stellar types, nearly all brighter than 11th magnitude.

Special studies of a number of open clusters (such as the Pleiades) provide standard magnitudes down to the 15th magnitude. The purpose of the latter studies was to establish data for an accurate colour-magnitude diagram of each cluster. Superposition of such diagrams for different clusters shows population differences which give important clues to the age of the cluster and the evolution of the stars within it..

Beyond the 1 jth magnitude, photoelectric magnitude work has concentrated on recalibration of stars in certain selected areas, particularly those most used in establishing the magnitudes of Cepheid variables in external galaxies. The initial study by Stebbins, Whitford and Johnson showed the first serious systematic difference in scale between the photographic and the photoelectric method. The photographic results had made the stars too bright by a third of a magnitude at 18th magnitude, an error in the sense that leads to an underestimate of the true distance of the galaxies. Completion of the photoelectric calibration of magnitude standards to the limit of the 200-in. telescope. as undertaken by Baum, is an essential step in establishing a correct cosmic distance scale. In order to be satisfactory measuring rods for the known universe, stellar magnitudes must cover an enormous range of intensities. The ratio between the brightest and faintest stars is 10^{10}; if the sun is included the ratio approaches 10^{20}. A single photoelectric photometer can cover a factor of 10^4 to 10^5 with good precision. so that not many overlaps using different optical systems are necessary. The photoelectric method has therefore been considered the one to be relied upon in establishing magnitude standards.

SPECTROPHOTOMETRY

Spectrophotometry of stars seeks to derive information about their physical properties by studying the distribution of energy through the range of the observable spectrum. A colour index is the simplest possible measurement of this type; the finest detail would be represented by high-dispersion analysis of the star's spectrum, including determination of the intensity profile of each spectrum line. Between these extremes, relative intensity measurements on short segments of the continuous spectrum of stars may be made with a resolving power ranging from 1 Å to a few hundred A. When the band is not more than a few Å wide, the measured intensity ratios can be said to represent a system of monochromatic magnitudes. Such a system has not been used to any extent in comparing the brightness of stars. even though it would have an advantage in elimination of the previously mentioned instrumental differences between observers which make a unique definition of heterochromatic magnitudes so difficult. Too small a fraction of the total light is contained in the narrow portion of the spectrum specified for the monochromatic magnitude, and the measurement is restricted to the brighter stars; heterochromatic magnitudes have to be used to reach the faint stars so important in cosmological problems. But for the comparison of the spectral distribution of radiation in different stars, the brighter stars furnish examples of most recognized types, and the specification of narrow bands gives the same advantage of uniqueness in defining the differences of magnitude that describe the distribution. The magnitude differences are in effect a series of colour indices, without the ambiguities that inevitably accompany heterochromatic photometry.

Photographic methods have been used for most of the spectrophotometric studies of stars. The spectrum is formed by placing a prism in front of a small telescope. A grating over the objective is a common method for introducing the intensity steps needed for calibration of the photographic intensities. W. M. H. Greaves, C. R. Davidson and E. G. Martin began the first series of measurements by this method at the Greenwich observatory in 1926. H. Kienle at Gottingen, R. C. Williams at the University of Michigan (Ann Arbor), and D. Barbier and D. Chalonge of Paris made important contributions. The French workers used the clear air of a high altitude station on the Jungfraujoch in the Alps to extend their measures farther into the ultra-violet.

Spectrophotometry by photoelectric methods labours under the handicap that only one portion of the spectrum can be measured at a time. On account of the long observing periods that would be necessary, high resolving power is not ordinarily attempted. When wide bands must be used in order to reach faint objects, a series of filters is a simple expedient. A single photoelectric cathode can cover the spectrum from 3,400 Å to 10,000 Å. Stebbins and Whitford used six filter bands distributed over this range. Because of the lines and bands of the star's spectrum necessarily included, results with filters are not strictly comparable with monochromatic magnitudes read at selected points in the continuous spectrum. Hall introduced the technique of scanning the spectrum with a photoelectric cell behind the exit slit. In this early work the exit slit was 400 Å wide. A. D. Code was able to reduce it to 10 Å, narrow enough to show the principal spectrum features and to give true monochromatic magnitudes.

The temperatures of the stars can be found much more precisely from monochromatic magnitudes than from colour indices. It is necessary, however, to establish an absolute standard for the relative monochromatic comparisons between stars. This can be done by comparing the stars with a terrestrial source of known spectral energy distribution, such as a carefully calibrated tungsten filament lamp. Such a source serves as an artificial star at a suitable distance from the telescope. and is measured in the same way as are the actual stars. The stellar temperatures derived in this way are called colour temperatures. For the range of the spectrum between 3,700 Å and 4,500 Å, Barbier and Chalonge found that an Ao star had a colour temperature of 16,500° K.

Spectrophotometric comparisons of reddened and unreddened stars of the same type have shown how the interstellar absorption varies with wave length. Since most of the highly reddened objects thus far identified are O- and B-stars. whose spectra are not complicated by strong spectrai lines and bands. photoelectric photometry with filters is well adapted to the study. The wide range of the cesium oxide cathode is an advantage. The law of variation of absorption with wave length appears to be the same for all parts of the interstellar medium. Once the law is known. a measured colour excess. which is merely the amount that the absorption in the shorter wave length band of a colour system exceeds that at the longer, can be multiplied by an appropriate factor to give the total absorption at any desired wave length for any specified magnitude system. Then the observed magnitude may be corrected to restore the star to its unobscured brightness, as is required in proper calculation of its photometric distance.

Spectrophotometric analysis of the light of galaxies has also been a task for photoelectric filter photometry. The diffuse nature of galaxies makes it impractical to form a spectrum of a whole system with spectroscopic equipment. As would be expected from a composite source made up of stars with a variety of spectral types. the spectral distribution is not like that of any single star. But since most of the light of external galaxies comes from stars that can never be resolved and studied individually, the spectral

distribution curve contains one of the slender clues to the nature of the stellar population in these systems.

See also ASTRONOMY and PHOTOGRAPHY, CELESTIAL.

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PHOTON: see COMPTON EFFECT; NUCLEUS; PHYSICS; SPECTROSCOPY.

PHOTOPERIODISM, the responses of organisms to certain durations of light or darkness. Under natural conditions the periods are day and night. which vary with season and latitude. Temperature. nutrition and other environmental factors interact with photoperiod and modify the response. Closely related varieties of a species may respond differently to identical photoperiodic conditions because of inherited differences. Photoperiodism was discovered first in plants and soon afterward in animals, and they are here considered in that order.

Plants.—W. A:. Garner and H. A. Allard. of the U.S. department of agriculture. first reported in 1920 that flowering of some kinds of plants was controlled by the daily duration of light. They suggested the term "photoperiodism" to designate "the response of organisms to the relative length of day and night." Garner and Allard recognized three types of plants on the basis of day lengths Favourable to flonering: short-day plants, which fail to flower when days exceed a certain duration called the critical day length; long-day ones, u-hich fail to flower unless the days exceed a critical day length; and indeterminate ones. which flower about equally well regardless of day length. Critical day lengths for both long- and short-day plants differ widely from species to species and even among varieties of a single species.

Responses of plants other than flowering are influenced by pliotoperiod. Among these are the formation of bulbs, tubers, thickened roots and runners, colouration of stems and leaves, abscission of leaves and development of certain anatomical features.

The photoperiod response of plants depends on duration of darkness. not light. a fact not understood at the time the phenomenon was named. Thus, a short-day plant flowers when nights are long and a long-day one when nights are short or absent. A brief period of artificial light in the middle of a long dark period divides it into two short ones and thus promotes the flowering of long-day plants and inhibits that of short-day ones.

Growers of chrysanthemums now produce these highly seasonal flowers throughout the year by proper control of night length and other cultural conditions for adapted varieties. Artificial light keeps the plants from blooming until they attain sufficient size or until the desired date is reached. The light is then discontinued or in some times of the year the plants are covered with black cloth during part of the day. thereby increasing the night length adequately to bring them into bloom. This practice is in extensive use in greenhouse production of chrysanthemums in the United States and over several hundred acres of plants grown out-of-doors in Florida and California.

Artificial control of day length is similarly used to regulate the time of dowering of orchids. China asters, feverfew, and tuberous-rooted begonias. Experiments show that the growth of some kinds of woody nursery plants can be maintained in the greenhouse during the winter by the use of artificial light. The uses of artificial light to improve production of various kinds of plants are constantly increasing.

The photoperiodic reaction occurs in the leaf, but the response generally occurs elsewhere. A product generated in the leaves evidently moves to the growing points, where it controls flower-bud formation. This product is a flower-promoting one produced by dark periods favourable to flowering. not a flower-inhibiting one produced by unfavourable dark periods. Some workers believed this flower-inducing material to be a special flower-forming hormone, "florigen," but such a substance had not been isolated from a plant and identified by the late 1950s. Knowledge of the initial photochemical step in photoperiodism was obtained by studies of the way in which light acts. Red light having a spectral range of about 5,500 to 7,000 Å (Angstrom units) and an absorption maximum near 6,500 Å is more effective than any other kind for preventing flowering of short-day plants and promoting flowering of long-day ones. A second but far less effective region of absorption occurs in the blue. Flowering is controlled in both kinds of plants by light of the same wave length ranges; indicating that the basic photochemical reactions are identical. although in one type they suppress and in the other promote flowering.

Response of plants to light of certain wave lengths. but not of others. means that plant cells contain a pigment or pigments that absorb these particular wave lengths. The red-absorbing pigment involved in photoperiodism and related plant responses had not been isolated and identified by the late 19jos; since it absorbs red radiation its colour cannot be red; probably it is blue.

The inhibition of flowering of some short-day plants by red light can be prevented by red light of greater wave length: *i.e.,* far red of about 7,350 Å. A similar reversal of the action of red by far-red radiation occurs in the germination of light-sensitive seeds and in the control of growth of the various parts of dark-grown seedlings. Reversal of the red action by far red indicates the presence of another pigment having a far-red absorption. These photochemical actions of red and far red are repeatedly reversible. the kind of response depending on the kind of radiation given last. Reversibility is believed to result from photochemical interconversion of the two pigments, one having an absorption near 6.500 Å and the other near 7,350 Å. The chemical identities of the pigments and the kinds of reactions in which they participate were not known in the early 1960s, but the reversibility of responses such as flowering, seed germination, seedling growth and probably others by radiation of 6,500 and 7,350 Å showed that these seemingly unrelated phenomena were controlled by the same initial photochemical reactions. Photoperiodism is thus but one manifestation of a photochemical control mechanism of wide, perhaps universal occurrence among higher plants.

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Animals. — The most conspicuous activities of animals which are closely correlated with certain seasons of the year, and hence with changes in day length, are bird migration, reproduction and changes in pelage and plumage. Each of these occurs with marked regularity at a particular time each year. By retaining animals in captivity and subjecting them to artificial increases and decreases in day length. bird migration. reproduction and other activities have been induced out of season. It has been concluded, therefore, that in nature the changing daily periods of light and darkness determine to a great extent when many seasonal activities occur. Before the northward migration to the breeding grounds in spring. birds undergo a marked change in physiological state. This is shown by increased activity of the reproductive organs and deposition of large amounts of fat. When these same changes were induced experimentally in winter by exposing captive birds to artificial increases in day length, the birds migrated northward in winter when released. By employing different schedules of day

length at various seasons of the year. it has been demonstrated that the rate of change in physiological state depends on the daily amount of illumination. As little as nine hours of light per day is stimulating. The response is rapid under long days and slow under short days. Gradual increase in amount of light per day is not necessary. Constant day lengths are effective. as are decreasing day lengths, provided that the daily amount of light is stimulating. Therefore, migratory birds which winter on or near the equator. where the day lengths are constant, or in the southern hemisphere, where the day lengths decrease after Dec. 21, could have the onset of their spring migration regulated by day length. Prerequisite to the response to light which occurs in winter and spring is exposure to short days or long nights in autumn. Day lengths in autumn wind the "clock" within the bird. so to speak, while the day lengths of winter and spring make it run and determine how fast it runs.

In most birds. mammals and other vertebrates breeding is seasonal. By experimental manipulation of day length, reproductive activity has been induced out of season. Where the species breed normally beginning in autumn (*e.g.*, brook trout. deer, sheep and goats), decreasing or short days following long days are effective. For species which breed in spring (*e.g.*, starling. junco. ferret and mink). increasing or long days following short days are effective. Change in breeding season occurs in some birds and mammals when they are transported from the southern to the northern hemisphere, or from the region of the equator to temperate latitudes. Although day lengths are constant on the equator and change little in the tropics, there is some evidence that day length regulates the breeding and plumage cycles of tropical birds. Experimental modification of the breeding cycle of invertebrate animals (*e.g.*, snails. crustaceans and insects) by means of day length has also been demonstrated.

Attempts to discover how day length affects the breeding cycle have shown that the light stimulates the eye or part of the brain near the eye. The stimulus produced by the light eventually reaches the pituitary gland (the master endocrine gland located at the base of the brain). which secretes the hormones that. among other functions, control the growth of the reproductive organs. There is good evidence that the length of the dark period and the ratio of light to darkness are important factors in determining the reproductive response. The effects of day length on the migratory response (mentioned above) also apply to the reproductive response in some birds. Response to light can he modified by temperature, nutrition and inherent internal iactors. A few species of birds and mammals studied did not show any influence of light on the reproductive cycle.

The most conspicuous seasonal change in pelage and plumage occurs in those mammals and birds which are white in autumn and winter and brown in spring and summer (*e.g.*, varying hare, ermine and ptarmigan). By experimental manipulation of light, either of these colours was produced out of season. Molt into white plumage or pelage was induced by short days. Temperature was not a factor. Day length also influences the time of annual molt in birds, growth of wool in sheep and production of winter pelage in mink and ferret.

A number of less obvious seasonal activities also occur in response to day lengths. In the potato aphid, the production of winged individuals (as opposed to wingless individuals) normally occurs in autumn and is dependent on a period of darkness of 12 to 14 hours. In the strawberry root louse, occurrence of sexually reproducing individuals, which occurs normally in autumn, was produced out of season by shortening the days.

Practical application of knowledge of photoperiodism is feasible and common in poultry management, ior day length affects laying, sperm production and body weight of the fowl.

See also PHOTOCHEMISTRY: *Photochemical Reactions of Biological Importance;* PHOTOSYNTHESIS; PLANTS AND PLANT SCIENCE: *Growth.*

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PHOTOSPHERE of the sun, the layer from which most of the sun's light is emitted which reaches us directly; *i.e.,* without absorption and re-emission. The sun is a globe of gas with no sharply defined surface, and we look down into it through absorbing layers of very low density; the photosphere may be regarded as the layer which is the limit to which we can see into the interior. (See SUN.)

PHOTOSYNTHESIS. Photosynthesis is the process by which green plants harness the energy of sunlight absorbed by chlorophyll to build carbohydrates from carbon dioxide and water. This reaction is often referred to as assirnilation or fixation of carbon.

Fundamental Role of Photosynthesis. — For their subsistence. growth and multiplication all living beings, plants and animals alike, need organic food. The organic foodstuffs are 'utilized by living cells as building stones and as sources of energy. The energy stored in the foodstuffs is released mainly by respiration, the reaction in which organic matter combines with the oxygen of the air yielding carbon dioxide and water as final products. The rate at which living beings die and consume each other is so high that they would all disappear from the earth within the lifetime of a human generation if there were not a process providing for the reformation of organic matter. While there are many ways by which organic substances are decomposed in respiration and similar reactions, there is only one reaction. photosynthesis. which for millions of years has counterbalanced death and decomposition. In the course of photosynthesis the hydrogen of water is used to transform carbon dioxide into carbohydrate; simultaneously the oxygen of the water is liberated as free oxygen gas. Among the many pigments appearing in plants only chlorophyll and. to a lesser extent. carotenoids and phycobilins are known to convert sunlight into chemical energy (*see* below). Chlorophyll is the green dye whose colour is so characteristic of meadows and forests. The green plants may transform the carbohydrates produced by photosynthesis into fats. proteins and many other substances. Thus. directly or indirectly, all the organic food of plants or animals depends upon the photosynthetic process. In the cycle of synthesis and death the basic materials. carbon dioxide and water, can be used over and over again. while the energy released upon the destruction of organic matter is lost forever; it is dissipated as heat in space and must constantly be replaced by the sun's radiation.

Rate of Carbon Dioxide Reduction. — In bright sunlight the rate of the photosynthetic reaction is about 15 to 30 times the respiratory rate. A sunflower leai may gain 9% of its dry weight per hour. Considering that respiration proceeds continuously while photosynthesis occurs only during the hours of light, the net rate of the latter is about five times greater. This means an excess of carbohydrate, which is partly stored and partly used ior the growth oi the plant. Nongreen plants and animals, which constitute the hcterotrophic organisms, depend upon this excess ior their organic food.

Land plants utilize the carbon dioxide present in the air. This averages only 0.03% of the gas volume at the earth's surface. Aquatic plants thrive on the carbon dioxide dissolved as gas or as carbonates in the water. The best estimate ior the rate of the total carbon dioxide reduction on earth is a turnover oi 10^{11} tons of carbon per year, more than four-fiiths oi which is contributed by the flora of the oceans. An amount of carbon dioxide equal to the total readily available reservoir passes through the liie cycle in about 350 years. The cycle of carbon requires also one oi oxygen and of hydrogen. Since both these elements are available in larger quantities, it takes about 2,000 years to renew all the osygen in the air and 2,000,000 years to decompose all water on earth. The land plants grow faster if supplied with more carbon dioxide than they can now find in nature. It may be assumed that at the time in the history of our planet when its crust cooled down below the boiling point of water—the upper temperature limit for the existence of liie--there was little or no free oxygen but plenty oi carbon dioxide present. It is quite probable that our entire supply oi iree oxygen, one-fifth of the atmosphere, has been furnished by photosynthesis.

Origin of Life.—The chlorophyll system is a highly complex structure which ceases to iunction whenever its protein components are damaged. Obviously, thrreiore, life cannot have started with that particular synthetic reaction which at present is its sole support. Liie probably began with the aid of organic substances produced by ultraviolet radiation or by electrical discharges when the earth's atmbsphere

consisted mainly of hydrogen, methane, ammonia and water vapour. Experiments have shown that such a gas mixture, if subjected to electrical discharges, yields amino acids, the building stones of proteins.

Factors Governing Photosynthesis. — Photosynthesis is influenced by temperature, light intensity, carbon dioxide concentration and water supply as external factors. The internal factors influencing its course are twofold: first, the concentration of the pigments and the activity of the enzymatic catalysts involved in photosynthesis; second, other metabolic reactions, such as respiration and fermentation, which have no direct connection with the photosynthetic process. Among the internal factors must be included also the inherited traits characteristic for different species. It is well known that certain plants can grow in arctic regions and others only in the tropics. It has been found, however, that the chemistry of photosynthesis is identical in lower and in higher plants. For experimental purposes, therefore, the plant material suitable for the particular measuring device may be chosen.

Each of the factors influencing photosynthesis may become the one which is mainly responsible for the limitation of the over-all rate. At low light intensities and otherwise favourable conditions, photosynthesis proceeds at a rate directly proportional to the incident radiation. Under these circumstances the light energy is utilized with the greatest efficiency. At high light intensities and high temperatures, the rate remains a function of the carbon dioxide concentration so long as the mechanism of photosynthesis is not saturated with this substrate. If carbon dioxide also is present in sufficient amounts, the rate is determined by internal factors, most likely by the slowest of several enzymatic processes connected with the reduction of carbon dioxide. Since a truly photochemical reaction is not influenced by changes in temperature which determine the rate of ordinary processes, the rate of photosynthesis remains practically constant in spite of temperature changes as long as the light intensity is the rate-determining factor. This is the case at low or moderate light intensities and high temperatures. Conversely, in bright sunshine and at moderate temperatures photosynthesis is influenced by changes in temperature exactly as are other metabolic processes. These observations on limiting factors were among the first which led to the concept of photosynthesis as consisting of a sequence of photochemical and thermal enzymatic or "dark" reactions. An ingenious way of separating photochemical from dark reactions in the analysis of photosynthesis was first described in 1929. It consists of illuminating a plant with light flashes of very short duration (less than 1/1000 sec.) separated by dark periods of considerably greater length (1/100 sec. to 1 sec.). In this way the temperature dependencies just mentioned were clearly demonstrated. It was further shown that most metabolic poisons inhibit not the photochemical but the dark reactions in photosynthesis. Studies of the influence of poisons on the course of photosynthesis, performed in analogy to similar investigations in the field of respiration, allowed for a separation, in theory, of reactions preceding the photochemical reduction of carbon dioxide and reactions following it. These theoretical deductions were borne out by later experimental analyses of the mechanism of photosynthesis (see below).

Active Pigments. — (See also CHLOROPHYLL, CHEMISTRY OF; PLANTS AND PLANT SCIENCE.) The site of photosynthesis is in very small structural units called grana. In most plants the grana are arranged within larger structures, the chloroplasts. The green or brown colour of most chloroplasts is attributable to the chlorophylls and carotenoids. The two green chlorophylls a ($C_{55}H_{72}O_5N_4Mg$) and b ($C_{55}H_{70}O_6N_4Mg$) were isolated in 1905 and their structure finally established about 1936. The bacterio-chlorophylls a and b, occurring in purple bacteria, are related pigments whose absorption spectrum is shifted toward the infra-red. The chlorophylls are identical in all plants. They belong, like haemin — the dye responsible for the colour of blood — to the class of porphyrin metal complexes. An important difference between chlorophylls and haemins exists in their photochemical properties. The presence of a complex bound atom of magnesium does not destroy the typical porphyrin fluorescence of the chlorophylls, but the presence of the heavy metal iron in the haemins quenches the porphyrin fluorescence completely and makes the latter dyes photochemically inert. The slight difference between chlorophyll a and chlorophyll b — a formyl group (—C.H:O) in b where a has a methyl group (—CH_3) — is reflected in the absorption spectrum. Chlorophyll b absorbs at slightly shorter wave lengths.

One of the side chains of the porphyrin ring in chlorophyll is esterified with phytol, $C_{20}H_{40}O$, a colourless alcohol, which also is found as a side chain in vitamin K. The role of phytol in both substances is obscure. Chlorophyll looks green because it is somewhat more transparent for green light than for blue and red, yet green light is equally effective if absorbed. For the wave lengths longer than 7,300 A chlorophyll is quite transparent. This is the reason a landscape seen through a dark-red filter shows the leaves of trees and the lawn brighter than the surroundings (including the blue sky), an effect familiar from infra-red photography. Chlorophyll is insoluble in water. Extracts can be obtained simply by immersing green leaves in alcohol or acetone. In the cell, chlorophyll is bound to protein. It can be extracted in its combination with protein, in the form of a colloidal aqueous solution, if the plant cells are mechanically crushed.

The carotenoids present in the chloroplasts vary in composition and number with different species of plants. Their chemical structure has nothing in common with that of chlorophyll. The formula for carotene is $C_{40}H_{56}$, for xanthophyll $C_{40}H_{56}O_2$ and for fucoxanthin $C_{40}H_{56}O_6$. Some of these pigments were known to act as photoreceptors in such phenomena as phototaxis and phototropism, but until 1930 it was believed that only the light absorbed by chlorophyll was available for photosynthesis. Botanists, however, wondered how brown algae, in which most of the incident radiation is absorbed by the yellow pigments, could use light so effectively for growth. In 1941 it was finally established that some of the yellow pigments participate in photosynthesis. The degree to which this takes place varies considerably in different plants. In the diatoms, which are responsible for the bulk of photosynthesis in the ocean, the light absorbed by carotenoids is just as effective as that absorbed by chlorophyll. The mode of action of the carotenoids is, however, merely that of an "accessory pigment." The excitation energy is not utilized within the molecule itself but is transferred to chlorophyll a as shown by the colour of the resulting fluorescence. This is also the way in which phycocyanin and phycoerythrin, the characteristic pigments in blue-green and red algae, contribute to photosynthesis in these plants. No cell capable of photosynthesis has been found which did not contain chlorophyll a in addition to the other pigments mentioned. Even chlorophyll b seems to act as an accessory pigment by letting the excitation energy go over to chlorophyll a. The latter, therefore, appears to be the one pigment engaged in the actual conversion of light (electromagnetic energy; photons) into chemical energy.

Photochemically inactive pigments of the cytochrome type have been extracted in small amounts from chloroplasts of green plants and from purple bacteria. They are believed to act catalytically in the disposal of the hydroxyl groups derived from the photolysis of water.

Activity of Chloroplasts. — Photosynthesis survives for a short time in chloroplasts which have been removed from the cell. Certain cofactors restore some activity even to washed chloroplasts. Whenever the fine structure of the protoplasm or of the chloroplasts has been damaged, the process stops and only partial reactions can be seen to continue. In 1939 it was first shown by R. Hill that it is possible to obtain suspensions of chloroplasts from higher plants which still produce oxygen upon illumination yet have lost the ability to reduce carbon dioxide. The chloroplasts have to be suspended in a solution of ferric oxalate and ferricyanide. The ferric salts are photochemically reduced to ferrous salts. No carbon dioxide takes part in this reaction. In the same way quinones and dyestuffs are reduced in the light while oxygen is evolved. These experiments show that the chlorophyll complex and the enzyme system concerned with the photolysis of water can be kept functioning after the faculty to fix carbon dioxide has been lost. If enzymes and substrates extracted separately from either plant or animal tissues are recombined with illuminated chloroplasts, carbon dioxide may be taken up and incorporated into the carboxyl group of phosphoglyceric or malic acid.

Illuminated chloroplasts, as well as intact green cells, phosphoresce after illumination ceases. With sensitive instruments it can be shown that after the light has been turned off a red light of the same colour as the fluorescence of chlorophyll is emitted. Its intensity first declines steeply within a few seconds, but some residua: light emission lingers on for many minutes. This phenomenon, a chemiluminescence, is caused by the reversal of the very first photochemical steps in photosynthesis.

Efficiency of Photosynthesis. — The average data available to the mid-1950s concerning land plants indicated that between 1% and 3% of the light falling upon a green plant is transformed into chemical energy. Important as this answer may be for problems of agriculture, it is of no value in respect to the theoretical understanding of the process of photosynthesis. Most of the incident radiation is lost by reflection, transmission and ineffective absorption by pigments other than those in the chloroplasts. Only a fraction is absorbed by the active pigments. The efficiency with which this latter fraction is utilized in the course of the photochemical process is of great theoretical interest. It is measured by the minimum number of light quanta necessary to bring one molecule of carbon dioxide to the energetic level of a carbohydrate. From the mid-1920s to the mid-1950s, a prodigious amount of work was devoted to the determination of this number. It is certain that eight quanta of red light totalling 320 kg.cal. suffice to store the equivalent of 112 kg.cal. in terms of organic matter. The net efficiency of photosynthesis, therefore, is about 35%. Much higher efficiencies are alleged to have been found in certain experiments where plants were kept under unusual conditions, but these reports remained unconfirmed in the 1950s. In the unicellular green alga Chlorella the quantum yield remains essentially constant over the entire range of the chlorophyll absorption spectrum. This means that expressed in terms of calories the efficiency increases in the direction from blue to red in the spectrum, because the energy content of the light quanta decreases according to the laws of physics. Chlorophyll in the living cell obeys these laws exactly as do the chlorophyll-sensitizing photochemical oxidations in vitro.

Products and Intermediates of Photosynthesis. — The photosynthetic reaction is summarized in the most general chemical terms by the equation:

$n CO_2$ (carbon dioxide) $+ n H_2O$ (water) $+$ light $= n O_2$ (oxygen) $+ (CH_2O)_n$ (carbohydrate).

The factor n is introduced because a number of different carbohydrates are made in the course of the reaction. It is a matter of definition which ones should be called the "product(s) of photosynthesis." A derivative of a three-carbon sugar, triose phosphate, is the first carbohydrate to appear after the photochemical reduction of carbon dioxide has run its course, but only cane sugar (sucrose) or starch or, in some cases, fats are accumulated as storage products in the plants. The validity of this equation was established beyond doubt by the following experimental results: First, all measurements of photosynthesis extending over periods longer than 30 minutes showed that the volume of oxygen evolved is exactly equal to the volume of carbon dioxide absorbed; the assimilatory quotient is unity ($AQ = \triangle O_2 / \triangle CO_2 = 1$). Second, the amount of carbohydrate accumulated during 15 minutes of illumination was found to be equivalent to the amount of carbon dioxide taken up during the same time. In the above equation for the over-all process, the carbohydrate formed is symbolized by $(CH_2O)n$ and not by CH_2O, the formula of formaldehyde. For 60 years after it was first proposed in 1870, the hypothesis that formaldehyde is produced in photosynthesis was a favourite assumption in various theories. This hypothesis can safely be discarded because, mainly through the efforts of M. Calvin and A. Benson, it is known definitely that the first recognizable organic compound which contains the carbon dioxide taken up by the plant is phosphoglyceric acid:

$H_2O_3P.OCH_2.CHOH.COOH.$

The newly assimilated carbon forms the carboxyl group —COOH of this acid. An important step forward in research on photosynthesis was made possible by the discovery since 1939 of the isotopes of the element carbon (see ISOTOPE: *Naturally Occurring Radioactive Isotopes)*. The bulk of the ordinary carbon has the atomic weight of 12. The other isotopes have the weights of 10, 11, 13, 14 and 15. All are radioactive except C^{13} which is stable like C^{12}. C^{11}, C^{13} and C^{14} have been used in research in photosynthesis to trace the path of freshly fixed carbon on its way into various organic compounds of increasing number and complexity. The first attempts to use such "tracer" carbon in 1940 could not get very far because only C^{11}, whose half life is about 20 minutes, was then available. The atomic bomb project after World War II provided comparatively large amounts of C^{14}, which, having a half life of about 5,000 years, made possible many kinds of analyses requiring considerable time. The very first experiments with isotopes settled the long-disputed question of whether carbon dioxide reacts directly with chlorophyll, particularly with the magnesium atom in the molecule. No such reaction occurs.

The same experiments revealed that in a growing photosynthesizing plant the reduced carbon is quickly distributed among all organic compounds taking an active part in the metabolism of the cell. After a few minutes of illumination, a tiny fraction of the radioactive carbon was found even in the basic skeleton of the chlorophyll. Thus it became clear that the use of radioactive carbon would not automatically divulge the path of carbon in photosynthesis proper, since the assimilation of carbon is so interwoven with its utilization in other processes, such as fermentation, respiration and prntein synthesis.

Mechanism of Photosynthesis. — A few species of autotrophic bacteria are known to grow with carbon dioxide as the sole source of carbon in the absence of light. They utilize the energy derived from the oxidation of inorganic compounds, such as ferrous iron salts, sulphur, thiosulphate, hydrogen sulphide and molecular hydrogen. This fact was generally ignored in earlier attempts to understand the mechanism of photosynthesis. The amount of oreanic matter formed hy this means was considered insignificantly small as compared with photosynthesis, and the reduction of carbon dioxide in the dark appeared to be fundamentally different from photochemical reduction. In the decade between 1930 and 1940, however, it became evident that many organisms and tissues, from propionic acid bacteria to pigeon liver, include carhon dioxide among their metabolic substrates. In these cases a specific enzymatic system provides for the proper coupling between an energy-yielding reaction, respiration or fermentation, and a reaction in which hydrogen is transferred to carbon dioxide or its equivalent derivative. The great difference between these oxidoreductions and photosynthesis lies not in the way by which the carbon dioxide molecule is attacked but in the energy balance. No ordinary metabolic synthesis can end with an over-all gain and storage of chemical energy, because an excess of combustible material, previously synthesized, has to be sacrificed to make the reaction go. In photosynthesis it is the energy of light which in the course of the very rcaction furnishes the necessary combustible material or hydrogen donor by the "oxidation" of water. The utilization of light energy, however, is not sufficient to guarantee a successiul accumulation of chemical energy. This was shown by studies on the metabolism of purple bacteria, strongly coloured yellowish, red or purple unicellular microorganisms. Because their growth depends on light. they were first believed to photosynthesize as do the green plants. Investigations after 1930 proved that purple bacteria are unable to produce molecular oxygen and are unable to reduce carhon dioxide simply with water. In addition to radiant energy they need energetically valuable hydrogen donors. According to the specificity of each species, the purple bacteria require for the assimilation of a certain amount of carbon dioxide an equivalent amount of either sulphur, hydrogen sulphide, thiosulphate, molecular hydrogen, aliphatic acids or alcohols. In purple bacteria, therefore, the energy of light is not successfully stored as in the green plants, but is partially or completely wasted. The light serves here only as a promoter, as it were, of reactions which might as well be carried on thermally in the dark. In 1940, however, it was found that the photochemical reaction proper is the same in purple bacteria and in green plants. Certain species of unicellular green algae change to a type of metabolism similar to that of some purple bacteria if they are incubated during a few hours in pure hydrogen gas. Upon subsequent moderate illumination, they reduce carhon dioxide as usual, but they do not evolve oxygen. Instead they absorb the equivalent amount (twice the volume) of hydrogen. Once adapted to the use of hydrogen the same algae can reduce carbon dioxide, as do the "Knallgas" bacteria, in the dark, if some oxygen is supplied instead of light. Under the influence of intense irradiation the algae revert to normal photosynthesis with the production of oxygen. This reversible separation of carbon dioxide reduction from oxygen evolution or from the absorption of light demonstrated — what had been postulated long before — that photosynthesis consists of a series of complicated reactions which must be studied separately before the process as a whole is clearly understood. After 1940 all students of the problem agreed that at least three sets of partial reactions may be distinguished: (1) decomposition of water with the aid of light absorbed by chlorophyll, leading, on the one hand, to compounds (as yet unknown) having a surplus of hydrogen and serving as intermediary hydrogen donors, and, on the other hand, to compounds having a surplus of oxygen; (2) transfer of hydrogen from the intermediary donors to carbon dioxide; (3) disposal of the compounds having a surplus of oxygen. The permanent conversion of radiant energy into chemical energy is possible only because green plants accomplish the task of removing the surplus of oxygen by liberating molecular oxygen and not by consuming hydrogen donors, as do, for instance, the purple bacteria. This picture of photosynthesis requires, among other things, that all the oxygen evolved be derived from water and not from the reduced carhon dioxide molecule.

The discovery of phosphoglyceric acid as the first intermediate fixation product by means of the radioactive tracer method showed that an organic two-carbon compound (or two-carbon fragment derived from a larger molecule — probably pentose) must be the substance which accepts carbon dioxide and thus is transformed into the three-carbon acid. The acceptor molecule is constantly regenerated from the sugars produced by photosynthesis. A special metabolic cycle, therefore, exists which furnishes the two-carbon acceptor. Since this cycle has phosphoglyceric acid as one of its intermediates and since the latter is known to be aiso an intermediate in the respiratory metabolism of most living organisms, including the plants, it can be understood why, occasionally, respiration and photosynthesis in the same cell seem to influence each other quite strongly. By increasing or decreasing the amount of a photosynthetic intermediate, respiration can interiere with the kinetic pattern of the reaction proceeding in the light. This is particularly true in dim light when the reactions leading to the synthesis of sugars are not much faster than those causing their breakdown.

Food Production and Artificial Photosynthesis. — Because the earth's human population is increasing so rapidly with no corresponding increase in iood production, scientists have wondered how much more food would be available if full use could be made of the great efficiency of photosynthesis, which in laboratory experiments has been found to approach 35% of the intensity of the radiation absorbed by the active pigments. The average acre of land under cultivation yields hardly more than one ton of total dry organic matter per year because most of the light falling on the suriace is not trapped by chlorophyll and thus is lost for photosynthesis. If agriculture were superseded by the continuous cultivation of tiny aquatic algae in thin layers of fertilized water, the same area could produce between 30 and 50 times more edible material. Before such a project can become practical two other problems must be solved: how to maintain easily and cheaply over large areas conditions for optimal growth of algae, and how to induce people to eat them.

Of even greater importance is the relation of photosynthesis to the problem of a continuous supply of energy. The supply of oil, coal and nuclear energy on earth is definitely limited. Sooner or later every one of these sources will be exhausted. The only source of energy which cannot be depleted by the activities of the human race is solar radiation. Continued research in photosynthesis may teach us how to transform, in an entirely artificial way, visible light into a form of potential energy suited for general energy needs. *(See* also PHOTOCHEMISTRY.)

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(1953). (H. GN.)

PHRAATES (PHRAHATES), the name of five Parthian kings.

1. PHRAATES I. son of Priapatius, reigned c. 176–171 B.C. He subdued the Mardi, a mountainous tribe in the Elburz. He died young, and appointed as his successor not one of his sons but his brother Mithradates I.

2. PHRAATES II, son of Mithradates I, the conqueror of Babylonia, reigned 138–128 B.C. He was attacked in 130 by Antiochus VII. Sidetes. who, however, in 129 was defeated and killed in a battle in Media, which ended the Seleucid rule east of the Euphrates. (See SELEUCID DYNASTY.) Meanwhile the kingdom was invaded by the Scythians (the Tochari of Bactria), who had helped Antiochus. Phraates was defeated and killed.

3. PHRAATES III, "the God," succeeded his father, Sanatruces, in 70 B.C., at the time when Lucullus was preparing to attack Tigranes of Armenia, who was supreme in western Asia and had wrested Mesopotamia and several vassal states from the Parthian kingdom. Naturally, Phraates declined to assist Mithradates of Pontus and Tigranes against the Romans. (See TIGRANES.) He supported his son-in-law. the younger Tigranes, when he rebelled against his father, and invaded Armenia (65 B.C.) in alliance with Pompey, who abandoned Mesopotamia to the Parthians. But Pompey soon overrode the treaty; he acknowledged the elder Tigranes, took his son prisoner, occupied the vassal states Gordyene and Osroene for the Romans, and denied the title of "king of kings," which Phraates had adopted again, to the Parthian king. About 57 Phraates was murdered by his two sons, Orodes I and Mithradates III.

4. PHRAATES IV, son of Orodes I, by whom he was appointed successor in 37 B.C., after the death of Pacorus. He soon murdered his father and all his 30 brothers. He was attacked in 36 by Antonius (Mark Antony), who marched through Armenia into Media Atropatene. and was defeated and lost the greater part of his army. Believing himself betrayed by Artavasdes, king of Armenia, he invaded his kingdom in 34, took him prisoner, and concluded a treaty with another Artavasdes, king of Atropatene. But when the war with Octavianus Xugustus broke out, he could not maintain his conquests; Phraates recovered Atropatene and drove Artaxes, the son of Artavasdes, back into Armenia. But by his many cruelties Phraates had roused the indignation of his subjects, who raised Tiridates II to the throne in 32. Phraates was restored by the Scythians, and Tiridates fled into Syria.

The Romans hoped that Augustu's would avenge the defeat of Crassus on the Parthians, but he contented himself with a treaty, by which Phraates gave back the prisoners and the conquered eagles (20 B.C.); Armenia also was recognized as a Roman dependency. Soon afterward Phraates. whose greatest enemies were his own family, sent five of his sons as hostages to Augustus, thus acknowledging his dependence on Rome. This plan he adopted on the advice of an Italian concubine whom he made his wife under the name of "the goddess Musa"; her son Phraates, commonly called Phraataces (a diminutive form), he appointed successor. In 2 B.C. he was murdered by Musa and her son.

5. PHRAATES V, or PHRAATACES. the younger son of Phraates IV and "the goddess Musa," with whom he is associated on his coins. Under him a war threatened to break out with Rome about the supremacy in Armenia and Media. But when Augustus sent his adopted son Gaius Caesar into the east in order to invade Parthia. the Parthians preferred to conclude a treaty (A.D. 1) by which once again Armenia was recognized as in the Roman sphere. Soon after Phraataces and his mother were slain by the Parthians. about A.D. 5. (ED. M.)

PHRAORTES, the Greek form of *Fravartish*, king of Media. According to Herodotus (i. 102) he was the son of Deioces, and began the Median conquests. He first subjugated the Persians, and then a great many other peoples of Asia, till at last he attacked the Assyrians. He was defeated and killed in a battle. after a reign of 22 years. about 646–625 B C

When after the assassination of Smerdis all the Iranian tribes. the Babylonians and the Armenians rebelled against Darius and the Persian rule. "a man of the name of Fravartish (*i* e., Phraortes), a Mede. rebelled in Media and spoke to the people thus: I am Khshathrita, of the family of Uvakhshatra (Cyaxares)." He reigned for a short time, but was defeated by Hydarnes, and aftenvard by Darius himself, taken prisoner in Rhagae (Rai), and executed in Ecbatana (520 B.C.). (ED. M.)

PHRENOLOGY, the name given to an empirical system of psychology formulated by F. J. Gall (*q.v.*) about 1800. Phrenology was based upon a belief in strict localization of function in the human brain. According to Gall, each mental faculty has its seat in a definite region of the surface of the brain. The size of this region creates correspondent anatomical changes in the skull. The phrenologist, by examination of the skull, could assess the abilities and personality of the subject. Phrenology enjoyed popular appeal but was discredited by later scientific research.

PHRYGIA, the name of a large district of Asia Minor in ancient times, derived from a people whom the Greeks called Phryges; *i.e.,* freemen. Taken at its widest extent, Phrygia comprised the whole northwest and centre of Asia Minor as far as the river Halys and the southern mountain edge of the peninsula, and had sea fronts on the Black sea and the Aegean. But most ancient authors confined the name to an inland district stretching roughly from long. 29° to 32° or 33°, and from lat. 38" to 40°; and the real core of Phrygia at all times lay in the comparatively small plateau between the river Sangarius and the upper course of the Maeander. Phrygia in its narrower sense is a tableland 3,000 to 5,000 ft. high, dotted with isolated mountains that rise to 8,000 ft.. and intersected by several river systems.

The Phrygian **Immigration.**—Phrygia always contained a large element of that indigenous "Asianic" stock, whose survival to the present day has been noted by modern travelers. The persistence of this element in ancient times is indicated by the continued prevalence of native Asianic cults in Phrygia (see Religion). But the Phrygians properly so-called were an immigrant folk. According to Greek tradition they entered Asia Minor from Thrace or Macedonia; and this tradition is confirmed by the fact that their language was certainly Indo-European.

Homer represents the Phrygians as rendering aid to King Priam at the siege of Troy, in return for assistance which he had given to them in their wars against the Amazons (=the Hittites?) on the banks of the Sangarius. This story indicates that the Phrygian had entered Asia Minor some time before 1200 B.C. A date not later than 1500 B.C. has beeninferred from the furniture of certain burial mounds in northwestern Asia Minor.

It would appear from Homer that the incoming Phrygians made their principal settlement in the Sangarius valley. Their chief surviving monuments are also found in this valley (at Gordium), and on the adjacent plateau to the southwest of the Sangarius. But it is probable that about 1000 B.C. all the northern and central parts of Asia Minor had'come under Phrygian occupation. The extension of Phrygian power to the western seaboard of Asia Minor may be inferred from a somewhat enigmatic Greek tradition. that in the 9th century B.C. they exercised a "thalassocracy" or "lordship of the seas" in Aegean waters, and from the abundance of Phrygian remains on Mt. Sipylus in the lower Hermus valley. The description of Sinope as a "Phrygian" town indicates a Phrygian settlement along the Black sea. Another Greek tradition, that the Armenians were an offshoot of the Phrygian stock, is supported by the resemblance between the Phrygian and the Armenian tongues.

The expansion of the Phrygians into eastern Asia Minor is proved by the discovery of an inscription in the Phrygian language at Tyana in Cappadocia. This text, it is true, does not appear to be of earlier date than the 8th century B.C. But the presence of Phrygians on the borders of the Euphrates may perhaps be inferred from Assyrian records which relate victories by Tiglath-Pileser I (c. 1120 B.C.) and by Sargon (717–709 B.C.) over a tribe named the Mushki. The fact that in one of Sargon's inscriptions the chief of the Mushki bears the name "Mita" suggests the Mushki were Phrygian. or had Phrygian rulers.

The relation between the Phrygians and the Hittites. who were the predominant people in Asia Minor c. 1500 B.C., is not yet quite clear. The existence of a group of rock carvings in Hittite style, extending from Ancyra to Sardes and Smyrna, suggests

that Phrygia proper may at one time have been under kittite government, but the character of Hittite influence in north-western Asia Minor still remains uncertain. On the other hand there is little doubt that the decline of Hittite culture and the disappearance of Hittite power from Asia Minor after 1000 B.C. was in large measure due to the expansion of the Phrygians.

Decline of **Phrygia.**—About 1000 B.C. the Phrygians had penetrated southward in Asia Minor as far as the Hermus and the Maeander, and eastward to the Halys, if not to the Euphrates. But over the greater part of this territory they were unable to consolidate their power, or to extend their culture. East of the Halys they disappear from history about 700 B.C. Their frontage on the Black sea was taken from them by the Bithynians, who probably entered Asia Minor from Europe soon after 1000 B.C. Their access to the Aegean was shut off at some unknown date by the Greek colonists of the coastland and by the Lydians of the Hermus valley. After 800 B.C. the only districts which remained' in Phrygian occupation were the tableland between the Sangarius and the Hermus, and the borderland of the Dardanelles and the Sea of Marmora, known later as "Hellespontine Phrygia."

In the 8th century B.C. Phrygia proper achieved a considerable measure of prosperity under a line of kings who had their capital at Gordium and were called alternately "Gordius" and "Midas." The last and greatest of this dynasty was a king Midas who reigned from 738 to 695 B.C. This ruler cultivated close relations with the Greeks. He was the first foreign ruler to dedicate offerings to Apollo at Delphi, and he took to wife the daughter of Agamemnon, king of the Aeolic Greek city of Cyme.

Soon after 700 B.C. the reign of Midas was brought to a sudden end by the incursion of a Thracian people named the Cimmerians, of which Greeks, Lydians and Assyrians felt the force, but the Phrygians took the full brunt. By the second half of the 7th century the Cimmerians disappeared from Asia Minor without leaving a trace, but Phrygia was now so far enfeebled that it fell under the dominion of the neighbouring kingdom of Lydia.

Phrygia under Foreign Rule.—Under the Lydian rule Phrygia seems to have recovered some of its former prosperity. If the dates usually assigned to Phrygian monuments are correct, Phrygian art reached its highest development about 600 B.C. A resumption of commerce with the Greeks at this period is indicated by finds of Corinthian pottery at Gordium. But after the conquest of Lydia by the Persians (546 B.C.) Phrygia shared in the general decline which now befell western Asia Minor; about 400 B.C. it was divided into two portions, "Great Phrygia" and Hellespontine Phrygia.

After two centuries of uneventful history under Persian rule Phrygia passed into the hands of Alexander of Macedon, who visited Gordium (333 B.C.) and there cut the "Gordian knot"; legend declared that this knot, which secured 'the yoke to the shaft of an archaic farm wagon, had been tied by Gordius, the founder of the Phrygian dynasty, and that whosoever might unravel it should become lord of Asia. After Alexander's death Phrygia became a battleground for the contending forces of his former marshals. At first it formed the nucleus of the territory of Antigonus, who set up his capital at Celaenae; but after the decisive action at the neighbouring site of Ipsus (301 B.C.) it was transferred to Seleucus as an annex to the kingdom of Syria.

About 275 B.C. all the Phrygian lands east of the Sangarius came into the possession of a horde of Celtic invaders from the Danube lands and was renamed Galatia. The western portion of Phrygia at the same time was taken from the kings of Syria by the newly founded monarchy of Pergamum. For nearly a century the Phrygian territory remained a bone of contention between the kings of Pergamum and Syria and the Galatian Celts, until in 189 B.C. the Romans expelled the Syrian kings from Asia Minor, confined the Celts to Galatia, and left the western half of the peninsula under the undisputed control of the Pergamene rulers. After the annexation of the Pergamene kingdom by Rome in 133 B.C., Phrygia west of the Sangarius became part of the province of Asia. and remained in this condition until *c.* A.D. 300, when the emperor Diocletian constituted it into two independent provinces, Phrygia Prima and Secunda. Under the Byzantine empire the name Phrygia disappeared altogether.

Economic Life and Culture

Economic **Conditions.**—Phrygia was at all times an agricultural and, still more, a pastoral land. The only industrial products of importance were the marble of Docimium and the dark-coloured woolens of Laodiceia and Colossae (in South Phrygia, on the River Lycus). The southern border of Phrygia, as we have seen, was traversed by a trade route which, in the days of Greek and Roman rule, attained considerable importance. Phrygia's chief source of wealth lay in its grasslands, which produced fine breeds of horses and of sheep. The horses were exported as far as Rome for use in the circus. The sheep provided a clip of wool which supplied the looms of Phrygia, Miletus, Pergamum and other Greek textile centres.

Phrygia was always a land of villages rather than of cities. In the days of the native monarchy Gordium and the "Midas city" grew to be considerable towns, and Celaenae (subsequently renamed Apameia) was probably at all times a trading centre of some importance. Under the rule of the Syrian and Pergamene dynasties a number of new cities with a predominantly Greek population were founded, but most of these were little more than garrison towns or settlements of veterans. The villages were usually built on the slopes of the lower hills, near the site of a temple or of a great landowner's manor house. The soil for the most part belonged to the successive kings or overlords of the country, their principal vassals and to the priesthoods of the more important temples. The actual cultivators lived mostly in a condition of serfdom.

Culture.—The history of Phrygian art is not easy to trace, because the chronological order of the surviving monuments is not yet certain. Its most typical products are rock-cut tombs and houses, and ornamented rock-façades. The entrances to the tombs are often decorated with a gable like that of a Greek temple, supported on pillars in a primitive Dorian or Ionic style. The subjects most commonly represented in the sculptured reliefs are the native goddess Cybele. and pairs of rampant lions, heraldically opposed. Another characteristic ornament consists of a maeander pattern carved in flat relief. The native pottery is ornamented with geometric patterns in matt paint. In the relations of Phrygian art to that of other peoples the one clear point is that its technique of rock carving bears close resemblance to that of the Hittites, as exhibited at Boghaz Keui and in eastern Asia Minor, and was probably borrowed from this people. The maeander patterns. which are no doubt in imitation of tapestry work, also appear to have been derived from Hittite models. and it was perhaps through a Hittite medium that the heraldic lions and the Ionic pillars were introduced into Phrygia from Mesopotamia. The gables and the Doric columns of the Phrygian rock tombs are strongly reminiscent of archaic Greek art, and it is not unlikely that they are Greek in origin.

Phrygian music is only known to us from the descriptions of Greek critics. who considered it too florid and exciting.

The alphabetic script of the Phrygians bears a closer resemblance to archaic Greek than to Phoenician; but its exact relation to either of these has not yet been determined. The Phrygian tongue, which may best be studied in the texts (mostly epitaphs) of the early centuries A.D.. is akin to Armenian. In the period of Greek and Roman rule it gave way to Greek in the towns, but on the countryside it remained in use until the 5th or 6th century A.D. See Anatolian Languages.

Religion.—The religion of Phrygia was plainly a composite product. The Phrygian immigrants of c. 1200 B.C. brought with them several typical Indo-European gods, such as Papas, the equivalent of the Greek Zeus, and Men, a male moon deity. The god Sabazius, who was usually equated by ancient writers with the Thracian Dionysus, may be referred to the same group. But the gods of the Phrygian invaders were never able to displace the original Asianic deities, of whom the foremost were Cybele, the "Great Mother," and Attis. a youth who died untimely but in death retained his beauty of figure. This couple, which had several parallels in the religions of the near east, evidently repre-

sented the generative force of nature and the vegetation that withers and blooms with each new season. The worship of these deities was highly orgiastic, and their priests. the so-called "galli," carried their devotion to the point of self-mutilation. The principal sanctuary of Cybele stood at Pessinus, by Mt. Dindymus in central Phrygia. where a hierarchy of priests exercised theocratic rule over the inhabitants of the extensive temple estates. Not only did the cult of Cybele and Attis maintain itself against the religion of the Phrygian newcomers, but it partially absorbed them. It more than held its own against the religions of Greece and Rome, and it competed against these on European soil. The worship of Cybele spread to Greece in the 5th century B.C.; in 204 B.C. it was officially established at Rome; in the days of the Roman empire it was carried on the tide of oriental immigration into every part of Italy and penetrated the western provinces as far as the Rhineland and Britain. Thus the religion of Phrygia was its most distinctive contribution to ancient Mediterranean civilization. The influence of the native Asianic religion may also be traced in the various heresies, and especially the heresy of Montanus (himself a Phrygian), that arose in Phrygia after the spread of Christianity. Nevertheless the conversion of Phrygia to Christianity was remarkably early and complete. Christian inscriptions begin there in the 2nd century and are abundant in the 3rd. In all probability the mass of the people had been converted by 300, and Eusebius is no doubt correct in saying that in one Phrygian city at that time every soul was a Christian.

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PHRYNE, Greek courtesan, lived in the 4th century B.C. Her real name was Mnesarete, but because of her complexion she was called Phryne (toad). She was born at Thespiae in Boeotia, but seems to have lived at Athens. She acquired so much wealth that she offered to rebuild the walls of Thebes, on condition that the words "Destroyed by Alexander, restored by Phryne the courtesan," were inscribed upon them. On the occasion of a festival of Poseidon at Eleusis she laid aside her garments, let down her hair and stepped into the sea in the sight of the people, thus suggesting to the painter Apelles his great picture of Aphrodite Anadyomene. for which Phryne sat as model. She was also (according to some) the model for the statue of the Cnidian Aphrodite by Praxiteles. When accused of profaning the Eleusinian mysteries she was defended by the orator Hypereides. When it seemed as if the verdict would be unfavourable, he rent her robe and displayed her bosom, which so moved her judges that they acquitted her.

PHRYNICHUS. 1. Athenian tragic poet (fl. *c.* 500 B.C.), older contemporary of Aeschylus and the earliest tragedian of whose work some conception can be formed. His first victory was probably about 510 B.C., and according to the Suda lexicon he was the first to introduce the female mask, *i.e.,* women characters, into his plays. The extant fragments are too meagre to be revealing: the titles *Danaides* and *Aegyptii* indicate the same theme as an Aeschylean trilogy, and the *Alcestis* (whether tragedy or satyr-play is not clear) anticipates Euripides. After the fall of Miletus in 494 he produced the *Capture of Miletus,* which so harrowed Athenian feelings that he was fined 1,000 drachmae; in 476 his *Phoenissae,* in which news of the battle of Salamis comes to the Persian court, proved a more acceptable subject and won the first prize. Themistocles, archon in 493 and choregus in 476, may have been behind this venture into contemporary history instead of myth; except for Aeschylus' *Persae* in 472 the precedent was not followed up. Aristophanes in the *Wasps* and *Birds* recalls affectionately the honeyed sweetness of the old Phrynichan lyrics, which were still favourites in his day.

For fragments *see* A. Nauck (ed.), *Tragicorum Graecorum fragmenta,* "Teubner Series" (1926).

2. Athenian poet of the Old Comedy (fl. *c.* 420 B.C.), contemporary of Aristophanes. who began producing in 430 and won two victories. His most clearly recognizable subjects show an odd parallelism with Aristophanes: his *Monotropos* ("The Solitary"), who rejected contemporary civilization. was placed third when the *Birds* was second, in 414, and his *Muses,* second to the *Frogs* in 405, presided over a contest between Sophocles and Euripides.

For fragments *see* T. Kock (ed.). *Comicorum Atticorum fragmenta* (1880–88) and J. Demianczuk, *Supplementum comicum* (1913).

3. PHRYNICHUS ARABIUS. of Bithynia (2nd century A.D.). grammarian and rhetorician. whose chief works were *Sophistike Paraskeue ("A* Grounding in Sophistic"), of which a few fragments and a summary by Photius survive. and an *Attikistes,* extant in an abridged form, called the *Ekloge* ("Selected Atticisms"). He is critical not only of contemporary deviations from the best Old Attic usage but also of what he considers the lapses of his Attic models themselves. In spite of some mistaken pedantry his judgments are often acute and learned, and a useful commentary on the language of his own day.

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4. An Athenian general in the Peloponnesian War. He took a leading part in establishing the oligarchy of the Four Hundred at Athens in 411 B.C., and, according to Thucydides, was assassinated in the same year. (A. M. DE.)

PHTHALIC ANHYDRIDE AND PHTHALIC ACIDS. As would be expected, there are three dicarboxylic acids of benzene, the ortho, meta and para. In the case of the ortho isomer, water is easily lost at temperatures above 200° C. with the formation of phthalic anhydride, an extremely important chemical compound. Commercially. however, the anhydride is not made from the acid, but from naphthalene.

Phthalic **Anhydride.**—$C_6H_4(CO)_2O$, phthalic anhydride, is the starting material for the production of many chemical compounds of importance in the chemical and allied industries. It is a colourless solid, melting at 131.1° C. to a liquid which boils at 284° C. It sublimes at temperatures below the boiling point, the sublimed product taking the form of beautiful threadlike crystals which are flexible and have a silky lustre. On contact with water the anhydride is converted to the acid $C_6H_4(CO_2H)_2$, orthophthalic acid or orthobenzenedicarboxylic acid, known in commerce simply as phthalic acid. The term "phthalic" was derived from "naphthalene," for from this coal-tar derivative the anhydride and the parent acid were first prepared.

Phthalic anhydride mas first obtained by Auguste Laurent in 1836 by oxidizing tetrachloronaphthalene with nitric acid. It was made by this and other relatively costly methods until the discovery of a less expensive process based upon the oxidation of naphthalene with sulfuric acid (patented in 1896). The oxidation was effected with the aid of mercuric sulfate as a catalyst. The reaction, it is alleged, was discovered by chance when a thermometer in a hot mixture of naphthalene and sulfuric acid was accidentally broken. The process was applied on a huge scale in the manufacture of phthalic anhydride for use in the preparation of synthetic indigo. This process was superseded about 1917 by a more economical one in which naphthalene is oxidized with air, at temperatures from 350° C. to 450° C., in the presence of a vanadium oxide catalyst, a process discovered by H. D. Gibbs of the bureau of chemistry and soils: U.S. department of agriculture, and almost simultaneously in Germany.

When phthalic anhydride is treated with a dihydric or polyhydric alcohol a resinlike ester is formed. Esters of this nature, which belong to the class of alkyd resins and especially mixed esters made by treating phthalic anhydride and fatty acids with glycerin, are extensively used in industry, in paints, varnishes, lacquers, enamels and electrical insulating materials. The esters impart to the protective coatings the valuable property of adhering especially well to metallic surfaces.

Other esters of phthalic acid, made by treating phthalic anhydride with monohydric alcohols, are oily liquids boiling at high temperatures. The dimethyl, diethyl and dibutyl esters are used in large quantities in plastics and protective coatings as solvents and plasticizers of cellulose esters and synthetic resins. In addition. the dimethyl ester is used as an insect repellent, the diethyl ester as an ingredient of perfumes and the dibutyl ester as a retardant in smokeless gunpowders.

Phthalic acid, dissolved either in water or in phthalic anhydride,

at temperatures above 200° C., and in the presence of certain catalysts. breaks down into benzoic acid and carbon dioxide. These products are similarly formed when the vapour of phthalic anhydride mixed with steam is subjected to the action of suitable catalysts at high temperatures; *e.g.*, 450° C. These methods for decarboxylating phthalic acid are employed on a large scale in the manufacture of benzoic acid.

In the dye industry phthalic anhydride is used as such in the preparation of a number of dyes *(see* FLUORESCEIN) but a much more important use in that industry is in the synthesis of anthraquinone and its derivatives *(see* ANTHRAQUINONE). A minor use of phthalic anhydride is in the preparation of phenolphthalein *(see* PHENOLPHTHALEIS).

Simple derivatives of phthalic anhydride which are of some interest in chemical technology are tetrachlorophthalic anhydride, $C_6Cl_4(CO)_2O$; phthalyl chloride. $C_6H_4(COCl)_2$ or $C_6H_4(CCl_2)$-$(CO)O$; and phthalimide. $C_6H_4(CO)_2NH$, the latter being used in large quantities for the manufacture of anthranilic acid (o-aminobenzoic acid). whose methyl ester is much used for artificial grape flavouring.

The tremendous importance of phthalic anhydride in commerce is shown in the figures on its production and sales in the Cnited States as compiled by the U.S. Tariff commission:

Year	Production	Sales*	Value per lb.
1935	23,421,000 lb.	$ 17,932,000	$ .12
1945	125,825,000 "	85,829,000	.13
1955	331,351,000 "	271,366,000	.19

*Many producers of phthalic anhydride also consume it.

The above table illustrates clearly the principle found true in so many cases in the chemical industry — that when a product becomes cheap. many uses are found for it. In this connection it should be emphasized that the many esters of ortho phthalic acid are made, as mentioned above, from phthalic anhydride rather than the acid.

Phthalic Acids. — Ortho phthalic. of itself. is of no importance commercially. The same holds true for the meta acid, called isophthalic acid, which can be most readily prepared by the oxidation of m-xylene. It melts at temperatures above 300° C. and is sparingly soluble in cold water, but much more so in hot. It forms no anhydride. The para acid, well known as terephthalic acid. is prepared by the oxidation of p-xylene or caraway oil, the latter a mixture of cymene and cuminol. It can also be made from p-toluidine, as follows:

$$CH_3.C_6H_4.NH_2 \rightarrow CH_3.C_6H_4.CN \rightarrow CH_3.C_6H_4.COOH \rightarrow COOH.C_6H_4.COOH.$$

It sublimes without melting and is very sparingly soluble in water, alcohol and ether. It also forms no anhydride. Since 1950 this acid has become of considerable commercial importance, for its ethylene glycol ester is the important synthetic fibre Terylene or Dacron. Inasmuch, however, as it is made by only one or two industrial firms in the United States, figures on its production and value are not available. (G. C. C.; J. H. Ss.)

PHTHISIS, a Greek word meaning "wasting" or "consumption." formerly applied to tuberculosis (*q.v.*) from the wasting often ohserved. This wasting depends mainly upon secondary infection of tuberculous areas by pyogenetic micrococci and is accompanied by much fever and profuse sweating. Modern tendency is to use the term "phthisis" only when implying the existence of this double infection.

PHYFE, DUNCAN (*c.* 1768–1854), U.S. cabinetmaker who interpreted fashionable European styles in a manner distinguished by grace and excellent proportions. was born near Inverness. Scot. Duncan was brought to the United States by his mother in 1784. The Fife family settled in Albany. N.Y., where Duncan worked as an apprentice cabinetmaker and eventually opened his own shop. The new wealth of New York city drew him there in 1792. About 1793 he changed his name to Phyfe. In 1837 Phyfe took his two sons into partnership and the firm was listed by a contemporary directory as "Duncan Phyfe and Sons." In 1847 he sold his business and went into retirement. He was one of the first U.S. cabinetmakers to successfully use the factory method to manufacture furniture. Phyfe's first New York shop was located on Broad street. Subsequently he moved to Fulton street. west of Broadway, where in later years he employed over 100 carvers and cabinetmakers. He died on Aug. 16, 1854.

THE HENRY FRANCIS DU PONT WINTERTHUR MUSEUM WINTERTHUR DEL

MAHOGANY SIDE CHAIR WITH LYRE AND ACANTHUS LEAF USED AS DECORATIVE MOTIFS BY DUNCAN PHYFE, NEW YORK, 1810–15

Phyfe did not originate a new furniture style. About 1800 his workshop was executing delicate furniture in the Sheraton style; by 1825, as taste changed, his pieces became heavier and in the Empire style. The Sheraton chairs. tables and sofas often had delicate, reeded legs; and the Empire pieces. massive claw feet. His furniture was decorated with typical period ornaments — harps, lyres, acanthus leaves, bow knots and lion masks. The furniture, generally made of high-quality mahogany. was often executed in sets for fashionable New Yorkers. The popularity of Phyfe furniture came about after John Jacob Astor noted its excellent quality. In 1821 Phyfe was commissioned to make a box which was fitted with glass bottles containing water from the Erie canal which was sent to Lafayette as a souvenir of the opening of the canal. Interest in Phyfe's cabinetwork was revived in 1922 when the Metropolitan Museum of Art, New York, organized a comprehensive exhibition of his work.

See Charles *O.* Cornelius, *Furniture Masterpieces of Duncan Phyfe,* (1922); Nancy McClelland, *Duncan Phyfe and the English Regency, 1795–1830,* (1939). (J. T. BR.)

PHYLACTERY, a term applied in Matt. xxiii. 5 to the *tefillin* of the Jews on the assumption that these were amulets *phylacteria,* against physical evil. *Tefillin,* either from פָּצַל, to attach, or פָּלַל, whence תְּפִלָּה, prayer, are certain Pentateuchal texts which, in accordance with Exod. xii. 16 and Deut. vi. 5–9, were to be worn as constant reminders of God during the daily avocations. Hence they were not used on Sabbaths and festivals: as the day itself was a reminder and the schools and markets were closed. The idea of such an outward sign is common. The modern habit of wearing a cross on a watchchain may be compared. Romans had tablets for memoranda hanging from the wrists. Isaiah xlix. 16 evidently denotes this custom. Possibly the origin is to be sought in tattooing. Tefillin are worn on the hand and head, the verses being enclosed in leather boxes fixed in position by leather thongs. The hand phylactery has one compartment, in which the texts figure on one parchment, the head phylactery having four such compartments, each with one text. The extracts are Ex. xiii. 1–10:11–16; Deut. vi. 4–9, xi. 13–21.

BIBLIOGRAPHY.—For iurther details, illustrations and historical and critical views, see *Jewish Encyclopedin, s.v.* For the prayers and meditations, *see* S. Singer's *Authorized Daily Prayer Book,* pp. 19 *sqq.* For certain Jewish objections *see* A. Asher's *Collected Writings,* pp. 80–89 (1916, privately printed). Linked with *Tefillin* are the *Mezūzah* (door text) and *Çīçith* (fringes). The iormer is a text containing Deut. vi. 4–9 rolled in a glass or metal tube on the right-hand of each door, so that everyone who enters or leaves shall think of God (see *Jew. Enc. s.v.* Singer, *op. cit.,* p. 292). The latter (see *Jew. Enc. s.v.* Fringes) is based on Numbers xv. 37–41, which ordains the knotted tassel as a mnemonic.

PHYLLITE, in petrology, **a** group of rocks which are in practically all cases metamorphosed clayey sediments, consisting essentially of quartz. chlorite and muscovite. and possessing a well-marked parallel arrangement or schistosity. The name is from the Greek *phyllon,* a leaf, probably because the rocks yield leaflike plates. They form an intermediate group in the series of altered clays or shaly deposits between clay slates and mica schists (*q.v.*). The clay slates have a similar mineral constitution to the phyllites, but are finer grained and are distinguished also by a much better

cleavage; in the phyllites white mica (muscovite or sericite) is more abundant as a rule than in slate, and its crystalline plates are larger; the abundance of mica gives these rocks a glossy sheen on the smooth cleavage planes. The foliation is generally flat or linear, but in some rocks is undulose or crumpled. From the imperfection of their cleavage phyllites are rarely suitable for roofing materials; their softness renders them valueless as road stones, but they are not uncommonly employed as inferior building materials. 'They are exceedingly common in all parts of the world where metamorphic rocks occur, as in the Scottish Highlands, Cornwall in England. Anglesey in Wales, northwest Ireland, the Ardennes. the Harz mountains, Saxony, the Alps, Norway, the Appalachians, the Great Lakes region in the United States, etc.

A microscopical section of a typical phyllite shows green chlorite and colourless mica, both in irregular plates disposed in parallel order. uith a greater or smaller amount of quartz which forms small lenticular grains elongated parallel to the foliation. Grains of iron oxide (magnetite and hematite) and black graphitic dust are commonly present. Feldspar generally is absent or scarce, but some phyllites are characterized by the development of small rounded grains of a plagioclase feldspar, albite, often in considerable numbers. The minute needles of rutile, so often seen in clay slates, are not often met uith in phyllites, but this mineral forms small prisms which may be intergrown with black magnetite; at other times it occurs as networks of sagenite. Other phyllites contain carbonates (usually calcite but sometimes dolomite) in flat or spindle-shaped crystals. which often give evidence of crushing. Tiny blue needles of tourmaline are by no means rare in phyllites, though easily overlooked. Garnet occurs sometimes. a good example of the garnetiferous phyllite being furnished by the whetstones of the Xrdennes, in which there are many small isotropic crystals of manganesian garnet. Hornblende, often in branching feathery crystals, is a less frequent accessory. In some phyllites a mineral of the chloritoid group makes its appearance; this may be ottrelite, sismondine or other varieties of chloritoid, and occurs in large sub-hexagonal plates showing complex twinning, and lying across the foliation planes of the rock. The structural variations presented are comparatively few. The most finely crystalline specimens have generally the most perfect parallel arrangement of their constituents. (J. S. F.; X.)

PHYLLOXERA, a genus of insects belonging to the group Phylloxerinae of the family *Aphididae* which comprises the aphides (*q.v.*) or plant lice. The Phylloxerinae are sometimes placed in a separate family of their own, since they differ from true aphides in characters exhibited in the wing-veins. and also in the fact that the parthenogenetic forms lay eggs instead of producing living young. The genus *Phylloxera* includes over 30 species, the best known being the grape Phylloxera (*P. vastatrix*), which is native to the United States. It was imported into Europe between 1858 and 1863, when American vines were brought over for grafting purposes. and has since reached almost every vine-growing country in the world. It was first discovered in California in 1880, being introduced along with American vines from east of the Rocky Mountains. It mas the advent of the highly susceptible European grape that led to the Phylloxera becoming a pest in the California vineyards. The presence of this insect is manifested by the vines being stunted and bearing smaller and fewer leaves. When the disease is advanced the leaves are discoloured and galls are present on their under surface. These galls are wrinkled and hairy and their cavity communicates by means of an opening upon the upper surface of the leaf. If the roots be examined, numerous knotty swellings are found upon the smaller rootlets; at first yellowish in colour and fleshy, they finally assume a brown or black colour and become rotten. At the same time the grapes themselves are arrested in their growth and their skins become wrinkled. The damage wrought by the Phylloxera is occasioned by the extraction of the sap by means of the piercing suctorial mouth-parts of this insect, and the subsequent deformation of the plant that is brought about. Millions of acres of vineyards have been destroyed by this pest.

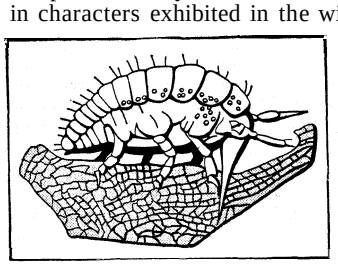

FIG. I.— ROOT INHABITING FORM OF THE PHYLLOXERA. WITH ITS PROBOSCIS INSERTED INTO TISSUE OF ROOT OF VINE

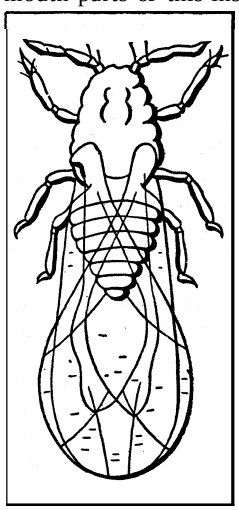

FIG. 2.—WINGED MIGRANT FEMALE

Hatched from the egg of the root Phylloxera, this form flies to other vines where it lays parthenogenetically, eggs of two kinds, male and female

The complete life-history of Phylloxera is briefly as follows: A single egg is laid by the fertilized female on the bark of the vine where it passes the winter. It hatches in spring into a wingless female or *fundatrix* which, creeping into an opening bud of the vine, forms a gall on the young leaf and lays therein a number of eggs. The latter develop into further wingless forms or *gallicolae* which multiply rapidly and produce new generations of gall-formers on the leaves. Among their progeny there appear, later in the season, wingless females of different behaviour, the *radicolae* (fig. 1), which pass to the roots. The *radicolae* continue reproducing generations of their own kind, but among them winged migrants (fig. 2) eventually appear. These occur from July until October and fly to other vines where they lay two kinds of eggs—small male-producing eggs and large female-producing eggs. The true sexual forms derived from these eggs (fig. 3) are small wingless individuals with vestigial mouth-parts and an aborted alimentary canal. Fertilization takes place and each fertilized female deposits a single over-wintering egg which hatches into a fundatrix as already described. All the rest of the reproduction of the species is by parthenogenesis (*q.v.*).

It is noteworthy that in Europe and California the fundatrices usually fail to develop in the absence of certain American vines and the gallicolae generations are consequently rare. Reproduction and spread are brought about by the radicolae, many of which hibernate and continue multiplying in spring.

Many control measures have been suggested against the Phylloxera but few have been generally adopted in practice. The enforcement of quarantine regulations precluding the distribution of rooted vines from infested areas is important. The utilization of vine-stocks less susceptible to the root-feeding form of the insect is generally recognized. Varieties of American grapes. such as *Vitis riparia, V. rupestris, V. berlandieri* and their hybrids, are not seriously injured by the radicolae, and by growing these varieties, or using them as stocks upon which the susceptible European varieties have been grafted, injuries by the pest have been greatly reduced. In certain cases the injection of carbon bisulphide into the soil to kill the root form of the insect has been profitable. The flooding of infested vineyards has been a recog-

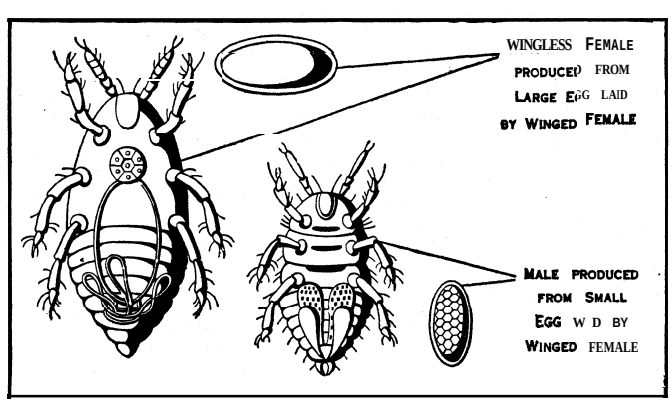

FIG. 3.— MALE AND FEMALE FROM EGGS LAID BY WINGED MIGRANT FEMALE

The female dies after laying a single egg which hatches out in the spring as a female insect known as a fundatrix. This form produces eggs from which are hatched gallicolae. Some of these remain in the buds while others descend to the roots as radicolae

nized procedure where conditions are favourable.

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PHYSICAL EDUCATION. While physical education is one of the later subjects in curricula, it is also one of the oldest forms of education. Primitive people and prehistoric man used it to train their young people for various purposes according to their culture and the period in which they lived. Rhythms and dancing are among the oldest of activities; since ancient times they have been used in religious rituals and for recreational purposes. The hunt and the chase were also important phases in the education of youths. They served to develop the body, mold the character and discipline the mind.

Greece.— The Greeks were a highly civilized, reflective and beauty-loving people whose aim in education was to develop citizens both physically and mentally. Gymnastics were considered a necessary part of education. In Sparta and Athens the training of youths aged 7 through 18 consisted primarily of games, sports, rhythms. music and military training. Sparta trained the warrior-citizen to take his place in the military state. Athens gave its youths a broader training including intellectual and aesthetic foundations for citizenship. Plato advocated music and gymnastics for the education of youths until the 18th year. Aristotle recommended little or no intellectual training before the 14th year with emphasis on play. physical activities, stories and morals. The states took over the children at the seventh year and trained them in establishments state supported and state administered. The states held great national festivals such as the one at Olympia. nhere winners were crowned with the sacred wild olive wreath, which was one of the highest Greek honours. Two hundred and ninety-three consecutive Olympiads were held before they were abolished in A.D. 394. They were re-established as the Olympic games (*q.v.*) in Athens in 1896.

Rome.— The Romans' aim in education was to develop the good citizen skilled in oratory; they lacked the intense love of physical competition. Although Quintilian stressed the value of physical activity for the graceful use of the body, the Romans were not interested in physical education except as it contributed to military training

Middle Ages and Renaissance.— During the 6th–13th centuries, physical education was at a low ebb. There was little of it, except for the sport training involved in preparing for knighthood and tournaments.

Physical education slowly came back into education under the leadership of Vittorino da Feltre (1378–1446), the Italian schoolmaster who combined physical and mental training; Martin Luther (1483–1546) of Germany, who emphasized the recreative and moral value of bodily exercise; Michel de Montaigne; Richard Mulcaster (1530–1611); John Milton; and Johann Amos Comcnius (1592–1670) of Czechoslovakia, who recommended a half hour of recreation for each hour of study.

18th–20th Centuries.— The prominent European leaders in physical education during those centuries were Johann Bernhard Basedow (1723–90), originator of modern physical education in German schools, where five hours a day were allotted to studies, three hours to recreation and two hours to manual labour; Christian Gotthili Salzmann (1744–1811), who used free exercises in his school; Johann Christoph Friedrich Guts-Muths (1759–1839), who wrote books on gymnastics and games; Friedrich Ludwig Jahn (1778–1853), originator of popular gymnastics for all people and the creator of the Turner societies; and Adolf Spiess (1810–58), who taught at Friedrich Froebel's school in Switzerland and latcr became known as the father of school gymnastics in Germany. Konrad Koch (1846–1911), August Hermann (1835–1906) and Emil Theodor Gustav von Schenchendorff (1837–1915) were leaders in the playground movement.

In the Scandinavian countries Per Henrik Ling (1776–1839) introduced physical education into Sweden. His son Hjalmar Fredrick Ling (1820–86) carried on his work. In Denmark Franz Nachtegall (1777–1837) and, a century latcr, Niels Bukh pioneered physical educalion. Denmark was the first modern nation to make physical education a requirement in schools.

The backbone of the physical education program in England was consistently a wide variety of sports and organized games. Archibald Maclaren (1820–84) mas the foremost English leader. He also worked out the physical education system for the British army.

Physical education systems in Europe were chiefly: (1) the Turn-*verein,* or popular gymnastic societies, of Germany; (2) the school gymnastics of Sweden and Germany; (3) England's sports program with its emphasis on play and recreation. German and Swedish systems developed in response to political, social and military needs. Physical education was always closely allied with military training.

In the United States, school programs in physical education began first in the colleges, then in the high schools and finally in the elementary schools. Early leaders in physical education in the United States were the German refugees Charles Follen (1796–1840), Charles Beck (1798–1866) and Francis Lieber (1800–72), who introduced the German gymnastic system in 1824. George Brosius (1839–1920) at Milwaukee, Wis., Carl Betz (1854–98) at Kansas City, Mo., and Emil Rath at Indianapolis, Ind., were pioneers in German-American gymnastic societies.

Swedish school gymnastics were introduced, among others, by Baron Nils Posse (1862–95) at Boston, Mass.; Edward Mussey Hartwell (1850–1922) also at Boston; Hartwig Nissen (1855–1924) at Washington, D.C.; Jakob Bolin (1863–1914) at the University of Utah, Salt Lake City, and New York; and William Skarstrom (1869–1951) at New York, Boston, Columbia university and Wellesley college, Wellesley, Mass.

Dio Lewis (1823–86) and his "new gymnastics for all" included calisthenics, dumbbells, wands and Indian club drill, all set to music. He established the first teacher-training school in Boston in 1861. Important college and university leaders were Edward Hitchcock (1828–1911), who taught 50 years at Amherst college, Amherst, Mass.; Dudley Allen Sargent (1849–1924) at Hemenway gymnasium, Harvard university; William Gilbert Anderson (b. 1860) and Ernst Herman Arnold (1865–1929) at Yale; Amy Morris Homans at Wellesley college; and Robert Tait McKenzie (1867–1938) at the University of Pennsylvania, Philadelphia.

Joseph Lee, Howard Braucher, George Johnson and Clark Hetherington were leaders in the playground movement. Lee served as president of the National Recreation association for 27 years. Robert Jeffries Roberts (1849–1920) at Boston and Luther Halsey Gulick (1865–1918) and James Huff McCurdy (1866–1940) at Springfield, Mass., were leaders in the Y.M.C.A. movement and in the Y.M.C.A. training school at Springfield.

Programs of physical education in the United States retained some good features of German and Swedish gymnastics. Their total systems, however, were never satisfactory for they did not meet American ceeds. The English influence was stronger, since England's culture and social philosophy more nearly resemble that of the United States. The U.S. program is mainly a natural play and sports activity program directed toward the all-round development of the individual.

PHYSICAL EDUCATION IN U.S. SCHOOLS

Physical education in U.S. schools may be considered in three phases: instructional, intramural and interscholastic athletic.

Instructional Programs.— In good schools instruction in physical education is provided for all students. Class periods are devoted primarily to helping students develop skills, power, efficiency, endurance and conditioning, and attitudes and understandings that lead to total well-being. For students who have temporary or permanent disabilities and cannot participate in the regular program, adaptations according to need are usually made. These modifications range all the way from limited participation in the regular program to remedial programs planned in conference with the student's physician.

Elementary school students, grades 1 through 6, should participate daily in a program of directed physical education activities. These should be varied in nature, graded according to levels of maturation and progressing from simple to complex. They should include opportunities to experiment with movement, to throw, catch, climb and hang and opportunities for learning experiences in dance, games, sports, relays, stunts, tumbling and apparatus work, also hiking, cycling and other outdoor activities and, wherever feasible, water sports and winter activities.

The daily instructional period should be at least 30 minutes in length. In addition, there should be periods of free and supervised play, and integration of physical education activities with other phases of the curriculum. It must be kept in mind that children who are in normal physical condition need four to five hours of vigorous activity each day, and that good programs should be geared to their needs, interests and capacities.

Classes in physical education should be of a size to permit afficient instruction. Twenty-five to 40 students per period constitute a desirable range in teaching load.

Junior and senior high school students should participate in daily programs of directed physical education with broad and varied content. They should include a variety of games, skills and techniques of team games such as football, basketball, baseball, softball, soccer, speedball, volleyball and field hockey; track and field; many individual and dual sports such as horseshoes, paddle tennis, table tennis, archery, golf, handball, bowling, badminton; simple comhatives and wrestling; stunts, tumbling, pyramid building, gymnastic drills and apparatus work; rhythmic activities, including folk, tap, square, social and modern dance; hiking, camping. cycling and other activities related to nature and the. outdoors; and, where possible, water sports and winter activities. A number of these activities should be taught and conducted

on a coeducational basis. The minimum time allotment for class instruction and activity should be the equivalent of the school's regular academic periods.

College programs should also provide activities suited to the student's capacities, interests and needs.. Greater emphasis is placed on body mechanics, relaxation skills, individual and dual sports and developing a high degree of competency in one or two sports in college programs than is placed in those of secondary schools. Attempts should be made to develop lifelong interests in satisfying leisure activities.

Intramural Programs. — These are an outgrowth of the instructional program of the elementary school, junior and senior high school and college. The intramural and instructional programs should motivate each other. The intramural phase provides competition in games and sports which have been taught in the required class. They are voluntary programs in which all students are invited to participate during noon hours, regular school periods set aside for intramural purposes or after school hours. In certain activities suitable for boys and girls, co-educational events are planned. Intramural programs offer opportunities for the development of student leadership.

Interscholastic Athletic Program. — Designed to provide suitable competition in individual and team contests for the more highly skilled athletes, interscholastic athletics originated at the demand of the students. Although it is the most highly publicized phase of the total program of physical education, it should be, together with the intramural program, merely the laboratory aspect of the instructional program, in which moderately and highly skilled competitors may gain the benefits of competitive experience in sports. Because of the great public interest and frequent overemphasis on winning teams, athletic programs require careful administration and close supervision for desirable results. The health and general welfare of the participants should be the prime consideration, and for this strong leadership is essential.

Highly organized competitive athletic leagues are not desirable for children and youths of elementary and junior high school age grades one through eight. Physical education in elementary and junior high schools should stress a well-rounded program of instruction for all children and—for as many as possible—an interesting and widely varied program of intramural competition in team, dual and individual sports, supplemented by sports days and play days. In schools where intramural competition is not possible, sports days and play days should be given particular emphasis.

All girls' athletic activities should be taught and coached by trained women leaders, and refereed by competent, certified officials. They should be separated entirely from any interscholastic athletic contests for boys. Organized interschool competition for girls should be confined largely to invitational events, chiefly in the form of sports days and play days, involving mass participation.

Coaches should he regular members of the faculty and duly certified; they should have adequate professional preparation for teaching and coaching, and be trained in the science of conditioning boys for athletic events.

Adequate medical examinations, including chest X-ray, should be provided for all athletes at the beginning of, and as needed during, each year of participation, together with-medical service at all contests Eligibility requirements should be set up and rigidly enforced. Competition between teams of comparable ability should be determined by age, height and weight classification standards, and contests scheduled which will not overtax the physical capacities of immature individuals. The playing seasons should be held to a moderate length of time, frequency of practice sessions limited and the number of contests kept within reason.

See also GYMNASIUM; GYMNASTICS; TRACK ASD FIELD SPORTS; etc.

(E. I. JE.; C. A TR.)

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(A. PN.)

PHYSICAL THERAPY (PHYSIOTHERAPY or KINÉSITHÉRAPIE), the treatment of bodily ailment by the application of physical agents such as heat and exercise. is a specialized medical service aimed at the rehabilitation of persons disabled by pain or ailments affecting the motor functions of the body. Physical therapy is one means employed to assist these patients to return to a comfortable and productive life. often despite the persistence of a medical problem. For centuries man used such natural physical agents as hot springs and sunlight to treat his ailments, but the development of physical therapy as a specialized medical service took place largely after World War I. Two forces influenced its growth, epidemic poliomyelitis and the world wars, both of which created large numbers of young, seriously handicapped persons. Physical therapy then became available for the treatment of patients with such diverse problems as fractures, burns, tuberculosis, painful backs, strokes and nerve injuries. Physical therapy is closely associated with orthopedic surgery (*q.v.*), but it is also prescribed by physicians and surgeons in all branches of medicine. A group of physicians also specializes in physical medicine.

The objectives of physical therapy may be summarized as follows: relief of pain; improvement or maintenance of functions such as strength and mobility; training in the most effective method of performing essential activities; and testing of function in various areas. Tests cover such fields as muscle strength, degree of joint mobility, breathing capacity and muscular co-ordination.

Types of Treatment. — Themethods most commonly employed by the physical therapist include heat, massage, exercise, electrical currents and functional training.

Heat. — Heat is used generally for its effect in stimulating circulation and relieving pain in the area treated. It may be applied by infrared lamps, short-wave or diathermy, hot moist compresses or immersion in hot water, application of melted paraffin wax or by ultrasound.

Massage. — This is used primarily to assist circulation and relieve local pain or muscle spasm. It is usually applied by the therapist's hands alone, although swirling water or mechanical devices may be employed. Of the many massage strokes, the most commonly used are stroking and kneading of the tissues. The lubricant applied to the skin usually is a neutral substance such as talcum powder or mineral oil. *See* also MASSAGE.

Exercise. — Exercise. the most varied and widely used of all physical treatments, is usually designed to do one or more of three things: increase the amount of motion in a joint, increase the strength in a muscle or train a muscle to contract and relax in useful co-ordination with other muscles under the control of the patient. Exercises may be simple or complex, performed actively by the patient or passively with the therapist carrying the part through the motion. Such passive motion may be useful in improving mobility in a joint, but strengthening or training of a muscle can be accomplished only through its active contraction by the patient. Various exercise equipment is used; and treatment may be given with the patient immersed in warm water. While a patient is still confined to bed after illness or injury, exercises may be begun to prevent stiffness or weakness from developing. As he improves, the exercises become more complex and strenuous, until the damaged parts are again capable of meeting the demands of daily activity. In addition to its obvious use following stiffness or paralysis, exercise may be used to improve the breathing of patients with lung disorders, assist circulation, relax overly tense muscles, correct faulty posture, etc.

Electrical *Currents.*—Currents of very low strength may be applied through the skin to superficial muscles, causing them to contract spontaneously. This may be used to help train weakened muscles and also to test the status of nerves supplying those muscles. Electrical currents are applied to assist the penetration of the skin by certain medicines, and for numerous other purposes.

Functional Training — This teaches the patient how, in spite of a handicapping ailment, to carry out most safely and effectively the activities of his daily life. This may mean learning to use crutches. a brace or an artificial arm; or it may involve working out and practising the best way for a mother to do her housework with one hand or for a workman to board the factory bus with a stiff leg. Such training often requires long hours of practice; it may be facilitated by the use of assistive devices which make it easier to fasten buttons. hold a fork or dial a telephone.

Others. — Other treatments such as ultraviolet radiation and cold applications are also often used. Therapeutic use of X-rays is considered a separate specialty and not a physical therapy procedure. See RADIOLOGY.

Training of Physical Therapists. — Treatment usually is administered by a therapist rather than by the physician. The qualified therapist, however, can give only that treatment specifically prescribed by the physician. Training to prepare for this work includes courses in three fields: (1) a broad background in science, particularly anatomy, physiology and psychology; (2)

courses dealing nith the processes of disease and healing. such as medicine. orthopedics, pathology and neurology; and (3) treatment techniques. A period of internship under supervision also is required. Most physical therapy trainees are between the ages of 17 and 30, and the majority are xomen. In the U.S., training varies from a postgraduate professional certification course of 12 to 18 months to a four-year undergraduate program providing both professional certification and a college degree. Postgraduate students may be basically prepared through obtaining a university degree in sciences or through training as nurse, physical education instructor, etc.

Standards for training and practice vary somewhat from one country to another, but within each country they usually are set and maintained by a national professional organization. In the United States the American Physical Therapy association and in Great Britain the Chartered Society for Physiotherapy have done much to advance the standards of their members. In 1951 the World Confederation for Physical Therapy was inaugurated, and by 1958 the national associations of 15 countries were recognized as members: agreeing on basic standards and working for the advancement of the profession.

Physical therapy services developed most rapidly in those countries which first solved major problems of infectious disease and malnutrition. At mid-20th century. in some areas of the world, it a-as still nearly nonexistent; it was most widely developed in the Scandinavian countries, Great Britain and the commonwealth. and in the U.S. Physical therapists are usually employed in hospitals, but many also work in schools for crippled children, physicians' offices; factory health units and patients' homes.

See also REHABILITATION. MEDICAL AND VOCATIONAL.

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PHYSICAL UNITS. A civilization so primitive that men had not yet learned to barter food and clothing is difficult to imagine. The moment. however, that such an exchange of goods begins, the questions "How much?" and "How many?" arise; and before either of these queries can be answered, physical units of some kind. be they ever so crude, must be agreed upon. In the Book of Genesis (xxiii. 16) "Abraham weighed out for Ephron the silver which he had named"—the price of Sarah's tomb. From the dawn of civilization man employed the rotating earth to divide the steady flow of time into units which he came to call true solar days; and these were early refined by the astronomer into mean solar days. Natural units of length, such as the foot. have doubtless been in use ever since man began to walk in an upright position. Thus early in human history these three measurements of mass, time, and length were considered to be fundamental. Corresponding standards of mass. length and volume were preserved in the temples and other public buildings of antiquity for the purpose of stabilizing the measures employed in trade. Yet among these standards—these bases of comparison—there existed throughout the nations of Europe up to the beginning of the 19th century the utmost diversity of size and name.

In the 17th century when the great national academies sprang up and their members were exchanging opinions through a voluminous correspondence, there frequently occurred a diversity of results which could be harmonized only through a comparison of units. Among English-speaking nations the use of the foot. pound and second for commercial purposes has been universal. On the continent of Europe. however, the unit of time has been the only common standard. It was. indeed, only in the last decade of the 18th century that any serious action was taken to ease trade and facilitate exchanges by coming to an international agreement concerning units.

Invention of the Metric System.—The initiative was taken by the National Assembly of France in 1791 when it appointed a commission of 12 outstanding men of science to revise the French system of weights and measures. These men made this revision in a manner which was at once so simple, so clear and so natural that it later won acceptance by many other nations. The chief concern of this commission was of course the two units of length and mass, since the third fundamental unit, time, had been provided for by the astronomers who, in their observations and tables, were using 1/86,400 of a mean solar day as the second of time.

For the unit of length the National Assembly adopted a decimal fraction of the earth's meridian. Eight years were then employed by the geodesists in an accurate determination of the arc from Dunkirk to Barcelona. On Dec. 10, 1799, the French Legislative Assembly voted to define their standard of length—to be called the metre—as the 10^{-7} part of the earth's quadrant.

On the same day the mass of a cubic decimetre of water, at its maximum density, was chosen as the standard of mass and was named the kilogram.

One might expect that such a clear and simple system would obtain ready adoption among the nations of western Europe and America. France made the use of these units compulsory, beginning with the year 1801; but the conservatism of the merchants, who had been selling cloth by the ell. and of the farmers, who sold meat and vegetables by the livre, was too strong to be affected by the law of 1801. The result was that in 1837 a more stringent law was passed penalizing the users of any units except the metre and the kilogram after Jan. 1, 1840.

Up to this time (1840) only two nations besides France had adopted the metric system. These were Greece and the Netherlands. England authorized its use in 1864. the United States in 1866 and Germany in 1868. Since then the metric system has been legalized by all the leading nations of the world. In Europe and South America its use is almost exclusive. *See* also WEIGHTS AND MEASURES.

Creation of the International Bureau of Weights and Measures.—In 1875 each of 20 different nations accepted the invitation of France to send two delegates to a *conférence diplomatique du mètre* at Paris. A proposal to establish an international standardizing bureau had been discussed by an earlier international convention held in 1872; and this conference of 1872, before its adjournment, had practically created such a bureau. had outlined its duties as the custody and comparison of standards and had even made financial provision for the work. All of these plans were later ratified by the national governments concerned. The International Bureau of Weights and Measures was, therefore, by 1875, a *fait accompli;* and has ever since remained, in its pavilion near Sèvres, not only a safe depository for the international standards but also a laboratory for the certification of copies and the solving of related problems. As early as 1867 metrologists had already begun to suspect that the original standard metre, known as the *mètre des archives,* might not be very permanent since it was an end measure and therefore subject to slight abrasion in use. The choice of the proper material and the preparation from it of a new bar upon which the metre could be duplicated in line measure thus became one of the first problems which fell to the international committee.

Abandonment of Natural for Arbitrary Standards.—When, by the autumn of 1889, this committee had completed the new platinum-iridium bar for the metre and a platinum-iridium cylinder for the kilogram, it deposited these two prototypes in the underground vault at the International bureau and immediately proceeded to change the definitions of these two units from natural to purely arbitrary quantities. Without any reference to a quadrant of the earth's meridian, the following resolution was passed concerning the polished Pt-Ir bar, upon which two fine rulings had been selected as marking the standard of length: "This prototype. at the temperature of melting ice, shall henceforth represent the metric unit of length." Similar action, without any reference to a cubic decimetre of water. was taken with regard to the new kilogram: "This prototype will henceforth be considered to be the unit of mass." The fact that standards of length and weight can be copied with much greater accuracy

than they can be determined afresh from some natural unit thus decided the question forever in favour of the arbitrary standard.

When the kilogram was first defined as the mass of a cubic decimetre of water at the temperature of its maximum density. the unit of density was taken to be that of water at this same temperature. The litre was defined as the volume of a cubic decimetre; and was therefore taken to be identical with the volume of a kilogram of water.

During the first half of the 19th century, however. precision of measurements increased to such an extent that a distinct difference was detected between 1,000 c.c. and the volume of a kilogram of water. Accordingly in 1901, the following definition was formulated:

> The unit of volume, for determinations of higher precision, is the volume occupied by the mass of one kilogram of pure water at its maximum density and under normal atmospheric pressure; this volume is called the *litre*.

The relation between the litre and the cubic decimetre now became a matter of experimental determination. The accepted value is 1 litre = $1{,}000.028 \pm 0.002$ cm.^{3}

The practice recommended by the bureau of standards and the National Physical laboratory is to graduate standard volumetric glassware in millilitres — marked "ml." instead of "c.c." Where the volume is derived from geometrical dimensions. the appropriate unit is "cm.^{3}"

Introduction of Electrical Standards. — In the early years of the 19th century there had grown up a ne science of electricity and magnetism. whose phenomena exhibited themselves mainly by mechanical effects. In the industrial field units of power, work and energy had been introduced in a somewhat haphazard manner. Superposed upon these were certain electrical measurements. The earliest introduction of order into this chaos of units came in the three following steps, taken by men who had the vision to see that magnetic and electrical effects must be measured in terms of mechanical quantities.

1. The first advance was made by the astronomer. K. F. Gauss, in 1833. when he published from Gottingen his great paper "On the Intensity of the Earth's Magnetic Field, Expressed in Absolute Measure." Here, by two simple quantitative experiments. he measured the strength of the earth's magnetic field, H, in terms of length, mass and time, much after the manner of using the pendulum to measure the earth's gravitational field.

2. The second step was to determine in absolute measure, *i.e.*, in fundamental units. the force which produces electric currents, the force which Volta (1745–1827) called "electromotive" and which is generally denoted by e.m.f. This step was accomplished by F. E. Neumann (1798–1895) in 1845 when he formulated Faraday's great discovery of 1.831 in the following expression, $E = -dN/dt$, where E is the e.m.f. generated in a closed circuit, through which the number of magnetic lines of force is changing at the rate of dN/dt. Electromotive force is thus reduced to mechanical measure.

3. The third step was taken in 1851 by W. E. Weber (1804–91), who used Neumann's idea and C. S. M. Pouillet's tangent galvanometer to measure an induced current in absolute units. Having thus measured both e.m.f. and current, for one and the same circuit; he was able, by use of Ohm's law, to compute the electrical resistance of the circuit in absolute measure. Simpler and more accurate methods were later devised by Lorenz, Rosa and others (see Bibliography).

As early as 1851, Helmholtz and Kelvin had introduced the idea of electrical work and had explained the meaning of the equation: work = power × time = $Eit = i^2Rt$, which is the connecting link between electrical and mechanical quantities.

Coefficients of self- and mutual-induction had also been defined; and their values, in certain cases, had been computed from the mechanical dimensions of the system. Yet great confusion existed because various observers. using the same fundamental quantities, had employed different units. All was arbitrary. Nothing was coherent save the underlying principles of physics. Computation was tedious because of needless conversion factors.

Unit of Resistance. — At this stage the problem was taken up by the British Association for the Advancement of Science when, at the Manchester meeting in 1861, it acted upon the advice of two eminent telegraph engineers (Latimer Clark and Charles Bright) and appointed a committee on electrical standards of resistance. By 1869 this committee had established the essential theory of units (*i.e.*, the principles which must control any consistent and useful system), had recommended as fundamental units the metre, gram and second, and had prepared a wire standard (known as the "B.A. unit") which was as nearly as then possible equal to 10^7 m.g.s. units of resistance.

A second B.A. committee, appointed in 1872, recommended, in its annual report, a change to the centimetre-gram-second system and also the adoption of the name ohm for a unit of resistance which should be. as nearly as realizable. equal to 10^9 c.g.s. absolute units. Both of these recommendations were adopted by the first International Congress of Electricians meeting in Paris in 1881.

Unit of Electromotive Force. — Beginning with the year of its invention, 1800, a single voltaic cell has been steadily used as the unit of e.m.f. First came the Daniell cell; then the Bunsen; later the Ciark; but now the cadmium cell of Edward Weston is universally employed. Compared with any one of these cells, the c.g.s. unit of e.m.f., defined by Neumann's formula. is almost infinitesimal. Accordingly a practical unit of 10^8 c.g.s. units, bearing the name volt, was approved both by the British association and by the International Congress of Electricians in 1881.

The *Absolute Practical System of Units.* — In this terminology the word absolute signifies that the unit (volt, ohm. etc.) is defined in terms of the c.g.s mechanical unit by a numerically simple relationship; and the word practical signifies that the magnitude of the unit, except for the unit of capacitance, is of a size convenient to use in practical engineering work. Besides the ohm and volt. three other practical units were established, at this same congress, by the following resolutions:

> That the current produced by a volt in the ohm be called an ampere.
> That the quantity of electricity produced by a current of one ampere in one second be called a coulonzb.
> That the unit of capacity be called a farad, which is defined by the condition that a coulomb in a farad raises the potential one volt.

The second International Congress of Electricians, meeting at Paris in 1889, defined three more practical units as follows:

> The joule, the practical unit of energy is equal to 10^7 c.g.s. units. It is equal to the energy disengaged as heat in one second by a current of one ampere flowing through a resistance of one ohm.
> The practical unit of power is the watt. The watt is equal to 10^7 c.g.s. units and is the power of one joule per second.
> The practical unit of self-inductance is the quadrant which is equal to 10^9 c.g.s. units.

With these eight practical units already agreed upon, the subject came before the fourth International congress held at Chicago in 1893. There the name of the unit of inductance was changed from quadrant to henry, and the international system of units was set up.

For conversion factors for units of energy see CALORIMETRY: Table II.

The International System of Electrical Units. — Since the practical units were defined in terms of the c.g.s. electromagnetic units: there arose a need for a system of units to be used in electrical measurements. Such a system was called the International System of Units; its units were made as close as possible to the corresponding units in the absolute practical system. At the Chicago congress the international ohm was defined as "the resistance of a column of mercury of uniform cross-section, having a length of 106.300 cm and a mass of 14.4521 gm when the temperature is 0° C." The international ohm thus defined represented the best experimental result of that time (1893) in realizing a resistance of 10^9 c.g.s. units or one absolute practical ohm. It was larger than the B.A. ohm in the ratio of 1 to 0.9866. The congress at Chicago also defined the international ampere as that "unvarying current, which, when passed through a solution of nitrate of silver in water in accordance with standard specifications: deposits silver at the rate of 0.001118 grams per second." This was made as close as

possible to the absolute practical ampere which is 0.1 of the c.g.s. unit of current.

A third unit, the international volt, was so defined that a Clark cell at 15° C. had an e.m.f. of 1.434 international volts. This international volt was as close as possible to 10^8 c.g.s. units of potential difference. that is, an absolute practical volt.

As more and more units and standards were established a need was felt for standardizing laboratories in the various industrialized nations. Thus were established the German Physikalisch-Technische Reichsanstalt in 1887, the English National Physical laboratory in 1899 and the United States national bureau of standards in 1901. These laboratories carried on very careful measurements on the various standards.

From their work it became apparent that the recommendations at the Chicago congress were not consistent with the definition that the international volt is "the electromotive force that, steadily applied to a conductor whose resistance is 1 international ohm, will produce a current of 1 international ampere." This situation was corrected at the London International conference in 1908 by keeping the international ohm and ampere as primary units and letting the international volt be a derived unit.

The International Committee on Weights and Measures announced that after Jan. 1, 1948, the international units should become obsolete and that the absolute practical units. ampere, ohm, etc.. were to be measured in terms of forces and other mechanical units. The recommendations of this committee included the use of the metre, kilogram and second as fundamental units in place of the centimetre, gram and second. Thus the powers of ten, which were used with the c.g.s. electromagnetic units, could be eliminated. This fact was first pointed out by G. Giorgi of Rome in 1901.

The M.K.S. or Giorgi System of Units.—At the sixth International congress held in St. Louis, Mo., in 1904 Giorgi showed that by taking the metre, kilogram, second and ohm as the four fundamental and arbitrary units the system of absolute practical units would remain unchanged. The m.k.s. or metre-kilogram-second system of units forms a complete and logical system for the mechanical units. If the electrical practical units are to be included then a fourth unit from among the various electrical ones must be added. Giorgi used the ohm though any one from among such practical units as the following: ampere. ohm. volt. henry, farad. coulomb or weber, may equally well serve as the fourth unit since all these quantities are interrelated by electromagnetic theory. The International Committee on Weights and Measures adopted the following resolutions (definitions of mechanical and electrical units in the m.k.s. system) to be effective Jan. 1, 1948, from which it may be seen that the ampere was selected as the fourth unit:

I. *The Newton (unit of force).*—The newton is the force which gives to a mass of 1 kilogram an acceleration of 1 meter per second per second.

II. *The Joule (unit of energy or work).*—The joule is the work done when the point of application of the newton is displaced a distance of 1 meter in the direction of the force.

III. The Watt (unit of power).—The watt is the power which gives rise to the production of energy at the rate of 1 joule per second.

IV. The Ampere (unit of electric current).—The ampere is the constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular section's, and placed 1 meter apart in a vacuum, will produce between these conductors a force equal to 2×10^{-7} newtons per meter of length.

V. The Volt (unit of potential *difference* and electromotive *force*).—The volt is the difference of electric potential between two points of a conducting wire carrying a constant current of 1 ampere, when the power dissipated between these points is equal to 1 watt.

VI. The Ohm (unit of electric resistance).—The ohm is the electric resistance between two points of a conductor when a constant difference of potential of 1 volt, applied between these two points, produces in this conductor a current of 1 ampere, this conductor not being the seat of any electromotive force.

VII. The Coulomb *(unit* of quantity of electricity).—The coulomb is the quantity of electricity transported in 1 second by a current of 1 ampere.

VIII. The Farad (unit of electric capacitance).—The farad is the capacitance of a capacitor between the plates of which there apprars a difference of potential of 1 volt when it is charged by a quantity of electricity equal to 1 coulomb.

IX. The *Henry* (unit of electric inductance).—The henry is the inductance of a closed circuit in which an electromotive iorce of 1 volt is produced when the electric current in the circuit varies uniformly at a rate of 1 ampere per second.

X. The *Weber* (unit of *magnetic* flux).—The weber is the magnetic flux which, linking a circuit of 1 turn, produces in it an electromotive force of 1 volt as it is reduced to zero at a uniform rate in one second.

The definitions given above are intended to fix the magnitude of the units and are not necessarily the methods followed for their practical determination. For example. the definition of the ampere is only a particular case of the general formula expressing the forces between current-carrying conductors and is chosen for the simplicity of its verbal expression.

The experimental methods used in determining the absolute values of the electrical units can be found in the national bureau of standards circulars.

A question arising with every electrical system of units is whether the rationalized or the unrationalized form should be used. This question is concerned with the factor 2π or 4π in equations relating electrical quantities. In the rationalized system the factor 2π or 4π appears in the equations for those situations in which there is circular or spherical symmetry. In the unrationalized system the π factor does not appear in the equations for circular or spherical symmetry but does appear where there is no symmetry. It is not possible to get rid of π in one place without its appearing in another. The question was not new, for about 1890 Oliver Heaviside had written: "the unnatural suppression of 4π in the formulas of central force. where it has a right to be, drives it into the blood. there to multiply itself, and afterward break out all over the body of electromagnetic theory."

A system of units called the Heaviside-Lorentz system formed such a rationalized system and. though it was used in a number of theoretical treatises. did not come into general use because its units differ from those of the absolute practical system. In 1950 the International Electrotechnical commission voted the approval of the rationalized m.k.s.a. system. This action did not affect the absolute practical standards, ampere, volt, ohm, etc., but it did affect the values of the permeability and permittivity of free space.

In the rationalized system the equation for the force f per metre length between two infinite parallel wires carrying currents of I_1, I_2 amperes and a distance of d metres apart in a vacuum is given by

$$f\left(\frac{\text{newton}}{\text{metre}}\right) = \frac{\mu_0 I_1 I_2}{2\pi d}$$

where μ_0 is the permeability of free space in the rationalized system and has a value of $4\pi \times 10^{-7}$ newtons/ampere^2. If I_1 and I_2 are each one ampere and d is one metre then the force per metre length is 2×10^{-7} newtons/metre as given in definition iv for the ampere.

In the unrationalized system the permeability of free space, μ'_0 is 10^{-7} newtons/ampere^2 and the force per unit length is given by

$$f\left(\frac{\text{newton}}{\text{metre}}\right) = \frac{2\mu'_0 I_1 I_2}{d}$$

This result of course agrees with definition iv. However there is circular symmetry in this problem and one might expect the factor π in the equation for the force as is the case in the rationalized system.

A similar situation exists in electrostatics for the permittivity ϵ_0 of free space. The capacitance C, in farads, of an electric capacitor having plates of area A metre^2 separated by a uniform distance of d metres in a vacuum, is given in the rationalized system as

$$C = \frac{\epsilon_0 A}{d}$$

In the rationalized system ϵ_0 has the value of about 8.854×10^{-12} farads per metre. For the unrationalized system the permittivity ϵ'_0 of free space is about 1.113×10^{-10} ($4\pi \times 8.854 \times 10^{-12}$)

farads per metre and the capacitance C of this condenser is given by

$$C = \frac{\epsilon'_0 A}{4\pi d}$$

In this case there is no circular or spherical symmetry and the π factor does not appear in the equation written in the rationalized system.

These two constants, the permeability and permittivity of free space, are related by Maxwell's electromagnetic theory to the velocity of light c in free space in the following manner:

$$\mu_0 \epsilon_0 = \mu'_0 \epsilon'_0 = 1/c^2$$

The value of c is about 3×10^8 metres per second.

The introduction of the m.s.k.a. rationalized system greatly simplified electromagnetic calculations. Previously there had been at least eight different systems of electrical units in fairly common use.

Dimensions of Units.—An expression containing the fundamental units which enter into the measure of any physical quantity, together with the powers to which they enter, is known as the "dimensions" of that quantity. Thus the dimensions of velocity are LT^{-1}; those of acceleration LT^{-2}; those of force MLT^{-2}. The importance of the subject lies mainly in the fact that, in an equation between physical quantities, each term, in both right-hand and left-hand members, must have the same dimensions. For fuller discussion, see DIMENSIONAL ANALYSIS.

A List of Physical Units and Constants.—The following is a short list of important miscellaneous units and constants.

The *Metre*.—In 1892 A. A. Michelson measured ,the standard metre in terms of the red ray of cadmium and found that there were 1,553,164.13 of these red cadmium wave lengths in a distance of one standard metre. The International Solar union adopted this measurement in 1907. It has been suggested (1957) that greater accuracy for the standard metre could be obtained by using the wave length of the orange light emitted by the krypton isotope of mass number 86. This new standard metre would be 1,650,-763.73 times the chosen wave length.

Astronomical Units of Distance.—The astronomical unit is the distance from the earth to the sun (149,501,201 km.).

The light-year is the distance light travels in one year (9.4614×10^{12} km. or approximately 6×10^{12} mi.).

The parsec is the distance at which the annual parallax is one second of arc.

Unit Quantities of Heat.—The gram-calorie is the quantity of heat required to raise the temperature of one gram of water from 1j° to 16° C. The kilogram-calorie or the large calorie is 1,000 gram-calories. The British thermal unit, B.T.U., is the quantity of heat needed to raise the temperature of one pound of water through 1° F.

Units of Light Intensity and Light *Flux*.—The unit of intensity of light is the candle. which is one-sixtieth of the intensity of one square centimetre of a perfect radiator, known as a "black body," when operated at the temperature of freezing platinum.

The unit of light flux is the lumen. which is the flux in a unit of solid angle from a source of which the intensity is one candle. The total radiation from one candle is, therefore. 4π lumens.

The Curie and *Rutherford* Units.—Originally the curie was the amount of radon in equilibrium with one gram of radium. As radioactivity became more important the curie was used as a unit of disintegration rate and as such was not too satisfactory since it is difficult to measure accurately. Accordingly, the International Radium Standard commission recommended that the curie be defined as 3.7×10^{10} radioactive disintegrations per second. A more convenient unit for the rate of disintegration of a radioactive substance was recommended by the national bureau of standards. This is called the rutherford (rd) where one rutherford is the amount of radioactive substance which undergoes 10^6 disintegrations per second.

The Roentgen.—For personnel protection a unit of X- or gamma radiation called the roentgen (r) is used. By definition one roentgen unit is "that quantity of X or gamma radiation such that the associated corpuscular emission per 0.001293 gms of air produces, in air, ions carrying 1 esu (about $\frac{1}{3} \times 10^{-9}$ coulombs) of quantity of electricity of either sign."

Unit of Pressure and *Standard* Atmosphere.—The c.g.s. unit of pressure is the barye (dyne/cm.^{2}). The bar (10^6 dynes/cm.^{2} = 1.013 kg./cm.^{2} = 0.987 atm.) is the international unit of pressure. By definition the standard atmosphere A, = 1013250.00 dynes/-cm.2

Angstrom and X units.—The angstrom, Å, is 10^{-8} cm. and the X unit, used in X-ray work, is 10^{-11} cm. or 10^{-3} A.

The *Gravitational* Constant.—The gravitational constant, G, is equal to $(6.670 \pm 0.005) \times 10^{-8}$ dyne cm.^{2} g.$^{-2}$

Ice Point on the *Absolute Scale*.—The ice point on the absolute scale, T_0, is 273.16 ± 0.01° K.

Joule Equivalent.—By definition the thermochemical calorie is 4.1840 joules. The experimental value of the joule's equivalent at 15° C. is 4.1855 ± 0.0004 joules.

The Velocity of Light.—The value of the velocity of light, c, is 299793 ± 0.3 km.sec.$^{-1}$

Chemical and Physical Mass Units.—The chemical mass unit is one-sixteenth of the atomic weight of oxygen which is taken as exactly 16. It is known that oxygen consists of three isotopes of mass numbers 16, 17, 18 respectively, of which the mass number 16 has an abundance of over 99%. The physical mass unit (m.u.) is one-sixteenth of the isotope of mass number 16 and is a completely unambiguous unit. It has been found experimentally that different oxygen compounds yield slightly different abundance ratios of the three isotopes. Thus, the chemical mass unit depends on the type of oxygen compound used and is not an unambiguous unit.

Raymond T. Birge computed the conversion factor r as equal to 1.000272 ± 0.000005 as the ratio of chemical to physical scales based on the assumed abundance ratio $O^{16} : O^{18} : O^{17}$ as (506 ± 10): 1: (0.204 ± 0.008). On the basis of the abundance ratio for atmospheric oxygen, A. O. Nier revised this scale ratio to r = 1.000278. He stated that if the abundance ratio assumed were that found in iron ore or water. the value of r would be 1.000268. The value usually accepted by the chemists is r = 1.000275. The values of the following quantities are based on the physical mass unit scale.

Miscellaneous Constants.—The following are additional constants.

The mass of the neutron, n, is 1.008982 ± 0.000003.

The atomic mass of deuterium, D, is 2.014735 ± 0.000006.

The atomic mass of the helium isotope of mass number 4, He^4, is 4.003873 ± 0.00001 j.

The standard volume of a perfect gas, V_0, is 22420.7 ± 0.6 cm.^{3} atm. mol.$^{-1}$

The gas constant per mole. R,, is $(8.31662 \pm 0.00038) \times 10^7$ erg mol.$^{-1}$ deg.$^{-1}$ C., which is equal to 1.98772 ± 0.00009 kg.cal. mol.$^{-1}$ deg.$^{-1}$ C.

Least Squares Adjusted Values of Physical Constants.—Measurements of individual physical constants were. up until about 1929, usually treated as separate problems; but the manifold quantitative interrelationships connecting physically measurable quantities, coupled with a marked increase in the number of kinds of highly precise measurements of such quantities which have been made, have since then necessitated to an increasing degree that whole groups of constants be considered and evaluated simultaneously. The largest and most important group of this sort is known as the atomic constants, and it has been found necessary with the passage of time to include more and more of the fundamental physical constants as members of it. until, at the time of the 1952 evaluation, with the exception of such arbitrarily defined quantities as are required to set up a system of units, there remained only a few constants, such as G, which possessed no known relationship to any of the atomic constants. (*See* LEAST SQUARES, METHOD OF.)

In such an evaluation a group of fundamental constants is selected as the set of primary unknowns to be determined. If we let q be the number of these unknowns, the input material then consists of a set of equations, N in number, relating certain functions

of the unknowns to precisely measured numerical values. These numerical values are the results of a carefully selected list of reliable high precision experiments to each of which a weight, measuring its estimated reliability, can be attached. The number N must be at least equal to q to permit any solution at all, but it is desirable to have N exceed q as much as possible. The N equations in q unknowns constitute an overdetermined set which will never be completely compatible because of the unavoidable errors of measurement. and the mathematical method of "least squares adjustment" is then used to find a set of "best" values for the unknowns consistent with the input materiai.

In the 1952 calculations the values of q and N were 5 and 13 respectively. In 1955 this data was analyzed for systematic errors by a variance analysis performed by an electronic digital computer. The speed of light was treated as a fixed constant of known value and there remained eleven linear equations in four unknowns subject to least squares adjustment. A number of the values obtained by this analysis are given below.

Avogadro's constant, N, is $(6.02486 \pm 0.00016) \times 10^{23}$ (g. mol.)$^{-1}$.
Loschmidt's constant, $Lo\ N/V_0$, is $(2.68719 \pm 0.00010) \times 10^{19}$ cm.$^{-3}$
Electronic charge, e, is $(4.80286 \pm 0.00009) \times 10^{-10}$ E.S.U. or $(1.60206 \pm 0.00003) \times 10^{-19}$ coulombs.
Electron rest mass, m, is $(9.1083 \pm 0.0003) \times 10^{-28}$ g.
Proton rest mass, m_p or M_pN, is $(1.67239 \pm 0.00004) \times 10^{-24}$ g.
Neutron rest mass, m_n or n/N, is $(1.67470 \pm 0.00004) \times 10^{-24}$ g.
Planck's constant or the quantum of angular momentum, h, is $(6.62517 \pm 0.00023) \times 10^{-27}$ erg sec.
Faraday constant, F or Ne/c, is 96521.9 ± 1.1 coul. (g. mole)$^{-1}$.
Charge-to-mass ratio of the electron, e/m, is $(1.75890 \pm 0.00002) \times 10^{8}$ coul. g.$^{-1}$
Atomic mass of the electron, Nm, is $(5.48763 \pm 0.00006) \times 10^{-4}$ m.u.
Atomic mass of the proton, M_p or $H - Nm$, is 1.007593 ± 0.000003 m.u.
Ratio of the proton mass to the electron mass, M_p/Nm, is 1836.12 ± 0.02.
Classical electron radius, ro is e^2/mc^2, which is equal to $(2.81785 \pm 0.00004) \times 10^{-13}$ cm.
Boltzmann's constant, k or R_0/N, is $(1.38044 \pm 0.00007) \times 10^{-16}$ erg deg.$^{-1}$ C.
Wien displacement law constant $\lambda_{max}T$, is (0.289782 ± 0.000013) cm. deg. K.
Stefan-Boltzmann constant, δ, is $(0.56687 \pm 0.00010) \times 10^{-4}$ erg cm.$^{-2}$ deg.$^{-4}$ K. sec.$^{-1}$
Magnetic moment of the electron, μ_e is $(0.92837 \pm 0.00002) \times 10^{-20}$ erg gauss^{-1}.
Mass-energy conversion factors. The abbreviation ev stands for electron volt, a unit oi energy in common usage among physicists equal to the kinetic energy acquired by one electron ialling through a potential difference of one volt. One Mev stands ior 1,000,000 electron volts or 10^6 ev. 1 ev is $(1.60206 \pm 0.00003) \times 10^{-12}$ erg.
1 g. $= (5.61000 \pm 0.00011) \times 10^{26}$ Mev $= (2.496\,jj \pm 0.00005) \times 10^{7}$ kw.hr.
1 electron mass $= 0.510976 \pm 0.000007$ Mev.
1 atomic mass unit, 1 m.u., $= 931.141 \pm 0.010$ Mev.
1 proton mass $= 938.211 \pm 0.010$ Mev.
1 neutron mass $= 939.505 \pm 0.010$ Mev.
Hydrogen ionization potential, I_0, is 13.59765 ± 0.00022 ev.

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(H. Cw.; J. W. M. D.; E. R. CN.; R. J. Sw.)

PHYSICS (ARTICLES ON). The astonishing advances which the science of physics has made since the 11th edition of the *Encyclopædia Britannica* was prepared early in the 20th century is evidenced by the fact that the 11th edition contains nothing on relativity, on atomic structure or on the quantum theory, three questions which dominate modern physics and influence every branch.

The articles SCIENCE and PHYSICS: GENERAL SURVEY give a general view of the scope of physics and its place among the sciences. The fundamental nature of space and time in the physical world and of gravitation, is discussed under RELATIVITY and SPACE-TIME, while the history of the growth and another aspect of the nature of the relativity problem is given under ETHER (IN PHYSICS). An account of experiments and observations which played a great part in preparing the way for relativity will be found under MICHELSON-MORLEY EXPERIMENT and ABERRATION OF LIGHT. Measurements of the VELOCITY OF LIGHT, the constancy of which is fundamental, are described under the article so entitled. The historical, experimental and theoretical aspects of the subject. thus are all readily accessible.

The subject matter oi physics can be broadly classed as matter and radiation. The physical nature of matter is expounded under KINETIC THEORY OF MATTER, which deals mainly with gases. Supplementary to this article is BROWNIAN MOVEMENT. The transition from gas to liquid is handled from the general theoretical point of view in the article LIQUEFACTION OF GASES, which also deals with technically important aspects of the subject. The modern view of solids comes under SOLID STATE PHYSICS. For the arrangement of atoms and molecules in crystalline solids the article CRYSTALLOGRAPHY should be consulted. Crystals have a regular ordered structure; in many ways the antithesis of the crystalline state is the colloidal state, dealt with under COLLOID. Important general properties of liquids have special articles, SURFACE TENSION and VISCOSITY, devoted to them. These articles, then, deal with the general properties of matter; the field of radiation is covered in ELECTROMAGNETIC WAVES. which deals broadly with the various kinds of waves comprised in the electromagnetic soectrum.

The peculiar task of physics in the present century has been to effect a synthesis of the properties of matter and radiation in terms of units of electric charge, of matter and of radiation. Modern atomic physics, which comprises this field, is well represented in the *Encyclopadia.* The unit of electricity is the ELECTRON, to which an article is devoted. A vast body of work that established and developed the electron theory is described under ELECTRICITY, CONDUCTION OF. The connecting link between matter and radiation is furnished by the nuclear theory of the atom. which asserts that an atom consists of a minute, positively charged massive nucleus, surrounded by groupings of electrons in motion. The general nuclear theory is explained under ATOM; the properties of the nucleus! and their profound consequences for physics and chemistry under NUCLEUS; NEUTRON; ISOTOPE.

RADIOACTIVITY, ARTIFICIAL and RADIOACTIVITY, NATURAL are articles of first importance for the understanding of modern physics. The theory of emission of light and X-rays by an atom, described under ATOM, is based upon the quantum theory, discussed in QUANTUM MECHANICS. COMPTON EFFECT; MOLECULAR SPECTRA; PHOTOELECTRICITY; RAMAN EFFECT; RESONANCE ENERGIES; SPECTROSCOPY; THERMIONICS; X-RAYS deal with the experimental and theoretical side of radiation phenomena which have a prominent place in atomic physics, while ACCELERATORS, PARTICLE and CLOUD CHAMBERS describe experimental methods that have had far-reaching results. *See* also ATOMIC ENERGY; PARTICLES, ELEMENTARY.

The general body of physics is dealt with under comprehensive articles devoted to the main conventional divisions—ELECTRICITY; ENERGY; HEAT; LIGHT; MAGNETISM; MECHANICS; SOUND; with important supplementary articles, among which may be mentioned: under heat, CALORIMETRY; THERMODYNAMICS; THERMOMETRY; under light, LUMINESCENCE; OPTICS; SHADOW; SPECTROSCOPY; under electricity, ELECTRICITY, CONDUCTION OF.

Important instruments and their uses are described under: BALANCE;

BAROMETER; BINOCULAR INSTRUMENT; CHRONOGRAPH; COMPASS; CONDENSER; GYROSCOPE; HYDROMETER; INDUCTION COIL; INSTRUMENTS, ELECTRICAL MEASURING; INTERFEROMETER; MICROSCOPE; MICROSCOPY; MIRROR; SELENIUM CELL; VACUUM.

Applied physics is another aspect of the subject which receives full representation. The meteorological side is represented by ELECTRICITY, ATMOSPHERIC; METEOROLOGY; the geophysical by GEODESY; GEOMAGNETISM; GEOPHYSICS; GRAVITATION; and the astronomical by ASTROPHYSICS. Some of the chief heads under which the bearing of physics in everyday life and industry is described in detail are: ACOUSTICS OF BUILDINGS; AERODYNAMICS; CAMERA LUCIDA AND CAMERA OBSCURA; ELECTROMAGNET; LENS; PHONOGRAPH; PHOTOGRAPHY; PHOTOMETRY; RADAR; RADIO; TELEGRAPH; TELEPHONE; TELEVISION; X-RAYS: *Modern Industrial Applications.* (E. N. DA C. A.; H. B. LM.)

PHYSICS: GENERAL SURVEY. Physics, which may be defined broadly as the study of nature. was long called natural philosophy (from the Greek *physikos*); its exact scope is not fixed nor easily delimited. From decade to decade in modern times. the principal effort in physics has changed as, on the one hand. fields of scientific knowledge were reduced to practice. whereupon they were regarded as branches of engineering or applied physics; and, on the other hand, new fields were opened by fresh experimental or theoretical discoveries. Physics may be called a point of view about the natural world and a method of attack on its problems, a method based upon certain general principles and disciplined by the close interplay between experiment and theory. With a kind of confidence that the understanding of nature may be reduced to a few comprehensive principles, physicists seek for those central ideas by which great areas of common experience may be brought into order and coherence. To achieve their purpose, they proceed by use of mathematical and logical tools, and by experimentation,

Physics comprises especially the study of the structure of matter, the nature of radiation and its interactions with matter, and an attempt at a unified description of fields of force. It has been guided for the past century or more by three powerful conservation principles which appear to be valid in new areas of investigation and which in turn acquire increased stature as they meet the test in new experimental situations. The principle of conservation of linear and angular momentum. first applied to mechanics by the Englishman Sir Isaac Newton (1642–1727), but later generalized to include the electrodynamic field. was the earliest of these. A principle of conservation of energy in mechanics was extended to other forms of energy. especially to heat, about the middle of the 19th century. The third principle is the conservation of electric charge. often an important guide. with the other two conservation principles. in the field of nuclear physics.

Since the enunciation of the mass-energy relation. $E = mc^2$, by Albert Einstein in 1905. the chemist's principle of the conservation of mass has been merged with the principle of conservation of energy into the more comprehensive principle of conservation of mass-energy. It appears that mass and energy have complementary properties: all transfers of energy from one body or system of bodies to another are accompanied by a corresponding transfer of mass rather than by annihilation of mass. All energy appears to exhibit inertia. In the equations of nuclear reactions, a term representing mass or energy changes is important. corresponding to the energy term in a complete chemical equation.

Insofar as these three conservation principles apply and are helpful in other sciences. physics may contribute to them and promote their development; it has often happened that instruments designed for research in physics have found wide application elsewhere. The cathode-ray tube, for example. was not invented to forward the art of television: rather, it was designed in prototype for the study of electrons.

This article will deal more with basic ideas than with applications of physics. Because of the rapid growth of all science, it has been convenient to set up somewhat arbitrary and often indefinite boundaries between the various fields. In particular. physics was once regarded as dealing with inanimate objects; it has been said, somewhat jocularly, that if there was any life in a subject, it could not be physics. Biology deals with the great area of life sciences, but a growing field of biophysics suggests the temporary nature of such a boundary.

Astronomy underwent radical changes after 1850 as it became to an increasing extent astrophysics. To the telescope, spectroscope, spectroheliograph and kindred instruments was added the radiotelescope; there has been a busy two-way traffic of ideas bet een atomic and nuclear physics and astronomy. Geology has become in part geophysics. Meteorology is largely a study of the physics of the air. At no time has it ever been possible to draw a sharp line between chemistry and physics, as each has contributed continuously to the other. Few ideas are important in one field that do not have wide applicability in the other. This relationship is obviously apparent in the rapid development of such fields as radioactivity, nuclear energy and isotopes, in which progress has been shared repeatedly by those who called themselves either physicists or chemists.

For convenience, the field of physics is often broken into several related subfields, all of which are viewed through the same general conservation principles. although each field may have in addition its own distinctive ideas and generalizations. These fields are (somewhat in historical order of development) mechanics, heat, sound. light (*q.v.*), magnetism, electricity (*qq.v.*) and atomic and nuclear structure (*see* ATOM; NUCLEUS). In addition there have developed certain broad mathematical theories by which fields of knowledge are for the time systematized. (See *Theory* below.) A partial list of these subfields, starting with *Philosophiae Naturalis Principia Mathematica,* Newton's great 1686–87 treatise on mathematical principles of natural philosophy, includes kinetic theory, electrodynamics (*see* ELECTROMAGNETIC WAVES), thermodynamics, statistical mechanics, quantum mechanics (*q.v.*) and relativity (*q.v.*). In this article, only brief mention will be made of some of these fields; but the reader may also consult PHYSICS (ARTICLES ON) for the titles of the separate articles dealing with the various subfields. This article treats, in succession, in the history of physics, the solar system, the electrical nature of matter, radiation. atomic and nuclear structure. solid state physics. theory and instrumentation.

History.—Throughout the centuries men gained a certain practical working knowledge of nature but it was seldom systematized or elevated to the level of general principles. Early philosophical ideas about nature were often void of adequate basis in observation and many were barren of consequences. For example. the Greeks Democritus and Leucippus (both 5th century B.C.) are referred to as early atomists, but it is not evident that their ideas bore fruit. The development of a productive atomic theory had to await the experimental researches of the 19th century. For 24 centuries. little came from Thales's early reports of static electricity and magnetism. The fact that, before 400 B.C., Philolaus reduced the earth to the status of a planet seems to have had little influence on men's thinking for the next 1.800 years. Archimedes (*c.* 287–212 B.C.) was one of the more successful mathematicians and experimentalists, and his law of the lever and principle of buoyancy laid the foundation of a science of mechanics. Throughout the first 15 centuries of the Christian era, little concerted effort was expended on understanding nature. although it would be uncharitable to discount the value of the accumulated ideas. mathematical and astronomical. which were available when the renaissance of learning occurred.

The birth of physics may be said to have resulted from a new attitude typified by precise, quantitative observation and controlled experimentation. coupled with mathematical reasoning. With control of experiments and success of logical predictions derived from them. there came a sense of man's growing power to bend nature to his needs. The physical world was increasingly regarded as understandable and predictable, rather than capricious. Two of the larger developments will be sketched briefly as examples of how physics proceeds not at a uniform rate unerring in direction but by large and small steps and by the interplay of observation and theory. The first of these, in the very large, concerns the solution of the solar system: the second, in the very small, the growth and consequences of the electrical nature of matter.

Solar System.—Despite a few early claims for the earth's sphericity and its planetary status a geocentric view of the solar system prevailed for many centuries. Copernicus demonstrated in 1543

that a great simplification in the observed motions of the planets could be made by assuming the earth also to be a planet revolving around the sun. His hypothesis reopened the question of the earth's position in the universe, but it remained only hypothesis for more than a hundred years before other significant steps were taken. The Danish astronomer Tycho Brahe (1546–1601) contributed a vast quantity of precise observational material on the positions of the planets. His disciple, the German astronomer Johann Kepler (1571–1630) reduced these data to order and extracted from them three empirical laws of planetary motion. These conclusions were that the planets (1) move in ellipses about the sun, with the sun at one focus; (2) sweep out, by their radius vectors, equal areas in equal times; (3) have periods of revolution about the sun such that the squares of these periods are proportional to the cubes of the respective major axes of their elliptical orbits. Kepler could not guess the full meaning of his findings because of the prevailing lack of knowledge of mechanics and of any comprehensive system of understanding.

In Italy Galileo (1564–1642) contributed two important advances: first, by the invention of a telescope which revealed the moons of Jupiter like a miniature Copernican system and showed the phases of the planet Venus as it moved about the sun; second, by laying a firmer foundation in mechanics as a forerunner of the more complete work of Newton. Newton grasped the work of the four men previously mentioned and in his Principia performed a major synthesis of terrestrial and celestial mechanics made valid by his penetrating use of mathematical logic, including the rudiments of the calculus which he devised for his purposes. The magnitude of this step can scarcely be overestimated. it showed the wide validity of physical principles and their extension by the law of gravitation to regions far beyond the earth; it removed all boundaries to man's attempts to apply new-found ideas; and, by the many deductions and predictions drawn from the laws of motion, it gave increased confidence in the power of mathematical theory when applied to measurements in the physical world. Newton's laws of motion, in part anticipated by Galileo, were clear guides to all subsequent studies of motion.

The law of gravitation (*q* v) provides an elegant example of what may be called a useful theory. Aside from its impact on philosophy and theology, it illustrates what a good theory should do. First, it took into account and employed quantitatively all relevant prior knonledge and observation. For example, Newton showed Kepler's first and second laws to be characteristic of a motion taking place with conservation of angular momentum under a centrally directed force acting between a planet and the sun. The third law was shonn to be a necessary consequence of an inverse square lam of gravitation, when applied to the motion of an object moving in a curved path; this was in accordance with the then recently stated (1673) law of centripetal force of the Dutch mathematician, astronomer and physicist Christiaan Huygens. Second, Nev ton's work led to the solution of several baffling problems of long standing — problems to which it was not originally directed — such as the cause of the tides and the orbits of comets. Newton pointed out the necessary oblateness of the earth because of its rotation, a fact then not even suspected, and proceeded to employ the existence of this equatorial bulge to explain the slow precession of the equinoxes. Finally, under constant testing. the Principia and its various descendants in mathematical deduction led to a fuller understanding of motion of all kinds. The later ideas of relativity superseded Newton's only in the case of velocities approaching the speed of light. Newtonian mechanics could thus still be regarded as a good first approximation to the more general mechanics of relativity.

The full mathematical development of Newton's mechanics took place in the 18th century, culminating in the publishing in France of J. L. Lagrange's *Mécanique* Analytique (1788) and the *Mécanique Célèste* (1799–1825) of P. S. Laplace. In these works, the implications of gravitational potential and the principle of conservation of mechanical (potential and kinetic) energy played a leading part; and they provided a firm foundation for the subsequent bringing of all forms of energy into the more general conservation principle of the 19th century Application of Newton's law of gravitation to the detailed examination of planetary motions led, in one memorable triumph. to the discovery of the planet Neptune independently by U. J. J. Leverrier in France and by J. C. Adams in England in 1846.

Finally. discrepancies in the precession of the perihelion of the planet Mercury, whose motion did not completely satisfy Newtonian mechanics, mas a source of discomfort to astronomers until the German-born Albert Einstein (then of Berne, Switz.) removed most of the observed discrepancy by application of his relativity theory (1905). Hence. in numerous steps, of which the foregoing are but a few important examples, physics advanced to a fuller understanding of mechanics, both terrestrial and celestial, by the interplay of observation, laboratory equipment and theoretical deduction. Discrepancies between theory and observation, however small, often were the guide to new experiments which in turn were the source either of new discoveries or of a revision of basic ideas in the conceptual framework of thinking.

The Electrical Nature of Matter. — A second example of how physics progresses is the growth of the atomic view and its extension to the atomicity of electric charge, from which base the development of nuclear physics proceeded. The chemical experiments of John Dalton of Manchester, Eng., in the first decade of the 19th century laid the experimental foundation for the concept of atomic weight. Rapidly, throughout the 19th century, there grew the idea of a limited number of elements which could combine in an almost limitless number of ways to form chemical compounds —outward complexity with an underlying simplicity. The periodic system of the elements as formulated by the Russian chemist D. I. Mendeleyev served as a framework for the few scores of elements known. In mid-19th century there arose the kinetic theory of gases, which successfully attributed such phenomena as the pressure and viscosity of a gas to the motions of myriad submicroscopic atomic and molecular particles. This theory did much to bring quantitative measurement to bear upon invisible particles and their motions. and it assisted in bringing thermal phenomena firmly within the scope of the newly enlarged principle of conservation of energy. J. Clerk Maxwell of Scotland and Ludwig Boltzmann of Austria, among others, gave the kinetic theory extensive mathematical form, and produced an expression for the molecular velocity distribution function that in subsequent years was verified experimentally.

By 1895 the growing weight of chemical evidence and the success of the kinetic theory in dealing statistically with large numbers of particles left little doubt that atoms and molecules were real. Whatever doubt remained was in large part dispelled by Einstein's analysis and Jean Perrin's experiments in France on the Brownian movement, the random motions of microscopic particles, which had remained unexplained for 80 years. Near the turn of the century, physicists were on the threshold of several significant discoveries which stemmed from experiments on the passage of electric current through gases at low pressure and from the study of optical spectra which, since the work of R. W. von Bunsen and G. R. Kirchhoff in Germany in 1859, had played a prominent part in chemical analysis. An important question persisted: how could simple atoms give rise to such complex spectra as were found? These characteristic spectra must in some way be connected with the structure and inner properties of atoms. In approximately 20 years, several strands of the tangle were unraveled, principally from the discovery of the electron.

The electron, or corpuscle of negative electricity, was the first subatomic particle to be identified as a constituent of all atoms. It was shown by Sir J. J. Thomson of England, in his studies of cathode rays, to have the same ratio of charge to mass, e/m (1.76×10^8 coulomb/gram), regardless of the element from which the rays were derived. Thomson showed by deflecting cathode rays with electric and magnetic fields that this elm was 1.837 times greater than elm for the lightest known substance, hydrogen, as measured by electrolysis. The presumption was strong that this snift new-found particle bore the same charge but had only 1/1.837 the mass of the hydrogen atom, a surmise that has stood the test of experiment. The subsequent measurement of the electronic charge by Robert A. Millikan (then of Chicago) in his well-conceived oil-

drop experiments *(1909–16)* demonstrated the definiteness of this charge, now stated as -4.80×10^{-10} electrostatic units, regardless of the source of the electrons. Millikan's work showed that all electric charges, whether positive or negative, must be regarded as composed of these definite small charges, and that electricity instead of being infinitely divisible has an atomic nature. The English chemist and physicist Michael Faraday *(1791–1867)* had approached this position by his experiments in electrolysis many decades earlier, and his work now returned to prominence as, with knowledge of the charge on an ion in electrolysis, it became possible to compute with accuracy Avogadro's number, the important number representing the aggregate of atoms in a gram-atom, measured to be 6.0228×10^{23}.

At almost the same time that Thomson was measuring elm for electrons, W. Rontgen of Germany found the penetrating radiation which he called X-rays. These rays were generated by the sudden stopping of cathode rays or electrons upon impact with metal targets. Thus, the electron was demonstrably connected with the emission of radiation. It was suspected that this agile particle might be the source of atomic spectra but three important steps had to be taken to prove this connection. These were in turn the discovery by Max Planck of Germany of the quantum nature of radiation, the discovery of the nuclear atom by Sir Ernest Rutherford of Great Britain and the synthesis of a suitable atomic model by Niels Bohr of Denmark.

It was shown by Planck in *1900* from his theoretical studies of thermal or "black body" radiation that light must be considered not as transmitted by energy infinitely divisible, as had been previously assumed, but rather as being emitted and absorbed in small bundles of energy which he called quanta. The magnitude of a quantum or photon he showed to be $h\nu$, where ν is the frequency of light and h is a constant of action or energy $\times$ time $(6.6252 \pm 0.002 \times 10^{-27}$ ergs $\times$ sec.), which Planck introduced into physics and which appears to be one of the fundamental atomic constants. In this way was born the quantum theory which, with its descendant, quantum mechanics, became indispensable to the understanding of atomic and nuclear phenomena.

The early quantum theory was given considerable assistance by Einstein who adopted it in explanation of the photoelectric effect. In his important *1905* equation, Einstein showed that the maximum kinetic energy of an electron ejected by light from a metal could be expressed by $\frac{1}{2}mv^2_{max.} = h\nu - \phi e$ where $h\nu$ is, as before, the energy of the photon and ϕe represents work done to assist the electron across the potential barrier of the metal. This equation made no pretense of supplying a detailed mechanism for the potential barrier nor for extraction of electrons from metals, yet it was based firmly upon the concept of energy conservation. More than a half-century later, it still had been successful in every experimental test to which it had been put, ranging from the infrared region of the spectrum to gamma rays.

Also, late in the 19th century A. H. Becquerel, Pierre and Marie Curie (all of France) and Rutherford were leaders in the exploration of radioactivity. These studies were destined to lead to the discovery of other subatomic particles and to the whole field of nuclear physics. In examining the growth of atomic theory, the discovery of the atomic nucleus by Rutherford *(1911)* is the most relevant matter. From the scattering of swift alpha particles from radioactive substances as these particles were directed against thin metal foils. such as gold leaf. Rutherford concluded that the alpha particles often encounter strong centres of repulsion and that most of the mass and the positive charge of the gold atoms must be concentrated in a small region less than 10^{-12} cm. in diameter. If, as became apparent from these experiments, the positive charge was concentrated in a small nucleus, each neutral atom could be regarded as having positive and negative charges of equal magnitude, each charge being an integral number of the fundamental electronic charges. Both the scattering experiments and contemporaneous experiments on the X-ray spectra of metals conducted by H. G. J. Moseley in England in 1913 showed that this positive charge on the nucleus is Ze where Z is the atomic number or ordinal position of an atom in the periodic table of Mendeleyev. Hence a neutral atom must have Z electrons also. The atomic number was recognized as the sure indicator of the chemical element to which an atom belongs, whereas it had become abundantly evident in the discovery of isotopes that atomic weight is a less definite indicator. This field of isotopes, so important to both chemistry and physics, will be discussed later.

In view of the definite photon energy represented by each line in the spectrum of an atom, Bohr was led in *1913* to postulate a large but finite number of recognizable energy states for electrons in atoms, with the transition of an electron from one state of energy to another of lower potential energy as the source of each photon. Inasmuch as the number of such possible transitions is large. the number of spectral lines is likewise Iarge for a given type of atom. Thus a comparatively simple mechanism was again proposed to explain the complex spectral emission of even the simplest atoms. Bohr's theory of atomic structure, whatever its limitations, is a good example of the application of basic physical principles. Central in Bohr's treatment was the quantization of angular momentum, from which the quantization of the energy of photons erupted as a consequence. Bohr postulated a number of "stationary energy states" — states of comparative performance only—which electrons could occupy in the atom. These were limited to those mechanical orbits of electron rotation about the nucleus characterized by angular momentum $nh/2\pi$, where n is an integer now called a quantum number and h is Planck's constant. Energy exchanges were considered to occur as follows: in order for an atom to emit radiation it must first be excited or receive energy by impact. thermal or electrical, or by the absorption of other radiation Bohr viewed this as the forcible removal of the electron to a greater distance from the nucleus to which it was bound electrostatically. As the electron settled down from such an excited state, it would emit one or more quanta of radiant energy by one or more successive transitions between energy states. The total energy emitted by the atom in returning to its lowest state of potential energy was thus set equal to the energy originally absorbed. Bohr's model now is mostly of historical interest, but the quantization of angular momentum, the concept of energy states, the emission and absorption of definite quanta of energy in transitions of electrons from one state to another — all these remain. It was necessary to modify the idea of orbits and to revise the system of quantum numbers in favour of a wave-mechanical view that fit the observed facts of spectroscopy better. The work which Bohr did in synthesizing the available knowledge of the time was comparable with that performed by Newton in the earlier illustration: he united into a coherent system the quantum emission and absorption of radiant energy, the basic ideas of conservation of angular momentum, conservation of energy and the balance of electrostatic and mechanical forces. From the simplified view uhich evolved, he was able to account for the spectrum of hydrogen, the simplest atom. Experimental checking of the consequences of his theory led to the discovery of certain series of lines in the hydrogen spectrum and in the spectra of hydrogen-like atoms (singly ionized helium. doubly ionized lithium, etc.) consistent nith theory. A decade or more of intensive research into optical spectra was stimulated by the application of quantum ideas. As experimental evidence piled up, significant discrepancies were apparent in the Bohr model. but the way to modify it was not immediately at hand; when a change came it was in a form more sweeping than expected. as the older quantum notions of Planck. Einstein and Bohr gave nay to the new quantum and wave mechanics of Werner K. Heisenberg of Germany. Erwin Schrodinger of Austria, the German-born English physicist Max Born and P. 4 M. Dirac of England (More will be said of this in later sections.)

In both of these extended examples, there mere certain similarities in procedure. Experimental evidence sometimes led theory. a's in Kepler's laws of planetary motion or Faraday's laws of electrolysis. At other times the reverse was true, and theory led to new experiments. The final arbiter is experiment, and physicists are accustomed to relinquish even attractive theories when they are found to be at variance with clear experimental evidence. Relativity surpassed Newtonian mechanics, and quantum mechanics surpassed the earlier quantum theory from which it came In both cases, discrepancies between observation and theory prompted the

change to a more comprehensive view; and in each case the result was a more productive theory that gave direction to new experiments.

It may be observed in closing this account of the electrical nature of matter. illustrated strongly by the identification of the electron, that the electron soon after its discovery offered one of the earliest and best evidences for the variation of mass with speed, as inferred from the theory of relativity. Thomson's early measurements of elm were followed by others made by Walter Kaufmann and A. H. Bucherer of Germany that showed e/m to decrease with increase of speed of the electrons. This variation was properly attributed to an increase in mass of the electron and was shown to be in good experimental agreement with the equation

$$m = \frac{m_o}{\sqrt{1 - v^2/c^2}}$$

as specified in the relativity equations by Einstein; where m_0 is the rest mass, v is the velocity of the particle and c is the speed of light. The observations just reported throw light also on another aspect of development in physics, namely the groning coherence of scientific knowledge: here can be seen a close link between the forefront of knowledge in mechanics, as given in relativity, and the details of atomic structure as met in the study of the electron.

At this point, we shall leave these historical examples to treat recent developments in physics under five headings: radiation; atomic and nuclear structures; solid state physics; some major areas of theory; and instrumentation.

Radiation. — Examining the interactions of radiant energy with matter serves to give a better understanding both of matter and of light and its allied radiations. This tno-way traffic is well illustrated in the case of X-rays, where the discoveries of the nature of the rays and of the nature of matter struck by them were complementary. From the early conjectures of Huygens, who viewed light as a wave motion, and of Newton, who viewed it as corpuscular, the view now is of an inseparable duality, although certain experiments accented one characteristic more than the other. The wave aspect gained pre-eminence during the 19th century from the experiments (1811) of T. Young of England, who showed interference of two light beams, best interpreted as evidence of waves. A. J. Fresnel of France extended Young's treatment, discussed diffraction phenomena and formulated a detailed wave theory nhich was the forerunner of the elegant electromagnetic theory of J. Clerk Maxwell. The discovery of electromagnetic waves by the German physicist H. R. Hertz and the subsequent development of wireless, radio and radar reinforced Maxwell's theory and extended the electromagnetic spectrum from the infrared end of the optical region to waves thousands of metres long. At the other end of the spectrum, diffraction effects were used to identify the very short wave length:, (about 10^{-10} cm.) of X-rays and gamma rays. However, the high-frequency end of the spectrum gave inescapable evidence for the photon or quantum nature of the radiation. (The interpretation of spectra on the quantum basis has been introduced above.)

Advances in instrumentation in spectroscopy became significant as greater precision in wave length measurement and greater resolving power gave the necessary numerical evidence to implement the quantum view. Massive accumulations of precise dsta in optical spectra mere made, as in the *M* I.T. *Wavelength* Tables compiled by G. R. Harrison of Cambridge, Mass., and others. The Zeeman effect. which was discovered at the time when Thomson was measuring e/m for electrons, gave evidence that a particle of the same e/m was present in the splitting of spectral lines from a source situated in a strong magnetic field The refined extension of Zeeman spectra when combined with the Pauli exclusion principle (see below) did much to permit a complete description of the outer electronic architecture for all of the electrons in atoms throughout the periodic table. Thus, the details of the electronic structure of matter could be considered as reasonably complete.

X-ray spectroscopy, particularly the study of X-rays characteristic of each element, shoned how the inner electrons of an atom's electronic cloud are disposed and, through the work of the English physicist H. G. J. Moseley, showed additional evidence for the validity of atomic number as the determining factor in element identification.

Two further experimental developments in radiation will be reported because both contributed to the rise of quantum mechanics. The first is the photoelectric effect mentioned above, which gave clear evidence of the absorption of radiation in definite energy bundles and the transfer of this energy to the ejection of a single electron. More recently, nuclear photoeffects were discovered by the ejection of neutrons, protons and mesons from nuclei and by the photodisintegration of light nuclei under the impact of gamma rays, further showing the validity of the energy quantum aspect of electromagnetic radiation. The experiments in 1922 of Arthur H. Compton (then of St. Louis, Mo.) on the ejection of electrons from atoms by X-rays and the accompanying modification of the wave length of the X-rays scattered in the process, appeared likely to remain significant as clear evidence for the ballistic impact of photons on electrons to which the conservation principles of momentum and energy have been applied in detail. The extension of these principles into the atomic and nuclear regions gave added confidence in their extraordinary range of validity. The Compton effect subsequently was extended to the scattering of visible light and the slight modification of wave length accompanying such scattering, as shown in 1928 by C. V. Raman in Calcutta.

Perhaps the most remarkable offspringof these experiments was the postulation of particle waves in 1924 by Louis de Broglie of France, who considered that if a photon which has demonstrable wave properties can also show such ballistic properties, a "particle" (such as an electron, proton, neutron, etc.) may show wave properties. This extension of the dual nature of wave and corpuscle in radiation'to a similar duality in particles produced extensive results in both theory and experiment. The wave mechanics which sprang from it are described below. Diffraction effects for electrons (C. J. Davisson and L. H. Germer of the U.S., G. P. Thomson of England, S. Kikuchi of Japan), for protons (O. Stern, then at Hamburg) and for neutrons (E. O. Wollan and C. G. Shull of Oak Ridge, Tenn.) showed the experimental validity of De Broglie's bold suggestion. This is an example of what may be called reversibility of effects, a viewpoint or policy of investigation that has frequently guided physicists to the discovery of converse effects.

The final item under radiation is a brief examination of cosmic radiation — a mixture of electromagnetic radiation and swift particles. The study of cosmic radiation resulted in fruitful by-products that were not expected when it began. In an effort to trace the cause of leakage of electric charge in a well-insulated electroscope, first J. C. McLennan of Canada, then Millikan, following the earlier experiments of V. F. Hess of Austria, sent electroscopes aloft in balloons and verified Hess's discovery that, contrary to expectation, the leakage increased with elevation. This suggested a source of ionization high in the atmosphere; and as subsequent world-wide observation showed, the radiation causing the ionization was entering from beyond the earth and was not intimately connected with the sun, as shown by lack of pronounced day and night or seasonal variations. The origin of these rays called cosmic (so named by Marie Curie of France) is not known, but they appear to be due primarily to very high-energy atomic particles (*e.g.*, protons) which in turn may generate electromagnetic waves and mesons when they collide with atoms high in the atmosphere. The energy of the primary particles is great, often in excess of 10^{18} electron volts (ev).

Directly from cosmic ray studies came the detection by Carl D. Anderson at Pasadena, Calif., of the positron or positively charged electron (1932) and of mesons (Anderson and S. H. Neddermeyer). Electron-positron pair formation was also observed as important evidence that radiant energy could be converted back into mass with conservation of mass-energy. Physicists learned to copy nature by bringing high-energy reactions under laboratory control. These efforts surpassed the most energetic reactions of natural radioactivity but they still fell far short of the more energetic cosmic ray effects. The laboratory generation of mesons and of antiprotons (negatively charged protons) were among

the successes achieved by laboratory means. Cosmic rays offered a stern challenge to the experimenter to devise means for measuring energy bundles far greater than those encountered earlier, and means for differentiating between photons and energetic particles moving near the speed of light and made massive by their enormous energies according to the $E = mc^2$ relation.

Atomic **and** Nuclear Structure. — It has been seen how the discovery of the electron and the pursuit of spectroscopic knowledge led to the idea of specific energy levels characteristic of atoms. This section first looks further into electronic structure, then more deeply into nuclear structure as represented by radioactivity, natural and induced, and by isotopes and nuclear reactions; it concludes with a resumé of the "particles" of physics.

Additional evidence other than spectroscopic for electronic energy levels came in 1913 from the study of excitation and ionization potentials by electron bombardment (J. Franck and G. Hertz, then of Berlin), wherein atoms were shown to receive energy in inelastic collisions. The ionization potential of an atom (expressed in electron volts) indicates the minimum energy which must be given to the least tightly bound electron to extract it completely. It is greatest (24.5 ev) for helium and least for the alkali metals (*e.g.,* cesium, 3.87 ev). Electrons may likewise be removed by the absorption of photon energy of suitable magnitude, as in X-ray absorption. Studies of these effects contributed much to the allocation of electrons to specified shells as described below.

For many elements: further ionization potentials were known, signifying the energies required to extract the second, third, etc., electrons from an atom. The chemical inertness of the noble gases —helium 2, neon 10, argon 18, krypton 36, xenon 54 and radon 86 —and the chemical activity of the alkali metals next above them in the periodic table of the elements — lithium 3, sodium 11, potassium 19, rubidium 37, cesium 55 and francium 87 (the last not as fully studied as the others since no stable isotope had been found) — were suggestive of the part played by electrons in the chemical bond, a matter pursued by Linus C. Pauling of Pasadena, Calif., and others. The inert gases were regarded as important division points in the periodic system where successive electronic shells become filled and atoms become electronically "satisfied." These shells took their designation from the underlying similarity of X-ray spectra which arise from the disturbance of inner .electrons. being in order from the nucleus outward called K, L, M, N, O and P. The number of electrons in successive completed shells is 2, 8. 18, 32. 18 and 8, which were the same numbers "allowed" by detailed application of a principle stated by the Austrian-born physicist Wolfgang Pauli (then of Ziirich), that no two electrons are to be described by the same set of quantum numbers. The elements next above each of the noble gases have one additional electron, called a valence electron, which apparently plays the major role in their chemical behaviour. (For a fuller explanation of electron structure, see SPECTROSCOPY and SPECTROSCOPY, X-RAY.)

Looking beyond the electron configuration, it has been seen how Rutherford discovered the atomic nucleus by alpha particle scattering. To examine nuclear structure, radioactivity and some of the ideas that have stemmed from it should first be considered. Radium. the classic example of an unstable element, spontaneously gives off swift alpha particles and becomes a new element, radon or radium emanation, element number 86 and the heaviest of the noble gases. Rutherford identified the alpha particle as the nucleus of the helium atom of mass 4 and charge $+2e$, designated ${}_2\mathrm{H}^4$. Hence, its ejection from the nucleus transfers radium from mass 226 to mass 222, and from atomic number 88 to 86, meaning that a neutral atom of radon would have 86 electrons distributed in six shells as follows: 2K, 8L, 18M. 32N, 180 and 8P. Some substances emit beta particles. identified as swift electrons. Loss of a beta particle from the nucleus enhances the net positive charge by one electronic unit and causes the substance to rise one in the scale of atomic numbers; but, as the electron is so light, no change in mass number is assigned.

Most radioactive substances also give off penetrating gamma rays, the more energetic, shorter nave length and higher frequency cousins of the X-ray, giving evidence of a settling down of the nucleus from an excited state [in the manner of electron settling in the emission of optical spectra, but with far greater energy). Much effort was spent in identifying distinct nuclear energy levels by gamma ray spectroscopy. Each of the 40 or more natural radioactive types was identified by the energy of the rays and particles emitted and by its half life; *i.e.,* the time in which half of its atoms transmute into some other type. Half lives range from a few ten millionths of a second to a few thousand million years. As the many radioactive species. generally grouped in four families springing from the slowly decaying ancestors — uranium, thorium, actinium and radium — must all find their places within a range of atomic numbers from 94 to 82, it became evident that there was a crowding of atoms of different atomic weight in the same positions in the table. Thus arose the concept of isotopes; *i.e.,* atoms of different mass but of similar chemical nature and atomic number.

Isotopes were also found among nonradioactive elements throughout the periodic table, starting with the discovery by J. J. Thomson (1913) of isotopes of neon and chlorine. Thomson demonstrated that the chemical atomic weights of neon (20.2) and of chlorine (35.46) were the result of mechanical mixtures of isotopes with atomic weights of 20 and 22 in the case of neon, and 35 and 37 in the case of chlorine. From this sprang much activity in the field of mass spectroscopy with F. W. Aston of England and A. J. Dempster, K. T. Bainbridge, A. O. Nier and M. G. Inghram of the U.S. as major contributors. One importance of mass spectroscopy lies in its usefulness in finding increasingly precise values of atomic masses, information important in the detailed balancing of energy in nuclear equations.

An important conclusion could be drawn from the precise knowledge of atomic masses as supplied by mass spectroscopy; namely, evidence of the binding energies of the atomic nucleus. This evidence appeared first in Aston's so-called packing fraction curve which demonstrated a decrease in mass among atoms of progressively higher atomic number if they were considered to be made up of protons (and, later, neutrons). For example, if 16 protons (or their equivalent in mass) were to unite to form one oxygen atom (mass 16.000 as the basis of the atomic mass scale) there would result a decrease in mass of 0.128 atomic mass units, equivalent to a decrease in energy of 120 Mev (million electron volts). Energy of this amount may be considered to have been released on formation as kinetic energy and gamma radiation; and a similar amount would be required to restore the oxygen atom to its original constituent particles. now' regarded as eight neutrons and eight protons. The implications of Aston's curve were clear: among the lighter elements, consolidation (fusion) would lead to significant energy release; as also among the heaviest elements, splitting into smaller components (fission) would release energy. Both of these effects were shown to exist in the large scale release of nuclear energy.

The discovery in 1919. by Rutherford, Sir James Chadwick and Sir Charles D. Ellis of Cambridge, Eng., of the ejection of protons (hydrogen nuclei) from nitrogen atoms when bombarded with alpha particles led directly into a vast region of nuclear physics and chemistry somewhat indicated by Aston's curve. The equation of this first observed nuclear reaction is worthy of examination:

$$ {}_2\mathrm{He}^4 + {}_7\mathrm{N}^{14} \rightarrow {}_8\mathrm{O}^{17} + {}_1\mathrm{H}^1 + Q. $$

Subscripts designate atomic numbers, superscripts show mass numbers on the basis of oxygen 16; Q represents energy change on the mass-energy basis. In this case a net decrease of mass of 0.0082 atomic mass units signifies an increase of kinetic energy of 7 6 Mev. so the reaction is exothermic and releases energy.

Another important reaction which proved to be the key to countless others nas that accompanying the discovery of the neutron (q v.) by Chadwick (1932) while he was attempting to interpret the strange effects reported by W. Bothe and H Becker of Germany and by Frédéric and Irene Joliot-Curie at Paris. In these experiments. alpha particles striking beryllium were found to eject radiation of great penetrating poner. Chadnick shoned by the recoil ejection of protons when struck by this radiation

that, by postulating a new particle with no electric charge but with mass comparable with that of the proton, all observed effects could be accounted for.

The equation for the reaction was:

$$2He^4 + {}_4Be^9 \rightarrow {}_6C^{12} + on' + Q \text{ (where Q is 5.6 Mev)}$$

There also had been success in causing nuclear disintegrations by high-energy protons, as in the work of the physicists Sir J. D. Cockcroft of England and E. T. S. Walton of Ireland, high energy being needed to cause the proton to overcome the electrostatic repulsion of the bombarded nucleus. Neutrons do not encounter adverse electrostatic repulsion as protons do; hence they can drift into nuclei even at low speed and upon entry they can bring about hundreds of nuclear reactions, as was early shown by Enrico Fermi and his collaborators in Rome, by the Joliot-Curies and by others.

A further outcome of alpha particle (and later neutron) bombardment was the discovery of induced or artificial radioactivity, or the ability to render nuclei unstable and truly radioactive by bombardment. The original experiment was performed by the Joliot-Curies (1934). who bombarded aluminum with alpha rays and found a reaction as follows:

$$_2He^4 + {}_{13}Al^{27} \rightarrow {}_{15}P^{30*} + {}_0n^1 \rightarrow {}_{14}Si^{30} + {}_1e^0$$

Here P* indicates radiophosphorus which decays with half life of 195 sec. into silicon. with the ejection of a positron, designated ${}_1e^0$ to indicate unit positive charge but negligible mass. As a result of this initial observation, and the subsequent discovery of neutron-produced types. many hundreds of radioactive tracer elements became available for experimental work in medicine, agriculture. biology and chemistry. The particular virtue of radioactive tracer atoms is that chemically they are indistinguishable from normal atoms. pet their presence can be detected by radiation counters. (See *Instrumentation* below.)

The finding of the neutron simplified the concepts of nuclear structure, as only protons and neutrons were needed to satisfy theoretical requirements. The possibility of electrons in the nucleus could be dismissed on theoretical grounds by Heisenberg's principle of uncertainty, as they are too big to fit into the small space afforded. The ejection of beta particles from the nucleus was regarded as resulting from the formation of the electron at the instant of ejection when a neutron turns into a proton; similarly, positron emission was evidence of a proton becoming a neutron.

The neutron also played a prominent part in the release of nuclear energy from uranium and plutonium by the process called fission. with explosive violence in the nuclear bomb or at a slower, controlled rate in the nuclear power reactor. Slow neutrons caught by U^{235} or by Pu^{239} caused these atoms to split into fission fragments of intermediate atomic mass with a large release of energy. At the same time, additional neutrons were released and were able to produce new fissions in available material in a self-sustaining reaction.

Three fundamental stable particles sufficed for the rudimentary structure of the atom. For any given type of atom of mass A (basis oxygen 16) and atomic number Z, commonly accepted views called simply for a nucleus composed of Z protons and N neutrons so that $Z + N = A$. There were also required in a neutral atom Z electrons to balance the nuclear charge $+Ze$. Neutrons which when free are radioactive with a half life of about 13 min. are. for some unknown reason, stable when bound in the nucleus. Photons may be regarded as particles of zero rest mass which act as carriers of bundles of energy from atom to atom, existing only until their mission is accomplished. even though this may take millions of years. as in the case of stellar radiation. There are a number of other particles whose transitory existence was demonstrated in the late 1940s and 1950s. Neutrinos are ephemeral neutral particle? postulated as necessarily ejected in cases of beta particle emission and in meson disintegration. Were it not for the quite convincing experimental evidence of their existence by F. Reines and C. L. Cowan of Los Alamos, N.M., and others, one might regard neutrinos as the necessary but undetectable scapegoats whose subtle function was to permit the application of conservation of energy and momentum to atomic reactions.

A number of other particles of exceedingly transitory yet demonstrated existence were found in cosmic ray and high-energy accelerator research. but the function of most of these was not clearly understood in the years immediately following their discovery. Only the mesons seemed to serve in binding nuclei together in a way analogous to the binding of atoms into molecules by electronic forces. The catalog of particles with their masses given in terms of electron masses included neutrinos 0; positive and negative electrons 1; positive and negative m -mesons 207; positive, negative and neutral pi-mesons 270; neutral, negative and positive K-particles 966; neutrons. protons and antiprotons 1.837; neutral lambda particles 2,182. Those more massive than the neutron and proton are called hyperons. The antiproton generated by the bevatron and studied by Emilio Segrè and others at Berkeley, Calif., was the expected negative counterpart of the proton, just as the positron was anticipated by Dirac before its discovery by Anderson. *(See* PARTICLES, ELEMENTARY.) The phenomenon of positron-electron pair production requires gamma ray energy at least as great as the self-energy of two electrons, or 1.02 Mev. Antiproton-proton pair production requires 1,837 times this energy. When antiproton and proton meet they annihilate one another with liberation of their self-energy, as detected in numerous meson "stars" produced in photographic emulsions.

Solid State Physics. — Atomic physics proceeded most rapidly as it dealt with matter in a highly dispersed state; as in gases at low pressure. Matter in the solid state presented a challenge which was being met in experimental and theoretical studies of solids. Much data in this field was gathered through the years as useful engineering information on the elastic, thermal, electrical: magnetic and optical properties of materials. As the 20th century advanced, physics was attempting to explain these properties and hoped eventually to predict them from knowledge of atoms and their interactions. To this end, the tools of the physics laboratory were used to study crystal structure by X-ray and neutron diffraction, to create single crystals of very pure substances under carefully controlled conditions, to show the effects of small but controlled amounts of impurities on the properties of metals, and to seek the properties of plastics, ferrites and semiconductors. The knowledge of low-temperature performance of metals (near 0° K.), including the phenomenon of superconductivity, allowed an increasingly effective application of quantum mechanics to atomic and molecular aggregates.

Theory. — It is unlikely that physicists will rest from their labours so long as ignorance about the forces of nature remains. One of the major theoretical endeavours is to gain a more unified view of the several forces which exhibit themselves, as in the gravitational attraction between large masses even at very great distances; the magnetic and electrical forces evident between objects at distances from atomic to terrestrial; the molecular forces between atoms and molecules appreciable from 10^{-8} to 10^{-5} cm.; and the extremely strong but short-range forces which hold nuclear particles together, strong at 10^{-12} cm. but dwindling rapidly at greater distances. None of these forces is fully understood and even less is known of the relationship between them. For the binding of atoms into molecules. "electronic exchange" forces were postulated; for the binding of nucleons (protons and neutrons) in nuclei. "mesonic exchange" forces. By analogy. but with little experimental evidence for their existence, gravitons were postulated for gravitational forces.

Calculus and differential equations, ably assisted by more elementary mathematics and by vectors and matrices, may be said to be the mathematical language of physics. Newton is commonly regarded to share with the German mathematician G. W. Leibniz the invention of the calculus, a system of computation which he needed to solve in detail the problem of the gravitational attraction between two moving and approximately spherical bodies such as the sun and a planet. Differential equations were developed and applied with signal success to the formal growth of mechanics. wave motions and problems of the gravitational field. As electricity and magnetism developed experimentally, they were given

systematic treatment by Maxwell, who demonstrated the close relationship between electromagnetic phenomena and light. H. R. Hertz's discovery of electromagnetic waves based thereon led, through the engineering development of electronics, into the arts of radio, radar and television. Other major theoretical developments of the second half of the 19th century were thermodynamics and statistical mechanics. The first gave broad form to the relation of heat to other forms of energy and raised the principle of conservation of energy to a pinnacle; the second treated the mechanics of large numbers of particles and joined the mathematics of probability firmly with physical ideas, as in the kinetic theory of gases and, in the hands of J. Willard Gibbs of New Haven, Conn., extended thermodynamics to the field of chemistry.

Each new and promising burst of theoretical ideas was followed by a period of extended testing as these ideas were applied to a widening array of phenomena and, as usually happens, limitations were found at some point. Thus, thermodynamics reached a barrier when applied to the study of wave length distribution of radiant energy from hot bodies, a field for which it was hopefully deemed adequate. Only by Planck's drastic assumption of energy quanta (mentioned earlier in this article) was a satisfactory escape shown. This new theory soon established a domain of its own where it demonstrated its superiority over thermodynamics, as in explaining the photoelectric effect (Einstein); specific heats of solids and gases (Einstein, then of Berlin, F. A. Lindemann of England and P. J. W. Debye, then of Berlin); the early interpretation of spectra (Bohr and the German-born Arnold Sommerfeld); and the scattering of radiation by electrons (Compton). Again, discrepancies and new experimental evidences, particularly the demonstration of particle waves postulated by De Broglie, forced drastic modification in the earlier quantum ideas. There developed after 1925 the wave mechanics of Schrodinger, Heisenberg, Born and Dirac, augmented by the concepts of the spinning electron (the physicists S. A. Goudsmit and G. E. Uhlenbeck of the Netherlands), the exclusion principle (Pauli) and the uncertainty principle (Heisenberg).

The quantum mechanics demonstrated its right to displace earlier theories by its capacity to treat more accurately the evidence of spectroscopy, to recognize and utilize the wave-particle duality and to give a more complete explanation of radioactivity and nuclear structure than did its predecessors. Considerable success was attained in unifying the mechanics. electrodynamics and thermodynamics of 1890 and the quantum theory of 1920 (often called classical) into a more comprehensive body of theory that covered an array of physical phenomena including many not even known at the earlier dates. Foremost in this achievement were relativity, quantum mechanics and quantum electrodynamics. Physicists weathered a number of shocks occasioned by the proposal of drastic new ideas and the need to discard earlier formulations. For example, experiments performed in 1957 at Columbia university, the Institute for Advanced Study at Princeton, the U.S. bureau of standards and The University of Chicago raised serious reconsideration of the idea of "parity," an idea which previously had been accepted without question (see PARITY: LAW OF CONSERVATION OF). . It may be said that both theory and experiment proceeding alternately step by step usually maintain a healthy state of mutual stimulation, justifying the special faith of the scientist that if he can only find the right question to ask the answer will ultimately be forthcoming.

Instrumentation.— Experimentation requires careful observation and quantitative measurement, there being nothing entitled to the name of science unless facts determined by measurement and expressible by number or symbols thereof can be set down. This implies the use of apparatus designed to bring a phenomenon under control and instruments to measure the effects observed. Much of the progress in physics sprang from the development of meters and other devices to meet special needs. For example. vacuum pumps and high vacuum technique led to the industrial production of electronic tubes of many uses, especially in the field of communications. The cathode-ray tube, so useful in television, radar and a host of other applications requiring quick response for the study of rapidly changing phenomena, came directly from the tubes that J. J. Thomson used in his early experiments on the elm of electrons. already described. Electron optics, applied at first to the better focusing of electron beams, later found extensive use in the electron microscope, which surpassed by about 100 times the best optical microscope. The field of spectroscopy, with its triumphs in delineating atomic structure: made progress with the help of instruments of higher resolving power, especially when augmented by interferometers of the Fabry-Perot or Michelson type.

Mass spectroscopy progressed from the early mass spectrographs of Thomson and Aston to instruments of high resolving power by which the masses of isotopes could be compared with an accuracy of the order of 1 part in 10,000,000; and rare isotopes were found by even more sensitive means of detection. These instruments employed a combination of electrostatic and magnetic focusing whereby ions were sorted specifically according to their mass. They added a new element of precision to the determination of atomic weights and contributed directly to the experimental validation of the important $E = mc^2$ equation.

Through the design of ultra-high-frequency generators such as the klystron and magnetron. microwave radio (in the 10.000-megacycle region) became important in radar systems in World War II; and these generators afterward found use in the extension of spectroscopy into the 1.000 to 10,000 megacycle region where molecular absorption and magnetic resonance phenomena were studied.

With the rapid growth of interest in nuclear physics. instrumentation likewise grew. For generating high-energy atomic particles, two chief kinds of accelerators became important: those that applied high voltage directly and those that gave charged particles successive increments of energy. Of the first kind were the electrostatic generator of the C.S. physicist R. J. van de Graaff and the voltage multiplier of Cockroft and Walton. Examples of the second type were the linear accelerator and the cyclotron (E. O. Lawrence of Berkeley. Calif.) and its modifications—the synchrocyclotron, which extended the energy range by adjusting the period of acceleration of the ions to allow for relativity increase of mass with velocity; the cosmotron at Brookhaven National laboratory. Long Island, N.Y.; and the bevatron, the 6,000.000.000-ev accelerator. at Berkeley. The betatron of D. W. Kerst (University of Illinois. Urbana), an electromagnetic induction accelerator for electrons, was successfully employed for generating electron and X-ray energies approaching 500,000,000 ev.

From its early function of producing nuclear fuels for explosive bombs, the nuclear "pile" or reactor came to be used as a power reactor in which nuclear fuels (uranium and plutonium) replaced coal and oil in the production of power and as an experimental reactor in which the dense flux of neutrons was employed for producing nuclear reactions in substances exposed therein and from which neutron beams could emerge for experimental uses.

The need for detection of nuclear particles led to the development of several important tools. Basically. detection was by photographic means. as in the original discovery of radioactivity by Becquerel, or by means of ionization effects produced by penetrating radiations and swift particles, as in the case of electrometers. ionization chambers, Geiger-Müller tube counters and the Wilson cloud chamber. In the last named, a combination of photography and ionization made possible the recording of evidence of the passage of swift particles, since they leave visible paths due to fog particles formed on ions which they produce in passing.

Four significant improvements on the original cloud chamber techniques of Wilson increased the chamber's effectiveness as a research tool: the use of magnetic fields to deflect charged particles and enhance the ability to identify them as to charge and momentum; the use of Geiger-Müller counters to control the chamber so as to photograph only those events for which the "trap is set"; the introduction of sheets of absorbing material, such as lead. within the chamber to study the penetrating properties of cosmic ray particles; and the modification of the chamber to the so-called bubble chamber in which ion paths were produced in liquid hydrogen near its boiling point. The bubble chamber, by the greater density of the medium in which tracks were formed. allowed a kind of compacting of the evidence into smaller space, a feature highly desirable in studying interactions of the very short-lived mesons with

matter *(see* BUBBLE CHAMBER; CLOUD CHAMBERS).

Electronic circuitry added much to the flexibility of the Geiger-Müller counter as an instrument for particle detection, inasmuch as automatic counting at high rates was made possible and the counters could be connected to detect simultaneous events (coincidence counting) or to reject such events (anticoincidence). By treating the walls of the counter with a suitable material, or by introducing a suitable gas, such as boron trifluoride, a counter could be rendered sensitive to neutrons which by themselves leave no tracks and produce no ionization. The technique of employing photographic emulsions for the detection of nuclear reactions was, in a sense, an extension of the cloud chamber, inasmuch as ion tracks were permanently registered directly in the prepared emulsion. These could be studied at leisure under the microscope. thus bringing into the space of a few millimetres or centimetres the whole history of nuclear events caused by energetic cosmic ray particles or the mutual annihilation of positive and negative particles. *See* NUCLEAR INSTRUMENTS; *see* also Index references under "Physics: General Survey" in vol. 24. (R. M. SN.)

PHYSIOCRATIC SCHOOL, a group of French political economists in the second half of the 18th century. Physiocracy (Greek *phusis*, nature. *kratein*, to rule) denoted the rule of nature; and the physiocrats envisaged a society in which natural economic and moral laws should have full play and in which positive law should be in harmony with natural law. They also pictured a predominantly agricultural society and therefore attacked mercantilism not only for its mass of economic regulations but also for its emphasis on manufactures and foreign trade. Whereas mercantilists held that each nation must regulate trade and manufacture to increase its wealth and power. the physiocrats contended that labour, trade and commerce should be freed from all restraint. Again, whereas mercantilists claimed that coin and bullion were the essence of wealth, the physiocrats asserted that wealth consisted solely of the products of the soil.

The origins of these ideas may be traced in numerous works, in France and in England, from the end of the 17th century; but the so-called Physiocratic school was founded by François Quesnay (*q.v.;* 1694–1774), a court physician. Despite a long residence at Versailles, Quesnay remained a countryman at heart. and his economic ideas were coloured by his early studies of Aristotle and Thomas Xquinas. Shortly after 1750 his rooms at the *Entresol* at Versailles became the meeting place of persons interested in economic and administrative problems. Among them was J. C. M. Vincent de Gournay (1712–59), but although this economist influenced Quesnay. he himself was never a physiocrat. Quesnay's first important disciple was Victor Riqueti de Mirabeau (1715–89), the author of *L'Ami des hommes* (1756, etc.), whom in 1757 Quesnay sought out and whom he convinced of his error in making population the source of wealth and in adopting too freely ideas from R. Cantillon's *Essai sur la nature du commerce* (1755). Mirabeau's admiration for Quesnay increased when he read the *Tableau économique,* which Quesnay had written for Louis XV in 1758. This work demonstrated. by happily chosen figures. the economic relationship between a workshop and a farm and purported to prove that the farm alone added to a nation's wealth. In 1; 59 Mirabeau published his *Explication du Tableau économique,* which was followed by his *Théorie de l'impôt* (1760) and *Philosophie rurale* (1763). These three works were an elaboration of Quesnay's theories. In 1763 the young Pierre Samuel du Pont de Nemours (*q.v.;* 1739–1817) came to Quesnay's notice, and it is this event that marks the real beginning of the Physiocratic school, which was joined. among others, by P. P. le Mercier de la Riviere (1719–92), G. F. le Trosne (1728–80), the *abbé* Nicolas Baudeau (1730–92) and the *abbe'* P. J. *A.* Roubaud (1730–91). As editor of the *Gazette du commerce,* Roubaud gave publicity to Quesnay's ideas. Baudeau controlled the *Ephémérides du citoyen* and. from 1766. put that journal entirely at the disposal of the school. which not only was supported by a faction at the court but also had provincial branches in certain of the societies of agriculture. Du Pont became virtually a party secretary. In 1767 he published under the title of *La Physiocratie* a collection of Quesnay's writings. This is the origin of the term "physiocracy," but Quesnay's following continued to call themselves *économistes,* the less ambiguous designation *physiocrates* not becoming current until the 19th century.

By 1768 the Physiocratic school was in decline. In 1774, however, shortly before Quesnay died, the hopes of both school and party were raised by the appointment of A. R. J. Turgot (*q.v.*) as comptroller general. Turgot himself was not a physiocrat; though he had affinities with the school, he was as much Gournay's disciple as Quesnay's and, like Gournay, did not accept the physiocratic thesis that industry was sterile. Nevertheless, the physiocrats rallied round him. But the enthusiasm of Turgot's supporters and a spate of physiocratic polemics in 1775 served only to give weight to the accusation that the government was in the hands of theorists. Turgot was dismissed in 1776 and the leading physiocrats were exiled; but Baudeau subsequently revived the school and kept it going till 1781.

Legal Despotism. — Like Pierre le Pesant de Boisguillebert (1646–1714), who had attacked J. B. Colbert's mercantilism, the physiocrats advocated the establishment of an *ordre naturel* in place of the existing order, which, they claimed. violated both the physical and the moral laws of the *jus naturale*. Society, they held, was a contractual union, not necessarily of equals in all respects, but of individuals who at least possessed equal natural rights and who by nature followed their own interests. These individual interests were, for the most part, identified in a natural way and led to no clash; but where the natural harmony was not possible. interests must be identified artificially — that is to say, by the action of government. Government, like society. they believed to rest upon consent; but as they considered it easier to enlighten the one than the many. they did not develop the democratic implicatians of their political theory but pronounced for enlightened despotism or, as they termed it, legal despotism.

Like many 18th-century thinkers, they were more concerned with the scope than with the machinery or form of government. They contended that the field of governmental action should be drastically reduced but that, where action was necessary. the government should act firmly, overriding sectional and perverted interests and enabling the laws of nature to prevail.

Produit **Net** and **Impôt** Unique. — Of all the natural physical laws none was more vital to physiocratic theory than that which pointed to the soil as being the unique source of wealth. Manufactures were useful, even necessary; but they merely gave natural wealth or materials a different shape. Manufacture did indeed raise the price of a commodity, but such an addition was merely the equivalent of the consumption of the manufacturer and not an increase in intrinsic value. Similarly, commerce merely circulated goods and products and made no addition to their value. Only where the merchant exported an unwanted surplus of agricultural products did he add to a nation's wealth. Had the physiocrats pondered more on this admission they might have been led, like Turgot, toward the problem of exchange value; but they did not conceive of an unwanted surplus as normal or as a likely development in agriculture. and they therefore remained steadfast in their belief that the soil alone yields a clear profit (*produit net),* or the gift of nature that remains after the cultivators have deducted from the yield their cost of living and have put by the seed for the next sowing. In his revised *Tableau économique* of 1766, Quesnay attempted to illustrate the *produit net* on a national scale. He assumes a nation of 30,000,000 people, one-half of them being producers, one-quarter being proprietors and the remainder belonging to what he calls the sterile classes. The total money in the country is 3,000,000,000; of this, 2.000.000.000 is in the possession of the producers and 1,000.000.000 is in the hands of the sterile classes. With their 2,000,000,000 the producers get a return to the value of 5,000,000,000. Of this. 1,000,000,000 goes to replenish their fixed capital and 2,000.000,000 goes as *produit net* to the landlords. who exchange 1,000.000.000 for agricultural products and 1,000,000,000 for manufactured goods. The sterile classes obtain food and ran. materials to the value of 2,000,000,000 and receive from the cultivators 1.000.000.000 in return for manufactured goods. This simplified picture ignored many of the features and the developments of the contemporary economic

structure. It is moreover very obscure: it omits all mention of the consumption of manufactured goods by the manufacturing classes; it fails to explain how the sterile class obtains its capital; and it merely assumes and does not prove that the proprietors received the so-called *produit net*. But granted that assumption, it mas logical to propose a single tax, the *impôt unique,* levied solely on the proprietors of land.

Place of **Physiocracy** in Economic Thought. — Given their assumptions and the social system that they desired, the physiocrats were logical and systematic. What they did was to rationalize medieval economic ideals, employing to that end the more modern philosophical and scientific methods. They asserted in a general way that prices were determined by cost of production and by supply and demand; but they assumed that there was a constant fair price (*bon prix*) which obtained under a regime of free trade. On the other hand, they claimed that government should fix the rate of interest. Again, they glorified tillage and lauded the cultivators but assigned the *produit net* to the landlords. The land tax established by the constituent assembly on Dec. 1, 1790, followed physiocratic precepts; but the issue of assignats or paper money in April 1790 ignored their theory of wealth. Indeed, this last theory soon ceased to hold respect.

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PHYSIOGNOMY, a pseudoscience dealing with personality traits supposedly revealed by facial features or by body structure and form.

Aristotle wrote the first systematic treatise on physiognomy; the chief basis of his work. as well as of subsequent works, was analogical reasoning. Temperamental characteristics known to be possessed by different kinds of animals are thought also to be possessed by persons who have facial features resembling particular animals; *e.g.*, bulldog jaw = tenacity.

The 20th century is characterized by quantitative studies of the validity of general and specific physiognomic principles and generalizations. Sir Charles Goring published his monumental study of the Lombrosian system of criminal anthropology which demonstrated criminological physiognomy to be fallacious (*see* CRIMINOLOGY); Harry L. Hollingworth summarized many experiments and found little relation between physiognomic measurements and psychological traits; Donald G. Paterson in 1930 published an evaluation of studies made during the preceding 40 years which revealed a consistent trend of negative results.

Body build as a subdivision of physiognomy has persisted from the time of Hippocrates (450 B.C.) as having medical significance. Verification of the medical significance of differences in body build has been established. but Ernst Kretschmer's attempt (1925) to create a morphological basis for psychiatric diagnosis and classification did not meet with widespread acceptance in the United States.

Physiognomic claims are hard to kill. however. as shown by the constant revival of old beliefs or the creation of new beliefs and systems. An attitude of suspended judgment is indicated for the work of W. H. Sheldon in this field. beginning in 1940 (*see* PERSONALITY: *Theories* of *Physical Types*). Eventually science may unlock the secrets of human character and personality by the codisciplinary study of the same individuals by specialists in human genetics. biochemistry and psychology.

BIBLIOGRAPHY.—The most elaborate development of the subject of physiognomy is contained in John Kaspar Lavater, *Essays on Physiognomy,* Eng. trans. by T. Holcroft, 4 vol. (1804). *See* also Aristotle, *History of Animals and a Treatise on Physiognomy,* Eng. trans. by T. Taylor (1809); Sir Charles Goring, *The English Convict* (191.3); H. L. Hollingmorth, *Judging Human Character* (1922); *D.* G. Paterson, *Physique and Intellect* (1930); George Draper, *Human Constitution* (1924); G. Draper, C. W. Dupertuis and J. L. Caughey, *Human Constitution iiz Clinical Medicine* (1944); Anne Anastasi, *Differential Psychology,* 3rd ed. (1958); W. H. Sheldon, S. S. Stevens and W. B. Tucker, *Varieties of Human Physique* (1940); *W.* H. Sheldon and S. S. Stevens, *Varieties of Temperament* (1942); *R.* J. Williams, *Biochemical Individuality* (1956). (*D.* G. P.)

PHYSIOLOGICAL CHEMISTRY: *see* BIOCHEMISTRY.

PHYSIOLOGICAL PSYCHOLOGY: *see* PSYCHOLOGY.

PHYSIOLOGY (ARTICLES ON). The functions that characterize living organisms in general and the major divisions of the science devoted to their study are outlined in PHYSIOLOGY. This general survey is supplemented by PHYSIOLOGY, COMPARATIVE which discusses the tracing of relationships between different organisms through functional similarities.

Physiology is discussed in relation to various broad fields of biology in such articles as CYTOLOGY; EMBRYOLOGY; ENDOCRINOLOGY; HISTOLOGY; NEUROLOGY, COMPARATIVE, etc. Special applications of physiology in the plant kingdom are treated in the section on physiology in BOTANY and in PLANTS AKD PLANT SCIENCE: *Plant Physiology.*

Articles on bodilv functions include CIRCULATION OF BLOOD: DIGESTION; HEART, COMPARATIVE PHYSIOLOGY OF; REPRODUCTIOK; RESPIRATION; SLEEP, etc. Also, many articles on components of the body deal with anatomy and physiology; *i.e.,* BONE; BRAIN; GASTROINTESTINAL TRACT: MCSCLE AND MUSCULAR SYSTEM; REPRODUCTIVE SYSTEM; SPINAL CORD, etc. The physiology, as well as the anatomy, of old age is discussed in DEATH, BIOLOGICAL ASPECTS OF and GERONTOLOGY AND GERIATRICS.

Hereditary aspects of physiology are treated in the context of evolution in GENETICS: *Physiological Genetics;* environmental factors in ECOLOGY, ANIMAL and PLANTS AND PLANT SCIENCE: *Plant Ecology.* Background material pertaining to both sets of factors will be found in EVOLUTION, ORGANIC; MAN, EVOLUTION OF; and SELECTIOX.

Nerves and other excitable tissues require a minimum stimulus for excitation. but n-hen this is produced the response is always one of maximum individual capacity; this principle is discussed in ALL-OR-NONE LAW. Additional articles containing discussions of the physiology of sensory phenomena include HEARING; NERVE CONDUCTION; OLFACTORY SYSTEM; PAIN; SENSATION; SKIN, SENSORY FUNCTIONS OF; SMELL AND TASTE; TOUCH, SENSE OF; VISION, etc. EMOTION includes discussions of the physiological aspects of emotional states.

All physiological processes involve the physics or chemistry of biological tissues which are composed of the same atomic building-blocks as inanimate matter. Sciences related to these studies are outlined in BIOCHEMISTRY and BIOPHYSICS.

Among additional articles and sections of articles contributing important insights are ANATOMY, GROSS; ANATOMY, MICROSCOPIC; ANIMAL EXPERIMENTATION: BIOLOGY: *Physiology;* MEDICAL RESEARCH: *Physiology;* and MEDICINE: *Applied Physiology and Biochemistry.*

The work of such great exponents of the science as Galen, Liebig, Harvey, etc., is summarized in biographical articles.

Many topics not represented by separate articles are treated in articles on broad areas of biology. Also, special aspects of a subject may be discussed in several articles. For example, the All-Or-None law is treated not only under that title but also in sections of CIRCULATION OF BLOOD; HEART, COMPARATIVE PHYSIOLOGY OF; and MUSCLE AND MUSCULAR SYSTEM. For comprehensive information on any topic. the Index should he consulted.

PHYSIOLOGY is that branch of the study of plants and animals (biological science) which concerns itself with the ways in which these living organisms carry out the various processes necessary to life. Among biologists it is common to say that "physiology is the study of function." This is a way of saying that physiologists ask about an organism. "What makes it work?" "What does a heart (or a liver or a kidney) do and how does it do it?" "How does an amoeba move or a muscle lift a n-eight?" These and a multitude of other questions the physiologist asks and seeks to answer.

This article seeks merely to state in some detail what physiology is as a science. to state the problems with which a physiologist is properly concerned, to outline some of the methods by which a physiologist approaches the solution to these problems and to state in general terms the things organisms do and how they do them. No attempt is made to describe in detail the functions of individual organisms, of organs of which they are made up or of individual cells which in turn make up the organs. These are described elsewhere. *See* PHYSIOLOGY (ARTICLES ON).

Scope of **Physiology.**—Physiologists as a group have as objects of interest the vast variety of living organisms ranging from single-celled organisms such as bacteria. protozoa. algae. etc., through the multicellular animals and plants. Since the things done by the organism as a whole, the roles of individual organs and even the contributions made by cells or parts of cells (*e.g.*, the cell surface, the nucleus, mitochondria. etc.) may be studied. the boundaries of physiology may he said to be virtually limitless. With so many objects and processes for study it is not surprising that specialization has occurred among physiologists and that subfields bearing names indicative of the interest of the workers therein have arisen. Thus there is human physiology. which deals with functions in man, and this may he further subdivided into neurophysiology (functioning of the nervous system). cardiovascular physiology (heart and blood vessels). etc. Plant physiology and other comprehensive major fields have similar subdivisions.

Some physiologists are concerned n-ith similarities and differences between the methods used by various organisms to solve the problems of existence. This branch is known as comparative physiology (*sre* PHYSIOLOGY, COMPARATIVE). Closely allied to this is a branch which seeks to integrate the findings of all the other branches into one coherent picture. Those having this catholicity of interest call themselves general physiologists.

In addition to all the above. virtually every other specialized field in the biological sciences. such as embryology, anatomy and pathology (*qq.v.*), is concerned with the physiological aspects of the phenomena of interest to it.

The above amounts to little more than naming the subdivisions of physiology, What questions and what investigations may a physiologist properly pursue? Let us take human physiology. We are conceived. we are born. we grow, live, love, beget offspring, work for a living. grow old and finally die. We have ideas and desires, converse. write books and lead an intellectual life which includes thinking about our relations to God and our fellow man. All these are things we do, but are they proper subjects for investigation by the physiologist? The answer is. "Not all of them. at least not now." The physiologist must be modest in his assault on the mysteries of nature. As stated before he asks questions such as "How does a muscle lift a weight?" "How does a kidney secrete urine?" "Why does one's heart beat. faster following exercise?" Such questions are amenable to experimental investigation in that single. possibly influential factors. such as temperature, magnitude of a weight, speed of lifting, etc., can be varied and rules deduced which permit predictions about what will happen in a given set of circumstances in the future. It may ultimately be possible to predict the most complex manifestations of human behaviour from an integration of a large number of these simpler findings.

Experimental Methods of Physiology.— If a person is presented with a complex thing. how is he to go about ascertaining what it does and how it does it? One way is simply to observe it grossly and see what It does. For example. it may move spontaneously. Alternatively it may move only if kicked, shocked with electricity, heated or otherwise stimulated. If it is desired to know more about how and why it does these things. it will help to know more about the parts which go to make up the machine. Some of these may in turn be complex; for example, the engine or gear box in an automobile.

Ultimately the investigator would like to know what the smallest parts are, what role they play in the substructures and what each of these contributes to functioning of the machine as a whole. He will want to know what the fuel or energy source is for work which is done. what kind of temperatures are attained, what kind of pressures can be exerted. etc. Also he will want to know how the whole machine integrates its activities, how messages are sent by one part to another or influence otherwise exerted.

The gross observational, descriptive phase of the study of the functioning of many (but far from all) living organisms has been carried very far. including description of the major role of individual organs. Thus it is known that in man the heart is a muscular pump which causes the blood to circulate through a closed system of tubes, the blood vessels; the kidneys secrete urine; the stomach digests food; etc. Modern physiologists are more concerned with a detailed understanding of the ways in which these over-all processes are accomplished and controlled, the role of the different kinds of cells which make up the organ and the exact chemical and physical processes which contribute to the final result.

How does the physiologist go about establishing the function of a part of an organism? One obvious method is to remove the part and see nhat deficiency. if any. the organism suffers as a result of the removal. In some cases removal may be fatal, and the investigator cannot observe the organism long enough to learn much. Less drastically. chemical (*e.g.*, drugs) or physical (*e.g.*, clamping off a blood vessel) means of temporarily handicapping the part may be found. Still less drastically, the investigator may induce a change in the degree of a particular activity and see what organ (or part of an organ) increases or decreases its own activity in parallel with the change. In favourable instances a part may be removed and its role taken over by some mechanical device; for example, a heart may be replaced by a mechanical pump. Alternatively, giving certain chemical substances to an organism may compensate for removal of an organ; *e.g.*, the hormone thyroxine may be taken by mouth to compensate for removal of the thyroid gland. Organs having several functions may require. in compensation for their removal, complex measures. Thus the giving of the hormone insulin can compensate only in part for the removal of the pancreas of an animal. The utilization of sugar may be regulated. but other measures are required to compensate for the loss of substances normally produced by the pancreas which assist in the digestion of food. In summary, much that has been learned and is being learned in physiology depends on observation of the changes which take place when the activities of the organism are disturbed.

To assist him in inducing these changes and in observing them, the physiologist uses instruments for controlling and measuring temperatures. pressures, electrical potentials and currents. acidity or alkalinity. oxygen consumption, etc. To visualize the parts he is studying he may use the unaided eye for gross structures, the ordinary microscope for cells and their parts, or the electron microscope for very small cells and the fine structure of cells. Hardly an instrument is invented for producing, measuring or recording a physical or chemical change which does not find a use in the hands of the physiologist.

Characteristics of Living Organisms.— When we look around us and see the vast variety of things which me are willing to accept as living organisms. the thing which almost invariably impresses us is their diversity of form and activity. A plant has no legs, lungs or liver. An animal has no leaves or roots. Even among those things we call "animal" there are great differences in structure and gross activity. Must there be a separate science of physiology for each kind of living thing? In detail. yes, hut if we look at the broad outlines, the kinds of things organisms do, we find surprising similarities which may in a sense be taken as a definition of a living organism. Living organisms arc discrete from their environment and differ from it in chemical composition. They are forced to make exchanges of materials with the environment but manage to maintain enough control over the exchange so as to retain their structure and composition. They metabolize; *i.e.*, burn or degrade some materials to ohtain energy for growth, activity and repair of the living machinery. They reproduce themselves in kind, co-ordinate the activities of their various parts and manage to adjust to the nature of and changes in their environnient. These characteristics are discussed more fully in the following sections. Admitting that not all living organisms at

all times have all these characteristics (though exceptions are rare), we shall outline them, for it is within this context that the physiologist works.

Discontinuity From the Environment. — Living organisms are obviously different from the region which surrounds them. That is, they are made up in part of chemical compounds, such as proteins, nucleic acids, etc., which do not normally exist in this surrounding region called the environment. Furthermore the organism consists of a cell or group of cells each of which is surrounded by a membrane or cell surface. Within this cell surface the watery solution called protoplasm usually has a chemical composition quite different from the environment. This is true not only about proteins, fats, carbohydrates, etc., but even about the ions of simple salts. Some of these. such as sodium and chloride ions, though plentiful in the environment, may be virtually absent from the cell interiors. Others, such as potassium ions, may be accumulated by the cells so that the concentration inside is much greater (perhaps twentyfold) than that in the environment. The existence of organized structures and the differences in chemical composition between the organism and the environment represent work done by the organism.

It may be said that one of the characteristics of a living organism is that it exists as a discontinuity or inhomogeneity in the environment.

Exchanges With the Environment. — Mere existence as an inhomogeneity in the environment is not enough to distinguish a living organism. A lump of coal, a piece of wood or a complex machine has the same attribute. However. such inanimate things, once established, continue to exist with a given allotment of materials. Living organisms. on the other hand, maintain their structure in spite of changes in the identity of the molecules of which they are made. This requires that the organism exert control over what comes in and what goes out.

The surfaces which cover individual cells, the linings of certain organs (*e.g.*, gut, lung, kidney) and sometimes the external coverings of multicellular organisms are semipermeable. This means that they permit some substances to cross them with relatively little difficulty; other materials. usually large molecules. cannot pass the barrier. The semipermeable membranes control qualitatively the kinds of material which pass the barrier. If this were the only control exerted, those materials which could pass would tend to come to equal concentration inside and outside the organism. Only continued production or consumption of a material could maintain a concentration difference. However, there is frequently superimposed on this passive penetration of the membranes an active pumping mechanism which can move materials from a region of low concentration to one of higher concentration. This. in principle, is like pumping water uphill and requires expenditure of energy on the part of the organism.

Man and most multicellular organisms have two environments, an external environment and an internal environment. The air or water that surrounds the organism as a whole and that may penetrate into the lungs and gut constitutes the external environment, and it is with this that exchanges ultimately take place. So far as most of the cells of the body are concerned, however, they are remote from this external environment. They are surrounded by the blood and tissue fluids, and so far as such cells are concerned this is their environment, and they make exchanges with it. This is the internal environment of the organism.

The major places at which exchanges with the external environment occur in the case of man are the lungs, gut and kidney, The skin also participates to some extent. The lungs, gut and kidney have two characteristics in common: (1) they have a very large surface area, and (2) these surfaces are in intimate contact with the finest branches of the blood vessels (capillaries). In the cases of the lung and kidney the large surface is achieved by many successive branchings of a tubular system. In the case of the gut, much of its wall is lined by a multitude of fine, fingerlike protrusions (villi). giving it a somewhat velvetlike surface. The small intestine alone exposes an area of about 10 sq.m. (more than five times the external body surface area). the lung 55 sq.m. of respiratory surface and the kidney about 6 sq.m. In a similar fashion other organisms provide large surfaces for exchange with the external environment; *e.g.,* gills in fishes and other aquatic organisms. leaves and roots in plants. So it may be said that a second characteristic of living organisms is that they are only semi-isolated from the environment and maintain their composition and structure in spite of the necessity for exchanges of material with the environment.

Metabolism. — The tasks of accumulating some materials and ejecting others, as well as such tasks as transporting food and wastes, moving, creating electrical potentials, growing, etc., require energy expenditure. Living organisms obtain this energy from materials called food. Food serves the dual purpose of (1) providing energy and (2) providing materials for growth (increase in mass) and maintenance or repair of the living machinery. Animals obtain energy by oxidizing food materials such as carbohydrates, fats and proteins or by breaking down molecules such as glucose into smaller ones such as lactic acid. These destructive (degradative) processes which provide energy are called catabolism. The building up of more complex molecules from simple ones (synthesis or growth) which requires energy is called anabolism. The sum total of anabolic and catabolic processes is called metabolism.

A few bacteria (known as autotrophic bacteria) obtain their energy for growth by oxidizing simple inorganic materials such as hydrogen, sulfur. iron. ammonia, nitrites, etc. The rest of the living kingdom must be supplied with food directly or indirectly by green plants which obtain from sunlight the energy necessary for synthesis.

With the exception of the green plants which in the light consume carbon dioxide and water while producing oxygen (*see* PHOTOSYNTHESIS), organisms (including green plants in the dark) manifest metabolism in one or more of several ways: (1) consumption of oxygen. (2) production of carbon dioxide or other oxidation product (*e.g.,* sulfuric acid from sulfur). (3) production of heat. (4) consumption of food materials. (j) production of incompletely broken-down fragments of food materials. If there is an excess of food over and above that needed for maintennnce and activity. then growth or fat deposition will occur. Chemical and physical methods of measuring these changes are used by the physiologist to establish the rate of metabolism.

It is well established that a given quantity of food burned in the body produces the same amount of heat as if it had been burned outside. A piece of bread burned by a chemist using a calorimeter produces the same number of calories as it would if it had been eaten and burned in the body. Further, the amounts of oxygen consumed and carbon dioxide produced are the same in both cases.

One common misconception regarding the results of metabolism of living organisms should be disposed of. This has to do with their anabolic accomplishments. Living organisms synthesize large molecules of bewildering complexity from simple materials. In this they superficially oppose the general tendency of the inanimate world to convert complex things into simple ones, indeed to convert any thing or condition from a high energy state to a lower energy state.

The point which must not be overlooked, however, is that while living organisms are carrying out these marvelous. energy-consuming syntheses. they are simultaneously degrading other food materials to obtain the requisite energy. Indeed. in growth as in other work processes the efficiency with which living organisms capture and use the energy theoretically available from the foodstuffs they degrade is usually less than 25% and may be less than 5%. Even in the animate world it has yet to be demonstrated that something can be got for nothing.

Elucidation of the precise details of the chemical reactions involved in metabolism lies in the province of biochemistry (*q.v.*). The physiologist, however, must keep abreast of biochemical findings and integrate them into the over-all picture of the functioning of living organisms. Fortunately it appears that not only the different tissues of a given organism, but virtually all organisms that have been studied. employ much the same over-all schemes of metabolism. Thus the chain of reactions by which a yeast cell

breaks down glucose to two molecules of ethyl alcohol is, except for the final few steps, the same as that used by a muscle cell in man to prepare the fragments of glucose for oxidation. Particular organisms or cell types may be capable of carrying out reactions unique to them — such as production of a hormone, a bacterial toxin or an enzyme; but this usually represents only a small fraction of their total metabolic effort and is of interest only in special connections.

While the biochemist studies the individual intermediary chemical reactions of anabolism and catabolism, frequently isolating single enzyme systems which perform only one chemical step, the physiologist is more likely to study the grosser manifestations of metabolism, such as total oxygen consumed by an organism, the carbon dioxide produced, the amount of heat produced, the weight gained or lost by an individual, the nitrogen excreted. etc. The effect of various activities such as sleeping, sitting at a desk and thinking, walking, doing hard physical labour, etc., on metabolism may be studied as well as disturbances of metabolism caused by diseases or the malfunction of an endocrine gland. An attempt is then made to interpret the findings in terms of known biochemical reactions.

Internal **Co-ordination** of **the** Organism. — A living organism consisting of many parts which may be physically remote from each other would not long survive if the activities of these parts were not co-ordinated. The price of specialization is dependence on others for performance of activities given up. The gain, if all goes well, is in terms of increased versatility, efficiency, power and elegance of performance for the organism as a whole. For all to go well there must be communication between parts, some means of delivering goods and messages. This is particularly true when the demands for material or service vary from time to time. The mechanisms by which living organisms accomplish this internal co-ordination of their parts are three: (1) a transport system, the circulatory system, which brings some materials to individual cells and carries away others, (2) a system of organs, the endocrine system, which sends chemical messengers (hormones) via the circulatory system to the various parts, and (3) a nervous system, which rapidly carries electrical (and, terminally, chemical) messages from one part to another.

Only in the smallest organisms and individual cells are the distances which separate the parts short enough to permit the random movements of molecules to transport materials and to equalize temperatures. Even in small cells (*e.g.*, protozoa, individual plant cells) a sort of internal stirring of the cytoplasm is resorted to, and a cyclic current in the protoplasm (cyclosis) serves as a primitive transport system. Larger organisms speed up the process of transport by means of a circulatory system. In animals this typically consists of a muscular pumping organ, the heart, which forces a fluid through a system of ramifying tubes the terminal branches of which lie in close proximity to the individual body cells. In plants, vascular bundles carry materials between roots, leaves and other tissues. Typically, in both plants and animals, the tubes of the circulatory system are separated from the body cells by the tissue fluid which surrounds cells. Materials move largely by diffusion from the cells to the tissue fluid to the circulating fluid and vice versa. The tissue fluid is specifically what was called above the internal environment; *i.e.*, the environment of the individual body cells.

Circulatory systems carry materials from regions where they are in large supply to regions where they are to be (1) immediately utilized, (2) stored or (3) eliminated. Thus oxygen may be picked up from lungs, gills or skin in various organisms. Food is picked up from the gut following digestion or from storage depots such as the liver (carbohydrate) or subcutaneous tissue (fat). These are delivered to the tissues. Conversely the wastes of metabolism are picked up from the tissues and delivered to the lung (carbon dioxide) or kidney (urea and various materials) for elimination. Temperature throughout the body is equalized and controlled by the blood's being warmed in rapidly metabolizing tissues and cooled at the body surface or by less rapidly metabolizing tissues.

In addition to food and wastes the circulatory system carries the chemical messengers called hormones throughout the body. These are produced in endocrine glands (also called ductless glands or glands of internal secretion) or, in some cases, by cells located in organs primarily devoted to other tasks. These hormones induce a new state of activity in some other tissue or organ. Depending on the nature of the hormone and on the nature of the receptor tissue, activity may be either stimulated or inhibited. Indeed a single hormone may cause opposite reactions in two different regions. Thus adrenaline causes constriction of the blood vessels of the skin and viscera while causing dilation of the blood vessels in the muscles. Since adrenaline is secreted in times of stress, the net result is to shift blood from tissues where it can be temporarily dispensed with to the tissues which may need an unusually great supply. The organism is prepared for "fight or flight."

Hormones are used for communication in the organism when time, in terms of a fraction of a second, is of no great importance. Thus the growth hormone secreted by the pituitary gland may as well accomplish its work a few hours from now as immediately. Contrast this with the speed required when a person touches a hot stove. Thousandths of a second are important, and, as seen below, the faster-communicating nervous system is utilized. On the other hand, the hormones can induce a long-continued response which, if the nervous system were required to produce it, would call for long-continued, repetitive stimulation.

Finally, with regard to hormonal control of bodily activities, we find a method utilized which has been called push-pull control. By this is meant that one hormone stimulates while another inhibits the activity of a tissue. This principle also is involved in the nervous system. The advantage gained is that of more precise and delicate control of activity. It is the same advantage that exists in a motorcar equipped with both an accelerator and brakes. Better speed control is obtained than would be possible with either alone.

Control by hormones has been compared with sending letters through the postal system; that is, a message involving a material thing is sent and goes relatively slowly. The nervous system might by similar analogy be compared with a telephone or telegraph system. Messages involving electrical transmission along specifically designed conducting strands are transmitted rapidly from point to specific point. These analogies will not hold up in detail, but they are grossly accurate. While it is true that an electrical impulse travels along a nerve fibre, at the terminus the final stimulation of the cell to be affected is probably accomplished by release of a chemical.

However they do it, nerves can carry messages several feet in a few thousandths of a second, whereas (in man) one complete circuit of the blood may require a minute. Thus hormonal messages, even if the hormone were instantaneously secreted, are bound to travel more slowly.

Most of the internal co-ordination in man and the higher vertebrates is accomplished by that part of the nervous system known as the autonomic nervous system. This system is autonomous in the sense that it is not under the control of the will. Indeed we are not conscious of its activities. However, our emotions may affect the autonomic nervous system, causing dilatation or constriction of the blood vessels, acceleration or deceleration of the heart, secretion of hormones, etc.

The autonomic system sends both stimulatory and inhibitory nerve fibres to many organs, thus providing for push-pull action and greater delicacy of control.

Homeostasis. — One of the achievements of the internal co-ordination of organisms is the maintenance of homeostasis; that is, a considerable constancy of conditions within the body. The mechanisms whereby constancy is maintained are called homeostatic mechanisms.

Many conditions in the body are so constant that minor departures from the normal can be used in the diagnosis of disease, at least if they persist. Thus, in man the body temperature, and in the blood the amount of sugar, the slight alkalinity, the concentration of various salts, the number of red or white cells, etc., are constant or vary only within narrow limits. By and large, it is the internal environment which is kept constant. Indirectly the

individual body cells are thus helped to have a constant composition and level of activity or, at least, to return quickly to normal if temporarily altered. Those who care to pursue the matter further should keep homeostasis in mind, particularly when reading about respiration, circulation, kidney function, endocrine organs and the nervous system.

Co-ordination With the Environment. — In addition to co-ordinating itself internally, an organism must adjust its activities in such a way as to take into account the nature of and changes in its environment. This involves the ability to sense the nature of the environment and detect changes in it. In some less specialized organisms this ability seems to be simply a general property of the individual cell, although even here there may be localized regions of the cell which are particularly sensitive to given stimuli (*e.g.*, the light-sensitive regions in some protozoa). More specialized organisms have certain cells or groups of cells which are exquisitely sensitive to one or another kind of stimulus (eyes to light, ears to sound, etc.). These are called organs of special sense and along with the nervous system provide for co-ordination with the environment.

The kinds of influences in the environment which serve as signals to an organism may be classified roughly as light, mechanical vibrations, pressure, temperature and chemical constitution of the environment. All the organs sensitive to these environmental factors are of necessity located at or are in direct proximity to the surface of the body. In more highly developed animal organisms many of them are localized in the head region and their nervous connections go directly to the brain. This is particularly true of the organs of sight, hearing, taste and smell. Others, such as the end organs sensitive to touch, heat, cold and pressure, are rather diffusely distributed over the body surface.

The organs of special sense communicate by means of sensory or afferent nerves with the central nervous system (brain or spinal cord). From the central nervous system, motor or efferent nerves carry messages to effector organs such as muscles or glands, which respond by contracting or secreting. What happens in the central nervous system between the time of entry of the sensory nerve impulse and the exit of the motor impulse may be reasonably simple or bafflingly complex. When the spinal cord, and not the brain, is involved, the simplest arrangement is to have the sensory neuron connect directly in the cord with the motor neuron. Such a series — receptor, sensory neuron, motor neuron and effector-constitutes the basic reflex arc. Commonly one or more neurons are interposed between the sensory and motor ones. Such reflex arcs uith connections made at the cord level provide for quickly withdrawing a finger which touches a hot stove and other quick reactions. There is no time to think and no thought is necessary. Beyond the simple reflex, increasing degrees of complexity are found. Transmission of impulses up and down the cord and integrating actions of the brain involving large numbers of neurons occur. For a detailed description of these see BRAIN; NERVE; and SPINAL CORD.

Adaptation and Adaptive Amplification.—Seemingly opposed to homeostasis, discussed above, are the phenomena of adaptation. These consist of all the changes in position, activity and structure which an organism undergoes so that it can better survive. An animal may grow a heavier coat of fur in winter and shed it in the summer. A man in the same circumstances may eat more and become more active, thus producing more heat. Another animal may hibernate, changing the whole level of its metabolism. Of course there are limits to the stress which can be compensated for. Under extreme conditions an organism may be forced to alter its environment (*e.g.*, by building shelters or building a fire) or it may be forced to remove itself to a new and more favourable environment.

Adaptations are made not only to external situations but to changes within the organism. If one kidney is lost, the other enlarges so as to do the work of two. Similarly, the heart may enlarge in response to a work load. These compensatory hypertrophies are adaptive and their value is obvious, One way of looking at adaptation is to think of it as subserving homeostasis along with the general welfare of the organism. Some structures and activities change in order to maintain others constant.

One of the most distinguishing characteristics of living organisms is their capacity for adaptive amplification. By this is meant their capacity to expend a great deal of energy for an adaptive reaction in response to a small stimulus. Thus a small amount of light falling on the eye or a few sound waves striking the ear of a man may warn him of danger and call for a long-continued response requiring many times the energy put in by the stimulus. *See* also references under "Physiology" in the Index volume.

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(J. O. H.)

PHYSIOLOGY, COMPARATIVE. The subject of physiology falls into three areas: (1) the physiology of specific organisms: as human (mammalian) physiology, which is important in medicine; insect physiology, plant physiology and similar specialities; (2) general physiology, which is essentially the physics and chemistry of processes common to cells and tissues of most organisms; and (3) comparative physiology, which is distinguished by using kind of organism as one of its experimental variables; for example, comparing the same function in different phyla of animals (most comparative physiologists deal more with animals than plants).

Introduction.—The primary goal of comparative physiology is to learn how different kinds of organisms solve their life problems and thus to learn what functions are common to many kinds of organism and what ones are restricted to specific groups. From such an analysis, biological generalizations are reached that differ from those of general or special-group physiology.

A second goal is to find organisms that are most ideally suited for study of important general functions; for example, the giant nerve fibres of the squid have been exceptionally good for the study of the nature of the nerve impulse.

A third goal of comparative physiology is to study physiological adaptations as related to environmental stresses and thus to account for the distribution of organisms in nature; this is the area of physiological ecology.

Finally, comparative physiology is useful in showing the functional bases for: (1) phylogenetic relations of higher taxonomic groups, phyla and classes; and (2) the adaptations that are effective in establishment of species; that is, the physiological aspects of evolution.

Study of the comparative morphology of both adult and embryo animals formed the basis of animal classification and phylogeny during the first 75 years after Charles Darwin's death, but morphology was considerably supplemented and extended by comparative physiology and biochemistry. The fields of morphology and physiology found a common meeting ground in the molecular organization of cells.

Physiological characters are as definitely determined genetically as are structural characters. When physiological differences in response to an environmental stress are detected among closely related animals (or even among several populations of the same species), it is possible to ascertain, by acclimatization to an altered environment in the direction of the stress, whether such differences are genetically determined or are merely induced by the kinds of environment to which the animals have been exposed.

Maintenance of Water Balance. — All animals must maintain a proper water balance; the problem is different for animals living in the desert, in moist air, in fresh water, in the sea and in salt lakes. In many marine invertebrates the total concentration of all solutes in the blood (osmotic concentration) is the same as that in the sea. Marine bony fish, in contrast, must continually

excrete quantities of salts to keep their blood more dilute than their environment. For animals to colonize estuaries and other brackish waters they must maintain their blood more concentrated than the water, often by active absorption of salts. All freshwater animals have mechanisms for excreting excess uater which tends to diffuse into their more concentrated blood. Land animals have various mechanisms for limiting evaporative loss and urinary loss of water.

Availability of water also tends to correlate with the kind of nitrogen wastes that the animal excretes: aquatic animals excrete mainly ammonia; amphibians and land animals with ample water excrete urea; other land animals, many of which live chiefly in a dry environment. as insects, shakes and birds, excrete uric acid.

Related to water as a limiting factor for life is the concentration of specific salts; animals tend to use some elements and to exclude others. Potassium and sodium, for example, are handled very differently by most animals and have different effects on active tissues. Marine animals tend to select sodium. potassium and chloride ions and to exclude magnesium and sulphate. Some elements not much used by living things are concentrated by a few kinds of animals; for example, vanadium by some sea squirts or tunicates. Knowledge of water and salt economy as related to environmental stress was given considerable impetus by the Danish comparative physiologist August Krogh in his work on osmotic regulation.

Availability of Oxygen. — Another important environmental component is oxygen; various means exist for obtaining adequate amounts of it. Small or sluggish animals such as protozoans or jellyfish can rely simply on diffusion of dissolved oxygen; large active animals either have tubes for taking oxygen directly to the tissues (insects), or have respiratory pigments in their blood, as hemoglobin (vertebrates, some worms) and hemocyanin (some crustaceans and mollusks). Sensitivity to oxygen deprivation differs markedly; some mollusks and parasitic worms survive long periods nithout oxygen; diving mammals are adapted to longer deprivation than nondivers; while squid and fast-swimming fish die within seconds when their oxygen supply is shut off.

Ability to survive in low oxygen depends partly on biochemical adaptations and partly on favourable mechanisms for external respiration (breathing). Metabolic enzymes by which energy is made available are remarkably similar for all animals, but some, such as parasitic worms, can rely more on nonoxidative pathways than can animals that depend more on oxygen.

Birds and mammals living at high altitudes have more hemoglobin in their blood than do those living at sea level. In general, small animals have higher rates of metabolism than large ones; *i.e.*, mice consume more oxygen per gram than elephants. Hemoglobin has appeared several times in the course of evolution. The foundations of modern comparative thinking on oxygen and carbon dioxide transport in animals were laid by the British physiologist Sir Joseph Barcroft. (See also RESPIRATION.)

Body Temperature. — Most animals are at the temperature of their environment (are poikilothermic or cold-blooded), while birds and mammals regulate their body temperature with fair constancy (are homoiothermic or warm-blooded). A few, such as hibernating mammals, may shift from lack of regulation to regulation at different times. Temperature regulation includes chemical means of beat production and physical mechanisms controlling heat loss; arctic mammals differ from temperate ones primarily in insulation. Actually many poikilotherms adapt their activity so that they are not wholly dependent upon the environmental temperature. Arctic marine animals such as fish are more active metabolically at a given temperature than are similar fish from warmer waters. Many insects perceive and move into a preferred temperature. The cellular mechanisms by which temperature and similar environmental factors elicit adaptive changes in an animal remain largely unexplained. (See ANIMAL HEAT.)

Cold-blooded animals are extensively used for the study of various physiological properties because of the greater ease of experimentation when tissues need not be maintained at a high constant temperature.

Nutrition. — Nutritional patterns differ greatly, from the flagellate protozoans, which combine characteristics of both plants and animals and can either carry out photosynthesis or subsist on relatively simple organic compounds, to most other animals, which require complex foods. It is of interest that the essential amino acids are similar for a wide range of animals. The ability to synthesize vitamins diminished as animals became dependent on complex food sources; in fact the most important biochemical evolution occurred before the appearance of "higher" organisms. A few higher animals,. particularly insects, have acquired specialized digestive chemical mechanisms for such foads as wool, beeswax and cellulose. Digestion of protein by pepsin is restricted to vertebrates, whereas protein digestion by trypsin (as in man's intestine) is found throughout the animal kingdom. Thus nutrition and digestion (*qq.v.*) provide examples of general functions, common to many animals, and of restricted ones; digestive enzymes also differ according to the nature of the diet.

Effectors. — An important area of comparative physiology deals with effector organs. Animal movement may be by protoplasmic flow, as in amoeboid movement, or by ciliary beat, but most commonly it is by muscular contraction. Muscles range in speed from the very fast eye muscles of a mammal and the fast flight muscles of bees and flies through ordinary postural muscles used in walking and swimming to the slow muscles of visceral organs and the holding muscles of clams and oysters. A variety of physiological and biochemical adaptations are recognized, but the explanation of the time range in muscular contraction of different animals is far from complete. (See also MUSCLE AND MUSCULAR SYSTEM.)

Other important effectors are electric organs, colour cells or chromatophores and organs of bioluminescence; colour change produced by pigment movement in chromatophores may be controlled by endocrines (crustaceans and frogs) or by nerves (squids and many fish). (See ANIMAL COLORATION; BIOLUMINESCENCE.)

An instance of the value to other areas of science of comparative studies in physiology is illustrated by the work on the biochemistry of muscle as developed particularly by E. Baldwin and J. Needham: this work supports the idea that echinoderms are more closely related to chordates than to other invertebrate phyla.

Circulatory and Hormonal Systems. — Systems for the circulation of blood may be either open or closed. Open systems, as found in many mollusks and arthropods, lack capillaries to connect arteries with veins and have blood sinuses instead; open systems operate with larger blood volumes and at lower pressures than closed systems. (See CIRCULATORY SYSTEM.)

The comparative physiology of endocrine glands is a complex subject, and the endocrine secretions of many invertebrates remain to be identified. In general, hormones concerned with specific functions, such as growth, appear to be chemically different in different phyla. Study of the hormones of metamorphosis in insects has contributed to an understanding of the cellular action of hormones in-general. (See ENDOCRINOLOGY; HORMONES.)

Sense Organs and **Behaviour.**—In few areas of comparative physiology is the principle of levels of complexity so clear as in animal behaviour and its control by sense organs and nervous systems. In sensitivity to light, for example, there is general protoplasmic sensitivity in some protozoahs, special photoreceptors that are merely intensity detectors in many worms, complex compound eyes in insects and camera eyes in vertebrates and the highest mollusks (squid and octopus), which provide for pattern and colour vision. Visual pigments determine to some extent the spectral sensitivity of different eyes, but the number of kinds of such pigments appears to be definitely limited.

Sense organs for mechanical and chemical stimuli are widely distributed and may operate on different principles for the same sense in different animals; comparative studies have led to discovery of sense organs of types not known in man; for example, humidity receptors in insects. (See also NERVOUS SYSTEM.)

Behavioural responses may simply be direct and stereotyped, may be variable within narrow limits or may be highly modifiable according to experience and competing stimuli. Simple behaviour of animals, sometimes called "forced response," was well analyzed by J. Loeb, S. O. Mast, and others during the 1930s, but attempts to understand complex behaviour met with little success; after

1945 a resurgence of interest in animal behaviour occurred. In some animals. such as insects, innate or stereotyped behaviour is dominant over learned behaviour as found in higher vertebrates, but the neurological basis for these differences is unknown. Nervous systems present an interesting sequence from the diffuse nerve nets of jellyfish through segmental central nervous systems as in some worms and arthropods, local reflex centres, headward centres or "brains" and highly integrative centres which have no direct sensory or motor connections. Comparative physiologists have provided important experimental material for the study of nerve impulses and of transmission between neurons in central nervous systems. However, interpretation of modifiability of behaviour (learning) still baffled neurophysiologists at mid-20th century. *(See* also NEUROLOGY. COMPARATIVE; ANIMAL BEHAVIOUR.)

Reproduction. — In the field of reproduction comparative physiology merges with embryology and genetics (*qq.v.*). Study of marine eggs, for example, has contributed to an understanding of processes of fertilization, cell division and embryonic differentiation. No other animal has been as useful in genetics as the fruit fly, *Drosophila.* Also the study of the development of various functions in embryos permits a kind of understanding not possible when adult animals only are used. *(See* REPRODUCTION.)

Cellular Physiology. — Ultimate explanation of biological function appears most probable by pursuit of cellular physiology, or experimental cytology, and comparative physiologists become cellular physiologists when their experimental material is favourable for understanding some cell function. Comparative study of different cell and tissue types within the same animal is an important approach to basic cell function. *(See* also CYTOLOGY.)

Application.—The preceding examples show that comparative physiology is fundamental in describing the nature of vital processes in various animals. In addition. it has practical applications in describing the physiology of economically important animals such as domesticated birds and mammals, parasitic worms, harmful insects and edible fish. Since the ocean supports animals in large variety and numbers, many comparative physiologists work at marine laboratories such as those at Woods Hole, Mass.; Plymouth, Eng.; and Naples, Italy. For the ecologist, comparative physiology provides a basis for understanding the restriction of plants and animals to particular habitats. For the medical physiologists, the comparative viewpoint is important for placing man in his proper biological perspective.

See also ECOLOGY, ANIMAL; EMBRYOLOGY, EXPERIMENTAL; PSYCHOLOGY, COMPARATIVE.

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(C. L. PR.; X.)

PHYTOLACCACEAE, a small family of dicotyledonous plants with 22 genera and 115 species, chiefly tropical, occurring in both hemispheres but especially developed in Central and South America.

Phytolacca with 26 species is the largest genus, and in China and Japan, Mexico and the eastern United States the young shoots of P. *esculenta, P. octandra* and *P. decandra* are cooked as food, the latter being the pokeberry (*q.v.*) or pokeweed of the eastern United States.

For a monographic treatment *see* H. Walter, "Phytolaccaceae," in Engler, *Das Pflanzenreich,* no. 39 (iv, 83), pp. 1–154 (1909).

(E. D. ML.)

PI, the Greek letter π, used to denote the ratio of the circumference of a circle to its diameter: 3.14159 . . . .

PIACENZA (Lat. PLACENTIA), a town and episcopal see of Emilia-Romagna, Italy, capital of the province of Piacenza, 42½ mi. S.E. of Milan and 91 mi. N.W. of Bologna. Pop. (1951) 60,114 (province, 1961) 291,110. It lies on the Lombard plain, 217 ft. above sea level, near the Po below the confluence of the Trebia.

The cathedral was erected between 1122 and 1233, in the Lombard Romanesque style; the campanile (1341) is 223 ft. high The entire edifice was restored after 1898, and the frescoes by Guercino. Lodovico Carracci and Camillo Procaccini seem inappropriate to its severe style. The church of S. Antonio. formerly the cathedral, mas rebuilt in 1014. S. Francesco is a Gothic edifice begun by the Franciscans in 1278. S. Savino, a Romanesque building of AD. 903 (rebuilt in 1107 and restored in 1902), contains a mosaic pavement with curious representations, including one of a game of chess. S. Sisto (1499–1511) once contained Raphael's Sistine Madonna sold in 1754 to Frederick Augustus III of Saxony. The huge Farnese palace was begun after Giacomo da Vignola's designs by Margaret of Austria in 1558 but was never completed; from 1800 it was used as barracks. The town has an automobile factory. It is an important agricultural centre.

Placentia was made a Roman colony in 218 B.C., in which year it afforded protection to the remains of the Roman army after the battle of the Trebia (*q.v.*). In 207 it withstood a siege by Hasdrubal. Seven years later the Gauls burned it; and in 190 it was recruited with 3,000 families.—Later it was an important road centre.

Piacenza nas one of the leading members of the Lombard league. In 1447 it was sacked by Francesco Sforza. Papal forces occupied it in 1512. and Pope Paul III united it with Parma in 1545 to form a hereditary duchy for his son Pierluigi Farnese. The male line of the Farnese (*q.v.*) family held it till 1731, after which it passed with Parma to the infante Charles. *See* PARMA.

PIAGET, JEAN (1896–), Swiss psychologist, was born in Neuchbtel on Aug. 9, 1896. At the age of 10 he published an article on an albino sparrow, and his writings on mollusks made his name knoan to specialists in other countries soon after he was 15. He studied biology at the University of Neuchbtel, obtaining a doctorate of science in 1918. This biological training, coupled with an intense interest in epistemology and logic, led him finally to psychology. In 1921 he was appointed director of studies at the Institut J. J. Rousseau in Geneva; he became a professor at the University of Geneva in 1929, and later also held chairs at the Universities of Neuchâtel, Lausanne and Paris.

The most distinctive feature of Piaget's contribution to experimental psychology is his developmental or "genetic" approach. He has concentrated on the cognitive functions (*i.e.,* those which provide knowledge of the external world), believing that affective or emotional functions are closely bound up with these. He has studied the development of sensorimotor. perceptual and intellectual processes in the child. not primarily for the sake of solving pedagogical or other practical problems but for the light this study can throw on human psychology in general.

In five early books, including *Le Langage et la pensée chez l'enfant* (1923), *La Reprksentation du monde chez l'enfant* (1926) and *Le Jugement moral chez l'enfant* (1932), he reported the results of his interrogations of children on the way they saw the world; but his methodology was criticized. Adopting a more objective and behaviouristic experimental method, he embarked on a systematic chronological investigation of the intellectual development of the child. Three later books, based largely on observation of his own three children, treated the preschool period: La *Naissance de l'intelligence chez l'enfant* (1936). *La Construction du réel chez l'enfant* (1937) and *La Formation du symbole chez l'enfant* (1945). His work on school children up to the age of 12 is summed up in *La Psychologie de l'intelligence* (1947), and, finally, research on the adolescent is presented in *De la logique de l'enfant à la logique de l'adolescent* (written with *B.* Inhelder, 1955). He has also published, with various collaborators, a long series of experimental studies on perception in the *Archives de Psychologie* and several books on the development of systems of concepts relating to number, space, time and probability—*e.g., La Genèse du nombre chez l'enfant* (written with A. Szeminska, 1941) and *La Représentation de l'espace chez l'enfant* (written with B. Inhelder, 1948).

Piaget sees cognitive development as a gradual advance toward more thorough and "intelligent" adaptation to the environment. marked by more complete "equilibrium" between psychological processes. Perception is fraught with illusion, instability and distortion which the child tempers by systematically collating information obtained from different points of view. A much higher degree of consistency and objectivity, combined with flexibility, is afforded by the gradual acquisition of logical thinking, culmi-

nating in the scientific and formal reasoning of which the adolescent is capable. The symbolic "operations" that participate in thought are derived from concrete interactions with objects. Operations are organized in systems obeying certain rules which ensure the maintenance of their structure and thus the reliability of thought.

After about 1950, Piaget drew on modern logic to construct logico-mathematical models, representing the structures underlying intellectual activity at various ages. He also intensified an interest in "genetic epistemology"; *i.e.*, the study of the development of the notions and processes that subserve knowledge, both in the individual and in society. This includes the study of the bearing of experimental psychology on the traditional epistemological problems raised by philosophers. It is discussed in his Introduction *à l'épistémologie génétique,* 3 vol. (1950), and has been further promoted by the foundation of the Centre International d'Epistémologie Génétique in 1955.

See D. E. Berlyne, "Recent Developments in Piaget's Work," *Brit. J. Educ. Psychol.* (1957). (D. E. BE.; B. IN.)

PIANOFORTE. The group of keyed stringed musical instruments, among which the pianoforte is latest in order of time, has been invented and step by step developed with the modern art of music. During the 10th century the "organum" arose, an elementary system of accompaniment to the voice, consisting of fourths and octaves below the melody and moving with it, and the organ (*q.v.*), the earliest keyed instrument, was, in the first instance, the rude embodiment of this idea and convenient means for its expression. About the same time arose a large stringed instrument, the organistrum, the parent of the now obsolete hurdy-gurdy; as the organ needed a blower as well as an organist, so the player of the organistrum required a handle-turner, by whose aid the three strings of the instrument were made to sound simultaneously upon a wheel, and, according to the well-known sculptured relief of St. George de Boscherville, one of the strings was manipulated by means of a row of stoppers or tangents pressed inwards to produce the notes. The other strings were drones, analogous to the drones of the bagpipes, but originally the three strings followed the changing organum.

FIG. 1.—PRIMITIVE CLAVICHORD (BEFORE 1460); EARLIEST EXISTING REPRESENTATION OF A KEYED STRINGED INSTRUMENT, FROM ST. MARY'S, SHREWSBURY

In the 11th century (the epoch of Guido of Arezzo [*q.v.*], to whom the beginning of musical notation is attributed), the Pythagorean monochord, with its shifting bridge, was used in the singing schools to teach the intervals of the plain-song of the church. The practical necessity, not merely of demonstrating the proportionate relations of the intervals, but also of initiating pupils into the different gradations of the church tones, had soon after Guido's time brought into use quadruplex monochords, which were constructed with scales so that four lines indicated authentic and the four plagal tones. This arrangement found great acceptance, for Aribo, writing about fifty years after Guido, says that few monochords were to be found without it. Aribo strenuously endeavoured to improve it, and "by the grace of God" invented a monochord measure which, on account of the rapidity of the leaps he could make with it, he named a *caprea* (wild goat). Jean de Muris (*Musica speculativa,* 1323) describes the musical instruments known in his time, but does not mention the clavichord or monochord with keys, which could not have been then invented. Perhaps one of the earliest forms of such an instrument, in which stoppers or tangents had been adopted from the organistrum, is shown in fig. 1. The latest date to which this figure may be attributed is 1460.

In the Weimar Wunderbuch, a manuscript dated 1440 with pen and ink miniatures is given a "clavichordium" having 8 short and apparently 16 long keys. The artist has drawn 12 strings in a rectangular case, but no tangents are visible. A keyboard of balanced keys existed in the little portable organ known as the regal, used to give the singers in religious processions the note or pitch. We attribute the adaptation of the narrow regal keyboard to what nas still called the monochord, but was now a complex of monochords over one resonance board, to the latter half of the 14th century; it was accomplished by the substitution of tangents (fixed in the ends of the balanced keys) for the movable bridges of the monochord or such stoppers as are shown in fig. 1. Thus the monochordium or "payre of monochordis" became the clavichordium or "payre of clavichordis"—pair being applied, in the old sense of a "pair of steps," to a series of degrees. In the Weimar *Wunderbuch* is a pen-and-ink sketch of the "clavicimbalum" placed upon a table, in which we recognize the outline of the harpsichord, but on a smaller scale.

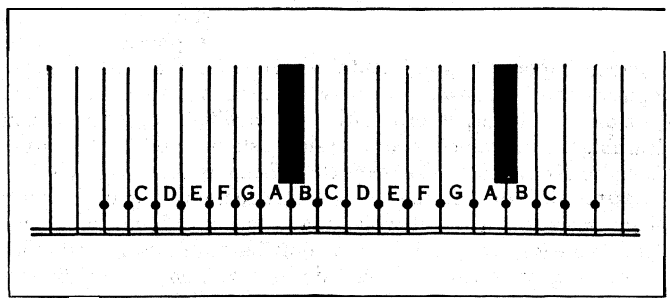

FIG. 2.—DIATONIC CLAVICHORD KEYBOARD (GUIDO'S SCALE) FROM VIRDUNG, BEFORE 1511, SHOWING THE SHORT KEYS B FLAT

The earliest known record of the clavichord occurs in some rules of the minnesingers, dated 1404. The monochord is named with it, showing a differentiation of these instruments, and of them from the clavicimbalum—the keyed cymbal, cembalo (Italian), or psaltery. From this we learn that a keyboard had been thus early adapted to that favourite medieval stringed instrument, the "cembalo" of Boccaccio. the "sautrie" of Chaucer.

There were two forms of the psaltery: (1) the trapeze, one of the oldest representations of which is to be found in Orcagna's famous Trionfo della Morte in the Campo Santo at Pisa, and another by the same painter in the National Gallery, London; and (2) the contemporary "testa di porco," the pig's head, which was of triangular shape as the name suggests. The trapeze psaltery was strung horizontally, the "istromento di porco" either horizontally or vertically—the notes, as in the common dulcimer, being in groups of three or four unisons. In these differences of form and stringing we see the cause of the ultimate differentiation of the spinet and harpsichord. The compass of the psalteries was nearly that of Guido's scale; but according to Mersenne (Harmonie *Universelle* Paris, 1636, liv. 3, p. 107), the lowest interval was a fourth, G to C, which is worthy of notice as anticipating the later "short measure" of the spinet and organ.

The simplicity of the clavichord inclines us to place it, in order of time, before the clavicimbalum or clavicembalo; but we do not know how the sounds of the latter were at first excited. In 1472 chromatic keyboards, which imply a considerable advance, were already in use.

But diatonic organs with eight steps or keys in the octave, which included the B flat and the B natural, as in Guido's scale, were long preserved, for Praetorius speaks of them as still existing nearly two hundred years later. This diatonic keyboard, we learn from Sebastian Virdung (*Musica* getutscht und *auszgezogen,* Basel, 1511), was the keyboard of the early clavichord. We reproduce his diagram as the only authority we have for the disposition of the one short key.

Virdung's diagram of the chromatic is the same as our own familiar keyboard, and comprises three octaves and a note, from F below the bass stave to G above the treble. But Virdung tells

us that even then clavichords were made longer than four octaves by repetition of the same order of keys. The introduction of the chromatic order he attributes to the study of Boetius, and the consequent endeavour to restore the three musical *genera* of the Greeks—the diatonic, chromatic and enharmonic. But the last-named was not attained until equal temperament tuning was developed by J. S. Bach. Virdung gives woodcuts of the clavi-

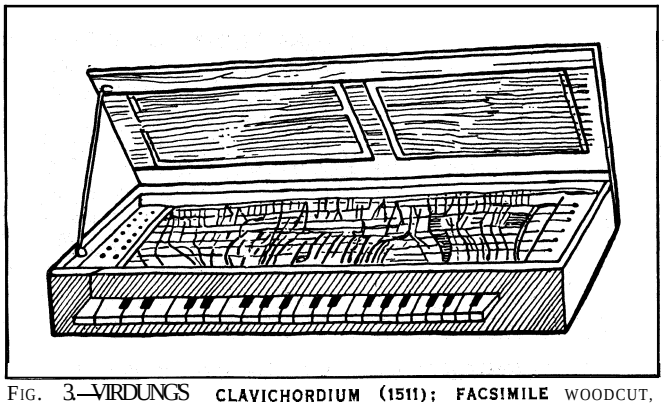

FIG. 3.—VIRDUNGS CLAVICHORDIUM (1511); FACSIMILE WOODCUT, REVERSED TO CORRECT THE KEYBOARD

chordium, the virginal, the clavicimbalum and the clavicytherium. We reproduce three of them (figs. 3, 6 and 8), omitting the virginal as obviously incorrect. Writers on musical instruments have continually repeated these drawings without discerning that in the printing they are reversed, which puts the keyboards entirely wrong, and that in Luscinius's Latin translation of Virdung (*Musurgia, sive praxis musicae,* Strasbourg, 1536), which has been hitherto chiefly followed, two of the engravings, the clavicimbalum and the clavicytherium, are transposed, another cause of error.

Still commonly known as monochord, Virdung's clavichord was really a box of monochords, all the strings being of the same length. We observe in this drawing (fig. 3) the short sound-board, which always remained a peculiarity of the clavichord, and the straight sound-board bridge—necessarily so when all the strings were of one length. To gain an angle of incidence for the tangents against the strings the keys were splayed, an expedient further rendered necessary by the "fretting"—three tangents being placed to give three different notes from each single group of strings tuned in unison. In the drawing the strings are merely indicated. The German for fret is *Bund,* and such a clavichord, in that language, is known as a "gebundenes Clavichord" both fret (to

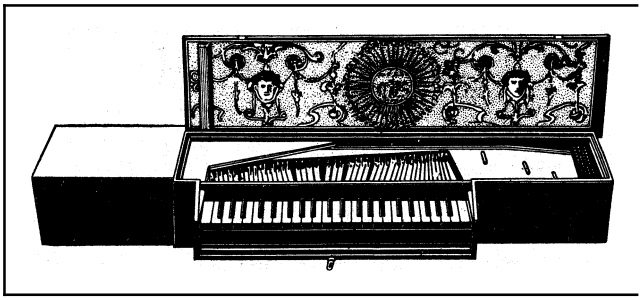

FIG. 4.—MANICORDO (CLAVICHORD) D'ELEONORA DI MONTALVO (1659); KRAUS MUSEUM, FLORENCE

rub) and *Bund* (from *binden,* to bind) having been taken over from the lute or viol. The French and Italians employ "touche" and "tasto" (touch). Praetorius who wrote a hundred years later than Virdung, says two, three and four tangents were thus employed in stopping.

Clavichords were made with double fretting up to about the year 1700—that is to say, to the epoch of J. S. Bach, who, taking advantage of its abolition and the consequent use of independent pairs of strings for each note, was enabled to tune in all keys equally, which had been impossible so long as the fretting was maintained. The modern scales having become established, Bach was now able to produce, in 1722, Dm *wohltemperirte Clavier,* his famous collection of preludes and fugues in all the twenty-four major and minor scales for a clavichord which was tuned to what is now known as "equal temperament."

An example of a 17th century clavichord, here called manicordo (as French *manicorde,* from monochord), is illustrated in fig. 4. The lowest octave is here already "bundfrei" or fret-free. The strings are no longer of equal length, and there are three bridges, divisions of the one bridge, in different positions on the sound-board. Mersenne's "manicorde" (*Harmonie Universelle,* Paris, 1636, p. 115), shown in an engraving in that work, has the strings still nearly of equal length, but the sound-board bridge is divided into five. The fretted clavichords made in Germany in the last years of the 17th century have the curved sound-board bridge, like a spinet. In the clavichord the tangents always formed the second bridge, deciding the pitch, besides acting as the sound exciters (fig. 5). The common damper to all the strings was a "list" of cloth, interwoven behind the tangents. As the tangents quitted the strings the cloth immediately stopped all vibration. As regards compass Handel's clavichord now in the museum at Maidstone (an Italian instrument dated 1726, and not fretted), has a compass of 33 octaves (F to A).

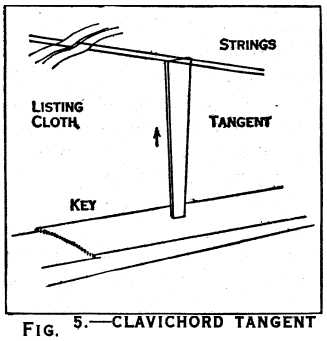

FIG. 5.—CLAVICHORD TANGENT
Showing position when front of keyboard is depressed; the tangent rises into contact with the strings and forms the end-point of the speaking length. The back string is kept from vibrating by means of the "Listing" cloth

The clavichord must have gone out of favour in Great Britain and the Netherlands early in the 16th century—the more brilliant and elegant spinet being preferred to it. Like the other keyboard instruments it had no German name, and can hardly have been of German origin, but it remained longest in use in Germany—until even the beginning of the 19th century.

The next instrument described by Virdung is the virginal (*virginalis,* proper for a girl), a parallelogram in shape, having the same projecting keyboard and compass of keys as the clavichordium. Here we trace derivation from the psaltery, in that the sound-board covers the entire inner surface of the instrument

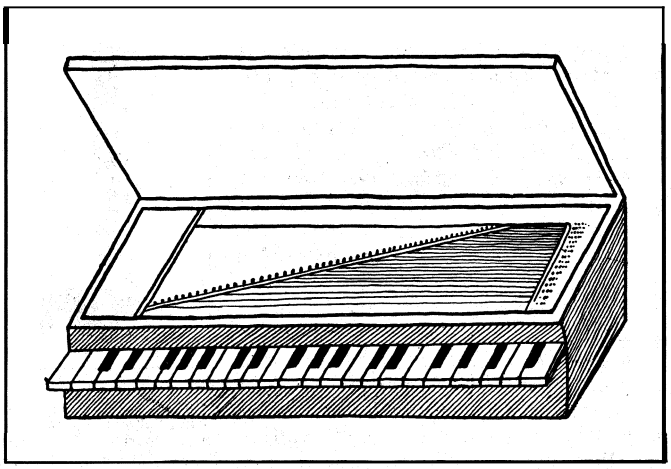

FIG. 6.—VIRDUNGS CLAVICIMBALUM (SPINET). 1511: REVERSED FACSIMILE WOODCUT

and the disposition of the strings is triangular. The virginal in Virdung's drawing has an impossible position with reference to the keyboard, which renders its reproduction as an illustration useless. But in the next drawing, the clavicimbalum, this is rectified, and the drawing, reversed on account of the keyboard, can be accepted as roughly representing the instrument so called (fig. 6). There would be no difference between the clavicimbalum and the virginal were it not for a peculiarity of keyboard compass, which emphatically refers itself to the Italian "spinetta," a name

unnoticed by Virdung or by his countryman Arnold Schlick, who, in the same year 1511, published nis *Spiegel* der *Orgelmacher* (Organ-builders' Mirror), and named the clavichordium and clavicimbalum as familiar instruments. In the first place, the keyboard, beginning apparently with B natural, instead of F, makes the clavicimbalum smaller than the virginal, the strings in this arrangement being shorter; in the next place it is almost certain that the Italian spinet compass, beginning apparently upon a semitone, is identical with a "short measure" or "short octave" organ compass, a very old keyboard arrangement, by which the first three notes while appearing to be B, C and C sharp were tuned to G, C and A. The origin of this may be deduced from the psaltery and many representations of the regal, and its object appears to have been to obtain dominant basses for cadences, harmonious closes having early been sought for as giving pleasure to the ear.

Authority for this practice is to be found in Mersenne, who, in 1636, expressly describes it as occurring in his own spinet (*espinette*). We read (Harmonie *Universelle,* Paris, 1636, liv. 3, p. 107)—"Its longest string is little more than a foot in length between the two bridges. It has only thirty-one keys [marches] in its keyboard, and as many strings over its sound-board, so that there are five keys hidden [he now refers to the illustration] on account of the perspective—that is to say, three diatonic and two chromatic, of which the first is cut into two; but these sharps serve to go down to the third and fourth below the first step, C sol [tenor clef C], in order to go as far as the third octave, for the eighteen principal steps make but an eighteenth, that is to say, a fourth more than two octaves." Mersenne's statement sufficiently proves, first, the use in spinets as well as in organs of what we now call "short measure," and, secondly, the object of divided sharps at the lower end of the keyboard to gain lower notes.

As regards the kind of plectra earliest used we have no evidence. The little crow-quill points project from centred tongues in uprights of wood known as "jacks" (fig. 7), which also carry the dampers, and rising by the depression of the keys in front, the quills set the strings vibrating as they pluck them in passing. J. C. Scaliger in *Poetices* libri septem (1561, p. 51. c. 1.) states that the clavicimbalum and harpichordum of his boyhood were called spinets on account of those quill points (ab *illis mucronibus*), and attributes the introduction of the name "spinetta" to them from *spina,* a thorn, the meaning being extended to any small pointed object such as a quill. We will leave "harpichordum" for the present, but the early identity of "clavicimbalum" and "spinetta" is certainly proved. Scaliger's etymology remained unquestioned until Signor Ponsic-'chi of Florence discovered another, but less acceptable derivation. He found in a rare book entitled Conclusione nel *suono* dell' *organo,* di D. *Adriano Banchieri* (Bologna, 1608), the following passage, which translated reads: "Spinetta was thus named from the inventor of that oblong form, who was one Maestro Giovanni Spinetti, a Venetian; and I have seen one of those instruments, in the possession of Francesco Stivori, organist of the magnificent community of Montagnana, within which was this inscription—Joannes *Spi*netvs *Venetvs fecit,* A.D. *1503.*" Scaliger's and Banchieri's statements may be combined, as there is no discrepancy of dates, or we may rely upon whichever seems to us to have the greater authority, always bearing in mind that neither invalidates the other. In France the word "épinette" still stands for both "spinet" and "chicken-house" which seems to strengthen the first-named theory. A spinet dated 1490 was shown at Bologna in 1888; another old spinet in the Conservatoire, Paris, is a pentagonal instrument made by Francesco di Portalupis at Verona. 1523.

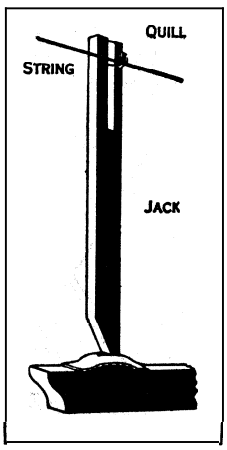

FIG. 7.—SPINET "JACK" Showing the quill which twangs the string on its upward journey, but, being hinged, slides quietly past on its return

The Milanese Rossi were famous spinet-makers, and have been accredited (La *Nobilità* di *Milano,* 1595) with the recessing of the keyboard, which had previously entirely projected; by this recessing a greater width was obtained for the sound-board. The spinets by Annibale Rosso at South Kensington, dated respectively 1555 and 1577, show this alteration, and may be compared with the older and purer form of one, dated 1568, by Marco Jadra (also known as Marco "dalle spinette," or "dai cembali"). The apparent compass of the keyboard in Italy generally exceeded four octaves by a semitone, E to F; but we may regard the lowest natural key as usually C, and the lowest sharp key as usually D, in these instruments, according to "short measure."

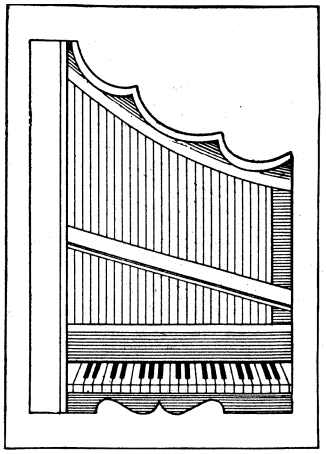

FIG. 8.—VIRDUNG'S CLAVICYTHERIUM (UPRIGHT HARPSICHORD), 1511: REVERSED FACSIMILE WOODCUT

The rectangular spinet, or "virginal," early assumed in Italy the fashion of the large "cassoni" or wedding chests. The oldest we knov of in this style, and dated, is the fine specimen belonging to M. Terme which figures in *L'Art* decoratif. Virginal is not an Italian name; the rectangular instrument in Italy is "spinetta tavola." In England, from Henry VII. to Charles II., all quilled instruments (*strumenti* di *penna*), without distinction as to form, were known as virginals. It was a common name, equivalent to the contemporary Italian clavicordo and Flemish *clavisingel.* From the latter we arrive at the French *clavecin* the spinet being simply a "petit clavecin."

Mersenne (op. *cit.,* liv. iii., p. 158) gives three sizes for spinets—one $2\frac{1}{2}$ ft. wide, tuned to the octave of the "ton de chapelle" (a half tone above the present English medium pitch), one of $3\frac{1}{2}$ ft. tuned to the fourth below, and one of 5 ft. tuned to the octave below the first, the last being therefore tuned in unison to the chapel pitch. The octave spinet, of trapeze form, was known in Italy as "ottavina" or "spinetta di serenata." It had a less compass of keys than the larger instrument, being apparently three and two-third octaves, E to C—which by the "short measure" would be four octaves, C to C. These little spinets were placed upon the larger ones in performance and used to heighten the brilliant effect. In the double rectangular clavisingel of the Netherlands, in which there was a movable octave instrument, we recognize a similar intention. There is a fine spinet of this kind at Nuremberg. Praetorius illustrates the Italian spinet by a form known as the "spinetta traversa," an approach towards the harpsichord, the tuning pins being immediately over the keyboard. This transposed spinet, more powerful than the old trapeze one, became fashionable in England after the Restoration, when Haward, Keene, Slade, Player, Baudin, the Hitchcocks, Mahoon, Haxby, the Harrir family, and others made such "spinets" during a period for which we have dates from 1664 to 1784. Pepys

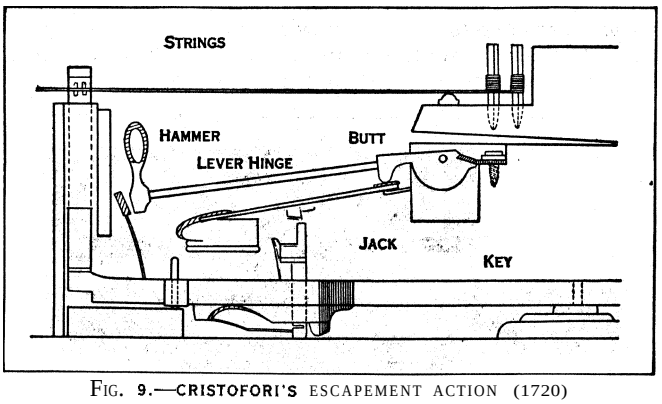

FIG. 9.—CRISTOFORI'S ESCAPEMENT ACTION (1720) The hinged lever, when struck by the jack, transmits the blow to the butt, thus having the effect of throwing the hammer towards the strings

bought his "Espinette" from Charles Haward for £5, July 13, 1664. Thomas Hitchcock (for whom there are dates 1664 and 1703 written on keys and jacks of spinets bearing Edward Blunt's name and having divided bass sharps) made a great advance in constructing spinets, giving them the wide compass of five octaves, from G to G, with very fine keyboards in which the sharps were inlaid with a slip of the ivory or ebony, as the case might be, of the naturals.

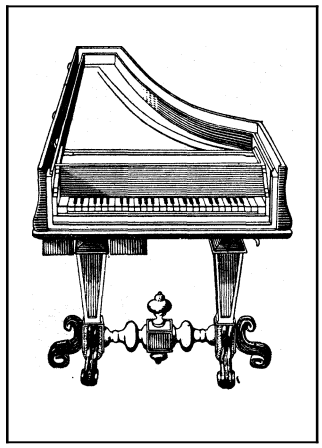

FIG. 10.—CRISTOFORI'S PIANO E FORTE (1726); KRAUS MUSEUM, FLORENCE

We have now to ask what was the difference between Scaliger's harpichordum and his clavicymbal. Galilei, the father of the astronomer of that name (*Dialogo della musica antica* e *moderna,* Florence, 1581), says that the harpichord was so named from having resembled an "arpa giacente," a prostrate or "couched" harp, proving that the clavicymbal was at first the trapeze-shaped spinet; and we should therefore differentiate harpichord and clavicymbal as derived from the harp and psaltery respectively.

The Latin name "clavicimbalum," having early been replaced by spinet and virginal, was in Italy and France bestowed upon the long harpichord, and was continued as clavicembalo and clavecin. Much later, after the restoration of the Stuarts, "harpichord" was accepted and naturalized in England as harpsichord, which we will define as the long instrument with quills, shaped like a modern grand piano. We can point out no long instrument of this kind so old as the Roman cembalo at South Kensington. The outer case is of finely tooled leather. It has a compass of nearly four octaves, E to D, and the natural keys are of boxwood.

The startling "piano e forte" of 1598, brought to light from the records of the house of D'Este by Count Valdrighi of Modena (see Van der Straeten, vi., 122), we are disposed to regard, not as an anticipation of Cristofori's subsequent invention of the pianoforte, but as an ordinary cembalo with power to shift by a stop, from two unisons (forte) to one string (piano), at that time a Flemish practice, and most likely brought to Italy by one of the Flemish musicians who founded the Italian school of composition.

About the year 1600, when accompaniment was invented for monody, large cembalos were made for the orchestras to bring out the bass part, the performer standing to play. Such an instrument was called "archicembalo," a name also applied to a large cembalo, made by Vito Trasuntino, a Venetian, in 1606, intended by thirty-one keys in each of its four octaves, to restore the three genera of the ancient Greeks.

Double keyboards and stops in the long cembalo or harpsichord came into use in the Netherlands early in the 16th century. We find them imported into England. The following citations, quoted by Rimbault in his History of *the* Pianoforte, are from the privy purse expenses of King Henry VIII.

"1530 (April). Item the vj daye paied to William Lewes for ii payer of virginalls in one coffer with iiii stoppes brought to Grenewiche iii. li. And for ii payer of virginalls in one coffer brought to the More other iii. li."

Now the second instrument may be explained ("virginals" meaning any quilled instrument) as a double spinet, like that at Nuremberg by Martin van der Beest, the octave division being movable. But the first cannot be so explained; the four stops can only belong to a harpsichord, and the two pair instrument to a double-manual. Again from the inventory after the king's death (see Brit. Mus. Harl. MS. 1419) fol. 247—

"Two fair pair of new long Virginalls made harp-fashion of Cipres, with keys of ivory, having the King's Arms crowned and supported by his Grace's beastes within a garter gilt, standing over the keys."

This is probably another double keyboard harpsichord. We read in an inventory of the furniture of Warwick Castle, 1584, "a faire paire of double virginalls," and in the Hengrave inventory, 1603, "one great payre of double virginalls." Hans Ruckers, the great clavisingel maker of Antwerp, lived too late to have invented the double keyboard and stops, evident adaptations from the organ, and the octave string was already in use when he began his work. Until the last harpsichord was made by Joseph Kirkman, in 1798, scarcely an instrument of the kind was constructed, except in Italy, without the octaves. The harpsichord as known throughout the 18th century, with "piano" upper and "forte" lower keyboard, was the invention of Hans Ruckers's grandson, Jean Ruckers's nephew, Jan Couchet, about 1640. Before that time the double keyboards in Flemish harpsichords were merely a transposing expedient, to change the pitch a fourth, from plagal to authentic and vice versa, while using the same groups of keys.

After the Antwerp make declined, London became pre-eminent for harpsichords—the representative makers being Jacob Kirckmann and Burckhard Tschudi, pupils of a Flemish master, one Tabel, who had settled in London, and whose business Kirckmann continued through marriage with Tabel's widow. Tschudi was of a noble Swiss family belonging to the canton of Glarus. According to the custom with foreign names obtaining at that time, by which Haendel became Handel, and Schmidt Smith, Kirckmann dropped his final *n* and Tschudi became Shudi, but he resumed the full spelling in the facies of the splendid harpsichords he made in 1766 for Frederick the Great, which are still preserved at Potsdam. By these great makers the harpsichord became a larger, heavier-strung and more powerful instrument, and fancy stops were added to vary the tone effects. To the three shifting registers of jacks were added the "lute," the charm of which was due to the favouring of high harmonics by plucking the strings close to the bridge, and the "harp," a muting effect produced by impeding the vibration of the strings by contact of small pieces of buff leather. Two pedals were also used, the left-hand one a combination of a unison and lute.

The right-hand pedal was to raise a hinged portion of the top or cover and thus gain some power of "swell" or crescendo, an invention of Roger Plenius, to whom also the harp stop may be rightly attributed. The first idea of pedals for the harpsichord to act as stops appears to have been John Hayward's (?Haward) as early as 1676, as we learn from Mace's *Musick's* Monument, p. 23j. The French makers preferred a kind of knee-pedal arrangement, known as the "genouillère," and sometimes a more complete muting by one long strip of buff leather, the "sourdine." As an improvement upon Plenius's clumsy swell, Shudi in 1769 patented the Venetian swell, a framing of louvres, like a Venetian blind, which opened by the movement of the pedal, and becoming in England a favourite addition to harpsichords, was early transferred to the organ, replacing the rude "nag's-head" swell.

To keep his collection of musical instruments in playing order Prince Ferdinand dei Medici engaged a Paduan harpsichord maker, Bartolommeo Cristofori, the man of genius who invented and produced the pianoforte. We fortunately possess the record of this invention in a literary form from a well-known writer, the Marchese Scipione Maffei; his description appeared in the Giornale dei *letterati d'Italia,* a publication conducted by Apostolo Zeno. The date of Maffei's paper was 1711. Rimbault reproduced it, with a technically imperfect translation, in his History of the Pianoforte. We learn from it that in 1709 Cristofori had completed four "gravecembali col piano e forte"—keyed-psalteries with soft and loud—three of them being of the long or usual harpsichord form. The sketch of his action in Maffei's essay shows an incomplete stage in the invention, although the kernel of it—the principle of escapement or the controlled rebound of the hammer—is already there. He obtains it by a centred lever (linguetta mobile) or hopper, working, when the key is depressed by the touch, in a small projection from the centred hammer-butt. The return, governed by a spring, must have been uncertain and incapable of further regulating than could be obtained by modifying the strength of the spring. Moreover, the hammer had each time to be raised the entire distance of its fall. There are, however, two pianofortes by Cristofori, dated respectively 1720 and

1726, which show a much improved construction, for the whole of an essential piano movement is there. The earlier instrument (now in the Metropolitan Museum, New York) has undergone considerable restoration, but the 1726 one, which is in the Kraus Museum at Florence, retains the original leather hammer-heads. Both instruments possess alike a contrivance for determining the radius of the hopper, and both have been unexpectedly found to have

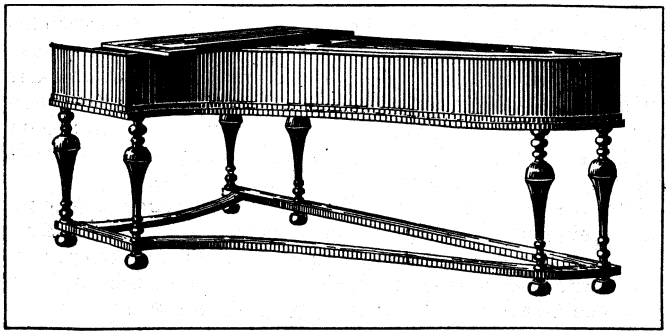

FIG. 11.—SILBERMANN FORTE PIANO (1746). STADTSCHLOSS, POTSDAM

the "check" (Ital. *paramartello),* which regulates the fall of the hammer according to the strength of the blow which has impelled it to the strings.

Thicker stringing, to withstand even Cristofori's light hammers, demanded in its turn a stronger framing than the harpsichord had needed. Accordingly to make his structure firm Cristofori considerably increased the strength of the block which holds the tuning-pins, and as he could not do so without materially adding to its thickness, he adopted the bold expedient of inverting it; driving his wrest-pins, harp-fashion, through it, so that tuning was affected at their upper, while the wires were attached to their lower, ends. Then, to guarantee the security of the case, he ran an independent string-block round it of stouter wood than had been used in harpsichords, in which block the hitch-pins were driven to hold the farther ends of the strings, which were spaced at equal distances (unlike the harpsichord), the dampers lying between the pairs of unisons.

Cristofori died in 1731. He had pupils, but did not found a school of Italian pianoforte-making. The 1711 essay of Scipione Maffei was translated into German, in 1725, by König, the court poet at Dresden, and friend of Gottfried Silbermann, the renowned organ builder and harpsichord and clavichord maker (*see* Dr. Oscar Paul's *Geschichte des Claviers,* Leipzig, 1868). Incited by this publication, and perhaps by having seen in Dresden one of Cristofori's pianofortes, Silbermann appears to have taken up the new instrument, and in 1726 to have manufactured two, which J. S. Bach, according to his pupil Agricola, pronounced failures. The trebles were too weak; the touch was too heavy. There has long been another version to this story, viz., that Silbermann borrowed the idea of his action from a very simple model contrived by a young musician named Schroeter, who had left it at the electoral court in 1721, and, quitting Saxony to travel, had not afterwards claimed it.

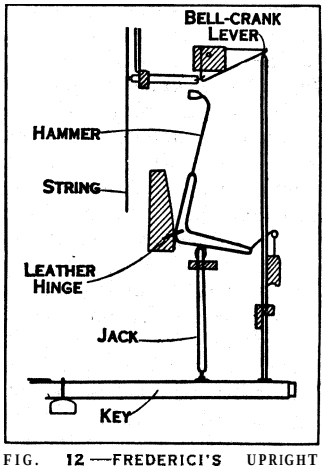

FIG. 12.—FREDERICI'S UPRIGHT GRAND PIANO ACTION (1745)

In the museum of the Brussels Conservatoire. The leather hinge allows the bellcrank lever to convert the upward throw of the jack into a forward motion of the hammer towards the string

Whatever Silbermann's first experiments were based upon, he ultimately adopted Cristofori's pianoforte without further alteration than the compass and colour of the keys and the style of joinery of the case. In the Silbermann grand pianofortes at Potsdam, known to have been Frederick the Great's, and to have been acquired by that monarch prior to J. S. Bach's visit to him in 1747, we find the Cristofori framing, stringing, inverted wrest-plank and action complete. Fig. 11 represents the instrument on which J. S. Bach played in the Stadtschloss, Potsdam.

It has been repeatedly stated in Germany that Frederici, of Gera in Saxony, an organ builder and musical instrument maker, invented the square or table-shaped piano, the "fort bien," as he is said to have called it, about 1758–60. No square piano by this maker is forthcoming, though an "upright grand" piano, made by Domenico del Mela in 1739, with an action adapted from Cristofori's has been discovered by Signor Ponsicchi of Florence. Victor

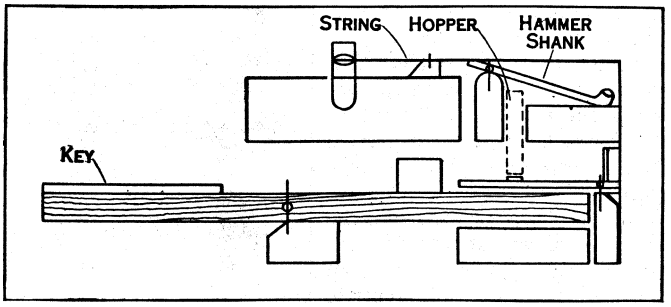

FIG. 13.—SCHROETER'S MODEL FOR AN ACTION (1721); SHOWING THE KEY READY TO LIFT THE HOPPER. AND MAKE IT STRIKE THE HAMMER SHANK

Mahillon of Brussels, however, acquired a Frederici "upright grand" piano, dated 1745. In Frederici's upright grand action (fig. 12) we have not to do with the ideas of either Cristofori or Schroeter; the movement is practically identical with the hammer action of a German clock, and has its counterpart in a piano at Nuremberg; a fact which needs further elucidation. We note here the earliest example of the leather hinge, afterwards so common in piano actions. An attempted combination of harpsichord and pianoforte appears very early. The English poet Mason, the friend of Gray, bought such an instrument at Hamburg in 1755, with "the cleverest mechanism imaginable."

It was only under date of 1763 that Schroeter published for the first time a diagram of his proposed invention, designed more than forty years before. It appeared in Marpurg's *Kritische Briefe* (Berlin, 1764). Now, immediately after, Johann Zumpe, a German in London, who had been one of Shudi's workmen introduced (there is some tradition that Mason had to do with the invention of it) a "square" piano, which was destined to become the most popular domestic instrument. Zumpe was in fact not the inventor of the square piano, which appears to have been well known in Germany before his date, a discovery made by Mr. George Rose. In Paul de Wit's Musical Instrument Museum—formerly in Leipzig, afterwards transferred to Cologne—there is a small square piano by Hildebrandt 27 in. long 10 in. wide and $4\frac{1}{2}$ in high, having a contracted keyboard of 3 octaves and 2 notes. The action of this small instrument is practically identical in every

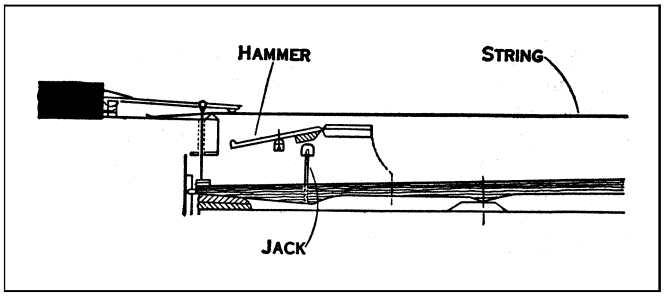

FIG. 14.—ZUMPE'S SQUARE PIANO ACTION (1765); GIVING A DIRECT BLOW WITH THE JACK NEAR THE BUTT END OF THE HAMMER

detail with that of the square pianofortes made much later by Zumpe (Paul de Wit, *Katalog des musikhistortschen Museums,* Leipzig, 1903. No. 55, illustration, p. 38). Inside is inscribed: "Friedrich Hildebrandt, Instrumentenmacher in Leipzig, Quergasse," with four figures almost illegible. Paul de Wit refers the instrument to the middle of the 18th century. It has all the

appearance of being a reduced copy of a well-established type, differing very little from the later models.

Burney tells us all about Zumpe; and his instruments still existing would fix the date of the first at about 1765. Fetis narrates, however, that he began the study of the piano on a square piano made by Zumpe in 1762. In this simple action (fig. 14) we have the nearest approach to a realization of Schroeter's idea. It will be noted that Schroeter's damper (fig. 13) would stop all vibration at once. This defect is met by Zumpe's "mopstick" damper.

Another piano action had, however, come into use about that time or even earlier in Germany. The discovery of it in the

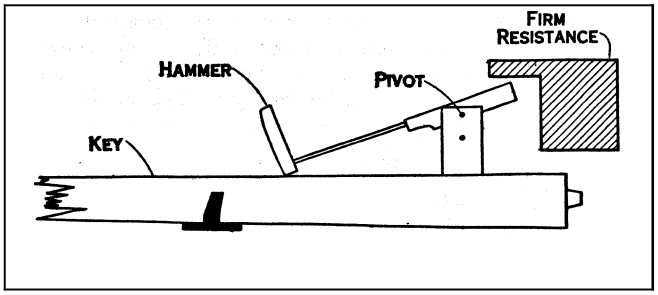

FIG. 15.— EARLIEST KNOWN PIANO ACTION ON THE GERMAN PRINCIPLE OF ESCAPEMENT. WHEREBY THE PIVOT RISES WITH THE KEY AND THROWS THE BUTT AGAINST A FIRM RESISTANCE

simplest form is to be attributed to V. C. Mahillon, who found it in a square piano belonging to Henri Gosselin, painter of Brussels (fig. 19). The principle of this action is that which was later perfected by the addition of a good escapement by Stein of Augsburg, and was again later experimented upon by Sebastian Erard. Its origin is perhaps due to the contrivance of a piano action that should suit the shallow clavichord and permit of its transformation into a square piano. It will be observed that the hammer is. as compared with other actions, reversed, and its pivot rises with the key, necessitating a fixed rail against which the hammer butt strikes. It was Stein's merit to graft the hopper principle upon this simple action; and Mozart's approbation of the invention, when he met with it at Augsburg in 1777, is expressed in a well-known letter addressed to his mother. No more "blocking" of the hammer, destroying all vibration, was henceforth to vex his mind. He had found the instrument that for the rest of his short life replaced the harpsichord. V. C. Mahillon secured for his museum the only Johann Andreas Stein piano which is known to remain. It is from Augsburg, dated 1780, and has Stein's escapement action (fig. 16), two unisons, and the knee pedal.

Mozart's own grand piano, preserved at Salzburg, and the two grand pianos (the latest dated 1790) by Huhn of Berlin! preserved

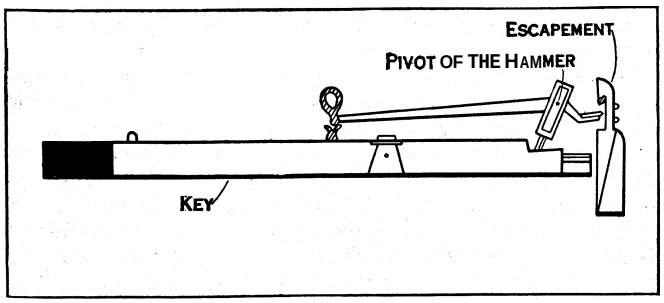

FIG. 16.— STEIN'S ACTION AFTERWARDS CALLED VIENNESE (1780)
The pivot of the hammer rises with the key and the blow is caused by the end of the hammer coming into contact with the escapement

at Berlin and Charlottenburg, follow Stein in all particulars. These instruments have three unisons upwards, and the muting movement known as celeste, which no doubt Stein had also. The wrest-plank is not inverted; nor is there any imitation of Cristofori. Stein's instrument was accepted as a model in Berlin as well as Vienna, to which city his business was transferred in 1794 by his daughter Nanette, known as an accomplished pianist and friend of Beethoven, who at that time used Stein's pianos. Streicher, a pianist, who married Nanette, further improved the Viennese instrument, famous for its lightness of touch.

We will quit the early German piano with an illustration (fig. 17) of a square piano action in an instrument made by Johann Gottlob Wagner of Dresden in 1783, and embodying the Cristofori principle rather than the Viennese.

Burney, who lived through the period of the displacement of the harpsichord by the pianoforte, is the only authority to whom

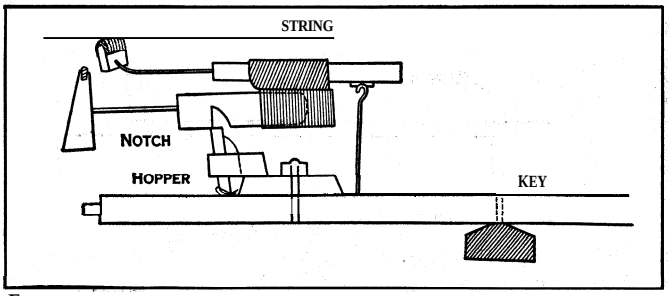

FIG. 17.— GERMAN SQUARE ACTION (1783); ESCAPEMENT IS EFFECTED AT THE POINT WHERE THE HOPPER FALLS INTO THE NOTCH. PIANO BY WAGNER, DRESDEN

we can refer as to the introduction of the latter instrument into England. He tells us without giving the exact date that the first hammer harpsichord that came to England was made by an English monk at Rome, a Father Wood, for an English gentleman, Samuel Crisp of Chesington; the tone of this instrument was superior to that produced by quills, with the advantage of piano and forte expression so that, although the touch and mechanism were imperfect, yet in a slow movement like the "Dead March" in Saul it excited wonder and delight. Fulke Greville afterwards bought this instrument for 100 guineas, and it remained unique in England for several years, until Plenius, the inventor of the lyrichord, made a pianoforte in imitation of it. In this instrument the touch was better, but the tone was inferior. Plenius produced his lyrichord, a sostenente harpsichord, in 1745, and Mason imported a pianoforte ten years later. Burney further tells us that the arrival in London of J. C. Bach in 1759 was the motive for several of the second-rate harpsichord makers trying to make pianofortes, but with no particular success. Of these Americus Backers (d. 1776), said to be a Dutchman, appears to have gained the first place. He was afterwards the inventor of the so-called English action, based upon Cristofori's, and may have made the instrument referred to in an old play-bill of Covent Garden in Messrs. Broadwoods' possession, dated May 16, 1767, which has the following announcement:—

"End of **Act** 1. Miss Brickler will sing a favourite song from Judith, accompanied by Mr. Dibdin **on** a new instrument call'd Piano Forte."

Backers's "Original Forte Piano" was played at the Thatched House in St. James's Street, London, in 1773. Ponsicchi has found a Backers grand piano at Pistoria, dated that year.

The escapement lever is suggested by Cristofori's first action, to which Backers added a contrivance for regulating it by means of a button and screw (see fig. 18). The check is from Cristofori's second action. John Broadwood and Robert Stodart were friends, Stodart having been Broadwood's pupil; and they were the assistants of Backers in the installation of his invention. On his deathbed he commended it to Broadwood's care, but Stodart appears to have been the first to advance it—Broadwood being probably held back by his partnership with his brother-in-law, the son of Shudi, in the harpsichord business. (The elder Shudi had died in 1773.) Stodart soon made a considerable reputation with his "grand" pianofortes, a designation he was the first to give them. In Stodart's grand piano we first find an adaptation from the lyrichord of Plenius, of steel arches between the wrest-plank and belly-rail, bridging the gap up which the hammers rise. These are not found in any contemporary German instruments, but may have been part of Backers's. Zumpe's small square piano had met with great success; he was soon enabled to retire, and his imitators, who were legion, continued his model with its hand stops for the dampers and sourdine, with little change but that

which straightened the keys from the divergences inherited from the clavichord.

John Broadwood took this domestic instrument in hand to improve it, and in the year 1780 succeeded in entirely reconstructing it. He transferred the wrest-plank and pins from the right-hand side, as in the clavichord, to the back of the case, an

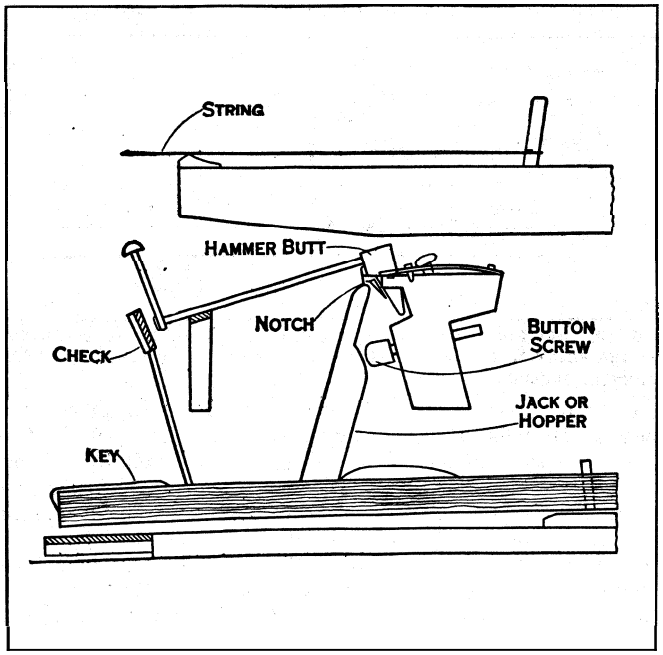

FIG. 18.—GRAND **PIANO ACTION** (1776). THE "ENGLISH" ACTION OF **AMERICUS** BACKERS
The button screw throws the jack out of the notch in the butt after making the blow; improved by Messrs. Collard (1835), who reversed the lever and hammer butt

improvement universally adopted after his patent, No. 1379 of 1783, expired. In this patent we first find the soft and sustaining pedals, since universally accepted, but at first in grand pianofortes only. John Geib patented (No. 1571 of 1786) the hopper with two separate escapements, one of which was soon adopted in the "grasshopper" of the square piano, it is believed by Geib himself;

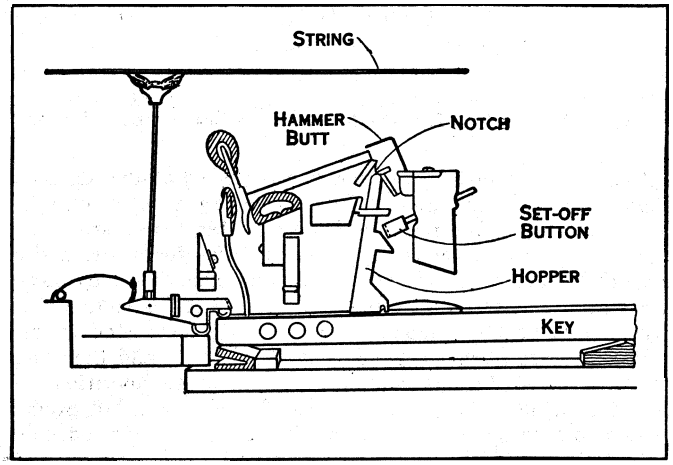

FIG. 19.—BROADWOODS GRAND PIANO ACTION (1884). ENGLISH **DIRECT** MECHANISM
The hopper is thrown from the notch in the butt, by the slanting blow given by the set-off button when the hopper rises

and Petzold, a Paris maker, appears to have taken later to the escapement effected upon the key.

To return to John Broadwood—having launched his reconstructed square piano, he next turned his attention to the grand piano to continue the improvement of it from the point where Backers had left it. He called in the aid of professed men of science—Tiberius Cavallo, who in 1788 published his calculations of the tension, and Dr. Gray, of the British Museum. The problem was solved by dividing the sound-board bridge, the lower half of which was advanced to carry the bass strings, which were still of brass. Even the first attempts to equalize the tension and improve the striking-place were successful in improving the tone greatly. To please Dussek, Broadwood in 1791 carried his five-octave, F to F, keyboard, by adding keys upwards, to five and a half octaves, F to C. In 1794 the additional bass half octave to C, which Shudi had first introduced in his double harpsichords, was given to the piano.

The first square piano made in France is said to have been constructed in 1776 by Sebastian Erard, a young Alsatian. In 1786 he came to England and founded the London manufactory of harps and pianofortes bearing his name. Erard took out his first patent for a "repetition" action in 1808. He did not, however, succeed in producing his famous repetition or double escapement action until 1821; it was then patented by his nephew Pierre Er-

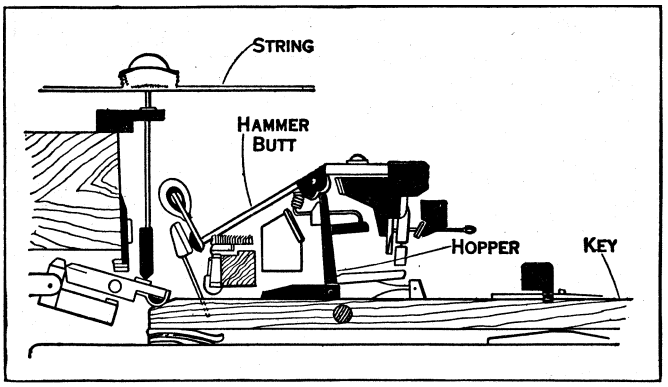

FIG. 20.—**COLLARD'S** GRAND **PIANO** ACTION (1884): ENGLISH ACTION. **WITH** REVERSED HOPPER AND CONTRIVANCE FOR REPETITION ADDED. OPERATING UNDER THE BUTT

ard. When the patent expired in England in 1835 it had proved a loss from the difficulties of carrying out the invention. This induced the House of Lords to grant an extension of the patent.

Erard invented in 1808 an upward bearing to the wrest-plank bridge, by means of agraffes or studs of metal, through holes in which the strings are made to pass, bearing against the upper side. A long brass bridge on this principle was introduced by William Stodart in 1822. A pressure-bar bearing of later introduction is claimed for the French maker, Bord.

The first to see the importance of iron combined with wood (ultimately almost supplanting it) in pianoforte framing was a native of England and a civil engineer by profession, John Isaac Hawkins, known as the inventor of the ever-pointed pencil. He was living at Philadelphia, U.S.A., when he invented and first produced the familiar upright pianoforte—"portable grand" as he then called it. He patented it in America, his father, Isaac Hawkins, taking out the patent for him in England in the same year, 1800.

There had been upright grand pianos as well as upright harpsichords, the horizontal instrument being turned up upon its wider end and a keyboard and action adapted to it. William Southwell, an Irish piano-maker, had in 1798 tried a similar experiment with a square piano, to be repeated in later years by W. F. Collard of London; but Hawkins was the first to make a piano with the strings descending to the floor, the keyboard being raised, and this, although at the moment the chief, was not his only merit. He anticipated nearly every discovery that has since been introduced as novel. His instrument is in a complete iron frame, independent of the case; and in this frame, strengthened by a system of iron resistance rods combined with an iron upper bridge, his sound-board is entirely suspended. An apparatus for tuning by mechanical screws regulates the tension of the strings, which are of equal length throughout. The action, in metal supports, anticipates Wornum's in the checking, and still later ideas in a contrivance for repetition. Southwell appears to have been one of the first to profit by Hawkins's ideas by bringing out the tall cabinet pianoforte, with hinged sticker action, in 1807. All that he could, however, patent in it was the simple damper action, turning on a pivot to relieve the dampers from the strings. The next

steps for producing the short or cottage upright piano were taken by Robert Wornum, who in 1811 produced a diagonally, and in 1813 a vertically, strung instrument. Wornum's improved crank action (fig. 23) was not complete until 1826, when it was patented for a cabinet piano; but it was not really introduced until three years later, when Wornum applied it to his little "piccolo." The principle of this centred lever check action was introduced

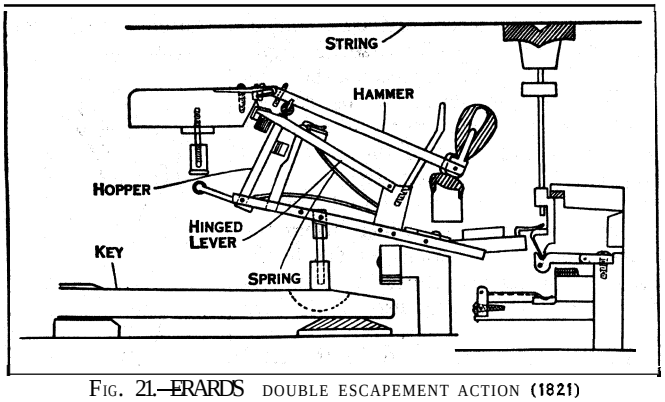

FIG. 21.—ERARD'S DOUBLE ESCAPEMENT ACTION (1821)
The escapement of repetition is effected by a spring pressing the hinged lever upwards, to allow the hopper which delivers the blow to return into position, before the key has risen again

into Paris by Pleyel and Pape, and thence into Germany and America. (Pleyel exhibited a small upright piano in Paris in 1827, but Pierre Erard did not turn his attention to upright pianos until 1831.)

Early in the 19th century William Allen, a young tuner in the employ of the Stodarts, devised a metal system of framing intended primarily for compensation, but soon to become, in other hands, a framing for resistance. His idea was to meet the divergence in tuning caused in brass and iron strings by atmospheric changes by compensating tubes and plates of the same metals, guaranteeing their stability by a cross batoning of stout wooden bars and a metal bar across the wrest-plank. Allen consulted Stodart's foreman, Thom; and Allen and Thom patented the invention in January 1820. The firm of Stodart at once acquired the patent.

We now arrive at an important epoch in pianoforte construction—the abolition of the wooden construction in favour of a combined construction of iron and wood, the former material gradually asserting pre-eminence. Allen's design is shown in fig. 24. The long bars are really tubes fixed at one end only; those

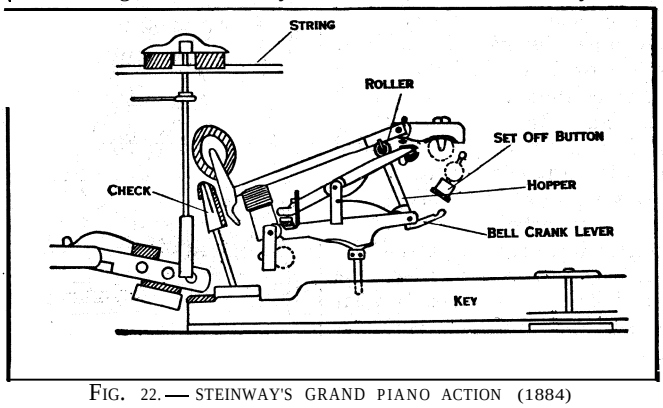

FIG. 22.—STEINWAY'S GRAND PIANO ACTION (1884)
The double escapement as in Erard's (fig. 21) but with shortened balance and usual check. The hopper escapes from under the roller owing to the ball-crank lever coming into contact with the set-off button

of iron lie over the iron or steel wire, while those of brass lie over the brass wire, the metal plates to which they are attached being in the same correspondence. At once a great advance was made in the possibility of using heavier strings without danger to the durability of the case and frame. In 1821, a fixed iron string-plate, the invention of one of Broadwood's workmen, Samuel Hervé, was applied to one of the square pianos of that firm. The great advantage in the fixed plate was a more even resistance to the tension of the strings and the reduction of their length behind the bridge. Long iron resistance bars were experimented on as substitutes for the wooden bracing by Joseph Smith in 1798; but to James Broadwood belongs the credit of trying them first above the sound-board in the treble part of the scale in 1808, and again in 1818; he did not succeed, however, in fixing them properly. Sebastian and Pierre Erard seem to have been first in the field in 1823 with a complete system of nine resistance bars from treble to bass; with a simple mode of fastening them through the sound-board to the wooden beams beneath. James Broadwood, by his patent of 1827, claimed the combination of string-plate and resistance bars, which was clearly the completion of the wood and metal instrument, differing from Allen's in the resistance being fixed. Broadwood left the bass bars out, but added a fourth bar in the middle to the three in the treble he had previously used But the weight of the stringing was always increasing, and a heavy close copper covering of the bass strings had become general. The resistance bars were increased to five, six. seven, eight and, as we have seen, even nine, according to the ideas of the different English and French makers who used them in their pursuit of stability.

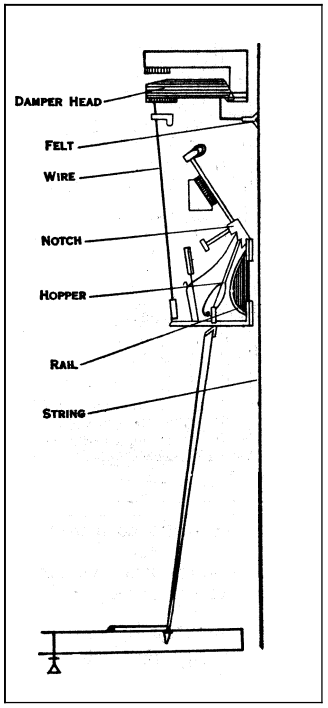

FIG. 23.—WORNUM'S UPRIGHT ACTION (1826), ORIGINAL OF THE NOW UNIVERSAL ACTION IN UPRIGHT PIANOS
The Hopper in its ascent drove the hammer forward at the same time contacting the rail which threw the upper end of the hopper out of the notch forming what is known as the escapement. Meanwhile the damper-head is raised by the wire, and the felt is taken from the string

A method of fastening the strings on the string-plate depending upon friction, and thus dispensing with "eyes," was a contribution of the Collards, who had retained James Stewart, a man of considerable inventive power, who had been in America with Chickering. This invention was introduced in 1827. Between 1847 and 1849 Mr. Henry Fowler Broadwood, grandson of John Broadwood, invented a grand pianoforte to depend practically upon iron, in which, to avoid the conspicuous inequalities caused by the breaking of the scale with resistance bars, there should be no bar parallel to the strings except a bass bar, while another flanged resistance bar, as an entirely novel feature, crossed over the strings from the bass corner of the wrest-plank to a point upon the string-plate where the greatest accumulation of tension strain was found. After the Great Exhibition of 1851 he employed an ordinary straight bar in the middle of his concert grand scale, his smaller grands having frequently two such as well as the long bass bar. After 1862 he covered his wrest-plank with a thick plate of iron into which the tuning pins screw as well as into the wood beneath, thus avoiding the crushing of the wood by the constant pressure of the pin across the pull of the string.

The introduction of iron into pianoforte structure was differently and independently effected in America, the fundamental idea there being to use a single casting for the metal plate and bars, instead of forging or casting them in separate pieces. Alphaeus Babcock was the pioneer of this kind of metal construction He also cast an iron ring for a square piano in 1825, which, although not a success, gave the clue to a single casting resistance framing, successfully accomplished by Conrad Meyer, in Philadelphia, in 1833, in a square piano which still exists, and was shown in the Paris Exhibition of 1878 Meyer's idea was improved upon by Jonas Chickering (1797–1853) of Boston, who applied it to the grand piano as well as to the square, since which time this prin-

ciple has been universally adopted.

We have now to consider over- or cross-stringing, by which the bass division of the strings is made to cross over the tenor part of the scale—the object being in the first instance to get longer bass strings than are attainable in a parallel scale, and in the next to open out the scale and extend the area of bridge pressure on the sound-board. In the 18th century clavichords were sometimes overstrung in the lowest octave to get a clearer tone in that very indistinct part of the instrument (strings tuned an octave higher being employed). The first suggestion for the overstringing in the piano was made by the celebrated flute-player and inventor Theobald Boehm, who carried it beyond theory in London, in 1831, by employing a small firm located in Cheapside, Gerock & Wolf, to make some overstrung pianos for him. Boehm expected to gain in tone; Pape, an ingenious mechanician in Paris, tried a like experiment to gain economy in dimensions, his notion being to supply the best piano possible with the least outlay of means. Tomkinson in London continued Pape's model, but neither Boehm's nor Pape's took permanent root. The Great Exhibition of 1851 contained a grand piano, made by Lichtenthal of St. Petersburg, overstrung in order to gain symmetry by two angle sides to the case. It was regarded as a curiosity only. Later, in 1855, Henry Engelhard Steinway (originally Steinweg; 1797–1871), who had emigrated from Brunswick to New York in 1849, and had established the firm of Steinway & Sons in 1853 in that city, effected the combination of an, overstrung scale with the American iron frame, which exhibited in grand and square instruments shown in London in the International Exhibition of 1862, excited the attention of European pianoforte makers, leading to important results.

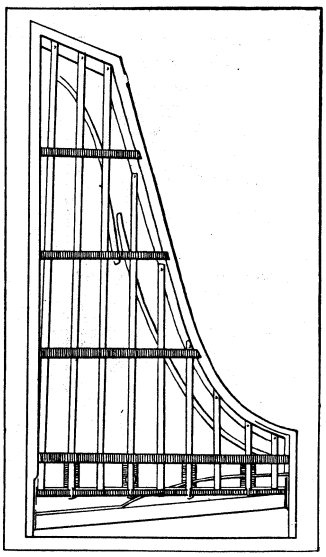

FIG. 24.— ALLEN'S COMPENSATING GRAND PIANO (1820) THE FIRST COMPLETE METAL FRAMING SYSTEM APPLIED OVER THE STRINGS

It would be inaccurate to say that no outstanding developments have taken place in pianoforte construction during the last fifty years, but few new principles have been discovered, and improvement has taken place almost entirely in the direction of applying in greater and greater measure scientific knowledge to methods and practices previously empirical (see PIANOFORTE MANUFACTURE) thus resulting in improvement in volume and richness of tone.

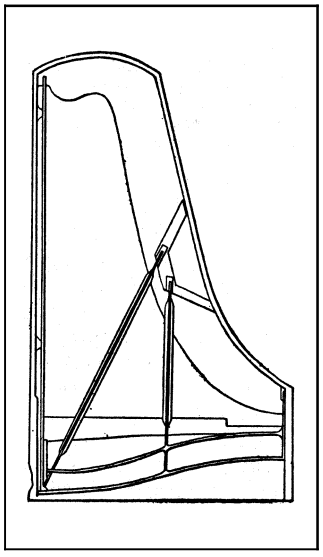

FIG. 25.—BROADWOOD'S IRON GRAND PIANO (1884), HAVING COMPLETE IRON FRAME WITH DIAGONAL RESISTANCE BAR

Summing up matters it may be said that the modern pianoforte retains six important characteristics of the clavichord, in that it has an independent sound-board (*i.e.*, the ends of the strings are not fastened to it), dampers to prevent vibration of the strings not in use, "listing" cloth to deaden the vibration from the ends of the strings beyond the bridges, groups of three strings tuned in unison and a tone production which depends upon a blow instead of a plucking (as in the spinet and harpsichord).

Five of the ideas developed in the harpsichord have also survived or have been revived from time to time, namely, the sustaining pedal, the celeste felt for soft playing, the transposing keyboard, the soft stop for practising very quietly, and the double manual (viz., as recently introduced by Emanuel Moór).

As regards the sustaining pedal the importance of this cannot be over-estimated, for not only does it allow of harmonies being maintained when necessary without holding the keys down, but it also modifies the tone quality by allowing all strings to take part simultaneously by means of their resonance. Moreover the sound-board is encouraged to increase its amplitude of vibration, thus increasing the tonal volume, which in skilful hands can be made to reach a maximum intensity of over twenty times that of the most powerful harpsichord. Contrariwise, the tone can be attenuated and diminished by means of the soft pedal, which brings the hammers nearer the strings, or (as in the case of grand pianos) shifts the hammers so that they strike two instead of three strings.

The "celeste" pedal and "soft stop" devices both involve the introduction of a strip of felt between the strings and the hammers at the point of contact, thus reducing the force of the blow.

For school pianos, which are used for practising almost continuously throughout the day, the soft stop is' a most useful adjunct and when properly designed need not interfere unduly with the touch of the instrument.

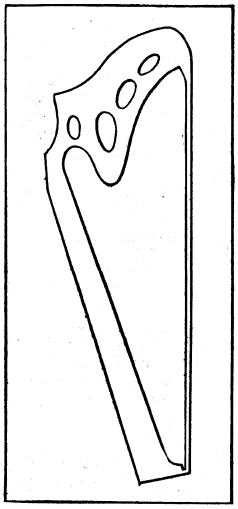

FIG. 26.—MEYER'S METAL FRAME FOR A SQUARE PIANO (1833)

The transposing device, a feature of the once popular player piano, has been found both difficult to apply to the piano and to keep in perfect order owing to the necessity for shifting the keys relative to the action, a movement which upsets the delicate regulation of the repetition, and renders the device unsatisfactory.

Finally, the double keyboard, as invented by Emanuel Moór, represents a new development, possibly extending the resources of both performer and composer to some degree. Such a revolutionary departure will doubtless take time to become commercially possible, but some musical opinion is entirely in its favour. Briefly stated, the second keyboard lies just behind and above the normal standard notes, and operates those strings which are an octave higher. Consequently it is possible to play extended chords, arpeggios and double octaves with some facility. There is also an octave coupler which further increases the possibilities of the instrument from the point of view of volume. To what extent the principle will ever secure general adoption it will be rash to prophesy, but as to its ingenuity and musical value there is no room for doubt.

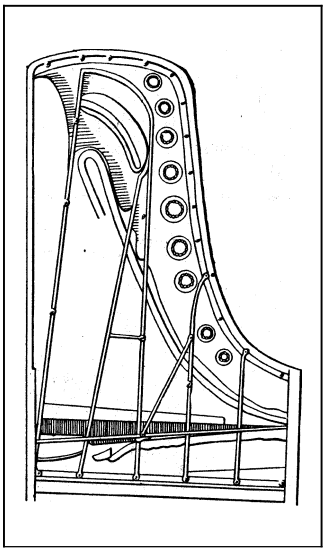

FIG. 27.—STEINWAY'S GRAND PIANO (1884), A METAL FRAMING IN A SINGLE CASTING AND OVERSTRUNG

The principles discovered in the early actions (Erard 1821 and Robert Wornum 1826) still stand firm, and all subsequent improvements have been built thereon.

The separate parts of the modern action are produced by automatic machinery, and assembled by hand with great skill and accuracy.

The pianoforte manufacturer has long recognized the advisability of allowing this important component to be made for him

by specialists, the hammers and hammer shanks being fitted after the action has been installed.

Present-day development is largely directed towards overcoming the physical handicaps to richness and volume of tone imposed by smaller overall dimensions to fit smaller rooms. The sound-board is made as sensitive as possible, supported in a rigid frame-work which absorbs little or no energy from the board at its edges. The modern sound-board sustains a continual down-pressure from the strings of nearly half a ton, whereas the early grand pianos had scarcely a hundred-weight pressure thereon. The string tension has tripled (from 60 to 180 lb. per string in some instances) with the ability of the wire drawers to supply stronger and stronger wire, and the iron founder has had to devise castings which stand a total stress of 16 tons and upwards without occupying too much room, or covering too large a portion of the surface of the sound-board Some early makers had the mistaken idea that an iron structure entailed the production of a "metallic" tone in the instrument; but those who adhered to the use of the wooden frame were soon left behind, mainly owing to the extreme susceptibility of the pitch of such pianos to temperature and humidity changes, which rendered the tuning very unstable.

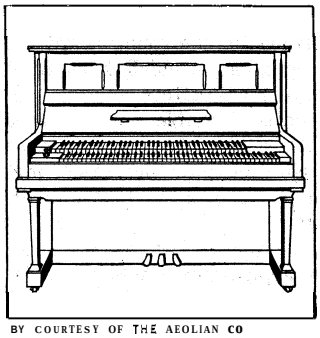

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FIG 28.—A WEBER PIANO SHOWING THE EMANUEL MOOR DUPLEX COUPLER KEYBOARD

As regards the future, experiments are now being made in the field of electrical amplification of string tone, by means of electrostatic and electro-magnetic "pick-up" devices applied to the struck strings or the structure of the piano. Amplification has so far resulted in also considerably increasing the duration of tone, causing blurred and confused results in the playing of rapid passages and staccato notes.

These effects have so far kept such new instruments acoustically outside the category of pianos due to altered tonal characteristics.

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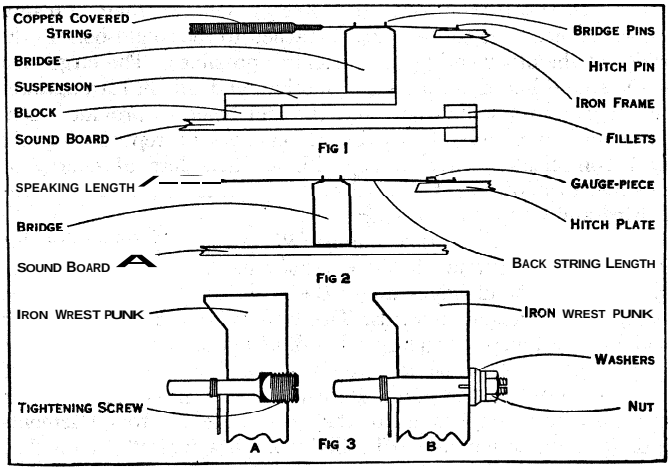
PIANOFORTE MANUFACTURE. There are eighty-eight notes in the full compass keyboard of the pianoforte, which gives a range of 73 octaves. The 49th tone from the bass end of the scale is called "Pitch A," and has a frequency of 440 double vibrations per second, adopted in the United States and Great Britain as the standard pitch from which all others are tuned. Since each note has to vibrate twice as fast as the note of the same name an octave below, and there are twelve semitones to the octave, it follows that the semitone ratio from note to note must be the twelfth root of 2, namely 1·05946, which is a geometrical progression giving the now generally adopted "equal temperament" tuning. Purely mathematical considerations make it essential that the string lengths should also proceed in geometrical progression, but in a slightly smaller octave ratio than 2:1. In Germany the ratio most favoured is 1·875:1, and in Great Britain 1·89:1. Both of these ratios approximately allow of half-size increases in the gauge of wire used, twice per octave, without departing far from the uniform tension initially decided upon. The English Music Wire Gauge advances one-thousandth of an inch in diameter per half size, while the New Westphalian Gauge advances 0·025 millimetre per half size, but there are irregularities in the English Gauge at various places, for reasons apparently unknown.



FIGS. 1, 2, & 3.—METHODS OF CONNECTING STRINGS TO SOUNDBOARD
1. Connecting of bass bridge to a sensitive part of the soundboard, 2. Slight dip of string after leaving bridge on its way to hitch-plate, 3. Two methods of avoiding the use of wooden-plank in extreme climates. (A) the screw pushes wrest-pin forward and holds it friction-tight, (B) the pin is held in a tapered hole by a nut

In small instruments, whether grands or uprights, it is impossible to carry theoretical string lengths throughout the piano, and compromises have to be made by shortening and thickening them in order to maintain the necessary high tension. Since short

and thick strings give a different and inferior tone quality it must not be expected that small instruments will give a pure and balanced "timbre" throughout the scale.

Cold drawn steel wire of the highest quality is specially made for the pianoforte trade, with a minimum breaking strength of 150 tons per square inch. Two types are now in favour, the polished and the plated. The latter has been successfully developed, and is especially useful for export models.

Length of Strings. — In practice the strings of the 88th note are always between 5·0 and 5·5 centimetres in length, the shorter length being used for small instruments. From this starting point the succeeding lengths are calculated mathematically until it becomes necessary to employ heavier strings weighted by means of one or two layers of copper wire closely and tightly spun upon them. In order to gain in length and to fix the bridge to a sensitive part of the sound-board, well away from its edges, about fifty of the bass strings (12 singles and 19 bichords) are planned to cross over the others, reaching to a separate and higher bridge. This method of "overstringing" is now general in all but the cheapest pianos. The lengths of the copper-covered strings are not calculated mathematically but are made so that the lowest note is as long as possible. Additional length is often secured by means of a "suspended" bridge, as shown in fig. 1, which transmits the vibrations of the bridge to a point which should be at least six inches from the edge of the sound-board.

It has been found that a tension of about 160lb. is advisable for the uncovered strings, and the diameter of wire is calculated from the formula, $\frac{18{,}600\,T}{nl}$ after which the nearest gauge to this diameter is selected, it being impracticable to manufacture a different diameter for each note. In the formula, "n" is the number of vibrations per second, "T" the tension in lb., and "l" the length of the vibrating portion of the string, in centimetres.

For the copper-covered strings some makers employ the formula $\frac{20{,}000\,T}{nl}$ which gives the all-over diameter of the required string. Others calculate the weight per centimetre instead of the diameter, using the formula $\frac{111{,}250\,T}{n^2l^2}$, afterwards spinning strings of the required weight, as found by experimental determinations. For bichord bass strings a considerable increase of tension is provided, varying from 10 to 15%, and for the single bass strings a further increase of 15% and upwards, according to the size of the instrument.

The Sound-board. — As the strings vibrate they transmit pressure differences to the bridge attached to the sound-board (the bridge at the other end being as rigid as possible). The large area of the sound-board is thus set in motion, and this in turn agitates the air in its immediate vicinity, the aim being to provide a sensitive and extremely elastic board, capable of reproducing the most complicated wave-forms, with as little loss of energy as possible. In addition, the board must be made of material of low density and of uniform texture.

The timber of the spruce family (*Picea excelsa*), when cut "on the quarter," answers all these requirements, the best qualities transmitting sound-waves along the grain at the rate of 16,000 feet per second and upwards. The transmission across the grain is about one-fourth of this speed, a difficulty which is surmounted by gluing bars of the same material across the back of the board at right angles to the grain. Research in the mode of vibration of the sound-board has led in the present decade to refinements in design; a new sound-board called "Diaphragmatic" is embodied in all Steinway pianos since 1937.

Most sound-boards are made with the grain running diagonally so that the long bridge runs almost parallel to the grain. The thickness is usually about $\frac{3}{8}$" all over, some manufacturers insisting, however, that the treble end should be thicker. Sound-boards are always fitted so that they are slightly "bucked" or high in the middle, as though part of the surface of a sphere of about 60ft. radius. This shape is secured in several ways, usually the best being to subject the board to a dry temperature of 120° F. for some hours, and then to glue on the bars, in a slightly hollowed form.

The subsequent expansion as the board takes up its usual 10% of moisture from the air coupled with the "set" secured in the hollowed form produces the desired curvature. Since the board is always under pressure from the strings it follows that it behaves as an arch, which shape is retained through the rigidity of the rim to which it is fixed.

The "Down-bearing." — Good contact is maintained between strings and bridge by leaving the bridge a little higher than the general level of the two extremities. The resulting pressure of the strings on the sound-board is known as the "down-bearing," the regulation of which is one of the most critical processes in pianoforte manufacture. It is agreed that about one-fortieth of the tension is a suitable amount for each string to press upon the bridge. Translated into degrees this means that the bridge must stand high enough to allow the string to dip one and a half degrees after it passes over the bridge on its way to the hitch-pin on the iron frame.

Allowance has to be made for the fact that as the tension is applied the whole board is pressed down somewhat, and the amount of such sinking depends upon its dimensions, barring and support round the edge. The extra height is not measured at the bridge, but by means of a straightedge laid across where the string will pass, the amount of clearance at the hitch-pin is allowed for. (See fig. 2.) It does not matter so much what the exact pressure is, but inequalities of pressure cause very serious results, affecting those strings which lie between places of excessive pressure, and robbing them of their adequate contact with the bridge. Good contact between strings and bridge is also maintained by means of bridge-pins which lie in the line of the strings and are inserted at an angle of 70 degrees with the plane of the bridge.

By passing the string to the left of the front pin and to the right of the back pin a frictional grip is secured. This practice is almost universal, an outstanding departure being Messrs. Broadwood's method of screwing studs to the bridge and passing the strings through these. Previous efforts to provide a studded bridge have been discarded owing to the studs working loose and causing falseness of tone, but Messrs. Broadwood claim to have overcome this difficulty.

Tone and Overtones. — Pianoforte tone is compound, each note consisting of a fundamental tone and its overtones, which, sounding together, form the "harmonic series," with their vibration rates in the ratio of 1:2:3:4, etc For instance, the tone of "middle C" has for harmonics the following notes, the frequencies of which are inserted in brackets: C (261·6), the fundamental; C (523·25), G (783·99), C (1046·5), E (1318·57), G (1567·9), B flat (1864·65), C (2093), D (2349·3) and so on. If these notes be played together as a chord it will be at once detected that the harmonics blend together pleasingly, with the exception of the seventh and ninth which are dissonant By striking the strings at one-eighth of their length from the fixed end, it is believed that the best tone quality is produced, whether by discouraging the 7th and 9th harmonics or by encouraging the 4th is not yet scientifically proved. This strike proportion is used for all notes from the bass up to or near the 51st note, after which other considerations make it necessary to strike the string gradually nearer the end, the fraction at the extreme treble being empirically decided upon at about &, Since the discordant harmonics of these notes are very weak and even beyond the limits of human audition it does not matter if they are produced, the striking point being arranged to allow of a quicker recoil of the hammer from the string.

Toning the Hammers. — The process known as "toning" or "voicing" the hammers is an attempt to control the time of contact between hammer and string, a soft hammer staying long enough to damp out some of the unwanted overtones, while a hard-nosed hammer accentuates them. If a string vibrates a thousand times per second, its "periodic time" is one-thousandth of a second, and experiment proves that the best tone is emitted if the hammer is toned so that contact is maintained for about half this period.

English and German felts are used wherever the highest quality is required, their resiliency being the desirable property. Great pressure is used in modern hammer-making and the density at the treble end where the hammer dimensions are small, is more than double that of the bass hammers. The toner, by means of pricking the felt, lessens the hardness at and beneath the nose of the hammer. In this he is entirely guided by his ear, the aim being to eliminate undesirable tone components and secure an evenly graded scale, with no audible break between the treble and bass strings.

The Action.—The hammers are actuated by a system of levers known as the "action," which is now made by firms specializing in this unit alone, rather than by the piano manufacturer himself. The noses of the hammers rest at a distance of two inches from the strings, but if a note is held down after having been played, the hammer is "checked" when it has rebounded five-eighths of an inch, so that the blow can be repeated rapidly. When the key is half-way down, the felt "damper" is lifted from the strings and remains lifted until the key is released.

Pedals.—The tone is modified by means of two pedals, the left-hand pedal taking the hammers nearer to the strings and thus decreasing the force of the blow. Sometimes the whole action is shifted to the right, so that the hammer only strikes two strings instead of three. The right-hand pedal lifts all the dampers from the strings so as to sustain harmonies as long as required, and not merely, for increased power. In America a central pedal is often added, called the "Sostenuto," which, instead of lifting all the dampers, affects only those which happen to be already lifted, keeping them so until the pedal is released. Thus one is able to sustain a chord, leaving the hand free for other notes.

The ideal point of contact for the dampers is at the same place as the striking point, and in grand pianos this is approximately arranged, the dampers lying along the strike line above the strings, and operated by gravity only. In upright pianos a position just under the strike line is favoured, such actions being known as "under-damper," and the pressure obtained by springs. The cheaper piano is sometimes provided with an older type wherein the damper is operated by gravity at a point just above the hammers. This is known as the "over-damper" action, and although the vibrations of the strings are of less amplitude above the hammer-line than below it, a well-made over-damper action is still in favour by certain Continental makers of repute, owing to its more effective silencing of the harmonics.

Touch.—The depth of touch for the keys has been standardized in all countries at g millimetres, with an additional millimetre to allow for the locking of the check and the free escapement of the "Jack" lever. The pivoting of the key has to be so placed as to give the correct amount of lift at the other end, usually about 6 millimetres, but varying a little with the different makes of action. The best "touch" is secured if the keys slope backwards a little when at rest, becoming exactly level when half depressed. At this point begins the extra load due to the lifting of the dampers, but the momentum already gained is sufficient to render it unnoticeable. A "touch weight" is used during the regulating of the action, so that when it is placed upon the end of the key, and suddenly released, the force exerted is just sufficient to make the note sound faintly This "dead weight" of touch is not standardized, but averages 60 grammes in the bass, down to 48 grammes in the treble.

Frame.—The iron frame, which takes most of the load exerted by the pull of the 220-odd strings, is cast in one piece at the foundry, from an iron pattern which has been made 1% larger than the finished frame, in order to allow for the contraction of the casting during cooling.

Tuning Pins.—The tuning pins of mild steel, about 7 millimetres in diameter, are driven into a wrest-plank of quartered beech or maple, usually of ply construction to prevent splitting. The holes are bored slightly smaller than the pins, a ratio of 15:17 giving the correct amount of tightness. Since the plank is bolted to the iron frame and glued to the wooden back it follows that the load is shared between the frame and the back, the tendency in cheaper construction being to eliminate the wooden back altogether. The wrest-plank is often covered with a web of iron into which maple plugs have been driven, the tuning pins passing through these plugs into the plank. This method has proved popular and has been adopted in many upright and grand pianos. Patent methods of securing the tuning-pins have been introduced from time to time, but the method above described would seem likely to survive all others, being efficient, inexpensive and free from complications.

For tropical climates, an all-metal wrest-plank has been designed, the wrest-pins being held "friction tight" from the back of the plank. Fig. 3 shows an Australian and a German method of providing sufficient hold for the pin, at the same time allowing it to be adjusted finely by the tuner. In order to prevent the two surfaces from rusting together, a very fine grade of graphite is used as a lubricant. The washers have a projection which fits into a slot running down the threaded portion of the pin, which ensures that they move with it during all adjustments.

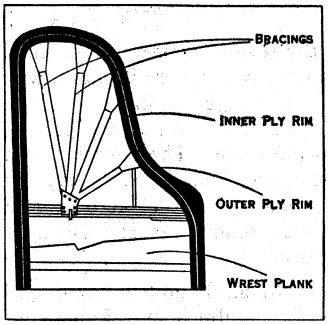


FIG. 4.—STEINWAY GRAND CASE-WORK, SHOWING PARTS

Standardization.—The similarity in methods and design of the leading manufacturers in all countries is accounted for by the necessity for standardization of the keyboard, its height from the floor, the provision of room for the knees, the situation of the pedals, and the natural laws controlling the vibration of stretched strings. In the upright piano the wooden back forms a convenient base to which the ends of the case are glued, besides being the means for securing rigidity for the edges of the sound-board and a support for both iron frame and wrest-plank.

The peculiar form of the grand piano enables an immensely strong inner rim to be built up in one continuous bend, into which bracings are dove-tailed, and to which the key-bottom (supporting the key-board) is secured. This inner rim, on which the sound-board and iron frame are fastened, may be six inches deep, and from $1\frac{1}{4}''$ to $1\frac{1}{2}''$ thick. Additional rigidity is further provided by gluing this unit to an outer rim, also of ply formation, about a foot deep and from 1" to $1\frac{1}{4}''$ thick. The skeleton formation of the case-work of a large Steinway grand is shown in fig. 4, but it must be remembered that the lateral stiffness of such a structure varies inversely as the cube of its length, and therefore small grands do not need such elaborate re-inforcement, the very smallest (4 ft. 3 in. to 4 ft. 6 in. in length) often having no bracings at all. (S. A. H.; X.)

See the BIBLIOGRAPHY under PIANOFORTE; also *Grove's Dictionary of Music and Musicians.*

PIANOLA: see PLAYER-PIANO.

PIANOSA (anc. *Planasia*), an island of Toscana, Italy, belonging to the province of Livorno, and forming part of the commune of Campo nell' Elba, from nhich it is 11 mi. S.W. Pop. (1951) 1,238. As its name indicates, it is quite flat, and the highest point is only 89 ft. above sea level. Its area is 6 sq.mi. The discovery of numerous fossilized bones of animals show that it was still united to the mainland in the quaternary period. Traces of human habitation in the neolithic period have been found. Augustus banished to it his grandson, Agrippa Postumus, and some ruins of baths near the harbour still bear his name. It was depopulated in 1553 by the Turkish fleet. and only resettled in 1835.

PIARISTS, the popular name of a Catholic educational order, the "clerici regulares scholarum *piarum*," the Pauline Congregation of the Mother of God, founded by Joseph of Calasanza at Rome in the beginning of the 17th century Here he organized, in 1607, a brotherhood ahich ultimately, in 1617, became an independent Congregation, numbering at that time fifteen priests, under Calasanza as their head To the three usual vows they added a fourth, that of devotion to the gratuitous instruction of youth. In 1622 the Congregation received a new constitution from Gregory XV, and had all the privileges of the mendicant

orders conferred upon it.

PIAROAN, a linguistic substock of South American Indians of the independent linguistic stock or family called Salivan.

Among the tribes belonging to the Piaroan group are the Ature (extinct), Quaqua, Macu and Piaroa proper. They are scattered along several tributaries of both sides of the middle course of the Orinoco river from the mouth of the Meta upstream to the confluence with the Ventuari river. They cultivate manioc. hunt and fish. By the 1950s they were reported to have mostly disappeared or to have been absorbed into other groups.

See *Handbook of South American Indians* (1946–50).

(J. P. G.; X.)

PIATRA-NEAMT, a town in the region of Bacău, Rumania, situated on the left bank of the Bistrita river, where it cuts a way through the Carpathian foothills. Pop. (1956) 32,648.

A branch railway passes through the town, and at the city of Bacău meets the main Czernowitz-Galatz line. The church of St. John's (or the Prince's) monastery was founded in 1497 by Stephen the Great. Piatra has saw mills and textile factories and trade in wine and timber. It is a popular summer resort. The area around Piatra-Neamt is densely forested.

PIAUÍ, a northeastern state of Brazil, bounded north and west by Maranhão, east by Ceara, Pernambuco and Bahia and south by Bahia. It has a few miles of Atlantic coast line on the north. and the Rio Parnaiba forms the boundary line with Maranhão throughout its entire length. Area, 97,175 sq.mi.; pop. (1950) 1,045,696.

Part of the state on the Atlantic coast and along the lower Parnaiba is low, swampy and malarial. South of this the country rises gradually to a high plateau with open *campos.* This plateau region is drained by numerous tributaries of the Parnaiba, chief of which are the Urussui, the Canindé and its tributary the Piaui, the Gurgueia and its tributary the Paraim, which drains the large inland lake of Parnagua, the Longa, and the Poti. The Parnaiba is navigable for boats of 3 ft. draught up to Nova York, a few miles above the mouth of the Gurgueia.

The climate is hot and humid in the lowlands and along the lower Parnaiba, but in the uplands it is dry with high sun temperatures and cool nights. The principal industry is stock raising. A secondary industry is the raising of goats. The agricultural products are cotton, sugar and tobacco. Much cotton is grown, and some of it manufactured. Forest products include rubber, carnaúba wax and dyewoods. The exports include hides, skins, rubber, wax, tobacco and cotton. The capital is Teresina, on the right bank of the Parnaiba, 250 mi. above Parnaiba (town). uith which it is connected by a line of light-draft river boats. The town dates from 1852, is attractively situated. and is regularly laid out with broad, straight streets. The population in 1950 was 51,418. Other cities with their populations in 1950 are Parnaiba (30,174); Floriano (9,101); Oeiras (3,748), founded in 1718 under the name of Moxa; Amarante (2,355); Valença do Piaui (1,886); and Campo Maior (6,992). (R. D'E.; X.)

PIAVE, a river in Italy, which played an important part in the latter period of World War I on the Italian front. It rises under the Paralba pass in the Carnic Alps and flows in a southwesterly direction past Belluno as far as Feltre and then turns to the southeast, flowing into the sea at Cortellazzo to the northeast of Venice, with another, older mouth nearer to Venice. Its course is 137 mi. in length. Its depth and width vary very considerably according to the seasons of the year. In its lower reaches its bed is a vast extent of gravel only filled in times of heavy rains or at the melting of the snows.

After the Austro-German break-through at Caporetto in Oct. 1917. the remains of the Italian and army and all the 3rd army fell back on the Piave between Pederobba and the sea and were reconstituted behind that river.

On June 15, 1918, the Austrians delivered a general attack along the greater part of the Italian front, known as the battle of the Piave, their object being to break through into the rich agricultural area of the Veneto. Two Austrian forces succeeded in getting across, but were forced by Italian counterattacks to recross the Piave, after suffering heavy losses. Later an Italian local attack resulted in the conquest of the area between the old and the new Piave near the estuary.

In Oct. 1918 an Italian offensive on a large scale was effected. The battle began on Oct. 23, but did not extend to the Piave until the 27th. On that day a small mixed Italian force crossed the river near Valdobbiadene and a part of the 10th (British) army also crossed the Piave at the Grave di Papadopoli. When the bridges of the 8th (Italian) army were swept away by the current, Gen. Enrico Caviglia, commander of the 8th army, sent his 18th corps across on the British bridges; while that corps advanced up the river the British pushed east toward the Monticano; thus by the 29th the Austrian forces on the Piave were cut in half. On the 30th the bulk of the Italian attacking forces were across the river and the Austrians in full retreat.

PIAZZETTA, GIOVANNI BATTISTA (1682–1754). one of the outstanding Venetian painters of the 18th century, was born at Venice on Feb. 13, 1682. He began his career in the studio of his father, Giacomo, a mediocre wood carver. Soon after assisting the latter to carve the still-surviving bookcases of the library of SS. Giovanni e Paolo at Venice, he abandoned the family profession and began to study painting under Antonio Molinari (1665–after 1727). About 1703 he went to Bologna, where he worked in the studio of G. M. Crespi. He was back in Venice by 1711, and continued to work there until his death on April 28, 1754. From Molinari, and the study of Bolognese painting (especially Guercino's work), he learned the heavily shadowed manner which he henceforth adopted; Crespi probably awakened his interest in genre painting. The caravaggesque lighting effects at which he aimed have become emphasized with time, for his olive-grey and brown colours have darkened and the deep red ground on which he invariably painted has become more prominent.

Little is known of the dating of Piazzetta's works, especially those of his youth. "St. James carried off to Martyrdom" (in S. Stae) is dated 1717; at this period he was a powerful influence on the young G. B. Tiepolo. About 1725–27 he undertook his only ceiling painting, the "Glorification of St. Domenic" for the chapel of the Sacrament in SS. Giovanni e Paolo, in which the reverse influence of the now mature Tiepolo on Piazzetta is apparent. The "Ecstasy of St. Francis" (Vicenza), perhaps his finest religious work, dates from about 1732, and some three years later he was commissioned to execute an "Assumption" for the elector of Cologne (museum. Lille). The celebrated "Fortune Teller" (Accademia, Venice) is dated 1740. "The Pastoral" (Chicago) and the "Idyll by the Seashore" (Cologne, copy in Dublin), both in the same rococo-pastoral vein, must have been painted about the same time or a little before. In his last years he carried out a number of large-scale decorations with subjects taken from classical history.

In 1727 Piazzetta had been elected a member of the Bolognese Accademia di S. Luca and, on the foundation of the Venetian academy in 1750, he was made its first director and teacher of drawing from the nude. He produced many works for private patrons, especially half-lengths of single saints, biblical subjects and studies of peasants, soldiers or adolescents, and a few portraits. He was a very slow worker and in spite of his popularity was compelled to produce innumerable drawings for sale to eke out a penurious existence for his large family. He also carried out very many designs for book illustrations, mostly for his friend the publisher G. B. Albrizzi, the edition of T. Tasso's *Gerusalemme Liberata* (1745) being among the finest illustrated books of the 18th century.

Piazzetta had many pupils of whom the most important are Giulia Lama, Giuseppe Angeli (1710–98), Francesco Daggiù (known as "il Capella"; 1714–84), Domenico Fideli ("il Maggiotto"; 1713–93), Antonio Marinotti ("il Chizzotto"; 1719–90) and Francesco Polazzo (1683–1743). Their works are frequently confused with their master's.

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(F. J. B. W.)

PIAZZI, GIUSEPPE (1746–1826), Italian astronomer and discoverer of the first minor planet Ceres, was born at Ponte in the

Valtellina, July 16, 1746. In 1780 he was appointed professor of higher mathematics at the Academy of Palermo. Later, with the aid of the viceroy of Sicily, he founded the observatory of Palermo. There he produced his great catalogue of the positions of 7,646 stars, a work notable for its high accuracy and for the large number of objects listed. There also, on Jan. 1, 1801, he discovered and named Ceres. He died at Naples, July 22, 1826.

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PICABIA, FRANCIS (1879–1953), French painter, illustrator and editor associated with the Cubist, Dadaist and Surrealist movements was born in Paris on Jan. 22, 1879. He came into contact with modern art through Impressionism and the influence of Alfred Sisley. In 1909 he moved on to early Cubism and became a member of the *Section d'Or* ("Section of Gold") Cubist group that met at the studio of Jacques Villon. During 1912–13 he weht through his period of Orphism or colour orchestration, gradually adopting proto-Dada names for these works, *e.g.*, "Catch as Catch Can." In 1913 he exhibited at the Armory show in New York and at the famous Alfred Stieglitz gallery, contributed to the proto-Dadaist review *291*, contributing also to the Stieglitz *Camera Work* magazine where he promulgated Amorphism, a satire on current art trends. In 1917, with Walter Arensberg, Picabia launched the periodical *391* and with Marcel Duchamp, Marius de Zayas and Man Ray he also organized a semi-Dadaist group. Later he was active as a Dadaist in Barcelona; Paris and Zurich, where he worked with Tristan Tzara. In 1918 he collaborated on the third issue of *Dada* magazine in Zurich; in Paris in 1920 he began to publish a review called *Cannibale*. For many years thereafter Picabia continued to exhibit in Paris, where he died on Nov. 30, 1953.

See Marie De La Hire, Francis *Picabia* (1920); Robert Motherwell (ed.), *Dada* Painters *and Poets* (1951). (B. S. Ms.)

PICARD, CHARLES ÉMILE (1856–1941), French mathematician, whose theories did much to advance researches into algebraic geometry, was born in Paris on July 24, 1856. In 1878 he was appointed *maitre de conférences* at Paris university; in 1879 he became professor at Toulouse university; from 1881 to 1898 he held various positions at the university and the Ecole Normale Supérieure, Paris; and in 1898 he became professor at Paris university. In 1917 he was elected permanent secretary for the mathematical sciences in the Paris Academy of Sciences.

One branch of Picard's work was concerned with Fuchsian and Abelian functions: and with the allied theories of discontinuous and continuous groups of transformations. This work led to a study of the algebraic manifold now known as the Picard variety. which plays a fundamental role in algebraic geometry. In 1879 Picard proved the theorem known by his name, that an integral function of the complex variable takes every finite value, with one possible exception; this theorem initiated many important investigations. Picard also created a theory of linear differential equations, later extended by his pupil E. Vessiot, analogous to the Galois theory of algebraic equations. His study (inspired by N. H. Abel and G. F. B. Riemann) of the integrals attached to algebraic surfaces; and the related topological questions, developed into an important department of algebraic geometry, with varied applications to topology and function theory. Picard's researches in this field were expounded in the treatise Picard-Simart, *Théorie des fonctions algébriques de deux variables indépendantes* (2 vol., 1897, 1906). Picard died in Paris on Dec. 12, 1941. (L. R.)

PICARD, JEAN (1620–1682). French astronomer, was born on July 21, 1620, at La Fleche, Anjou. After acting as prior of Rillé, Anjou, he went to Paris and was admitted to the Academy of Sciences as an astronomer in 1666. In 1671 he went to examine Tycho Brahe's observatory, Uranibourg. in Denmark, and returned with some of the originals of Tycho's work. Picard's measurement between Mahoisine and Amiens provided the first accurate measure of a degree of a meridian, and was used by Newton to verify his theory of gravitation. Picard founded *La Connaissance des Temps* in 1679, and edited it until his death on July 12, 1682. His works are published in the 6th and 7th vols. of the *Memoires* of the Academy of Sciences.

PICARDY, an old province of France, bounded on the north by Hainaut and Artois, on the east by Champagne, on the south by the fle-de-France and on the west by Normandy and the English channel. It included the basin of the Somme and part of that of the Oise. The chief towns were Amiens, Boulogne, Abbeville, Laon, Soissons, Montreuil, Péronne, Beauvais, Montdidier, Saint Quentin and Noyon. In 1789 Picardy was one of the provinces of the five great *fermes*. Its area now forms the *dkpartement* of the Somme and parts of the *départements* of Pas-de-Calais, Aisne and Oise.

The name of Picardy does not appear until the 13th century, and its regular organization as part of France dates only from the beginning of the 16th, when it was divided into northern and southern Picardy. Northern Picardy was a military governorship, while southern Picardy was included in the fle-de-France.

Under the Romans, Picardy was part of Belgica Secunda; it was inhabited by the Morini, the Ambiani, the Veromandui, the Bellovaci and the Suessiones. In the 5th century Picardy became the centre of Merovingian France. Of the Carolingians, Charlemagne often resided at Noyon, and later sovereigns took refuge at Laon.

During the feudal period, Picardy was disputed among several powerful houses. The countships of Amiens and Vermandois were united to the royal domain by Philip Augustus (1191) and became the seats of two bailliages. Ponthieu (around Abbeville) became a possession of the kings of England through Edward I's marriage to its heiress. The dukes of Burgundy, after annexing the Boulonnais (1416), were anxious to possess the rest of Picardy; in 1435, by the famous treaty of Arras, the royal towns and lands in the valley of the Somme were ceded by King Charles VII to Burgundy. However, after the death of Charles the Bold in 1477 Picardy was finally united with the crown of France. The Picard towns, enriched by their export trade in corn and wood, were noted for their love of independence, which often brought them into collision with the kings of France during the 13th century. In the next century, they developed a textile industry. In the middle ages the Picards formed one of the four "nations" recognized in the organization of the University of Paris, while the Picard dialect was spoken in the whole of northern France.

PICARESQUE NOVEL, THE. This special form of the *roman d'aventures* may be defined as the prose autobiography of a real or fictitious personage who describes his experiences as a social parasite and satirizes the society which he has exploited. The picaroon, or rogue type, is represented by Encolpios, Ascyltos and Giton in the *Satyrzcon*, which tradition ascribes to Petronius; it persists in Lucian. in the *Roman de Renart*, in the *fabliaux* and in other works popular during the middle ages. But in its final form the picaresque novel may be regarded as a Spanish invention. The word *picaro* was first used in texts of 1541 and 1547; the etymology which derives it from *picar* (to nibble, pick up) is unsatisfactory to philologists, although it does suggest the picaroon's chief business in life. A connection with French *picoreur (praedator)* is possible; and *picardo* (a native of Picardy, with which region Spanish soldiers in the low countries had many contacts) has also been advanced, *picardía* being the action of a *picaro*. The earliest application of the term to a character in fiction occurs in Mateo Alemán's *Guzmán de Aljarache* (1599), a work which was long known simply as *El Picaro*. But a genuine *novela picaresca* existed in Spain before the word *picaro* became generally current.

Spanish Examples.— The earliest specimen of the kind is La *Vida de Lazarillo de Tormes y de sus fortunas y adversidades*, an anonymous tale in seven brief *tratados* telling of Lazaro's experiences with as many masters, alternately lay and clerical, which was long attributed, on insufficient grounds, to Diego Hurtado de Mendoza (*q.v.*). The authorship of this brilliant book and the circumstances of its first publication remain obscure; three editions appeared in 1554 and it was thrice reprinted before 1559, when it was placed on the Index for its implied attacks on the clergy. In 1555 there appeared at Antwerp *La segunda Parte de Lazarillo de Tormes*, an anonymous sequel which completely misinterpreted the irreverent wit of the original and presented the hero as a de-

vout youth transformed into a tunny. Another, more estimable, sequel, by Juan de Luna, was published at Paris in **1620.** Meanwhile. many surreptitious copies of the first part were introduced into Spain; the Inquisition finally gave up the attempt to suppress it, and in 1573 an expurgated edition was authorized Not until 1599 did a second work of the kind appear. when hfateo Alemán (*q.v.*) published the *Przmera Parte de Guzmán de Alfarache,* the fictitious autobiography of the son of a ruined Genoese moneylender. The subtitle of *Atalaya de la vida humana* added to the second part explains the copious moralizings which threaten to swamp the story and contrast sharply aith the laconic cynicism of *Lazarzllo de Tormes;* but *Guzmán de Alfarache* is richer in invention. in variety of episode and in the presentation of character. Its extraordinary popularity tempted a Valencian lawyer named Juan José Martí to publish a *Segunda Parte* **(1602)** under the pseudonym of Mateo Luján de Sayavedra; in **1604** Alemán brought out the true continuation. A third part. written in Spanish by the Portuguese Felix Machado de Silva, was first printed in 1927. The *Viaje entretenido* **(1603)** of Agustin de Rojas, though not fiction in the accepted sense, has some claim to inclusion here. **A** realistic account of the writer's experiences as a strolling actor and playwright, it is apart from its considerable literary merits, an invaluable contribution to the history of the Spanish stage as well as a graphic record of contemporary low life.

The next in chronological order of the Spanish picaresque tales is *La Picara Justina* (160**j),** the history of a woman picaroon who deceives lovers as the *picaro* masters, which has been ascribed to Andrés Perez. a Dominican monk; there is no good reason to suppose that the Francisco López de Ubeda on the title page is a pseudonym. The *Picara Justina* has wrongly acquired a reputation for indecency; its real defects are an affected diction and a want of originality. It is now read chiefly by philologists in quest of verbal eccentricities Ginés de Pasamonte, one of the secondary figures in *Don Quzxote* (1605–15), is a singularly vivid sketch of the Spanish rogue. and in the comedy *Pedro de Urdemalas* Cervantes again presents a brilliant panorama of picaresque existence. He returns to the subject in *Rznconete* y *Cortadillo* and in the *Coloquzo de los perros,* two of the best stories in the *Novelas ejemplares* **(1613).** but it should be noted that the cynicism and pessimism characteristic of the kind are absent in Cervantes. In the *Viaje del mundo* **(1614)** the zealous missionary Pedro de Cevallos Interpolates amusing tales of what befell him in the slums of Andalusia before he fled from justice to America. In *El Pasajero* (1617) Cristobal Suarez de Figueroa fills in the sketch of the knavish innkeeper already outlined by Cervantes in *Don Quzxote.* Evidence of the widely diffused taste for picaresque literature is found in *Enriquez de Castro* **(1617).** a story in Spanish by the Frenchman François Loubayssin de Lamarca.

The roving instinct of Vicente Martinez Espinel (*q.v.*) had led him into strange and dangerous company before and after his ordination as a priest, and his *Relaczones de la vida del escudero Marcos de Obregdn* **(1618)** is remarkable for a baffling compound of fact with fiction written in the lucid style of which Espinel was a master; it was largely utilized by Le Sage in *Gil Blas.* Within five months of its publication at Madrid a fragmentary French version by the sieur d'Audiguier was issued at Paris, and at Paris also there appeared a Spanish picaresque story entitled *La desordenada Codzcza de los bienes ajenos* (1619), by Carlos Garcia, who reports the life story of a garrulous jailbird and appends a glossary of thieves' slang. Every kind of picaroon is portrayed with intelligent sympathy by Alonso Jerónimo de Salas Barbadillo, who is always described as a picaresque novelist, yet he so constantly neglects the recognized conventions of the Spanish school that his right to the title is disputable. Thus in *La Hija de Celestina* **(1612)** he abandons the autobiographical form, in *El subtil Cordobés Pedro de Urdemalas* **(1620)** he alternates between dialogue and verse, and in El *Necio bien afortunado* **(1621)** the chief character is rather a cunning dolt than a successful scoundrel. The pretense of warning newcomers against the innumerable occasions of sin in the capital is solemnly kept up by Antonio Liñán y Verdugo in his *Guia* y *avisos de forasteros que vienen a la corte* (1620), but in most of his tales there is more entertainment than decorum. An unusual gravity of intention is visible in Jerónimo de Alcalá Yáñez y Ribera's *Alonso, mozo de muchos amos* (1624–26), in which the repentant *picaro* Alonso, now a lay brother, tells the story of his past life to the superior of the monastery in which he has taken refuge.

The adventures of the ex-nun Catalina de Erauso (1592–*c.* **162j),** who fled from her convent, dressed herself in man's clothes, went to America, enlisted in the army and was promoted 2nd lieutenant. were not published till **1829** *(Historza de la monja alférez Doña Catalina de Erauso, escrita por ella mzsma)* by Joaquin Maria de Ferrer, whose character is not a satisfactory guarantee of the work's authenticity; but its interest is unquestionable. No such suspicion attaches to the *Vida* of Alonso de Contreras, first published in 1899, in which every convention of the picaresque novel is faithfully observed and the incidents are no doubt substantially true, though this ex-captain, like most converts, judges his own past with unnecessary harshness. This subtle form of vanity also pervades the *Comentarzos del desengaiiado de sí mzsmo* of Diego Duque de Estrada, a rakish soldier and inferior dramatist whose autobiography (begun in **1614** and continued at intervals during many years) was not printed till **1860. A** far higher order of talent distinguishes the *Capitulaciones de la vida de la corte y oficios entretenidos en ella,* a bitterly unsparing review of picaresque life written by the great satirist Francisco Gómez de Quevedo y Villegas (*q.v.*). These thumbnail sketches were the preparatory studies for the more elaborate *Vida del buscón Don Pablos* (1626), the cleverest and most repellent book of its class, in which, allied to profound psychological artistry, there may yet be seen a deep concern with moral values.

After *El Buscdn,* whose qualities derive rather from the author than from the kind. the picaresque novel declined insensibly into the novel of adventure, with an increasing predominance of narrative over description. The *Varia Fortunn del soldado Pindaro* **(1626)** added nothing to the established reputation of Gonzalo de Céspedes y Meneses. Alonso de Castillo Solbrzano (q *v*) tempted the public with three picaresque stories published in quick succession. *La Niña de los embustes, Teresa de Manzanares* (1634), the *Aventuras del bachiller Trapaza* **(1637)** and a sequel to the latter entitled *La Garduña de Sevilla* **(1642).** But the style was no longer welcomed with the old enthusiasm in Spain. The *Bachiller Trapaza* was destined to be continued by Mateo da Silva Cabral in Portugal and to be exploited by Le Sage, who likewise utilized in *Gil Blas* episodes taken from *El Siglo pitagórico* **(1644)** of , Antonio Enriquez Gómez. The primitive rogue returns to the scene in *La Vida* y *hechos de Estebanillo González* **(1646).** Le Sage drew upon him in the *Histoire d'Estevanille Gonzalès.*

Outside Spain.––Meanwhile, the rogue had forced his way into other European literatures. The Antwerp edition (1 5**54)** and spurious continuation (1 555) of *Lazarzllo de Tormes* brought the work to the notice of northern readers, and it was translated into French by Jean Saugrain in 1560 (reprinted **1561). A** Dutch version was issued anonymously in 1579.

The first-known edition of David Rowland's English version is dated 1586, but as a licence to print a translation was granted on July 22. 1568–69, it is probable that a 1576 edition which appears in the Harleian catalogue really existed. Numerous reprints (**1599, 1639** 1669–70, **1672.1677)** indicate that *Lazarzllo de Tormes* was very popular, and that Shakespeare had read it seems to follow from *Much Ado about Nothing* (Act. II, sc. i): "Now you strike like the blind man; 'tuas the boy that stole your meat, and you will beat the post." To Thomas Nash belongs the credit of writing the first picaresque novel in English, *The Unfortunate Traveller, or the Life of Jack Wilton* (1 594). *A* reference to "Spanish pickaroes" in Thomas Middleton's *Spanish Gipsie* indicates that the picaroon type had speedily become familiar enough for London playgoers to understand the reference. Interest in picaresque literature was kept alive by James Mabbe's admirable version **(1622)** of *Guzmán de Alfarache;* by *The Son of the Rogue, or the Politic Thzef* (1638), an anonymous translation, done through the French, of *La desordenada Codzcza;* and by another anonymous translation **(1657).** likeuise done through the French. of Quevedo's *Buscdn.* One result was *The Englzsh Rogue descrzbed in the Life*

of *Meriton Latroon, a witty Extravagant* (1665), by Richard Head and Francis Kirkman.

It is not till Daniel Defoe's time that the English picaresque novel acquires any real importance. There is a female picaroon in *Moll Flanders,* and, as Defoe read Spanish, it is conceivable that she was suggested by the *Picara Justina;* but this resemblance does not make of the book a picaresque novel. The satirical spirit which is lacking in *Moll Flanders* is, honever, abundantly present in *Colonel Jacques,* which bravely aims at exhibiting "vice and all kinds of wickedness attended with misery." Henceforward the picaroon is naturalized in English literature, and is notably reincarnated in Henry Fielding's *Jonathan Wild* and in Tobias Smollett's *Ferdinand, Count Fathom.*

The Dutch translation of *Lazarillo de Tormes* (1579) did not enable the picaresque novel to strike root in Holland. yet from it is derived one of the best Dutch comedies, *De Spaensche Brabander Jerolimo* (1616) of Gerbrand Bredero. A German translation of *Güzmán de Alfarache* was published by Aegidius Alberitnus in 161 j; in 1627 there appeared an anonymous version of the *Picara Justina;* and both *Lazarillo* and *Rinconete y Cortadillo* were translated by Niclas Llenhart in 1716. The Spanish tradition was followed by Martin Frewden in a continuation (1626) of *Guzmán de Alfarache,* but the only original picaresque novel of real value in German is H. J Grimmelhausen's *Simplicissimus.* The attempt to acclimatize the picaresque novel in Italy failed completely.

The first translation of the *Novelas ejemplares,* by Rosset and d'Audiguier, was published at Paris in 1615; and French translations of *Guzmán de Alfarache,* of *Marcos de Obregdn,* of *La desordenada Codicia,* of the *Buscón* and of the *Picara Justina* were printed in 1600, 1618. 1621, 1633 and 1635 respectively. Paul Scarron mentions Castillo Solórzano's *Garduña de Sevilla* in the *Roman comique* (1651), and his *Précaution inutile* and *Les Hypocrites* are convincing proofs of close study of Spanish picaresque stories: the *Précaution inutile* is taken from *Guzmán de Alfarache,* while *Les Hypocrites* is merely a translation of Salas Barbadillo's *Hija de Celestina.* The *Roman bourgeois* (1666) of Antoine Furetière is generally described as a picaresque novel, but it is concerned with the foibles of the middle class rather than with the sly devices of common vagahonds.

The Spanish picaroon lives again in *Gil Blas,* where, with a dexterity almost rarer than original genius. a master of literary manipulation fuses materials unearthed from forgotten and seemingly worthless Spanish quarries. Gil Blas is a creation of the gentler. sunnier French spirit; like Caron de Beaumarchais's Figaro he is a Spaniard born reared and humanized in Paris, and these two are the only picaroons uhose relative refinement has not been gained at the cost of verisimilitude. But the old original scoundrel was not yet extinct: in the interval between the appearance of the *Barbier de Séville* and the *Mariage de Figaro* Restif de la Bretonne produced a sequel (1776) to the *Buscón*—a sequel so dull as to be almost unreadable. The untamed Spanish rogue had become impossible touard the end of the 18th century; in the 19th he was deliberately rejected uhen Théophile Gautier wrote *Le Capitaine Fracasse.* Yet Gautier conscientiously provides a Spanish atmosphere in this, the last important book which continues the picaresque tradition. In Spanish literature elements of that tradition survived in 19th-century *costumbrismo,* and may still be met with in the novel. José María de Pereda (*q.v.*) in *Pedro Sánchez* (1884) touched the old theme with the accent of modernity; and the *pícaro* flourished afresh in the novels of Pio Baroja (cf. La *Busca,* 1904).

In Latin-American literature the earliest novel is a genuine romance of roguery on the Spanish pattern (José Joaquin Fernandez de Lizardi, El *Periquillo sarniento,* Mexico, 1816).

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(J. F.-K.; W. C. AN.)

PICASSO, PABLO RUIZ (Y) (1881–), Spanish painter, the initiator of Cubism and probably the paramount influence on the art of the 20th century, was born on Oct. 25, 1881, at Málaga. His father was an artist and professor at the Academy of Fine Arts at Barcelona, and under him Picasso received his first lessons in art. After many visits to Paris, he settled there in 1903. Though a Catalán by birth, he developed his art in France, where he became one of the leaders of the Postimpressionist school.

Picasso's early work displays his gift as an illustrator of somewhat sentimental character. Like Toulouse-Lautrec he chose the subject matter of his pictures from the life of the circus and from the morbid side of life in a big city, and he rendered with feeling the strained and sad look of young soubrettes, acrobats and harlequins. His contours were clear; his modeling in cool, bluish-gray tones was almost monochrome, but assumed rose tones after 1905. He thus, from the beginning, followed a line distinct from that of Matisse and his Fauvist following, who took pleasure in colour and flat patterns, as such, and who never entirely broke with the traditions of Impressionism.

To this early period belong "La Famille Soler" (1903), a rhythmically composed group; "L'Aveugle" (1903), archaic in the delineation of form; "La Tragédie" (1903), three gaunt, huddled figures by the illimitable sea; "La Boule" (1905), two acrobats; "La Toilette"; and a portrait of Gertrude Stein (1905–06) of the "rose period."

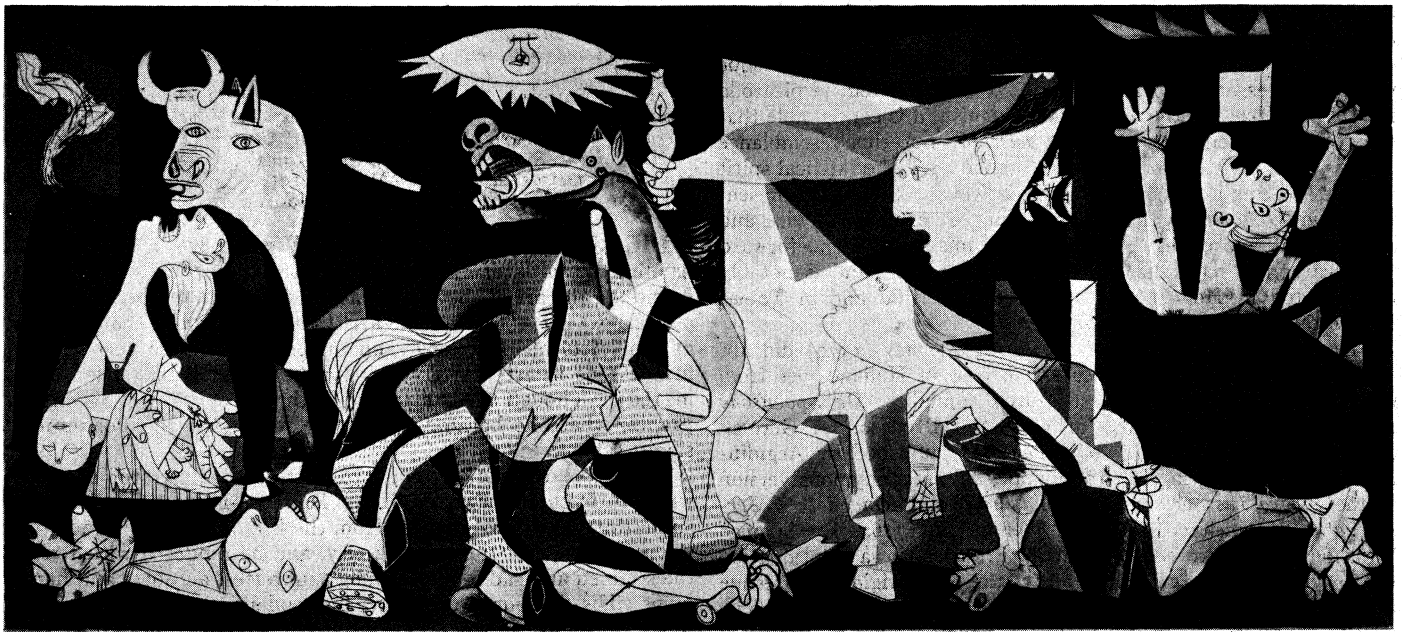
The Cubistic formula was evolved by Picasso and Georges Braque between 1906 and 1910, while studying the composition of still-life groups. It was Braque who first introduced into his designs bits of printed paper, delighting in the harmonious distribution of black letterpress on white paper. Picasso then added pieces of wood and other tangible objects, which led to a form of art in which sculpture and painting mere combined.

During Picasso's earlier Cubist period the surfaces of his canvases were delicately toned in brown or gray by dots in pointillist fashion, displaying some constructive design, mainly abstract, though here and there realistic fragments of recognizable objects were introduced. The gradations of light and dark suggested shading and space. At a later period this three-dimensional element disappeared; colour notes were introduced and the design formed a purely two-dimensional pattern.

The artist did not seek to imitate form, but to create form. As opposed to the Impressionist preoccupation with the rendering of ever-changing and superficial appearances, he wished to express the reaction of his sensibility to external objects. Following his convictions. he discarded resemblance to natural form and endeavoured to create a language of form—a visual music.

After 1918 Picasso returned mainly to traditional paths and based his pictures on natural form. His paintings became magnificently plastic and monumental. Then he changed again. Much of his work after 1925, in its fantastic and visionary character, suggested sympathy with surrealism. His large mural composition entitled "Guernica" (1937) presented the tragedy of the civil war in Spain as a nightmare. Although anti-Nazi, he remained in Paris during the German occupation and continued his work. After the liberation of Paris Picasso announced that he had become a Communist, and in 1949 the Paris Communist World Peace conference adopted a dove created by Picasso as the symbol of the various Communist peace movements.

Picasso's inventive gift, which led him from one experiment to another, inspired many followers. Painters such as Metzinger, Gleizes, Léger and Villon, and sculptors such as Archipenko and Lipschitz. to name only a few, follo ed in his wake. He was one of the first to appreciate the expressiveness of Negro sculpture;



BY COURTESY OF MUSEUM OF MODERN ART

"GUERNICA" BY PABLO PICASSO, 1997. IN THE MUSEUM OF MODERN ART, NEW YORK CITY

his style led to an appreciation of "significant form" and of constructive design in all branches of art. He became the outstanding influence in modern art among his contemporaries.

Picasso's influence was also felt on the stage He produced a series of designs for curtains, scenery and costumes for several Russian ballets The history of his collaboration with Jean Cocteau and Erik Satie in the ballet *Parade* (1917) is told by Cocteau in *Le Coq et L'Arlequin* (English trans , 1921) His work is represented in many galleries in the United States and Europe

Picasso's clear, incisive outline drawings are executed with forcible directness and with rigid economy of means He etched some plates and illustrated several books. notably André Salmon's *Le Manuscrit Trouvé dans un chapeau,* Ovid's *Metamorphoses,* Balzac's *Le Chef-d'oeuvre inconnu* and Pepe Hillo's *Tauromaquia.* He executed portrait drawings of contemporary writers and musicians such as I Stravinsky, J. Cocteau, M Jacob. G. Apollinaire, A. Salmon. I' Valéry, etc. He also wrote a play, *Le Désir attrapé par la Queue* (1945; English trans , *Desire,* 1948).

See also PAINTING: *Cubism*; *School of Paris;* PORTRAIT PAINTING: *19th and 20th centuries.*

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PICAYUNE, the name in Florida and Louisiana of the Spanish half-real = & of a dollar, $6\frac{1}{4}$ cents, and hence used of the United States five cent piece; from the French *picaillon,* an old copper coin of Piedmont, and possibly related to the Italian *piccolo* (little, small).

In the United States the word is used of anything trifling or contemptible.

PICCARD, a family of 20th-century scientists and explorers who designed and used a number of unique vehicles for investigations in the stratosphere and the depths of the oceans.

AUGUSTE PICCARD (1884–1962), Swiss physicist and educator who, at different times, held the world's altitude record and the record for the deepest descent into the ocean, was born at Basel, Switz., on Jan. 28, 1884. After attending school in Basel, Auguste, with his twin brother Jean, entered the Swiss Federal Institute of Technology at Ziirich, receiving his degree in mechanical engineering in 1907. After several years of graduate work and teaching he moved in 1922 to Belgium where he became professor at the Polytechnic institute of Brussels university. During the Nazi occupation of Belgium in World War II Auguste returned to Switzerland where he worked as a designer for the Swiss aluminum industry. Following the war he returned to Brussels university until 1954. He died at his home in Lausanne. Snitz., on March 24. 1962.

With his twin brother. Auguste in 1913 made a 16-hour balloon flight across France and Germany and in 1926–28 performed various experiments in balloons; these included the Michelson-Morley experiment. performed at an altitude of 2,500 m. In May 1931 he came to the attention of the world when he and Paul Kipfer ascended from Augsburg, Ger., in a free balloon and set a new world's altitude mark of 51,775 ft. This flight, which lasted 16 hours and ended on a glacier in Austria, was the first instance of the use of a pressurized cabin for manned flight. The cabin, or gondola. designed by Piccard, was seven feet in diameter and weighed, when fully loaded, about 850 lb. It was named the F N.R.S. (for Fonds National de la Recherche Scientifique) after the Belgian National Fund for Science Research, sponsors of the project. In August of the following year Piccard, accompanied by Max Cosyns, made a second flight, this time ascending from Ziirich. After having reached an altitude of 53,153 ft., another record, the F.N.R.S.1 came down near Garda. Italv.

Piccard made a number of other flights, including at least one at the request of Albert Einstein (under whom Piccard had studied at Zurich) in order to study certain aspects connected with Einstein's relativity theory.

From 1937, the year of his last flight, Auguste Piccard devoted his time to studying the problems of designing a vehicle to be used in submarine exploration. After being interrupted by World War II, work was resumed in 1946 on his bathyscaphe, uhich was based on ballooning principles The craft, consisting basically of buoyancy tanks and a chamber for the crew, was named the F.N.R.S 2 To provide both positive buoyancy and resistance to pressure, the tanks were filled with gasoline, which is both lighter than water and practically incompressible. Metal weights, attached to the craft by electromagnets, were to be used to make it sink. This ballast would then be dropped, causing the bathyscaphe to rise again. The first model was a failure but a second, the F N.R S 3, took Piccard and his son Jacques to a depth of more than 10.000 ft., more than three times as deep as William Beebe, the previous record holder, had been able to go in his bathysphere. A third bathyscaphe, the "Trieste," was sold in the late 1950s to the U.S. navy.

JEAN FELIX PICCARD (1884–), twin brother of Auguste, took his degree in chemical engineering (1907) and, like his brother, was awarded a doctorate in natural science (1909). After graduate work at the University of Munich, Ger., he taught at the

University of Lausanne (1914–16) and The University of Chicago (1916–19). He then became a professor at Lausanne but in 1926 he returned to the U.S. and taught at the Massachusetts Institute of Technology, Cambridge, until 1929, when he entered private research work for various organizations. He became a naturalized U.S. citizen in 1931. In 1936 he joined the faculty of the University of Minnesota, Duluth, and was appointed to a professorship the following year.

In 1934 he and his wife Jeannette (Ridlon) Piccard ascended in a balloon to an altitude of 57,579 ft., traveling from Dearborn, Mich., to Cadiz, O. Jean Piccard later experimented with cellophane and plastic balloons, helping design the polyethylene Skyhook series of high-altitude balloons with which the U.S. air force sent manned flights to altitudes in excess of 100.000 ft. Experiments with multiple small balloons also occupied Piccard's thoughts from 1937, when he made an ascent to about 10,000 ft. in an aerostat using 98 balloons for lift.

JACQUES PICCARD (1922–), only son of Auguste, assisted his father in designing, building and testing the bathyscaphe. On Jan. 23, 1960, he and Lieut. Don Walsh of the U.S. navy set a new submarine depth record by descending 37.800 ft. into the Mariana trench in the Pacific ocean using the bathyscaphe "Trieste."

DONALD LOUIS PICCARD (1926–), youngest son of Jean, aided in his father's balloon experiments and in the 1950s designed a balloon shaped like a milk bottle. Using 12 of these. with an improved valving system, he made a flight which tended to prove the feasibility of his father's idea of a practical multiple-balloon aerostat.

See also BALLOON; DIVING APPARATUS.

PICCINNI, NICCOLA (1728–1800), Italian composer, was born at Bari. Naples, on Jan. 16. 1728. He was educated under Leo and Durante. at the Conservatorio di Sant' Onofrio in Naples. His first opera. Le *Donne dispettose*, was produced in 1755, and in 1760 he composed, at Rome, *La* Cecchina, ossia la buonu *Figliuola,* an *opera buffa* which attained a European success. It was followed by many others, one of which. also an opera *buffa,* I1 *Viaggiatori* (Naples. 1774), had nearly as great a success as La *Cecchina.* In 1776 Marie Antoinette invited him to Paris. He had married in 1756 his pupil Yincenza Sibilla, a singer. whom he never allowed after her marriage to appear on the stage. All his next works were successful; but, unhappily. the directors of the Grand Opéra conceived the mad idea of deliberately opposing him, apparently against his will, to Gluck, by persuading the'two composers to treat the same subject—*Iphigénie* en *Tauride*—simultaneously. The Parisian public now divided itself into two rival parties, which, under the names of Gluckists and Piccinnists, carried on an unworthy and disgraceful war. Gluck's *Iphigénie* was first produced on May 18, 1779. Piccinni's *Iphigénie* followed on Jan. 23, 1781, and, though performed seventeen times! was soon forgotten.

Of the works of Piccinni's Paris period the best is *Didon* (1783), which kept the stage for half a century. In 1789. after the outbreak of the French Revolution: Piccinni returned to Naples, where he was at first well received by King Ferdinand IV; but the marriage of his daughter to a French democrat brought him into irretrievable disgrace. For nine years after this he maintained a precarious existence in Venice. Naples and Rome; but he returned in 1798 to Paris, where a small place was found for him at the Conservatoire. He died at Passy, Paris, on May 7, 1800.

See P. L. Ginguené, *Notice sur la vie et les ouvrnges de Niccola Piccinni* (1801); *E.* Demoiresterres, *La Musique française au 18^e siècle, Gluck et Piccinni, 1774–1800* (1872); *E.* Blom, *Stepchildren of Music* (1926). For a list of his operas, which number over 80, see *Rivista musicale italiana,* viii, 75.

PICCOLO, a small flute (*q.v.*) with an extremely high range. Its highest notes reach the fourth octave above middle C and produce a shrill, penetrating sound. This quality made the B♭ piccolo, or fife (*q.v.*), popular in marching bands. Music for the piccolo is written in the same octave as that for the flute. but the sound is pitched an octave higher.

The piccolo differs in construction from the flute only in the absence of low keys for C♯ and C.

PICCOLOMINI, the name of an Italian noble family, prominent in Siena (*q.v.*) from the early 13th century onward. In 1220 Enghelberto d'Ugo Piccolomini received the fief of Montertari in Val d'Orcia from the emperor Frederick II as a reward for services. They obtained great wealth through trade, and established counting-houses in Genoa, Venice, Aquileia, Trieste and in France', England and Germany.

Supporters of the Guelph cause in the Sienese civil broils, they were driven from the city in the time of Manfred, restored after the Angevin victories, expelled during the brief reign of Conradin and again restored with the help of Charles of Xnjou. Their commercial influence passed to the Florentines. Many members of the house were distinguished ecclesiastics, generals and statesmen; two were popes, viz., Aeneas Silvius (Pius II, *q.v.*) and Francesco (Pius III, *q.v.*) Piccolomini. In 1461 Pius II's nephew Antonio Piccolomini received from Ferdinand I of Naples the duchy of Amalfi, which remained in the family until the death of Giovanni Piccolomini in 1582.

PICCOLOMINI, OCTAVIO, PRINCE (1599–1656), duke of Amalfi, Austrian general, was born on Nov. 11, 1599, in Florence, and carried a pike in the Spanish service at the age of sixteen. On the outbreak of the Thirty Years' War he served in Bohemia and Hungary, then in Spain and Italy. In 1627 he reentered the Imperial service as colonel and captain of Wallenstein's lifeguard. He was disgraced for practising extortion at Stargard in Pomerania, but his adroitness soon secured him the rank of "colonel of horse and foot." In the Mantuan War Piccolomini acted both as subtle diplomatist and as plundering soldier of fortune when Gustavus Adolphus invaded Germany.

Piccolomini was interned at Ferrara as a hostage for the ratification of a treaty, but joined in urging Wallenstein's reappointment as commander in chief. He was not immediately promoted on the duke's reappearance, and served under General Holk, an officer brought in from the Danish service, in the preliminary operations and in the battle of Liitzen. After Liitzen, the Emperor made Piccolomini a general-feldwachtmeister. At the same time, however, Holk was created a field marshal at Wallenstein's instance, much to his rival's chagrin.

In 1633 Piccolomini commanded an important detachment posted at Koniggratz to bar the enemy's advance from Silesia into Bohemia. In May he accompanied Wallenstein on his advance into Silesia, but, disapproving of the duke's policy, joined in a military conspiracy which ended in the murder of Wallenstein (Feb. 29, 1634). Piccolomini's own part in the tragedy is commemorated in Schiller's *Wallenstein.* His material rewards for his activities in connection with the downfall of Wallenstein were his marshal's baton, 100,000 gulden and the beautiful estate of Nachod in the Riesengebirge.

In 1638 Piccolomini was made a count of the empire, and in 1639 he won a great victory over the French (relief of Thionville, July 7, 1639) and was rewarded with the office of privy councillor from the emperor and with the dukedom of Amalfi from the king of Spain. But instead of being appointed, as he hoped, Gallas's successor, he was called in to act as ad latus to the Archduke Leopold Wilhelm, with whom he was defeated in the second battle of Breitenfeld in 1642. After this he spent some years in the Spanish service, being granted the title of grandee and the order of the Golden Fleece. Having re-entered the Imperial army, he was again disappointed of the chief command by the selection of the brave veteran Peter Melander, Count Holzapfel; but in 1648 he was at last appointed lieutenant general of the emperor, and thus conducted as generalissimo the final campaign of the Thirty Years' War. At the end of that war he was made prince.

Piccolomini died on Aug. 11, 1656.

PICENES. These people of a pre-Roman culture of Italy do not figure prominently in the writings of ancient historians. They played a considerable role, however, in the confederacy of Italian states which challenged the hegemony of the growing Roman republic. The Picene capital was Ascoli, a little south of Ancona, on the eastern foothills of the Abruzzi.

The territory of the Picenes extended, to judge from the uni-

form character of the archaeological remains, all along the Adriatic coast from Rimini to the river Sangro; south of which again the Samnite mountaineers of Aufidena exhibited a civilization of identical character, though far less opulent. Inland, the Picene influence, and very probably the same population, extended as far as the midrib of the Apennines. A very ancient settlement at Terni, made long before 1000 B.C., may plausibly be attributed to them, and some writers think that they had a certain number of stations even in Latium. This would be perfectly natural if the Picenes were the principal survivors of a fairly homogeneous Neolithic population which once extended over the whole north and centre of Italy. According to this theory the Neolithic people were conquered and overwhelmed first by the invaders of the Bronze Age and then by the Villanovans (*q.v.*). Neither of these incursions, however, penetrated farther down the east coast than Rimini, at which point they were checked and diverted by the fighting forces of the Picenes.

This people retained its independence down to the third century B.C. when it finally succumbed to the Romans. It represents a phase of culture in the early Iron Age distinct from that of the Villanovans, derived from a different source and developed under different inspiration. The first contrast between Villanovans and Picenes is in their burial customs. The Villanovans usually cremated their dead. The Picenes buried their dead, generally in a contracted position.

The beginning of archaeological research in Picenum dates from the discovery by E. Brizio, in 1892, of two large cemeteries at Novilara. near Pesaro. Two remarkable stelae had been found in this neighbourhood 30 years earlier, with lines written in a script resembling Etruscan, but expressing a different language which is inferred to be Sabellic (*q.v.*). Several more of these stelae were found at Novilara itself, and at neighbouring places including Fano, but they still await translation. Two of them are engraved with pictures representing naval battles and scenes of hunting and fighting. They are further ornamented with spiral designs, which misled earlier investigators, who saw only their superficial resemblance to sub-Mycenaean patterns. The stelae probably are not older than 700 B.C.

About a dozen tombs at Novilara are as early as the 10th and 9th centuries B.C., while a few sporadic finds at Ancona and neighbouring points are no less ancient. From the contents of these it can be seen that the east coast of Italy was participating as early as the 10th century in the important trade in Baltic amber, which was transported down a main trunk route to the head of the Gulf of Venice.

It is to commercial relations, rather than to any movement of immigration. that the composite character of Picene civilization should be attributed. In spite of the numerous details of their life which suggest analogies with the Balkans, or with Greece of the Dipylon period. there is no evidence that the population was derived. or substantially recruited, from either of these sources. The general physical stock of the inhabitants remained as it always had been, predominantly composed of Mediterranean types.

Primarily fighting men, the Picenes succeeded in maintaining their independence for many centuries. The spear and the dagger were common. Swords were extremely handsome. Helmets were fairly frequent, shields very rare.

From graves of the 8th and 7th centuries B.C. at Novilara a complete picture may be recovered of the arms and equipment of a Picene foot soldier. His favourite sword was a broad and short weapon of iron, intended, like a sabre, for the heaviest cutting. Its edge was on the inside, and the hilt curved back at an angle like that of an ancient Bosnian hewing-knife. In fact there can be no doubt that swords of this kind were originally imported from the Balkans where the general type has always been well known. The curiously shaped wooden sheath was covered with sheets of bronze finely engraved with geometric patterns. Other swords found at Novilara are definitely Greek in origin. Similarly the helmets and shields are of Greek patterns, but the daggers, except when they seem to be original Italian products, follow the stock forms derived from the Hallstatt (*q.v.*) series prevalent all over Europe. Not less characteristic than the armament of the men were the ornaments and apparel of the women. A certain number of objects were imported from the factories of Etruria or Bologna. Such are the bronze manicuring sets hung upon chatelaines attached to the waist, and the bronze ear-cleaners terminating in the figure of a monkey or of Aphrodite surrounded by doves. But the narrow girdles made of chain mail in links, the huge and elaborate pendants terminating in imitation sea shells, the handsome torques and pectorals make an ensemble quite unlike anything found among Villanovans or Etruscans.

Belmonte cemetery, near Ancona, which dates to the 6th and 5th centuries B.C., yielded some very fine examples of Ionic Greek work in the minor arts. There are bronze bowls decorated with figurines of cast bronze, such as Hercules as the tamer of lions and horses; there are also jugs and vessels of hammered bronze and many superb carvings in amber. At Rapagnano were found two shield-bosses of bronze, ornamented with scenes of combat between mounted men and foot soldiers in the best Ionic style. Greek influence was entirely predominant in Picene art from the 6th century onwards, but it is important to observe that it found its way, not through Etruria, but quite directly from the Greek colonies of southern Italy. This is proved by the simultaneous presence in these tombs of the very distinctive and peculiar Apulian geometric pottery, which is unknown in Etruria.

Indeed, so far as present evidence avails, and allowing that it is dangerous to prophesy in regard to a region only partially explored, Etruscan influence on the Adriatic coast was very slight and unimportant. A tumulus of the 7th century found at Fabriano is almost entirely Etruscan in its contents, but as yet this is an isolated example. A certain amount of trade was undoubtedly carried on across the Apennines, but there is little in the general complex of Picene life which suggests a strong Etruscan impress. On the contrary, it remains a curiously individual and virile civilization, in spite of its many borrowings. The backbone of Picene commerce was constituted by a lively trade with Istria, which may be clearly traced by means of a comparative study of the objects found in the graves. Nothing, except the existence of a trade-system which centred at the head of the Gulf of Venice, could explain the remarkable circumstance that, in places as far apart as the Italian lakes, Istria, Picenum and Bosnia, there have been found torques, pendants and amulets so precisely similar that they must have been distributed by the same firm of agents.

See E. Brizio in *Monumenti Antichi,* vol. v.; *D.* Randall-MacIver, ***The** Iron **Age** in Italy (1927)*; and for a literary treatment from other points of view, F. von Duhn, *Italische Graberkunde,* vol. i. (1924).
(D. R.-M.)

PICENUM, a district of ancient Italy, situated between the Apennines and the Adriatic, bounded north by the Senones and south by the Vestini. The whole territory was divided up among Latin-speaking settlers by the Lex Flaminia in 232 B.C.

It was in Picenum (at Asculum) that the Social War broke out in go B.C. Under Augustus it formed the fifth region of Italy, and included twenty-three independent communities. It was reached from Rome by the Via Salaria and the Via Caecilia.

At the end of the and century A.D. the north-eastern portion of Umbria acquired the name Flaminia, from the high road. For the time it remained united with Umbria for administrative purposes, but finally passed to Picenum in the time of Constantine, and acquired the name of *Flaminia et Picenum Annonarium,* the main portion of Picenum being distinguished as *Suburbicarium.* When the exarchate of Ravenna was founded the part of Picenum Annonarium near the sea became the Pentapolis Maritima, which included the five cities of Ariminum, Pisaurum, Fanum Fortunae, Sena Gallica and Ancona. The exarchate was seized by Luitprand in 727, and Ravenna itself was taken by Aistulf in 752. In 753, however, the Emperor Pepin handed it over to the pope, a grant confirmed by Charlemagne.

PICHEGRU, CHARLES (1761–1804), French general, was born at Arbois, or at Les Planches, near Lons-le-Saulnier, on Feb. 16, 1 6 1 In 1783 he entered the 1st regiment of artillery, where he rapidly rose to the rank of adjutant sublieutenant. At the Revolution he became leader of the Jacobin party in Besançon,

and when a regiment of volunteers of Gard marched through the city he was elected lieutenant colonel. Quickly promoted to the command of the army of the Rhine, in co-operation with Hoche and the army of the Moselle, Pichegru reconquered Alsace and forced the lines of Haguenau and relieved Landau. In Dec. 1793 Hoche was arrested and Pichegru became commander in chief of the army of the Rhine and Moselle, succeeding Jourdan in the army of the north in Feb. **1794.**

It was then that he fought his three great campaigns of one year. The English and Austrians held a strong position along the Sambre to the sea. After vainly attempting to break the Austrian centre. Pichegru suddenly turned their left, and defeated Clerfayt at Cassel, Menin and Courtrai, while Moreau, his second in command, defeated Coburg at Tourcoing in May 1794; then after a pause, during which Pichegru feigned to besiege Ypres, he again dashed at Clerfayt and defeated him at Rousselaer and Hooglede, while Jourdan came up with the new army of the Sambre and Meuse, and utterly routed the Austrians at Fleurus on June 27. **1794.** Pichegru began his second campaign by crossing the Meuse on Oct. **18,** and after taking Nijmwegen drove the Austrians beyond the Rhine. Then, instead of going into minter quarters, he prepared his army for a winter campaign. On Dec. 28 he crossed the Meuse on the ice and stormed the island of Bommel, then crossed the Waal in the same manner and, driving the English before him, entered Utrecht on Jan. 19 and Amsterdam on Jan. 20 and soon occupied the whole of Holland. The former friend of Saint Just now offered his services to the Thermidorians and, after receiving from the Convention the title of *sauveur* de *la patrie,* subdued the *sans-culottes* of Paris when they rose in insurrection against the Convention on **12** Germinal (April 1). Pichegru then took command of the armies of the north. the Sambre and Meuse, and the Rhine, and crossing the Rhine in force took Mannheim in May 1795.

When his fame was at its height he took part in organizing a conspiracy for the return of Louis XVIII. His intrigues were suspected, and when he offered his resignation to the Directory in Oct. 1795 it was promptly accepted. In the Council of Five Hundred (May 1797) he was the royalist leader. and planned a *coup d'état,* but on **18** Fructidor he was arrested. and deported to Cayenne in **1797.** Escaping. he reached London in **1798.** and served on General Rorsakov's staff in the campaign of **1799.** He went to Paris in Aug. **1803** with Georges Cadoudal to head a royalist rising against Napoleon: but was arrested on Feb. **28,** 1804, and on April **15.** was found strangled in prison.

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PICHINCHA, a province of north central Ecuador. Area **6,474** sq.mi. Pop. **(1960** est.) **505,600; (1950) 386,520.** Most of the population is concentrated in the high Andean plateau and the temperate valleys. Because of its geographical characteristics—mountains, plains, valleys, forests—Pichincha is rich in natural products. It has deposits of lime. gypsum, silver, sulfur and marble. Noted for a variety of fruits and cereals, the province also produces potatoes, sugar cane. cacao, coffee and rice. Its tropical forests are sources of fine woods. Although agriculture and cattle raising are the main occupations, thriving industries —textile mills, processing plants—and flour mills contribute to its economic progress. Cerro Pichincha, an Andean volcano. was the site of a decisive battle in the Latin-American wars of independence, fought May 24, **1822,** on its lower slopes between the victorious patriot forces under Gen. Antonio José de Sucre and the Spanish royalists. Quito (*q.v.*), now the provincial capital, was occupied the following day. (C. R. J.)

PICKENS, ANDREW (1739–1817), American soldier in the Revolutionary War, was born in Paxton, Pa., on Sept. 19, 1739. His family settled at the Waxhaws (in what is now Lancaster county), S.C., in 1752. He fought against the Cherokees in 1761 as a lieutenant. In the Revolutionary War he rose to brigadier-general (after Cowpens) in the South Carolina militia. On Feb. **14,** 1779, with 300–400 men, he surprised and defeated about 700 Loyalists on Kettle Creek, Wilkes county, Ga.; and later in the same year at Toinassee defeated the Cherokees, who were allied with the British. Upon the surrender of Charleston (May **1780)** he became a prisoner on parole, which he observed rigidly until, contrary to the promises made to him, Maj. James Dunlap plundered his plantation; he then returned to active service. His command (about 150 men) joined Gen. Daniel Morgan immediately before the battle of Cowpens, in which Pickens commanded an advance guard (270–3jo men from Georgia and North Carolina) and twice rallied the broken American militia; for his services Congress gave him a sword. With Col. Henry Lee he harassed Lieut.-col. Banastre Tarleton, who was attempting to gather a Loyalist force just before the battle of Guilford court house; and with Lee and others, he captured Augusta (June 5, **1781)** after a siege. At Eutaw Springs (Sept. **8, 1781)** he commanded the left wing and was wounded. In 1782 he defeated the Cherokees again. After the war he was active for several years in state politics, and in 1793–95 was a representative in congress. He died in Pendleton district, S.C., Aug. 17, 1817.

PICKENS, FRANCIS WILKINSON (1805–1869), U.S. politician, was born in Togadoo, St. Paul's parish, S.C., April 7, 1805, grandson of Gen. Andrew Pickens (*q.v.*). He was educated at Franklin college, Athens. Ga.. and at South Carolina college, Columbia. and was admitted to the bar in 1829. In 1832 he was elected to the state house of representatives, where he submitted a report denying the right of congress to exercise any control over the states. He was a Democratic member of the national house of representatives in 1834–43, served in the South Carolina senate in 1844–45, was U.S. minister to Russia in 1858–60, and in 1860–62 was governor of South Carolina. He strongly advocated the secession of the Southern states and signed the South Carolina ordinance of secession; he sanctioned firing upon the "Star of the West" (Jan. 9, 1861), which was bringing supplies to Anderson, and the bombardment of Ft. Sumter. He died at Edgefield, S.C., Jan. 25, 1869.

PICKEREL, the name used, especially in the United States, where there are several species which never reach a large size, for certain small pike (*q.v.*). In England small specimens of *Esox lucius,* the only species represented, are usually termed jack.

PICKERING, EDWARD CHARLES (1846–1919), U.S. physicist and astronomer best known for his work in celestial photometry. He was born in Boston, Mass., July 19, 1846. He was graduated in 1865 from the Lawrence Scientific school of Harvard, where for the next two years he was a teacher of mathematics. Subsequently he became professor of physics at the Massachusetts Institute of Technology. where he established the first U.S. laboratory in which students were instructed by actual contact with physical instruments and measurements. In 1876 he was appointed professor of astronomy and director at the Harvard college observatory. In 1877, when most observatories were devoting themselves to the old "astronomy of position." Pickering. who was a physicist rather than an old school astronomer, chose as his particular field of labour the photometry of the stars, thus presaging the trend of the new astronomy along lines of physics. He invented the meridian photometers *(see* PHOTOMETRY. CELESTIAL), with which the brightness of more than 45,000 stars was measured at Cambridge and Arequipa (Peru) observatories, and the resulting system was generally adopted as an international standard. Pickering himself made more than 1,500,000 photometric settings.

Through the establishment of an observatory at Arequipa (1891), it became possible, after two years of study, to include measurements made on the stars throughout the southern heavens within the scope of the Harvard college observatory's work. The work of the observatory under Pickering included photometry; a scale of photographic magnitude; a system of classification of variable stars; and a system of stellar spectroscopy which was universally adopted. He died at Cambridge, Mass., Feb. 3, 1919.

PICKERING, TIMOTHY (1745–1829), **U.S.** politician, was born at Salem. Mass., on July 17, **1745.** He graduated from Harvard college in 1763 and was admitted to the bar in **1768.** In the pre-Revolutionary controversies he identified himself with

the American Whigs; and in 1776 he mas a representative from Salem in the general court of Massachusetts. Early in 1775 he published *An* Easy *Plan of* Discipline *for a* Militia. In the same year he became judge of the court of common pleas for Essex county, and in the winter of 1776–77 he led an Essex regiment of volunteers to New York. He subsequently served as adjutant general. later as quartermaster general and was also a member of the board of war. In April 1783 he drew up a plan for the settlement of the Northwest territory. which provided for the exclusion of slavery. In 1785 he became a commission merchant in Philadelphia; but in Oct. 1786, soon after the legislature of Pennsylvania had passed a bill for erecting Wyoming district into the county of Luzerne, he was commissioned to organize the county. He offered to purchase for himself the Connecticut title to a farm. and in 1787 he mas appointed a member of a commission to settle claims according to the terms of an act, of which he was the author, confirming the Connecticut titles (see WYOMING VALLEY, WILKES-BARRE). In 1790 he negotiated a peace with the Seneca Indians; he concluded treaties with the Six Nations in 1791–94. Under Washington he was postmaster general (1791–1795), secretary of war (1795), and after Dec. 1795, secretary of state, to which position he mas reappointed (1797) by Xdams.

In 1783, while he was quartermaster general, he had presented a plan for a military academy at West Point, and, as secretary of war, he supervised the West Point military post with a view to its conversion into a military academy. As head of the state department he soon came into conflict with Adams, and opposed the president's efforts to settle peaceably the differences with France. He was dismissed, after refusing to resign, in 1800. Returning to Massachusetts, he was elected a United States senator, 1803–11, and a member of the house of representatives, 1813–17. As an ultra Federalist—he was a member of the group known as the Essex junto—he opposed the purchase of Louisiana and opposed the War of 1812. He died at Salem, Mass., on Jan. 29, 1829.

See his biography by his son, Octavius Pickering (1791–1868); C. W. Upham, *The Life of Timothy Pickering* (Boston, 1867–1873).

PICKERING, WILLIAM HENRY (1858–1938), U.S. astronomer and discoverer of the ninth satellite of Saturn. He was born in Boston. Mass., on Feb. 15, 1858, and in 1879 graduated from the Massachusetts Institute of Technology. In 1891 he joined his brother Edward C. Pickering in establishing the Arequipa station of the Harvard observatory in Peru. He also established a meteorological station at an altitude of 16.650 ft. upon Mt. Chachani. and accomplished the ascent of El Misti, 19,167 ft. He surveyed and determined the altitude of many other Peruvian mountains and returned to the United States in 1893. In 1894 he erected the observatory and telescope for Dr. Percival Lowell (*q.v.*) at Flagstaff. Ariz., and in 1900 erected a station for the Harvard observatory at Mandeville, Jamaica, in the West Indies. In 1899 he discoveretl Phoebe, ninth satellite of Saturn. and noted its contrary revolution. His announcement of a tenth satellite in 1905 remains unconfirmed; hut he correctly predicted (1919) the existence of a trans-Xeptunian planet, later named Pluto. Pickering died in Jamaica, Jan. 21, 1938.

PICKERING, an urban district in the North Riding of Yorkshire, Eng., 26 mi. northnortheast of York by road. Pop. (1961) 4,193. Area 24.4 sq.mi. The town, lying on the southern edge of the Yorkshire moors at the entrance to one of the riverways into the Vale of Pickering. is a tourist centre for the moors. It is also the centre of an agricultural, horticultural and pastoral area, with a broad belt of arable land in the vale, given to cereal and fodder crops; and a moorland grazing area to the north. Agricultural implements are made and limestone and freestone are quarried in the vicinity. A castle existed at Pickering before the Conquest; the present ruin is partly Norman but mainly 14th century work. It was the prison of Richard II before his confinement at Pontefract. During the civil wars it was held by the royalists.

PICKETING: see STRIKES AND LOCKOUTS; TRADE (LABOUR) UNIONS.

PICKETT, GEORGE EDWARD (1825–1875), U.S. and Confederate army officer. whose division made the famous charge at the battle of Gettysburg. was born at Richmond. Va., Jan. 25, 1825. Upon graduation from West Point in 184.6 he was assigned to the 8th United States infantry; he served with distinguished valour in all the battles of Gen. Winfield Scott in Mexico, including the siege of Vera Cruz and the storming of Chapultepec, where, it is said, he was first to scale the parapets and unfurl the U.S. flag over the castle. After peace was restored. Pickett mas transferred to Washington territory where he played an important role in the northwest boundary controversy. In 1859 he was ordered to occupy San Juan Island, where he prevented the landing of a superior force of British troops. On the outbreak of the Civil War he resigned his command (June 1861) and offered his services to the Confederacy. He was commissioned captain and after a short time was made a colonel. In Feb. 1862 he was appointed a brigadier general and assigned to the command of a Virginia brigade of infantry. During that year he rendered able service in the battles of Williamsburg, Seven Pines, Gaines Mill and Fredericksburg. While leading his men at Gaines Mill he was severely wounded. but upon returning to his command in September he was made a major general. At Gettysburg his division was held in reserve until July 3, when it led the attack on Cemetery hill. The charge of Pickett's men is one of the most famous episodes of military history. More than three-quarters of the division, 3,393 officers and men out of 4,500, were left on the field. He subsequently commanded the Confederate forces in North Carolina but after the failure to take New Bern, he turned north to defend Petersburg. His troops participated in the assault on Gen. Ulysses Grant's line at Cold Harbor and in the closing campaign of 1865 at Dinwiddie court house and Five Forks. After the Civil War he went to Richmond and later to Norfolk where he mas engaged in the insurance business. He died in Norfolk, Va., July 30, 1875.

See La Salle Corbell Pickett, *Pickett and his Men* (rev. ed., 1913).

PICKFORD, MARY (GLADYS MARY SMITH) (1892–), U.S. motion-picture actress noted for her roles as an ingénue, was popularly known as "America's sweetheart." Born at Toronto, Ont.. April 8, 1892. she made her first stage appearance at the age of five; at eight she went on tour. She went to New York under the auspices of David Belasco, creating the part of Betty Warren in *The* Warrens *of* Virginia. Her first motion-picture work, as an extra. was undertaken with D. W. Griffith; but she returned to Belasco. taking the part of Juliet in *A* Good Little *Devil* at the Republic theatre in New York. In 1913 she turned permanently to the screen, rising to first rank with Famous Players company. In 1916 the Mary Pickford Film corporation was organized. and three years later Miss Pickford was prime mover in forming the United Artists corporation. She married Douglas Fairbanks in 1920, was divorced in 1935, and married Charles Rogers in 1937.

PICKLEWEED: see IODINE-BUSH.

PICKLING is a general term meaning to preserve in salt, acid, sugar, or any combination of the three. The word appears to be an adaption of the Dutch Pekel, "brine, pickle" (cf. Ger. *Pökel*). The term is applied to the preservation of wood by treating it with creosote, copper or zinc sulfate or similar solutions. Certain kinds of steel are pickled in sulfuric acid; the term may also refer to processes in metal casting and leather manufacturing.

The greatest use of pickling is in the food industry where it is one of the four (canning, freezing and dehydrating are the others) most commonly used methods of preserving food. In the preparation and preservation of fish; meat. especially pork. and meat products such as bologna. wieners, sausages, etc., a brine made of salt (sodium chloride), sodium nitrite and sodium nitrate is widely used.

Eggs are sometimes pickled in limewater (calcium hydroxide) or in water glass (sodium silicate).

Fruits, nuts and vegetables are pickled in a variety of ways. Crab-apples, peaches. pears and watermelon rind are pickled in a solution of vinegar, spices and sugar. Unripe walnut meats are pickled in salt, sugar and acid. Onions, cauliflower and mango peppers are pickled in strong (20%–24%) salt without fermentation. Other vegetables, such as cabbage (2% salt), green tomatoes and certain kinds of peppers (*e.g.*, banana, finger and tomato peppers [5%–10% salt]), undergo a lactic fermentation and are preserved by a combination of acid and salt.

Cucumber pickles are by far the most popular kind of pickles in the United States. Two varieties of cucumbers are used: the white

spine, which has a thick, smooth, dark green skin and is the produce variety used for slicing; and the smaller black spine; which has a thin, warty, light green skin and is grown especially for pickling. All types of fresh cucumber pickles are made by placing fresh, washed cucumbers (whole or sliced) in glass jars, adding salt, acetic acid, sugar, turmeric, alum and spices. and then pasteurizing; other processes are used for salt stock and for fermented cucumber pickles. (F. W. FN.)

PICO, an island in the Atlantic ocean, belongs to Portugal, and, forms part of the Azores archipelago. Pop. (1950) 22,j57; area 167 sq.mi. Pico rises to the height of 7,713 ft. The soil is of volcanic origin. The island was formerly famous for its Fayal wine (Fayal is, however, an adjacent island), but in 1852 the vines were destroyed by disease. Similar destruction affected the fruit trees (orange) and a period of emigration followed. The distress was alleviated by the planting of fig trees and the cultivation of apricots. The chief town is Lagens do Pico.

PICO DELLA MIRANDOLA, GIOVANNI, COUNT (1463–1494), Italian philosopher and scholar, was next in importance to Marsilio Ficino (*q.v.*) as an exponent of Renaissance Platonism and is still admired as a representative of Renaissance learning. He was born on Feb. 24. 1463, the youngest son of Giovanni Francesco Pico, prince of Mirandola, a small territory not far from Ferrara. Pico, who was a precocious child, received a thorough humanistic education at home and subsequently studied canon law at Bologna and Aristotelian philosophy at Padua. He also visited Florence and Paris and learned Hebrew. Aramaic and Arabic. Introduced by his Hebrew teachers to the Jewish Kabbalah, Pico was the first Christian scholar who tried to use Kabbalistic doctrine in support of Christian theology. In 1486 he proposed to defend in a public disputation in Rome 900 theses drawn from diverse Greek. Arabic. Hebrew and Latin thinkers, and composed for that occasion his famous *Oration* on the dignity of man; but 13 of the theses were declared heretical by a papal commission, and the disputation was prohibited by Pope Innocent VIII. Pico tried to defend the theses in an *Apologia* and fled to France. On the request of Lorenzo de' Medici. he was allowed to settle in Florence where he was connected with the famous Platonic Academy. There he spent the rest of his life except for short trips to Ferrara. He was absolved from the suspicion of heresy by Pope Alexander VI in 1493.

Pico published an exposition of Genesis under the title *Heptaplus* (Florence, n.d.); worked on a harmony of Plato and Aristotle, of which the completed treatise De *Ente* et *Uno* was part; and began a treatise against the enemies of the church, which included his famous and influential work against the astrologers. Toward the end of his life he came under the influence of Girolamo Savonarola. He died in Florence on Nov. 17, 1494. Although his early death prevented Pico from working out his philosophy, his writings contain significant and influential ideas. He found elements of truth in all the different schools and thinkers known to him and defended the merits of the medieval scholastic philosophers against Ermolao Barbaro. In exalting the dignity of man, he denied that man occupies any fixed place in the universal hierarchy, but asserted that he determines his place and nature through his own free choice.

His critique of astrology was based on religious rather than on scientific considerations and failed to gain general acceptance at the time, but it contained a good deal of weighty detail and influenced Johann Kepler in the 17th century.

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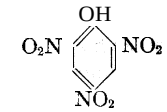
PICRIC ACID, an aromatic nitro compound that is an explosive, yellow crystalline solid. The name picric acid, introduced by J. B. A. Dumas, derives from the Greek word *pikros* indicating the extremely bitter taste of its yellow aqueous solution from which it can be crystallized in yellow scales, plates or needles, depending on the concentration of the solution. It melts at 122.5° C., sublimes with slow heat, but deflagrates with rapid heat. It was first obtained in 1771 by P. Woulfe on treating indigo with nitric acid.

The once great importance of picric acid as an explosive dates from 1882 when the French began using it under the name of Melinite as a bursting charge for shells. In 1888, Great Britain adopted its use under the name of Lyddite and in Japan it was referred to as Shimose. Because of its highly corrosive action on the metal surfaces of shells. which causes the formation of highly sensitive metal picrates, it has become obsolete as a military explosive. But one of its salts, ammonium picrate is used in armour piercing shell because it is insensitive enough to withstand the severe shock of penetration.

F'icric acid shows antiseptic properties and is incorporated with butesin. an anesthetic, into burn ointments in the amount of 1%. It is also used for the determination of creatinine in urine. Like all aromatic nitro compounds it is a blood poison and its vapors are toxic.

Picric acid is the common name for 2,4,6-trinitrophenol, a compound of the formula $HOC_6H_2(NO_2)_3$, in which three hydrogens of the benzene ring are replaced by nitro (NO_2) groups and one by a hydroxyl (OH) group, as indicated in the structural formula.



Preparation.—In one industrial method, phenol, heated with sulfuric acid at 120° C., is converted to phenolsulfonic acid, $C_6H_5OH + H_2SO_4 = HOC_6H_4SO_3H$, which on further treatment with 70% nitric acid, first at 0° C. and then at 100° C., yields the trinitrophenol as an oily liquid which solidifies on cooling. The crystals are washed with water until free of acid and are further purified by boiling in water in the proportion of 15 g. to the liter.

Another, more economical, method starts with chlorobenzene which is converted with a mixture of concentrated nitric and sulfuric acids to 2,4-dinitrochlorobenzene. Hydrolysis of the latter with aqueous sodium carbonate to 2.4-dinitrophenol, $ClC_6H_3(NO_2)_2 + Na_2CO_3 + H_2O \rightarrow HOC_6H_3(NO_2)_2$, and subsequent treatment with nitric acid gives picric acid. It is a much stronger acid than phenol; it decomposes carbonates and may be titrated with bases, sodium alizarinesulfonate being used as an indicator. Neutral lead acetate produces no precipitate, but in basic medium a bright yellow lead picrate is obtained.

The crystalline salts that it forms with organic bases are often used for their isolation and identification. It forms coloured molecular addition complexes of varying stability with many aromatic hydrocarbons, particularly with those containing a number of rings. such as naphthalene, anthracene. phenanthrene. etc. The stable complexes are utilized in the isolation of hydrocarbons from reaction mixtures, and in their purification and identification. The regeneration of the hydrocarbons from the complexes is often achieved by chromatographic adsorption. A benzene solution of the complex is passed through a tower packed with activated alumina powder. The picric acid is adsorbed more strongly by the alumina and the hydrocarbon appears first in the filtrate. (H. F.)

PICRITE, in petrology, an intrusive igneous rock of ultrabasic composition somewhat similar to peridotite (*q.v.*). The name. given by Australian mineralogist Gustav Tschermak von Seysenegg in 1866. is derived from the Greek word for bitter. because of the high percentage of magnesia (bitter earth) these rocks contain. The picrites are dark. heavy rocks largely composed of olivine and augite, a pyroxene, with a small but variable amount of plagioclase feldspar. Hornblende and biotite may also be present. The picrites usually occur in sills or sheets. and seldom in large plutonic masses (unlike peridotites). Varieties include augite, enstatite and hornblende picrité. The term picrite-basalt is reserved for feldspar-poor basalts rich in olivine.

The minerals of picrites are very frequently decomposed. Ser-

pentine (*q.v.*) partially or wholly replaces olivine, while hornblende (pilite), talc and chlorite appear as secondary products after the same mineral. Augite passes into hornblende or chlorite. and the essential feldspar is often represented by epidote, prehnite and white mica. In some picrites, as in the peridotites, a lustre mottling is given by the inclusion of unoriented grains of olivine in large crystals of augite or hornblende. In the porphyritic varieties a residual brown glass may be present. Such rocks are known as picrite-porphyrites.

Many picrites clearly possess alkaline affinities. Thus the augite picrites of the Midland valley of Scotland and of the type locality in Moravia contain interstitial analcite and are closely related to the teschenites with which they are associated (*see* THERALITE). Other picrites are more clearly calc-alkaline, being associated with diorites or diabases. The hornblende picrites of Caernarvonshire and Anglesey, Wales, and other places belong here. In the Devonian rocks of the Fichtelgebirge and Nassau picrites accompany diabases, as they do also in Cornwall and Devon. (C. E. T.)

PICROTOXIN, a neutral principle occurring in *Cocculus indicus,* the berry of *Anamirta cocculus,* indigenous to Malabar and the East Indies. The berries are also known as fishberries because of their use by the natives for poisoning fish. Because of their bitter and intoxicating properties, they have been added to beer and used externallv as an antiparasitic, but their extreme toxic properties make these uses dangerous. Picrotoxin is a compound of picrotin and picrotoxinin, the latter representing the active part. Its effects are somewhat similar to those of strychnine, except that the action of strychnine is predominantly on the spinal cord while that of picrotoxin is on the cortex and medulla. In small doses it stimulates and in larger doses depresses the central nervous system, so that the sequence of events in picrotoxin poisoning are convulsions. confusion and unconsciousness. The only justifiable use for picrotoxin is as an antidote in poisoning by central nervous system depressants, especially the barbiturates, in which case its stimulating action on the respiratory system acts as an effective physiological antagonist. Conversely, in picrotoxin poisoning, barbiturates, chloral hydrate or chloroform are indicated.

PICTISH. The language of the ancient Picts is of uncertain origin and of doubtful affinity. "The Picts have left us a number of inscriptions in the Ogham character. No attempt to interpret these inscriptions as any form of Celtic has produced anything but bosh. Whatever may have been the Pictish language, these inscriptions assure us that it was certainly not Celtic." (R. A. S. Macalister in *Antiquity,* ii, 7, p. 373, 1928.) Examination of the symbols found upon monumental stones in Pictland suggests analogies with certain elements in Bronze Age sculpturings—a highly probable affinity if the Picts were the survivors of Bronze Age aborigines, influenced by La Tène culture.

The term *Pict* itself may he connected with the Latin *Pictones* and *Pictari* of Gaul. In Irish they are known as *Cruithne,* in Welsh as *Puydyn,* which (*cf.* Prydein, or British) significantly resembles the earliest Greek name for the British Isle. *Pretonnic Islands.* From the matrilineal succession of their chiefs (the records being doubtful) it has been inferred that their social structure differed from that of other Gaelic speaking peoples. Pictish extended to the north of Ireland, and was finally ousted by the Goidelic speech of the Scots. which was derived from Ireland.

See T. R. Holmes, *Caesar's Invasion of Britain* (1907).

PICTOGRAPHY, in the widest sense, includes all human expression and communication by means of pictures, which are drawn, painted, scratched or incised. It includes primitive attempts at purely aesthetic expression; drawings with a communicative aim, which may be classified as the forerunners of writing; and full systems of writing utilizing pictures as basic forms. In a narrower sense. the term is applied only to primitive drawings on rocks, called petrograms if they are drawn or painted, and petroglyphs if they are incised or carved. It is in its restricted sense, as applied to the primitive forerunners of writing, that pictography is discussed in this article. (Full systems of writing, utilizing pictures for signs, such as Egyptian or Hittite, are often called hieroglyphic and are discussed in the articles HIEROGLYPHS; LOGOGRAM AND SYLLABARY; and WRITING.)

Primitive Drawings. — If writing is defined as a device for expressing linguistic elements by means of conventional visible marks, then it is no more than 5,000 years old. But even tens of thousands of years ago man felt the urge to draw pictures on walls and rocks. Primitive man is similar in this respect to a child, who no sooner learns to crawl than he begins to scribble on the wallpaper or to draw crude pictures in the sand. All over the world, man has left traces of his imaginative powers in rock drawings dating from Paleolithic to modern times. They usually depict man. deity and animal in various relations to each other. The faithful reproductions of animal figures left by Paleolithic man in Europe and the graceful paintings of the South African Bushmen are well-known examples. An immense number of rock drawings and carvings have been found in North America, especially in the mountainous regions.

In most cases it is very difficult to ascertain the purpose of a picture. since the circumstances of its execution are not known. The picture may be a manifestation of magic, religious or aesthetic expression, and several impulses may have been at work at the same time in its origin. The depiction of a successful hunt or military expedition, though it may have been essentially pictorial, may also have served as a monument to commemorate past experiences. It could also have had the magical purpose of securing another good hunt or a successful razzia in the future. Such pictures do not constitute writing because they do not form part of a conventional system of signs and can be understood only by the man who drew them and those who knew of the event.

Although the underlying aims of a picture cannot be established. certain differences in the form of execution may be discerned between pictorial art and drawings made for purposes of communication. The latter attempt to communicate a certain message in a way that can be understood by the people for whom the message is intended. Since they are drawn for communication and not for aesthetic expression, they are characterized by stereotyped execution and by omission of all details (background, mountains, trees, etc.) not necessary for the expression of the communication.

Pictography and **Ideography.**—The basis of all writing is the picture. Among primitives, a picture satisfies. in a crude way, the needs fulfilled among literate people by writing. In the course of time the picture developed in two directions: (1) toward pictorial art, in which pictures continued to reproduce more or less faithfully the objects of the surrounding world in a way independent of language; and (2) toward writing, in which signs, whether they retained their pictorial character or not, ultimately became symbols for linguistic elements. Ideography represents an intermediate stage between pictorial art and writing.

The term ideography includes the various forerunners of writing, which convey ideas or meanings directly and have a very loose connection with the elements of language. Both ideography and pictography are applied to the same kinds of forerunners of writing. but while pictography refers to the pictorial character of the symbols, the term ideography denotes inner, structural characteristics of the system, such as the fact that the individual symbols, called ideograms, stand for certain ideas or meanings.

A simple example of ideography is the communication "no thoroughfare," in a rock drawing near a precipitous trail in New Mexico. The design, representing a mountain goat standing upright and a horse and rider upside down, is intended to warn horsemen that, while a mountain goat could climb up the rocky trail, a horse would tumble down. This drawing employs no more detail than is necessary to indicate the two animals and the rider, and there is no indication whatever of a background.

The ideographic communication is somewhat different from a work of art and is completely independent of language. A person who is only slightly acquainted with the communication habits of American Indians is able to understand the message just described, even though he is ignorant of the language of the person who drew it. This stage of the forerunners of writing is called the descriptive-representational stage.

Another forerunner of writing, used more for recording rather than for communicating, is called the "identifying-mnemonic" de-

vice. Certain signs or combinations of signs are used as aids for memorizing songs, proverbs, dates or the like. The Ojibwa Indians record their ceremonial songs in this way by means of drawings on birch bark; the Ewe Negroes of Togo, in Africa, record proverbs in a similar manner. In all cases the individual drawings do not reproduce pictorially the verse or proverb but only give a suggestion of it. Thus, among the Ewe a drawing of a threaded needle does not reproduce the proverb "the thread follows the needle" (resembling in its meaning the English "a chip off the old block") but is a device to help recall it.

The pictorial character of all the symbols used as forerunners of writing can generally be recognized. But even in their earliest stages these systems use symbols that do not look like real objects but rather like simple linear, geometric designs composed of strokes, squares and circles. Most of these symbols are not abstract forms but are schematic developments from real pictures. Some signs which are geometric in form may owe their origin to imitation of signs in gesture language. In the systems used by American Indians, the sign for "all." which is drawn in the form of a circle, may go back to a gesture sign made by a circular motion of the hand.

The main object of writing, namely, efficiency of communication, is achieved through the omission of all details not necessary for the understanding of the symbol. One such economizing measure is the *pars* pro *toto* convention. found so frequently in American Indian writings. By this device an object, usually a man or an animal, is indicated by a picture of only a part of it, very often the head.

Meaning can also be conveyed by various auxiliary devices based on the use of colour, position and context of situation. American Indians, for example, have frequently employed coloured signs. Thus, among the Cherokee white is used for peace or happiness, black for death, red for success or triumph, blue for defeat or trouble.

The importance of position can be visualized in modern mathematical systems as, for instance, in "32" and "3^2"; meaning is here expressed by conventional positions of the signs in respect to each other. The principle of position may be illustrated by many examples used among the American Indians. Drawings of a hawk and a person may represent the two words individually, but a hawk directly above the head of a person indicates, by convention, the name of the person; namely, "Hawk." A drawing of a person facing in one direction conveys "coming," in contrast to a drawing of a person facing in the opposite direction, which conveys "going away."

The principle of context of situation, a term introduced by B. K. Malinowski in his study of the problem of meaning in preliterate societies. may be exemplified by the query ('where is the pen?" The question is usually perfectly understandable, even though the word pen may mean a writing instrument, a play pen or a different type of small enclosure, depending on the circumstances in which it is asked. In American Indian conventions, a drawing of a panther in one case may represent or imply a panther; in another case, the name of a person, especially if it is drawn above the person's picture; in still another case, at the end of a message, it serves as a sort of invocation to the panther, symbol of force, asking for help in a military expedition.

Forerunners of writing may be divided into several classes. In the primary class, objects and beings are represented by pictures of those objects or beings. The second, the associative class, includes signs that express ideas connected with the drawing by association of meanings. While a picture of the sun expresses "sun" by the primary device, it can also have the meanings "day," "bright." etc., by the associative device. Another device, phonetization or the rebus principle, plays a paramount role in all the fully developed writings, such as Sumerian, Egyptian, Chinese, etc., but is hardly ever attested among the forerunners of writing. Among the very rare examples is the Dakota writing of the name of the Indian tribe Hohe, which means "the voice" in the Dakota language; it is a drawing of the vocal organs.

Pictography is most widely used among the American Indians, and the Indians reached a level of systematization and standardization of symbols far above other comparable systems. One peculiarity of the Indian drawings is that, within each tribal system, every Indian draws in precisely the same manner. By contrast, in the drawings of the African Negroes the different local styles can be readily recognized.

Ideography and **Logography.**—Ideography, as used in this article, denotes a system of visual communication which conveys ideas, thoughts and contents but not linguistic elements. The term has often been confused with logography or word writing. Because of the double meaning of ideography, the term semasiography (from the Greek *sēmasía* "meaning," "signification" and *gráphein* "to write") is sometimes used in its place.

The difference between the ideographic and fully developed systems of writing may be illustrated by analyzing the method in which a communication such as "the king killed a lion" is expressed in the two systems. This message would be expressed in an ideographic system by a scene showing a man with some insignia of royalty, such as a crown or a sceptre, depicted in the process of attacking a lion with a weapon. In any of the fully developed writings, such as Sumerian or Egyptian, the same communication would be expressed not by a scene but by a sequence of signs, each standing for one word of the communication. Instead of a scene composed of two parts (man with a weapon facing a lion), three separate signs would indicate the three main words of the communication; namely, the signs for king, killing and lion. It should be noted that even the fully developed writing systems are not capable in their earliest stages of indicating such morphological features of the language as the definite and indefinite articles and the distinction in tense. Later Sumerian, Egyptian and other similar writings are, of course, capable of indicating any linguistic nuances.

Another illustration of the different methods used in ideography and logography can be seen in the way a communication "five lions" would be recorded. In ideography it would be expressed by five separate pictures of lions, while in logography this would be accomplished by only two signs, corresponding to the two words of the language. The plural mark *s* would be omitted in the early stages of logography.

Another important characteristic of logography is that the order of the signs follows the order of the spoken words; in ideography, the meaning is conveyed without any convention regarding order. The third important distinction pertains to the choice of symbols or signs in ideography and logography. In ideography, the sign for sun conveys "sun" and related ideas, such as "bright," "light," "clear," "shining," "pure," "white," "day." or even "the sun is shining." "the day has come"; in logography, the sign has only as many meanings as there are words which are habitually and conventionally associated with it. Thus. in Sumerian, the sun sign expresses at least seven words related to the basic meaning of "sun," but in Chinese the sun sign stands only for "sun" and "day," while the word *ch'ing* "pure," "clear" is expressed by a combination of the sign for "sun" with the sign for "colour"; the word *ming* "bright." "shining" by that of "sun" and "moon"; and the word for "white" by a sign of unknown interpretation evidently having no connection with the sun. Similarly, in Egyptian, the words for "sun," "day," "white" and "light" are expressed by the picture of the sun, but the word $\underline{t}^x\underline{h}^x n^x$ "shining" is written by a sign different from that for the sun. There are no logographic systems in which a sign can stand for a certain idea with all of its related ramifications, just as there are practically no signs in these systems which are not intended to correspond to words of language. Almost all cases claimed to be ideography turn out, upon investigation, to be false. When a writer intends to express a word by a word sign that stands for many words, he will usually try to make sure that the reader will read only the intended word. Semantic and phonetic indicators, the principle of position and context of situation are devices for the purpose of achieving this aim.

The oldest systems of writing, such as the Sumerian and Egyptian, being fully phonetic, employ conventional signs with definite word or syllabic values. Even in these fully phonetic writings, however, the meaning is sometimes expressed not by conventional signs but by descriptive-representational drawings. In Egyptian,

in a written context describing the victories of Ramses II over foreign lands, Pharaoh's honorary title, "he who binds the foreign peoples," is expressed not by individual hieroglyphs but by a scene depicting the Pharaoh binding the foreign king with cords. In another written context, the formula, "an offering which the king gives." is expressed by a picture of a king holding a mat with a loaf of bread. The meaning is conveyed in these two scenes in a form which is known from the earliest periods of Egyptian writing, as found, for example, on the Narmer palette.

Even in modern usage there are signs which have no conventional speech forms. For instance, an arrow on a sign along a road may mean "follow the direction of the arrow," but at the entrance to a cave it may mean "enter here." Such examples as there are of this sort of symbolism have many parallels in the semasiographic stage of writing in which meanings, rather than words or sounds. are suggested by signs. As part of a phonetic system of writing, an arrow sign would in time develop one or two unequivocal speech meanings, such as "go (there)" or "follow."

Certain symbols in comic strips are also generally understood even though they have no conventional counterpart in speech. Such symbols, called "sublinguistic ideographs," include: a balloon encircling print, signifying that a character is speaking; footprints, signifying that he is going; sawing wood, for snoring or sleeping; a light bulb with rays, for an idea; and]/!*§§="), for profanity.

Also outside normal phonetic systems are the conventions of mathematics, logic and science. Although each sign of a formula has or can have an exact correspondence in speech, the meaning is conveyed by the order arid form of the signs, which do not follow the conventions of phonetic writing.

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PICTON, SIR THOMAS (1758–1815), British general, born at Poyston, Pembrokeshire, joined the army in 1773 as an ensign. On the disbandment of the 75th regiment in 1783 Picton quelled a mutiny among the men by his prompt personal action and courage. After living in retirement on his father's estate for nearly 12 years, he went out to the West Indies in 1794. He took part in the capture of St. Lucia (for which he was promoted lieutenant-colonel) and in that of St. Vincent. After the reduction of Trinidad, Abercromby made him governor of the island. He administered the island with such success that the inhabitants petitioned against the retrocession of the island to Spain, and their protest, with Picton's and Abercromby's representations, ensured the retention of Trinidad as a British possession.

In October 1801 he was gazetted brigadier-general. But by this time the rigour of his government, as reported by his enemies, had led to a demand by humanitarians at home for his removal. He was charged with permitting the application of torture under the Spanish law which he had to administer. Colonel William Fullarton (1754–1808) procured the appointment of a commission to govern the island, with Picton as its junior member. Picton resigned, and on his return to England in Dec. 1803 he was arrested by order of the privy council. He was tried in the court of king's bench before Lord Ellenborough in 1806 on one of the charges, on which the court returned a merely technical verdict of guilty, which mas superseded in 1808 by a special verdict on retrial. The inhabitants of Trinidad, who had already given him a sword of honour and had petitioned the king not to accept his resignation, subscribed £4,000 toward his legal expenses, which sum Picton contributed in return to the relief of the suffering caused by a widespread fire in Port of Spain.

In 1810, at Wellington's request, he was appointed to command a division in Spain. For the remaining years of the Peninsular War, Picton was one of Wellington's principal subordinates. The commander-in-chief, it is true, never reposed in him the confidence that he gave to Beresford, Hill and Craufurd, but in the resolute, thorough and punctual execution of a well-defined task Picton had no superior in the army. His debut was unfortunate. On the Coa in July 1810 Craufurd's division became involved in an action, and Picton, his nearest neighbour, refused to support him, as Wellington's direct orders were to avoid an engagement. Details of the incident will be found in Oman, *Peninsular War,* vol. iii. Shortly after this, however, at Busaco, Picton found and used his first great opportunity for distinction. He repulsed the French attack with skill and resolution. After the winter in the lines of Torres Vedras, he added to his reputation and to that of his division at Fuentes d'Onor. In September he was given the local rank of lieutenant-general, and in the same month the division won great glory by its rapid and orderly retirement under severe pressure from the French cavalry at El Bodon. In the first operations of 1812 Picton and Craufurd stormed the two breaches of Ciudad Rodrigo, Craufurd being mortally wounded. At Badajoz, a month later, the successful storming of the fortress was due to Picton's daring self-reliance and penetration in converting the secondary attack on the castle, delivered by his division, into a real one. He was himself wounded in this terrible engagement, but would not leave the ramparts, and the day after, having recently inherited a fortune, he gave every survivor of his command a guinea. His wound and an attack of fever compelled him to return to England to recruit his health, but he reappeared at the front in April 1813. The conduct of his division under his leadership at the battle of Vittoria and in the engagements in the Pyrenees raised his reputation as a resolute and skilful fighting general to a still higher point. Early in 1814 he was offered, but after consulting Wellington declined, the command of the British forces operating on the side of Catalonia. He thus bore his share in the Orthez campaign and in the final victory before Toulouse.

On June 24, 1814, Picton received for the seventh time the thanks of the house of commons for his great services and in 1815 he was made a G.C.B. When Napoleon returned from Elba, Picton, at Wellington's request, accepted a high command in the Anglo-Dutch army. He was severely wounded at Quatre Bras June 16, but concealed his wound and retained command of his troops, and at Waterloo on June 18, while repulsing a serious attack, he was shot through the head by a musket ball. His body was brought home to London and buried in the family vault at St. George's, Hanover Square. A public monument was erected to his memory in St. Paul's cathedral, by order of parliament, and in 1823 another was erected at Carmarthen by subscription, the king contributing 100 guineas to it.

See Robinson's *Life of Sir Thomas Picton* (London, 1836), with which, however, compare Napier's and Oman's histories of the Peninsular War as to controversial points.

PICTS, an early people inhabiting Scotland: of uncertain affinities, probably pre-Celtic. They are first mentioned in A.D. 306. In 640 they defeated the Romans and harried the Roman provinces (*see* STRATHCLYDE) until conquered in 846 by Kenneth (*q.v.*) MacAlpin. Tradition associates the Picts with the great stone monuments.

PICUMNUS AND PILUMNUS, Roman deities of probably rustic origin whose attributes are unclear. Picumnus was credited with the discovery of manure as fertilizer and Pilumnus was the inventor of the grain-crushing pestle (pilum). They were also the protectors of women after childbirth. Pilumnus was one of a trio of deities who protected the mother and infant from the pranks of Silvanus (*q.v.*). The others were Intercidona (god of the hewing of timbers) and Deverra (sweeping of grain).

(R. B. LD.)

PICUS, the Latin woodpecker. As the woodpecker was sacred to the god Mars (*q.v.*) it was widely reverenced in ancient Italy and developed into a minor god. As a deity Picus is agricultural (not unlike Mars) and is associated particularly with the fertilization of the soil with manure; thus we find him at times called son of Sterculius (Stercutius or Stercenius. the dung god). Since the woodpecker was an important bird in augury, Picus is not only rustic but prophetic.

Later rationalizations made him an early king of Italy. Virgil (*Aeneid* vii. 45–49. 187–191) makes him son of Saturn, father of Faunus and grandfather of Latinus (*qq.v.*). His bride. Circe, for reasons of unrequited love. changed him into a noodpecker. Ovid (*Metamorphoses* xiv, 320 ff.). perhaps inventing the story. re-

lates that his wife was the beautiful nymph Canens ("Singer") and out of faithfulness to her he spurned the love of Circe and thus suffered the metamorphosis. According to others it was Pomona who was his beloved.

As son of Saturn he came to be identified with Zeus, and because of the similarity of their names is confused with another rustic deity, Picumnus (see PICUMNUS AND PILUMNUS). Picus and Faunus are associated in a story told by Ovid (Fasti iii, 291 ff.) where Numa captures the two by rendering them drunk and forces their assistance to avert a disaster.

His earliest representations were as a wooden pillar mounted with the image of a woodpecker. In more sophisticated form he is a youth carved of marble with a woodpecker on his head.

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PIDDOCK, several species of highly specialized marine bivalve mollusks (see MOLLUSCA) belonging to the family Pholadidae. They are adapted for boring into rock, shells, peat, hard clay or mud. The name was first applied to Pholas dactylus, a rock borer occurring in western Europe, but its use has been broadened to include species in various genera throughout the world. All of the species are characterized by having accessory plates in addition to the bivalve shell. The young stages have an anterior gape for the protrusion of a large muscular foot which aids in boring. The anterior portion of the valves is armed with rows of strong imbrications with which the animal abrades the substratum in the process of boring. In some groups the anterior gape is closed by a covering or callum when the animal has stopped boring. Some species bore to a depth only slightly more than the length of the shell, but others, which have extensible siphons, may bore to depths several times the length of their shell. Many of the deep borers have additional shelly or chitinous plates (the siphonoplax) for the protection of the siphons. The accessory plates on the dorsal surface of the valves are for the protection of the anterior adductor muscle. which has migrated to the outer surface of the shell. The alternate contraction of the anterior and posterior adductor muscles produces a rocking motion of the valves, pivoting on the dorsal and ventral condyles. It is this motion which brings the denticles of the anterior portion of the valves in contact with the substratum during boring.

Piddocks, like most bivalves, feed on minute organisms in the water. Food particles are brought into the mantle cavity through the incurrent siphon, and excretory products are carried out through the excurrent siphon. The late embryonic stage of all species is a free-swimming larva. The larva is microscopic in size and is very similar in appearance to the young of most clams, but when it settles on the substratum, it attaches itself by a single self-secreted filament (byssus thread) while the shell modifies its surface and becomes an efficient boring tool. Boring begins within a few hours after the attachment of the larvae.

Piddocks are world-wide in distribution; most species are found in the intertidal zone, and only a few extend into deeper water. The most famous species. *Pholas dactylus,* not only bores into gneiss, probably the hardest rock into which any pholadid can bore, but it is also the only known luminescent species (see BIOLUMINESCENCE). A number of species belonging to several genera including Penitella, *Parapholas* and *Zirfaea* are found on the west coast of Korth America. Penitella penita occasionally damages the cement jackets of pilings. The most destructive group is the wood-boring *Martesia,* which causes considerable damage to wharves and other water-front structures in warmer waters. The genus *Xylophaga* includes deeper-water species which may damage underwater cables. Species of two genera, *Diplothyra* and Penitella, bore into the shells of other mollusks, particularly oysters and abalones. Pholas *dactylus* was at one time highly esteemed as food and was sold in European markets. Though it is occasionally eaten today it is no longer seen on the market. Pholas *chiloensis* is considered a delicacy by natives of Chiloé Island, Chile.

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PIDGIN is a term applied to a number of varieties of speech uhich have grown out of English and other languages, and which have been used in various parts of the world since the 17th century. These languages are often termed "bastard jargons," "mongrel lingos" or th? like; but in fact they are languages like any others, and can be accurately delimited and described. Before doing so, however, it is necessary, in order to facilitate discussion, to define three terms clearly: lingua franca, pidgin and creole. When a language is used as a means of communication between persons having no other language in common, *e.g.,* French in 19th-century diplomacy, it is a lingua franca (written with lower-case initials to distinguish it from the original Lingua Franca, cf. the next paragraph). A lingua franca which is native to none of those using it, and with a sharply reduced grammar and vocabulary, is called a pidgin. (Defining pidgin thus eliminates both the broken English of, say, a beginning learner, and the skillful but non-native use of English in such countries as India.) When a whole speech community gives up its former language and comes to use a pidgin as its mother tongue, the pidgin has become a creole language (is creolized).

During the expansion of Europe since the middle ages, a number of pidgins and creoles have arisen on the basis of various European languages. The first known pidgin was the Lingua Franca, or "westerners' language," of the medieval levant and the Barbary coast, based chiefly on Italian. When Englishmen first came into contact with North American Indians in the 17th century, they developed a pidgin language; later in the same century, other varieties of pidgin English grew up as a result of English commercial contacts in China (where the word "pidgin" is said to have originated, from the English word "business") and slave-trading activities in west Africa. The establishment of plantation economies in the Caribbean area, with large groups of Negro slaves from different language backgrounds in west Africa, led to the development of a number of pidgins based on English, French, Spanish and Portuguese. Many of these have survived as creoles, *e.g.,* Gullah in South Carolina, the Negro English of the Antilles and the Taki-Taki of Dutch Guiana, all based on English; the French-based creoles of Louisiana, Haiti and the Lesser Antilles; and the Papiamento of Curaçao, an outgrowth of pidgin Spanish and Portuguese. Early contacts between settlers and natives led to the formation of pidgins in Australia and New Zealand, whereas the pidgin English of the South Seas ("Beach-la-Mar") grew out of the activities of whaling, trading and blackbirding (recruiting native labour). Pidgin English is extinct in New Zealand and the Carolines, and moribund in Australia, but is still flourishing in Melanesia (New Hebrides, Solomons, New Guinea) and has become creolized in Hawaii. One variety, that of the Rabaul area (New Britain), has become the widespread and indispensable lingua franca of the Territory of New Guinea, due to the official sanction given its use under German rule (1883–1914), and later Australian administrations.

Pidgin languages grow out of the initial, non-intimate contacts betneen speakers of different languages, when quick comprehension is more highly valued than correctness in grammatical usage of the differentiation of fine shades of meaning. As contacts grow closer. normally one group learns the other's language more fully, and pidgins survive the stages of initial contact only under special circumstances. In many instances, pidgins have been perpetuated where a dominant group regarded another as childlike or incapable of using anything but a simplified version of the "superior" language, as in the relations between Europeans and American Indians, West Africans or South Sea natives. On plantations and in other situations where European masters were in permanent contact with native servants or labourers, pidgins have served as status languages, as in New Guinea. Caste distinction, however, is not a necessary function of a pidgin, as is shown by the instance of Russonorsk, a reduced language used by Russians and Norwegians as equals in the arctic at the beginning of the 20th cen-

tury. Chinese pidgin English survived for three centuries, not only in master-servant relations but also in use between English merchants and Chinese dignitaries, primarily through the desire of each side to keep the other at arm's length. Slaves on Caribbean plantations, New Guinea natives in newly formed multilingual villages, and others who have come to live together, marry and raise children, with no language in common save a pidgin, have used the pidgin as the customary language of the group. In such instances, the resultant creole has usually re-expanded its structure and vocabulary by more or less heavy borrowing from the language of a culturally dominant group, *e.g.,* Haitian creole from French, Taki-Taki and Papiamento from Dutch, and Melanesian pidgin from English.

In its original function, as a lingua franca among unlettered folk, a pidgin language is a medium of purely oral communication, as also are creoles in their initial stages. Only later, and usually in connection with missionary or other educational programs, are spelling systems devised for pidgins or creoles. Speakers of European languages have often applied the orthographical conventions of their own languages, as when the Melanesian pidgin sentence for "Why did you hit this policeman?" is written *Belong what name you fight 'im dis fellow police boy?* Such a spelling embodies all the inconsistencies that characterize English orthography, and is therefore difficult to learn; it distorts the structure of pidgin; and it confirms the naïve European or American in his belief that pidgin is only a ridiculous reduction of English. Those who have devised orthographies for ease of learning, accuracy in representing linguistic structure, and emphasis of the independent status of the language, have used phonemically based systems. The most effective orthographies of this type use the letters available on typewriters or in print shops, but consistently and predictably. Thus, the Melanesian pidgin sentence just quoted would be written, in the orthography of the Alexishafen mission: *Bilong wonem yu faitim disfela plisboi?* In the following discussion, pidgin forms are cited only in this type of transcription.

The simplification which characterizes pidgin extends to all aspects of linguistic structure (sounds, forms, constructions) as well as vocabulary. In some varieties (*e.g.,* Melanesian pidgin, from which our examples will be taken unless otherwise stated), stress has come to be automatic on the first syllable of every word: *e.g., bíkos* "because," *máshin* "machine." A minimum of five distinctive vowels is necessary, those represented in Latin or Italian pronunciation by *a* ("ah"), *e* ("eh"), *i* ("ee"), *o* ("oh"), *u* ("oo"), as in *antap* "up," *em* "he," *winim* "defeat," *kot* "coat," *tu* "also." The vowel sound *a* ("ah") combines with *i* ("ee") and *u* ("oo") in the basic diphthongs *ai* (English "i") and *au* ("ow"), as in *dai* "cease" and *nau* "now." Some, but not all, speakers make further distinctions, *e.g.,* between the *e* of *em* "he" and the *ei* ("ay") of *neim* "name." In almost all varieties of pidgin English, the two consonant sounds represented by Eng. *th* have merged with *t* and *d* respectively: *saut* "south," *disfela* "this." Many speakers of Melanesian pidgin also merge *ch* and *sh* with *s,* as in *tumas* "very" (from Eng. "too much") and *masin* or *mashin* "machine." Users of pidgin often carry over habits of sound production from their native languages: for instance, many Melanesian languages have *mb, nd* as variants of *b, d* between vowels, and Melanesians therefore often pronounce *tabak* "tobacco" as *tambak,* and *sidaun* "sit" as *sindaun.*

Grammatical categories, such as number, gender, case, person, tense, mood, voice—are almost wholly absent from pidgin and creole languages, as well as from many other languages of the world. Pidgin is not, however, "devoid of grammar," as is often asserted. Melanesian pidgin, for example, has three inflected parts of speech: pronouns, adjectives and verbs. The suffix *-fela,* added to pronouns, makes plurals, in *mi* "I, me" versus *mifela* "we, us" and *yu* "you" (sing.) versus *yufela* "you" (pl.). Another suffix *-fela* serves as a marker for adjectives of one syllable, demonstratives, indefinites and numerals: *maisfela* "pretty," *disfela* "this," *samfela* "some," *wanfela* "one." Verbs having a direct object (expressed or implied) take the suffix *-im,* and verbs without this suffix are intransitive or passive: cf. *rausim* "eject, remove" versus *raus* "be out, come out." Other parts of speech—nouns, prepositions, adverbs, conjunctions—are invariable, but are distinguished by the types of combinations in which they occur. In other varieties of pidgin English, the specific criteria for distinguishing classes of linguistic forms are different, but the basic structure is similar. Chinese pidgin nouns and pronouns, for example, can take the locative suffix *-said,* as in *doksaid* "at the dock(s)," *maisaid* "at my house," and the verb suffix *-em* forms, not transitives, but passive participles, as in *dis tri blong spoilem* "this tree is rotten."

The basic types of combinations—phrases and clauses—found in pidgin are the same as those of English; here again, however, many details of syntax are different. Melanesian pidgin nouns are followed, not only by possessive phrases (*haus bilong mi* "house of me, my house"), but also by modifying nouns (*haus pepar* "house [for] paper, office"), verbs (*haus kuk* "house for cooking, kitchen"), adverbs (*man nogud* "evil man," *nogud* being an adverb meaning "undesirably"), and clauses (*man mi lukim em* "the man I saw"). In Chinese pidgin, pronouns simply precede nouns to indicate possession (*hi fes* "his face"), and relative position is shown by a noun preceding an adjective (*Ning-Po mo far* "further than Ning-Po"). With third person subjects, Melanesian pidgin predicates are normally preceded by the predicate-marker *i-*: *ol i-singaut* "they call"; *balus i-no kamap yet* "the plane hasn't yet arrived." Melanesian pidgin has the clause type called "equational" (also found in other languages, *e.g.,* Russian and Hungarian) in which no verb is present: *disfela kaikai i-gudfela* "this food (is) good." Chinese pidgin, on the other hand, has the copulative verb *blong* "be" with nouns and adjectives in the predicate (*e.g., yu fut blong plenti sor* "your foot is very sore"), but uses no verb with an adverb in the predicate indicating location: *tumachi dast tebal tapsaid* "a lot of dust (is) on the table."

Since vocabulary is restricted (about 700 words in Chinese pidgin, 1,500 in Melanesian), each word necessarily has a greater range of meaning than its English counterpart. The central meaning of Melanesian pidgin *sori* is not "sorry," but "emotionally moved," as shown by its extension to "sympathetic, grateful, glad"; similarly, *dai* means "cease" ("die" is *dai tru* "stop for good") and *stap* is "be located; remain; continue." For many concepts, pidgin uses phrases rather than single words: with *skru* "screw; joint" are formed *skru bilong arm* "elbow," *skru bilong leg* "knee," etc. Some pidgin words belong to different parts of speech from their English counterparts, *e.g.,* the Melanesian pidgin preposition *bilong* "of" and the Chinese pidgin copulative verb *blong* "be" from Eng. "belong." Non-English meanings of pidgin words often reflect native social structure, as when *papa* means "uncle," since a boy's maternal uncle, rather than his father (*papa tru*) is primarily responsible for his upbringing in New Guinea. Speakers of English are often naïvely amused or shocked by the disregard of some of our society's taboos evident in certain shifts of meaning, as when *ars* "buttocks" is extended to mean "bottom (of anything), foundation, reason, cause, source," for example, *ars bilong diwai* "the base of the tree," or *God i-ars bilong olgedar samting* "God is the source of all things." It must be realized, however, that in the context of native society and attitudes, these concepts are not taboo and no stigma attaches to the words or their use.

In the structural reduction from English to pidgin, the main grammatical characteristics have been kept (the part-of-speech system, the dichotomy between subject and predicate, the use of phrases taking the place of single words), though often with different identifying features. The various kinds of pidgin English are definitely English and Indo-European, not (as is often said), "native languages spoken with English words." Nevertheless, there have been extensive carry-overs from non-English structural patterns, because speakers of native languages have translated their own constructions into pidgin, especially in the early stages of its formation. For instance, in Chinese a numeral modifying a noun must be accompanied by a special word indicating a measure of quantity, called a "numeral classifier," as in *sān ge rén,* literally "three piece man." This type of combination was reflected in older Chinese pidgin *tufela man* "two men," *forpisi naif* "four

knives," etc., with *-fela* for animate objects, *-pisi* for inanimate objects. However, in modern Chinese pidgin. *-fela* has not survived, and *-pisi* has lost its independent status and become simply a numeral suffix. as in *tupisi man* "two men." Similarly, the presence of separate pronouns for "we" (excluding the hearer) and "we" (including the hearer) in Melanesian languages has led to the establishment in Melanesian pidgin of a parallel contrast between *mifela* "we" (but not you) and *yumi* "we" (including you).

The proportion of vocabulary elements in pidgin English derived from non-English sources is small, both in relation to the popular myth that pidgin is a "weird mixture of tongues" and in comparison to the non-Germanic element in English itself. Of the approximately 1.500 words in Melanesian pidgin, not over 20% are of non-English origin. Of these, perhaps half are Melanesian (that is. *kiau* "egg; bomb," *diwai* "tree.!' *malolo* "rest." *balus* "pigeon: aeroplane") and one quarter were borrowed from German, such as *mark* "shilling," *tais* "pond," *langsam* "slow" and *beten* "pray." The remaining 5% are from various languages—a few from Malay (that is. *karabau* "water buffalo'!) and three from Romance sources: *save* "know," *pikinini* "child" and *pato* "duck." The percentage of non-English elements in Chinese pidgin is even smaller, hardly over 5%.

With the coming of modern civilization and technology to New Guinea and similar areas. the use of pidgin has posed a problem, especially with regard to its use as a medium of instruction in elementary education and technical subjects. The use of pidgin has been opposed by some, partly on puristic grounds and partly because it is alleged to be ineradicably tainted by connotations of colonialistic exploitation. In answer, it is pointed out that pidgin and creole languages are not "corruptions," but normal linguistic developments; it has even been suggested that the Germanic languages (and hence English) may have arisen from a creolized variety of Indo-European. In New Guinea and the Solomons, pidgin is no longer a status language. nor imposed on the natives by white colonialists, but is the natives' own lingua franca. indispensable for communication, and easier for a Melanesian to learn than English. which is both more complicated and more foreign to him. If skillfully used, pidgin can serve both as a medium of instruction and as a bridge to English. In this connection, it has been suggested that new names, without pejorative connotations, be given to these languages, *e.g.*, Neo-Melanesian to the pidgin used in New Guinea, and Neo-Solomonic to that used in the Solomon Islands. *See* also BASIC ENGLISH.

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PIECEWORK, a method of industrial remuneration in which the worker is paid by the piece or job. *See* WAGES.

PIEDMONT is **a** territorial division of north Italy, enclosed on all sides except toward the Lombard plain by the vast semicircle of the Pennine, Graian. Cottian, Maritime and Ligurian Alps. In 1859 it was divided into the four provinces of Alessandria, Cuneo, Novara and Torino (Turin) to which Aosta and Vercelli were added in 192i and later Asti. It has an area of 9.807 sq.mi. The people are chiefly engaged in agriculture, which is helped by irrigation.

Agricultural products include wheat, rye, oats, rice, corn (maize), beans, sugar beets, hemp, garden produce, potatoes, forage and vines for the production of wine grapes.

Many are also occupied in the reeling and throwing of silk and in the manufacture of cotton (no fewer than 50.000 workers, of whom 37,000 are women), woolens and clothing; there are also considerable manufactures at Turin, Savigliano, etc. The Piedmontese dialect has been rather strongly influenced by French.

The total population of Piedmont was 3,518,177 in 1951. There are numerous summer resorts in the Alpine valleys.

The chief railway centres are 'Turin. communicating with the Mont Cenis line and with the Riviera by the railn-ay over the Col di Tenda. The communications with Liguria are difficult because of the approach of the mountains to the coast, but the electrification of the lines from Genoa to Turin and Milan greatly improved the traveling facilities of this region

Piedmont (Ital Piemonte; Lon Lat Pedemons and Pedemontium) in Roman times until 49 B C formed a part of Gallia Transpadana, and in Augustus' division of Italy formed nith what nas later knonn as Lombardy, the 11th region. It formed part of the Lombard kingdom. and it was not till about AD. 1000 that the house of Savoy (*q v*) arose.

PIEDRAS NEGRAS, formerly Ciudad Porfirio Díaz, a northern frontier city of Mexico in the state of Coahuila, 840 mi. north by west of Mexico City, on the Rio Grande del Norte, 720 ft above sea level, opposite the city of Eagle Pass. Tex The population in 1950 nas 27.578. An international bridge connects the two cities. and the Mexican National railways have a northern terminus at this point. The city has an important transfer trade nith the U S and is the centre of a fertile district devoted to agriculture and stock raising Coal is found in the vicinity: silver, zinc and copper are also mined. In 1958 a superhighway was opened betneen Piedras Negras and Mexico City via Saltillo and Querétaro. (J. A. Cw.)

PIEGAN: *see* BLACKFOOT.

PIER, in architecture usually denotes a vertical support in masonry. bricknork or concrete which carries an arch or superstructure. In this sense it is applied both to those portions of a structure nhich are visible above ground and to isolated or detached supports underground described as foundation piers. The term is sometimes applied to the solid parts of a wall betneen windows or voids, and also to the isolated masses of bricknork. masonry or concrete to which gates are hung. *See* also CAISSON; FOUNDATIONS

Bridge Piers.—In the construction of bridges (q **v.)** and viaducts. pier denotes the solid structure upon nhich the bridge superstructure (including arches) is supported. Occasionally in the case oi high piers supporting viaducts and bridge superstructures the upper portions are constructed of open-braced iron- or steelnork.

Harbour Piers.—In Great Britain the term pier is often applied to norks sheltering harbours such as the Tynemouth piers nhich are strictly breaknaters (*q.v.*). Landing stages also, nhether solid or open, have for a long time been called piers. A jetty (*q.v*) thrown out from the shore to protect the entrance to a

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ARCHED 16TH-CENTURY GATEWAY AT PONTA DELGADA. SAN MIGUEL, AZORES

river harhour is also sometimes described as a pier. In the United States and Canada the term is commonly employed for a aharf structure that projects into a river. fairway or harbour.

Promenade Piers.—Open promenade piers form a common feature at seaside resorts. Promenade piers are supported on open pile work of timber, cast iron or steel: reinforced concrete also has been frequently employed both for the pile supports and superstructure. (N. G G.; X.)

PIERCE, FRANKLIN (1804–1869), fourteenth president of the United States, was born at Hillsboro, New Hampshire, Nov. 23, 1804 His father, Benjamin Pierce (1757–1839), served in the American army throughout the Revolutionary War, was a Democratic member of the New Hampshire house of representatives from 1789 to 1801, and was governor of the State in 1827. The son was prepared for college at Hancock, Francestown and Exeter academies and entered Bowdoin in 1820, where he formed a lifelong friendship with Nathaniel Hawthorne. After his graduation in 1824he studied law and was admitted to the bar in 1827.

Entry into Politics.—Entering politics as a Democrat he became a member of the New Hampshire house of representatives in 1829,and was speaker of that body in 1831 and 1832. The following year he entered the national house of representatives. While he rarely spoke from the floor, he was an influential member of several committees, including the judiciary committee. A friend of President Jackson he supported administration policies. He adhered to a strict construction of the Federal Constitution, defended the Maysville veto, opposed the recharter of the bank of the United States, opposed appropriations to the U. S military academy and favoured a volunteer army. During his first term in Congress he married Jane Means Appleton, daughter of the president of Bowdoin college. In 1837 he entered the U S. Senate. Being its youngest member, he was overshadowed by a galaxy of older and more prominent men such as Benton, Clay and Webster. Before his term expired he resigned his seat (1842) and returned to the practice of law at Concord, NH., where he became Federal district attorney. In 1845 he was offered the Democratic nomination for governor of New Hampshire, also an appointment to fill an unexpired term in the U S. Senate, and the next year the position of attorney-general in Polk's cabinet; but he rejected them all, declaring that he had permanently retired from political life.

Service in Mexican War.—Shortly after the outbreak of the war with Mexico in 1846Pierce enlisted as a private at Concord, but soon became colonel of the 9th Regiment, and later a brigadier-general of volunteers. He was with Gen. Scott in the advance toward Mexico City. During the battle of Contreras he was thrown from his horse and received painful injuries. Despite the advice of Scott to the contrary he insisted on continuing the fight the next day and in the course of the battle he fainted. This fact, variously interpreted, was used both for and against him when he was later a candidate for the presidency. At the close of the war he returned to his law practice.

Election to Presidency.—Pierce became the Democratic nominee for president in 1852 "as a dark horse." Those in the foreground were Lewis Cass, Stephen A. Douglas and James Buchanan, but none of these proved to be available because of factional rivalries A few politicians, foreseeing a deadlock, had prepared Pierce for the place. At the convention in Baltimore in June his name was first brought forward by the Virginia delegation on the 35th ballot, and on the 49th ballot he received an almost unanimous vote Both the Democrats and the Whigs were too badly split for any real issues to appear in the campaign. The chief question in the public mind was the finality of the Compromise of 1850, and while both parties declared themselves in favour of it the Democrats were more thoroughly united in its support. As a result Pierce swept the country in the November election, receiving 254 electoral votes against 42 for his opponent, Gen Winfield Scott.

Presidential Administration.—The youngest man to have been elevated to the presidency, Pierce was handsome, genial and possessed of a certain brilliance, which however was not profound. The Eastern element of the Democratic party which he directly represented was inclined for the sake of harmony and prosperity to oppose anti-slavery agitation and generally to placate Southern opinion. It was hence pro-Southern as a matter not only of political strategy but also of business expediency. Thus in the selection of his cabinet, as in both domestic and foreign policies of his administration, Pierce represented a coalition of Southern planters and Eastern business men. His cabinet included William L. Marcy of New York, secretary of state; Jefferson Davis of Mississippi, secretary of war; James Guthrie of Kentucky, secretary of the treasury; James C. Dobbin of North Carolina, secretary of the navy; Robert McClelland of Michigan, secretary of the interior; James Campbell of Pennsylvania, postmaster-general; and Caleb Cushing of Massachusetts, attorney-general. In his inaugural address Pierce interpreted his election as a popular mandate to maintain the Compromise of 1850 and bury the slavery controversy. He also forecast an aggressive, but honourable, foreign policy; he would "not be controlled by any timid forebodings of evil from expansion." In fact "the acquisition of certain possessions" (doubtless referring to Cuba in particular) was deemed essential to the country's safety and commerce.

Foreign Policy.—In accordance with the declarations of the inaugural Pierre Soulé, who had openly advocated the annexation of Cuba by means other than purchase if necessary, was appointed minister to Spain. When the Spanish Government showed its unwillingness to sell the island, Soulé, at the suggestion of secretary of State Marcy, held a conference with James Buchanan, minister to Great Britain, and John Y. Mason, minister to France, at Ostend, Belgium, as a result of which they issued the famous Ostend Manifesto. This was to the effect that if the United States were unable to obtain Cuba peacefully, "by every law, human and divine, we shall be justified in wresting it from Spain if we possess the power." In the storm of controversy which followed, the administration disclaimed responsibility for the document and recalled Soulé. The following year William Walker conducted a notorious filibustering expedition into Central America with the purpose of establishing a pro-slavery government to be brought under the control of the United States. He established himself as military dictator, then as president, of Nicaragua, and his regime was recognized by the Pierce administration. More fruitful of permanent results was the expedition sent out under Commodore Perry to Japan (1853) to induce her to open her doors to American trade. Lured by Yankee ingenuity and frightened by Western guns, she responded, and the result was the opening up of Japan. In the Koszta affair (1853) the government vigorously asserted the protection which it would offer those in the process of becoming its naturalized citizens. The administration also effected a reorganization of the diplomatic and consular service and the creation of the U.S. court of claims.

Domestic **Policy.**—Among the domestic policies of the Pierce administration were preparations for a transcontinental railroad and the opening up of the Northwest for settlement. It was in order to open the way for a southerly route to California through the lowest mountain passes that the Gadsden Purchase of 29.640 sq.mi. of territory was acquired from Mexico in 1853 at a cost of $10,000,000. It was mainly to stimulate migration to the Northwest and facilitate the project of a central route to the Pacific that the Kansas-Nebraska hill was enacted in 1854, receiving the President's sanction. This opened two new territories for settlement with the slavery question to be settled in each by popular sovereignty. Thus the dread conflict was reawakened with the venom of incipient civil war. Pierce's administrative policies with reference to "bleeding Kansas" were pro-Southern. He thus lost much of his former support at the North and made himself unavailable as a candidate for a second term.

Save for a three years' tour in Europe, he lived at Concord, N.H., where he died on Oct. 8, 1869.

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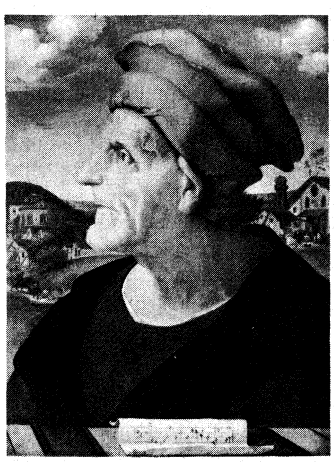
PIERO DELLA FRANCESCA: *see* FRANCESCA, PIERO DELLA.

PIERO DI COSIMO (PIERO DI LORENZO; 1462–1521), Florentine painter, noted for his mythological paintings. was born in Florence in 1462. He derived his name from that of his master, the painter Cosimo Rosselli, and he participated in this artist's frescoes in the Sistine chapel in the Vatican (1481). Thereafter, he worked exclusively in Florence, where, according to G. Vasari, he died in 1521. Piero di Cosimo's highly individual painting style was influenced successively by Luca Signorelli, Hugo van der Goes and Leonardo da Vinci. His most notable religious paintings are a tondo of the "Adoration of the Child" in the museum of art, Toledo, Ohio; an altarpiece for the Pugliese chapel in the Innocenti, now in the Spedale degli Innocenti. Florence; a "Visitation" in the National Gallery of Art, Washington. executed for the Camponi chapel in Santo Spirito. Florence; and an "Immaculate Conception" in the Uffizi gallery, Florence.

However he is best known for his mythological paintings, which combine a close study of nature with a romantic fantasy that is found in no other Renaissance artist. These include two large paintings of the "Fall of Vulcan" (Wadsworth Atheneum. Hartford, Conn.) and "Vulcan and Aeolus" (Ottawa). Along with two panels in the Metropolitan museum, New York, and the "Forest Fire" in the Ashmolean museum, Oxford, illustrating a Vitruvian program of the early history of man, these may have formed part of a cycle of paintings executed for Francesco del Pugliese, which is described by Vasari. A cycle of bacchanals. also mentioned by Vasari, was commissioned by Giovanni Vespucci; from this. two panels at Worcester. Mass., and in the Fogg Art museum. Cambridge. Mass., survive.



ALINARI

"PORTRAIT OF FRANCESCO GIAMBERTI" BY PIERO DI COSIMO. IN THE ROYAL PICTURE MUSEUM. THE HAGUE, NETHERLANDS

Piero di Cosimo's late style may be seen in scenes from the legend of Andromeda in the Uffizi gallery. Florence. The "Death of Procris" in the National gallery, London, is perhaps his most celebrated painting. Two remarkable portraits of Giuliano da Sangallo and Francesco Giamberti are in the Mauritshuis at The Hague.

Vasari supplies what is no doubt a well-founded account of the painter's personal eccentricities and observes that Piero di Cosimo's "works betray a spirit of great diversity distinct from those of others. for he was endowed with a subtlety for investigating curious matters in nature, and executed them solely for his delight and pleasure in art."

See R. Langton Douglas, *Piero di Cosimo* (1946); E. Panofsky, *Studies in Iconology* (1939). (J. W. P.-H.)

PIERRE, the capital city of South Dakota, C.S., and the county seat of Hughes county. is located on the Missouri river in almost the exact centre of the state. The town was first named Mahto, the Sioux word for "bear," when it was started in June 1880 as the western terminal of the Chicago and Northwestern railway. It became the county seat in November and on Dec. 16, 1880, was officially named Pierre (locally pronounced "Peer") for Pierre Chouteau, an early fur trader. For the next six years it was the railhead for the tremendous freighting by ox team on which the Black hills mining industry depended. Located between three Indian reservations and on the edge of a farming country to the east and cattle country to the west, the town had varied interests and was the trade centre of a large area. In 1885 the territorial legislature selected Pierre to replace Bismarck as capital but the governor vetoed the act; in 1889, when South Dakota became a state, Pierre was named the temporary capital and in elections in 1890 and 1904 was chosen the permanent capital. The state capitol building was erected (1905–10) on an attractive 30-ac. tract overlooking the Missouri river. Later additions include a world war memorial building, housing the State Historical society and museum (1930); the governor's mansion (1936); a state office building (1951); and a state highway building (1955); as well as a 7-ac. artesian-fed lake.

Pierre's population has fluctuated with the economy of the farm-ranching country in which it is located and for years it held the dubious distinction of being the nation's smallest state capital, with a population of 1.776 in 1895 and 5,715 in 1950. Thereafter the population increased considerably, stimulated by the construction of Oahe dam. starting in 1948 and continuing for several years. The dam. located 5 mi. above Pierre. is a power, irrigation and flood-control project, creating a 200-mi. lake along the Missouri.

Pierre is the site of a government Indian school (1891) and of St. Mary's hospital. Five miles downriver is Farm Island State park, a 1,800-ac. recreational area, with public golf course, swimming beach and other facilities.

The site of Pierre was for 400 years prior to 1800 the capital of the Arikara Indian nation; archaeological remains of it, as well as of many villages: are still to be seen. The Lewis and Clark expedition of 1804–06 brought news of the vast trade potential of the Missouri river and for the half century following 1817 Fort Pierre, across the river from Pierre, was the fur-trade capital of the northwest. With the decline of the fur trade and the coming of the railroads it decreased in importance although, like Pierre, it experienced an increase in population after 1950.

For comparative population figures *see* table in SOUTH DAKOTA: *Population.* (W. G. R.)

PIERROT (Ital. PEDROLINO), the name given to the leading character in the French pantomime plays since the 18th century; transferred from the Italian stage, and revived. He is always in white, both face and costume, with a loose and daintily clownish garb, and is represented as of a freakish disposition. Modern pierrot plays have converted the pierrot into a romantic and pathetic figure. *See* COMMEDIA DELL' ARTE.

PIETAS, in Roman mythology, the personification of the sense of duty toward God and man and toward the fatherland. According to legend, a young woman in humble circumstances, whose father (or mother) was lying in prison under sentence of death, without food, managed to gain admittance, and fed her parent with milk from her breast. To commemorate her filial affection, a temple to Pietas was dedicated in 181 B.C. by Manius Acilius Glabrio, Roman general and statesman, in the Forum Holitorium at Rome. on the spot where the young woman had formerly lived. The temple was probably originally vowed by Glabrio out of gratitude for the *pietas* shown during a battle by his son. who may have saved his life, as did the elder Xfricanus that of his father at the battle of Ticinus. The legend of the young woman (borrowed from the Greek story of Mycon and Pero) was then connected with the temple by the identification of its site with that of the prison.

Pietas is shown on coins as a matron throwing incense on an altar, her attribute being a stork.

PIETERMARITZBURG, the capital of Natal province, South Africa, lies on the Umsundusi river in hilly country, 2,218 ft. above sea level and 54 mi. N.W. of Durban by road and 73 mi. by rail. Pop. (1960) 90,077, including 39,472 Europeans. 26,598 Africans, 21.111 Asians and 4,377 coloured.

Founded by the Boers in 1839 after a victory over the Zulus, Pietermaritzburg was named in honour of the dead leaders, Pieter (Piet) Retief and Gert Maritz. It was believed to be free from cattle sickness and lor this reason was chosen as a Trekker capital in preference to Port Natal. The first houses of the European settlement were built in 1839 and Pietermaritzburg was proclaimed a city when the first bishop was appointed to the new see of Natal in 1853, Three years later it became the colonial capital of Natal.

The main town lies between the Umsundusi river and the Dorp spruit, but suburbs have spread to two ridges on the farther side of the river to the southeast, and also to the slopes of an escarpment which rises over *1,500* ft. to the northwest. On the low ground between the ridges across the river are Indian dwellings, public parks and sports grounds and some cultivation. To the west of the town are the botanical gardens. Among many striking buildings in the city are the Anglican and Roman Catholic cathedrals, the Voortrekkers' museum in what was formerly a Dutch church, an art gallery and the Natal museum which houses an excellent collection of South African fauna. The town hall has a fine organ and a good selection of pictures. There are a teachers' training college, a technical institute and a university college affiliated with the University of South Africa, as well as many schools.

The valleys among the hills are cultivated and Pietermaritzburg is an agricultural centre as well as having several industries. Manufactures include building materials, shoes and metal and rubber products. Iron is mined in the region.

There are rail communications with Durban, Johannesburg and other cities in the Union.

PIETERS HILL, 10 mi. S.S.E. of Ladysmith, gave its name to the fourth and finally successful British attempt to relieve Ladysmith at the end of Feb. *1900 (see* LADYSMITH and SOUTH AFRICAN WAR, *1899–1902).* Sir Redvers Buller, having tried a frontal attack and two attacks on the right of the Boer lines, resolved to assail their left and operations opened with the storming of their positions on the south bank of the Tugela east of Colenso, which fell into British hands after six days of methodical fighting.

Thereafter, Buller drew back the bulk of his force to the north bank, its next objective being the group of hills immediately north of Colenso. On Feb. *27,* the British right wing captured Pieters hill, the northern buttress of the ridge, and the next day Buller's cavalry entered Ladysmith, which had stood a four months' siege.

PIETISM, a movement in the Lutheran Church, which arose toward the end of the 17th and continued during the first half of the following century. The name of Pietists was given to the adherents of the movement as a term of ridicule, like that of "Methodists" somewhat later in England. The Lutheran Church had continued Philipp Melanchthon's attempt to construct the evangelical faith as a doctrinal system; and it appeared to many faithful adherents to have become a creed-bound theological and sacramentarian institution, where the dogmatic formularies of the church had usurped the position which Martin Luther himself had assigned to the Bible alone. The influence of the Reformed Church (*q.v.*) on the other hand, in spite of the predestinarianism of John Calvin, made less for doctrine than the practical formation of Christian life. The Presbyterian constitution gave the people a share in church life which the Lutherans lacked. but it involved a dogmatic legalism which imperiled Christian freedom and fostered self-righteousness.

The direct originator of the movement for the revival of a practical and devout Christianity mas Philipp Jakob Spener, who combined the Lutheran emphasis on biblical doctrine nith the Reformed tendency to vigorous Christian life. Born at Rappoltsweiler in Alsace on Jan. *13, 1635,* trained by a devout godmother, who used books of devotion like Johann Arndt's *True Christianity,* accustomed to hear the sermons of a pastor who preached the Bible more than the Lutheran creeds, Spener was early convinced of the necessity of a moral and religious reformation of the German church. He studied theology, with a view to the Christian ministry, at Strasbourg and entered upon his first pastoral charge at Frankfurt am Main. profoundly impressed with a sense of the danger of the Christian life being sacrificed to zeal for rigid orthodoxy. Pietism, as a distinct movement in the German church, was then originated by Spener by religious meetings at his house *(collegia pietatis),* at which he repeated his sermons, expounded passages of the New Testament and induced those present to join in conversation on religious questions that arose. They gave rise to the name "Pietists." In *1675* Spener published his *Pia desideria,* or *Earnest Desires for a Reform of the True Evangelical Church.* In this publication he made six proposals as the best means of restoring the life of the church: *(1)* the earnest and thorough study of the Bible in private meetings, *ecclesiolae in ecclesie;* (2) the Christian priesthood being universal, the laity should share in the spiritual government of the church; *(3)* a knowledge of Christianity must be attended by the practice of it as its indispensable sign and supplement; *(4)* instead of merely didactic, and often bitter, attacks on the heterodox and unbelievers. a sympathetic and kindly treatment of them; (5) a reorganization of the theological training of the universities, giving more prominence to the devotional life, and *(6)* a different style of preaching, namely, in the place of pleasing rhetoric, the implanting of Christianity in the inner or new man, the soul of which is faith, and its effects the fruits of life. This work produced a great impression throughout Germany, and although large numbers of the orthodox Lutheran theologians and pastors were deeply offended by Spener's book, its complaints and its demands were both too well justified to admit of their being point-blank denied. A large number of pastors at once practically adopted Spener's proposals. In Paul Gerhardt the movement found a singer whose hymns are genuine folk poetry. In *1686* Spener accepted an appointment to the court chaplaincy at Dresden, which opened to him a wider though more difficult sphere of labour. One of his most enthusiastic disciples was August Hermann Francke, who had founded the famous orphanage at Halle, and with the aid of Christian Thomasius and Spener founded the new university there. The theological chairs were filled in conformity with Spener's proposals. Spener died in *1705,* but the movement, guided by Francke, spread over middle and north Germany. One of its greatest achievements was the organization of the Moravian Church in *1727* by Count von Zinzendorf, Spener's godson and a pupil in the Halle orphanage.

Pietism, of course, had its weaknesses. Many Pietists maintained that the new birth must always be preceded by agonies of repentance, and that only a regenerated theologian could teach theology, while the whole school shunned all common worldly amusements, such as dancing, the theatre and public games. There thus arose a new form of justification by works. As a distinct movement Pietism had run its course before the middle of the 18th century; by its very individualism it had helped to prepare the way for another great movement, the Enlightenment (*q.v.*).

See also Index references under "Pietism" in vol. *24.*

PIETRO DELLA VIGNA (PIER DELLE VIGNE; PETRUS DE VINEAS or DE VINEIS) (*c.* 1190–1249), chancellor and secretary to the emperor Frederick II, born at Capua in humble circumstances, studied law at Padua. He became secretary to Frederick II. who made him *judex magnae curiae,* councilor, governor of Apulia, prothonotary and chancellor. The emperor, "of whose heart he held the keys." as Dante says, sent him to Rome in *1232* and *1237* to negotiate with the pope, to Padua in *1239* to induce the citizens to accept imperial protection, to England in 1234–35 to arrange a marriage between Frederick and Isabella. sister of King Henry III. He proved a skillful and trustworthy diplomat, and he persistently defended the emperor against his traducers and against the pope's menaces. At the council of Lyons Pietro della Vigna entrusted the defense of his master to the jurist Taddeo of Suessa, who failed to prevent his condemnation. Frederick had his chancellor imprisoned and blinded without giving him a chance to rebut his accusers. He is said to have committed suicide in his prison at Pisa in *1249.* His tragic fate gave rise to many legends.

Pietro della Vigna wrote verse in the vernacular tongue, of which two *canzoni* and a sonnet are extant. His letters (*Epistolarum libri* vi, *2* vol., Basel, *1740)* are of historical value. A collection of the laws of Sicily, a *Tractatus de potestate imperiali* and another treatise, "On Consolation," in the style of Boethius. are also attributed to him.

PIEZOELECTRICITY is the generation of electric charge in a substance by a mechanical stress that changes its shape, and a proportional change in the shape of a substance when voltage is applied. The prefix "piezo" comes from the Greek verb mean-

ing "to press." The phenomenon occurs only in matter of electrically polar nature, especially in single crystals of polar symmetry.

Piezoelectricity is a means of converting mechanical energy into electrical energy and vice versa. The technique is particularly effective at high frequencies. The principal applications are in the field of electroacoustics, including phonograph pickups, underwater sound signaling and ranging (sonar) and in the frequency control of electric circuits by the use of the very stable mechanical resonance frequencies of crystal plates, notably those cut in exactly specified orientations from quartz crystals.

High-precision, quartz-controlled circuits are a key element in Space Age communication systems.

History. — Piezoelectricity, as distinct from contact and frictional electricity, was discovered at the Sorbonne in 1880 by Pierre and Jacques Curie. Pierre, who 18 years later collaborated with his wife in the discovery of radium, was 21 years old, Jacques 24, when the brothers first demonstrated the piezoelectric effect. In her biography of Pierre, Marie Curie pointed out that the youthful discovery was not an accident but the product of extensive theoretical and experimental study of the symmetry of crystalline matter. Crystallographic and mathematical relations governing piezoelectricity were developed in the few years following the discovery. Crystals studied in this early period included quartz, tourmaline and Rochelle salt (sodium potassium tartrate), which were to become technically important 50 years later.

Piezoelectric quartz crystals found some use in electrostatic measurements in connection with studies of radioactivity by Pierre and Marie Curie. The first step toward an engineering application was taken about 1916 in France by Paul Langevin, who constructed an underwater ultrasonic source consisting of a piezoelectric quartz element sandwiched between steel plates; this device was to serve for submarine detection. While piezoelectricity did not become practical for this purpose until many years later. experimentation started during World War I led Walter G. Cady of Wesleyan university (Middletown, Conn.) to recognize the reaction of the mechanical resonance of a vibrating crystal on its electric behaviour, and hence to the invention of frequency control by quartz crystals. Crystal frequency control soon became essential for the growing broadcasting and radio communication industry. During World War II the United States alone used about 50,000,000 quartz crystal elements.

The closely related use of piezoelectric crystals in wave filters for multichannel telephony was largely developed in the Bell Telephone laboratories beginning about 1925.

Yet another result of the search for ultrasonic generators in 1917–18 was the observation of the exceptionally high dielectric constant and dielectric hysteresis in Rochelle salt. This behaviour was soon recognized to be a dielectric analogue to ferromagnetism. Since Rochelle salt is known in Europe as Seignette salt. after its discoverer P. Seignette, the phenomenon was termed Seignette electricity by Russian researchers, who led in its study in the early 1930s. After 1945. however, the term ferroelectricity was generally accepted. The ferroelectricity of Rochelle salt is the cause of its very high piezoelectric effect, which led to a wide use in microphones and phonograph pickups. The growth of these applications came about largely through the efforts of the Brush Development company in Cleveland, O., beginning in 1930.

Extensive studies were undertaken in the early 1940s to find water-soluble crystals which would approach Rochelle salt in piezoelectric effect without its dielectric anomalies and limited operating temperature range. These efforts were partly successful, as indicated by the introduction of ammonium dihydrogen phosphate, primarily for sonar applications. Major progress came, however, from an unexpected direction.

About 1940, a dielectric constant in excess of 1,000 was found in a refractory material, barium titanate ($BaTiO_3$). The ferroelectric nature of this compound was recognized by Arthur von Hippel and co-workers at Massachusetts Institute of Technology. Soon afternard it was discovered that treatment in a strong electric field can permanently reverse the direction of polarity in the crystallites of a ceramic, polycrystalline barium titanate body, and thereby render it strongly piezoelectric. This discovery opened the way for the development of piezoelectric elements comparable with Rochelle salt in sensitivity and with quartz in chemical stability. Ceramic preparation methods made possible shapes and sizes which were unattainable with single crystals.

Barium titanate is ferroelectric and piezoelectric only below 120° C. This limitation was overcome in the 1950s by the discovery of piezoelectric effects in ceramic lead metaniobate, $PbNb_2O_6$, and lead titanate zirconate, $Pb(Ti,Zr)O_3$, which are usable at least to 250° C. By the late 1950s barium titanate and the newer ceramics were dominant in the electroacoustic field in the United States, and novel applications as electric circuit elements were indicated. For frequency control and highly selective electric wave filters, quartz crystals remained unchallenged; dependence on high-quality natural quartz crystals, a near-monopoly of Brazil, however, was alleviated by the development of an industrial process for growing quartz crystals, and crystals of this type became commercially available in 1958.

THEORETICAL CONSIDERATIONS

Crystallographic and Molecular Considerations

Symmetry and Piezoelectric Effect. — Solid matter consists of electrically charged particles disposed in space, the positive and negative charges being in exact balance in an electrically uncharged body. The development of electric surface charges by mechanical deformation is therefore not unexpected. Considerations of symmetry, however, severely limit the conditions under which such charges can appear. The state of mechanical stress or resulting geometric deformation (strain) at any point in a solid is described by a tensor, which does not distinguish between opposite directions, whereas electric polarization and electric field are described by vectors which specify the sense of direction. If a mechanical stress is to produce an electric polarization, a directional quality must therefore be inherent in the body. Conversely, in an isotropic material (*i.e.*, a body without inherent directional quality) mechanical stress or strain caused by an electric field must be equal for opposite directions of the field; this implies a quadratic dependence on the field. This quadratic effect, known as electrostriction, is substantial only in materials of very high dielectric constant, notably ferroelectric materials. A necessary condition for the occurrence of the piezoelectric effect, including the converse linear dependence of stress or strain on electric field, is the absence of a centre of symmetry. Twenty-one of the 32 crystal symmetry classes (see CRYSTALLOGRAPHY) lack this symmetry element, and crystals in all but one of these classes can exhibit piezoelectricity. A qualitative test for presence of piezoelectricity is therefore useful in crystal structure determination.

Piezoelectricity has been observed by qualitative tests in about 1,000 crystal species, while more or less complete quantitative data have been taken on about 100 crystals. Sulfates, phosphates, tartrates and various sugars and their derivatives contribute heavily to the latter number.

The combination of symmetry planes and axes that is characteristic of any crystal class determines which components of stress and of electric polarization may be linked by piezoelectricity. It must be emphasized, however, that crystallographic symmetry merely states what effects are forbidden; the magnitude of the allowed effects is a matter of empirical observation or of calculation from atomic structure and atomic dynamics. While some principles of such calculations were outlined as early as 1920, the quantitative data available by the early 1960s were almost entirely derived from measurements.

A Molecular Model. — Symmetry as well as the molecular approach can be illustrated by the simplest crystal structure capable of piezoelectricity. This is the cubic modification of zinc sulfide, ZnS, knonn as sphalerite or zinc blende. A unit cell of this structure is shown in fig. 1. It contains only two different atoms. each atom of one kind surrounded by four atoms of the other kind placed at the corners of a tetrahedron. The symmetry class is $\bar{4}3m$ in the international designation. Compressional stress (stress = force per unit area) applied parallel to an edge of the unit cell will not produce an electric moment since

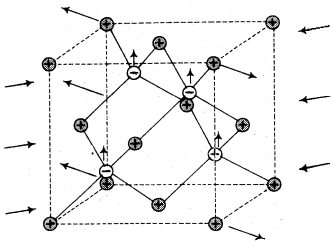


FIG. 1. — UNIT CELL OF CUBIC ZINC SULFIDE CRYSTAL WITH POSITIVE ZINC AND NEGATIVE SULFUR ATOMS

Long horizontal arrows indicate an applied shearing strain, short vertical arrows the internal electric charge displacement linked to this strain

the sulfur atoms (negative) lie in planes halfway between the zinc atoms (positive), and there is nothing in the nature of the applied stress to disturb this symmetry.

If, however. a shearing stress is applied in the horizontal plane. resulting in the shearing strain (displacement per unit length) indicated by long horizontal arrows in fig. 1, then tetrahedral symmetry of the four zinc atoms around each sulfur atom (and vice versa) is disturbed and the sulfur atom is displaced toward the two zinc atoms which have moved apart. The amount of displacement is calculated readily if one postulates that the distance between nearest neighbour atoms remains constant. For a shearing strain of $\frac{1}{1,000}$ (angle of distortion about $\frac{1}{20}°$) the displacement of the sulfur atoms against the zinc atoms in the direction perpendicular to the plane of the shear is $\frac{1}{4,000}$ of the unit cell dimension. The resulting electric polarization is the product of this displacement with the number of sulfur atoms per unit volume and the electric charge per atom. To obtain agreement with the observed piezoelectric effect it is necessary to place a negative charge of one-fourth of an electron on the sulfur and the same positive charge on the zinc. This is in accord with the partially polar character of zinc sulfide. A quantitative theory would have to consider also the distribution of electric charge within each atom.

Piezoelectricity in Various Crystal Classes. — In zinc sulfide and all other piezoelectric crystals of cubic symmetry, the piezoelectric effect of any mechanical stress can be expressed in terms of the single piezoelectric constant relating electric polarization parallel to a cubic axis to strain in the plane perpendicular to this axis. In crystals of lower symmetry, a number of independent piezoelectric constants are needed to describe all possible piezoelectric effects. For the triclinic asymmetric crystal class there are 18 independent coefficients. Fortunately, the most important piezoelectric crystals belong to classes having several symmetry elements, and are characterized by only two or three piezoelectric constants. If, starting from class $\bar{4}3m$, one of the three axes is made different from the other two, the tetragonal crystal class $\bar{4}2m$ results, of ahich ammonium dihydrogen phosphate is an important example. This class has two independent piezoelectric constants.

If all three axes are different, the orthorhombic crystal class 22, which includes Rochelle salt. is obtained.

The trigonal crystal system includes two very important piezoelectric crystals. quartz and tourmaline. The former has three twofold axes of symmetry in addition to the threefold, principal axis; the crystal class is 32, characterized by two piezoelectric constants, one relating compressional stress parallel to a twofold axis with an electric polarization in the same direction, while the second constant relates shearing stress in the plane perpendicular to a twofold axis with polarization parallel to that axis. Tourmaline, crystal class $3m$, has three planes of symmetry intersecting in the threefold axis. Its most important piezoelectric constant relates polarization parallel to this axis to compressional stress in the same direction.

It is in the general nature of stress and strain (see ELASTICITY) that a shearing stress or strain can be resolved into compression or expansion if related to rotated axes. Thus it is possible to obtain piezoelectric response to compressional stresses in the crystals of classes $43m$, $42m$ and 22 if crystal plates are used whose sides are at an angle. The optimum angle is 45°; in this case the effective piezoelectric coefficient for compression is one-half that of the shear coefficient for the original axes. Fig. 2 illustrates this for plates cut from a Rochelle salt crystal. Hydrostatic pressure. however, does not contain an element of shear in any co-ordinate system and cannot cause a piezoelectric effect in crystals of the three classes mentioned. Response to hydrostatic pressure is also absent in quartz due to a compensation of the effects on the three twofold axes. A piezoelectric effect of hydrostatic pressure is found only in crystals having a single polar axis. These are exactly the same crystals which show true pyroelectric effects. Strong electric response to hydrostatic pressure is found in tourmaline and lithium sulfate monohydrate (monoclinic, class 2).

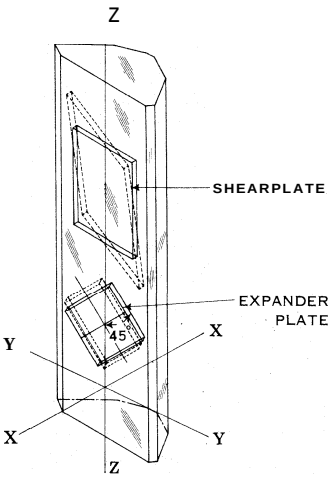


FIG. 2. — ROCHELLE SALT CRYSTAL

Ferroelectric and highest piezoelectric effects are connected with electric field in X direction. Crystal plate cut parallel to Y and Z axes deforms in shear when field is applied in X direction. Plate cut at 450 to Y and Z axes expands along one edge and contracts along the other edge

NUMERICAL EXPRESSION OF PIEZOELECTRIC EFFECTS

Basic Equations. — Piezoelectricity connects an elastic variable. stress or strain. with an electrical variable, electric polarization or electric field. Piezoelectric constants may be defined to connect either of the two elastic variables with either electric variable. The most useful piezoelectric constants (usually designated by the letter "d") relate electric polarization to the stress causing this polarization. It is found from the requirement of conservation of energy that then the same constant also gives the strain caused by an applied electric field. The vector component of electric field or polarization is indicated by subscripts 1, 2 and 3 for the X, Y and Z axes. The tensor components of stress or strain are indicated by 1. 2 and *3* for compressional components along the axes. while 4, 5 and 6 designate shear in the planes perpendicular to the axis. Thus for a crystal of class $\bar{4}3$ m (for example, zinc sulfide) the following relationships are shown:

$$P_1 = d_{14}T_4;\ P_2 = d_{14}T_5;\ P_3 = d_{14}T_6$$
$$S_4 = d_{14}E_1;\ S_5 = d_{14}E_2;\ S_6 = d_{14}E_3,$$

where T and E are components of applied stress or electric field, while P and *S* are components of resulting polarization or strain. For Rochelle salt, class 22, these relationships exist:

$$P_1 = d_{14}T_4;\ P_2 = d_{25}T_5;\ P_3 = d_{36}T_6$$
$$S_4 = d_{14}E_1;\ S_5 = d_{25}E_2;\ S_6 = d_{36}E_3.$$

The threefold symmetry of quartz makes the compressional piezoelectric constant d_{11} also responsible for a shear effect as expressed in the following system of equations:

$$P_1 = d_{11}T_1 - d_{11}T_2 + d_{14}T_4;\ P_2 = -d_{14}T_5 - 2d_{11}T_6$$
$$S_1 = d_{11}E_1;\ S_2 = -d_{11}E_1;\ S_4 = d_{14}E_1;\ S_5 = -d_{14}E_2;$$
$$S_6 = -2d_{11}E_2.$$

The strain component S_6 describes a shear in the horizontal plane of fig. *3*.

The equation indicates that this strain is excited by an electric field in the Y direction. By this relationship, an electric field applied between the surfaces of a quartz plate cut perpendicular to the Y axis will cause a shearing deformation of the side facets of such a plate.

Examples. — The units to be used for expressing piezoelectric constants derive from the units employed for elastic stress and electric polarization. For consistency, the electric and elastic units used must lead to the same unit of energy. Preference is given to the metre-kilogram-second system with rationalized electric units. With this choice, the unit of the piezoelectric d-constant becomes the coulomb/newton or metre/volt. Here 1 coulomb = 1 amp. × second and 1 newton = 1 kg.-mass × metre1 second^2 = 0.225 lb. = 102 gr. force. The two units are equivalent since 1 newton × metre = 1 joule = 1 volt × coulomb.

The values of the piezoelectric coefficients are found to be numerically so extremely small that they are best expressed as multiples of 10^{-12}. In Tables I and II this is expressed by giving the

unit as the micromicrocoulomb ($\mu\mu$C)/newton. The dielectric constants are relative, and are to be multiplied by the dielectric constant of empty space ϵ_0 or 8.85 micromicrofarad ($\mu\mu f$)/metre.

The meaning of the figures in Table I can be explained by a few practical examples:

1. A force of 10 lb. is exerted on the major face of a quartz plate 1 in square and 0.1 in thick cut with its major face perpendicular to an X axis (fig 3,"X-cut"). The generated charge is:

$d_{11} \times$ area $\times$ stress $= d_{11} \times$ force $= 2.3 \times 10/0.225 = 102$ $\mu\mu$C.
Capacitance = dielectric constant $\times$ area/thickness $= 4.5 \times 8.85 \times 0.0254/1 = 101$ $\mu\mu f$
Generated voltage = charge/capacitance $= 102/101 = 10.1$ v.

2. A plate of Rochelle salt 1 cm. long, 2 mm. wide and 0.5 mm. thick, mounted at one end, is subjected to shearing stress by application of 10 grams of force in the width direction at the free end.

The generated charge is:

$d_{14} \times$ area $\times$ stress $= d_{14} \times$ force $\times$ length/thickness $= 350 \times 10/(10^2 \times 0.05) = 700$ $\mu\mu$C.
Capacitance $= 550 \times 8.85 \times 0.01 \times 2/.5 = 200$ $\mu\mu f$.
Voltage $= 700/200 = 3.5$ v.

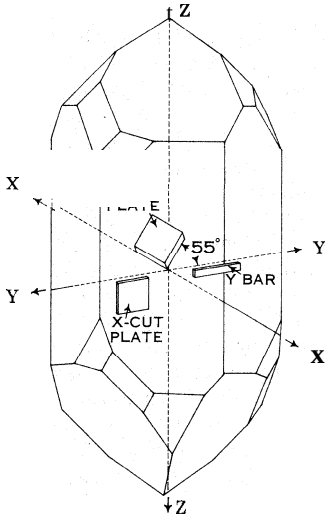


FIG 3.—QUARTZ CRYSTAL WITH THREE MOST IMPORTANT PIEZOELECTRIC ELEMENTS

X-cut plate is used for expansion or contraction in thickness direction on application of electric field in X direction; Y bar expands and contracts in length direction when field is applied in X direction. AT plate shows shear in side faces when field is applied in thickness direction; it exceils in low temperature variation on resonance frequency

TABLE I.—*Piezoelectric Crystals*

Crystal	Piezoelectric constants*	Dielectric constants†
Rochelle salt (30° C.)	d_{14} ± 550 d_{14} ± 330 d_{25} − 54	350 9.4
Quartz	d_{26} + 12 d_{11} + 2.3 d_{14} − .7	9.5 4.5 4.5
Ammonium dihydrogen phosphate (ADP)	d_{14} − 1.5 d_{36} + 48	56 15.5
Potassium dihydrogen phosphate (KDP)	d_{14} + 1.3 d_{36} + 21	42 21
Tourmaline	d_{15} + 3.6 d_{22} − 0.3 d_{31} + 0.3 d_{33} + 1.8	6.3 6.3 7.1 7.1
Zinc blende (ZnS)	d_{14} − 3.2	9
Barium titanate crystal	d_{31} ∓ 34 d_{33} ∓ 86 d_{15} + 392	170 170 2,900
Barium titanate ceramic	d_{31} ∓ 78 d_{33} ∓ 190 d_{15} + 260	1,700 1,700 1,450

*Unit is micromicrocoulomb/newton. †Relative to air.

3. A voltage of 1,000 is applied to an ammonium dihydrogen phosphate plate 1 cm. square and 1 mm. thick, with its major face perpendicular to the Z axis. The resulting shear deformation (change in angle between the X and Y axes) is:

$S_6 = d_{36}$ voltage/thickness = 0.000048 radians = 0.16 minutes.

These typical examples show that the electric charges generated are quite small but the voltages very substantial. Conversely, mechanical displacements caused by piezoelectric effects are minute, but due to the high elastic stiffness of crystals the forces created can be large.

FERROELECTRICITY

Ferroelectric Crystals.— Inspection of Table I shows Rochelle salt to be superior to the other listed crystals in the value of its piezoelectric constant d_{14}. At the same time, the dielectric constant is also in the order of 100 times higher than that of ordinary solids. The high values of these two constants are a result of the ferroelectricity of Rochelle salt. This term designates a dielectric phenomenon analogous to ferromagnetism in magnetic materials (see MAGNETISM). The basic condition for either phenomenon is a co-operative molecular effect. In magnetism it involves the electron spins associated with certain metallic elements, while in the dielectric case it involves electric dipoles which may be permanent or may be induced by local electric fields. Consideration of the value of the electrical charge and typical interatomic distances indicates that ferroelectricity should be a more widespread phenomenon than ferromagnetism. Extensive studies of dielectric properties of solids in the late 1950s indeed produced numerous examples of ferroelectric materials, especially among organic salt type compounds, but none of these latter were found to approach Rochelle salt in piezoelectric effects.

Characteristic of ferroelectrics is the formation of "domains"; *i.e.*, regions within each crystal which have a spontaneous electric polarization. Under the influence of an applied electric field these domains may reverse their orientation; this effect can contribute substantially to the dielectric constant. In most ferroelectrics a characteristic temperature, the Curie point, is observed above which domain structure disappears. The dielectric constant reaches particularly high values near this temperature. In the case of Rochelle salt, the Curie temperature occurs at 24° C., and thus a very high dielectric constant is found in the room-temperature range. This high dielectric constant may be said to enhance the piezoelectric effect, the origin of which, in Rochelle salt, as in other crystals containing asymmetrical organic molecules, is inherent in the molecular structure.

Barium Titanate.— Barium titanate, $BaTiO_3$, and related compounds including lead titanate, $PbTiO_3$, calcium titanate, $CaTiO_3$, and lead zirconate, $PbZrO_3$, belong to a simple crystal structure type, the perovskite type, which is cubic and has a centre of symmetry in the ideal case. This cubic symmetry is actually found for barium titanate above 120° C.; below this temperature barium titanate is tetragonal with a polar symmetry, class 4mm. The transition from cubic to tetragonal near 120° C. is a Curie point with a peak dielectric constant as high as 10,000. Below this temperature a barium titanate crystal is found to consist of domains having electric polarity in different directions but always parallel to a cube axis. Each of these domains is a true tetragonal crystal having definite piezoelectric coefficients. The multidomain

TABLE II.—*Piezoelectric Transducer Materials*

Material	Upper temperature limit* (° C.)	Field direction	Force direction	Effective piezoelectric constant (d) (coulomb/newton)	Young's modulus (Y) (newton/m.²)	Dielectric constant (K)	Electro-mechanical coupling factor (k)	Density (kg./m.³)	Elastic wave velocity (m./sec.)
Quartz	550	X X	X Y	2.3×10^{-12} 2.3×10^{-12}	8.0×10^{10} 8.0×10^{10}	4.5 4.5	.10 .10	2.65×10^3	5,400 5,400
Ammonium dihydrogen phosphate (ADP)	120	Z	45° XY	24×10^{-12}	1.9×10^{10}	15.5	.29	1.80×10^3	3,250
Rochelle salt (30° C.)	45 45	X Y	45° YZ 45° ZX	290×10^{-12} 27×10^{-12}	1.8×10^{10} 1.0×10^{10}	350 9.2	.68 .30	1.77×10^3	3,200 2,400
Barium titanate ceramic	100	Z Z	Z X	190×10^{-12} 78×10^{-12}	10.6×10^{10} 11.0×10^{10}	1,700 1,700	.52 .22	5.7×10^3	4,300 4,400
Lead titanate zirconate (45/55)	300	Z Z	Z X	140×10^{-12} 57×10^{-12}	7.1×10^{10} 8.7×10^{10}	450 450	.60 .26	7.6×10^3	3,100 3,400
Lead strontium titanate zirconate	300	Z Z	Z X	250×10^{-12} 105×10^{-12}	6.7×10^{10} 8.1×10^{10}	1,200 1,200	.64 .30	7.5×10^3	3,000 3,300
Lead metaniobate	500	Z Z	Z X	80×10^{-12} 11×10^{-12}	6.0×10^{10} 6.0×10^{10}	225 225	.42 .04	6.0×10^3	3,200 3,200

*Practical upper limits set either by approach to Curie point or chemical decomposition.

crystal is, in crystallographic terms, a multiple twin. The piezoelectric properties of such a crystal will depend on the domain distribution; reproducible data are found only if uniform domain orientation is induced by a maintained external electric field. Domain reversal may be caused by moderate applied fields such as 100 v./mm. This phenomenon has been applied in electric data storage.

Domain reversal by applied electric fields makes it possible to induce a resultant over-all polarization in polycrystalline ceramic masses of barium titanate crystallites. Due to forces acting between the crystals, the electric polarization of the ceramic is more stable than that of the single crystal. Barium titanate and ceramics of related structure have thus become major practical piezoelectric materials.

Ferroelectric Ceramics.— In barium titanate and other ferroelectric ceramics that have been rendered polar by treatment in a strong electric direct-current field, such as 50,000 v. per inch, is found an over-all symmetry comprising a polar axis and all planes intersecting in this axis. This leads to three independent piezoelectric constants, d_{33}, d_{31} and d_{15}. It is usually found that a compression parallel to the 3-axis causes electric polarization opposite to that originally applied in the poling process, while compression at right angles to this axis causes the polarization to increase. The effect of axial compression is predominant so that a decrease of polarization also results from hydrostatic pressure. The shear piezoelectric constant d_{15} has values even larger than d_{33} but this shear effect does not have such wide applications.

In the ferroelectric oxide ceramics the phenomenon of ferroelectricity does not merely enhance the piezoelectric effect. but is its basis. No piezoelectric effects are present above the Curie point. The asymmetry of the single crystal below the Curie point which permits piezoelectricity is a direct result of ferroelectricity. Further, the possibility of rendering a ceramic polar depends on reversal of ferroelectric domains.

High-Temperature **Ferroelectrics.**—Substantial variations in the properties of barium titanate ceramics have been obtained by modification of their composition. In some cases this has involved solid solution formation, with such elements as calcium and strontium replacing barium, or zirconium replacing titanium. A principal effect of such substitutions is a shift in the Curie point. More subtle changes in electric properties are obtained by additives, such as rare-earth oxides, from other columns of the periodic system. Additions in the range of 1% may destroy the ability of barium titanate ceramics to accept permanent polarization, but advantageous dielectric properties for capacitor applications have resulted. Solid solutions of lead titanate and lead zirconate, also of the perovskite structure type. are found to possess piezoelectric properties generally similar to those of barium titanate.

Lead titanate zirconate compositions, in addition to having high Curie points (300° to 400° C), have a higher electromechanical coupling than barium titanate A wide range of electric properties can be achieved by the controlled variation of composition in the preparation of lead titanate zirconate.

Further perovskite-type ferroelectrics of potential technical interest are obtained by partial substitution of potassium or lead for sodium in sodium niobate (columbate). $NaNbO_3$. Lead metaniobate. $PbNb_2O_6$, is of promise for high-temperature applications in view of its high Curie point (570° C) and is of theoretical interest as a prototype of a new crystal structure.

Preparation and Measurement Methods

Preparation of Crystals.— The manufacture of useful piezoelectric bodies from piezoelectric crystals depends on the services of the geologist and mineralogist in locating suitable high-quality single crystals of the minerals quartz and tourmaline. In the case of quartz the absence of crystallographic twinning is essential. This requirement has limited the supply of commercial piezoelectric quartz to a few locations. notably Brazil and Madagascar. Water-soluble crystals such as Rochelle salt and ammonium dihydrogen phosphate are grown from their solutions, under closely controlled conditions of temperature, with the use of seed crystals of definite shape and orientation. The art of crystal growing has been extended also to quartz. The solvent in this case is water with the addition of an alkali under supercritical conditions such as a temperature of 400° C. and a pressure of 1,000 atmospheres. Fig. 4 shows a large quartz crystal as grown in a seed-holding fixture.

To obtain the desired piezoelectric action. piezoelectric elements have to be cut from the natural or grown crystal to close tolerances of dimensions and orientation in regard to the crystal axes. In case of quartz crystal oscillators for precision frequency control. dimensional stability may have to be more than one billionth of an inch and dimensional accuracy closer than one minute of arc. The methods for cutting and finishing quartz oscillator plates are akin to those used in manufacture of precision optics.

Preparation of Ceramics.— Piezoelectric ceramics are obtained by methods generally applied in preparing electric insulator ceramics, but closer control over impurities usually is required. The addition of fluxes can affect the electric properties undesirably. After a ceramic firing process the ferroelectric bodies are given closely adhering electrodes, usually in the form of a fired-on silver preparation, and subjected to high direct-current voltage for a period of time that may be as long as one hour. Usually this takes place at an elevated temperature, preferably close to the Curie point.

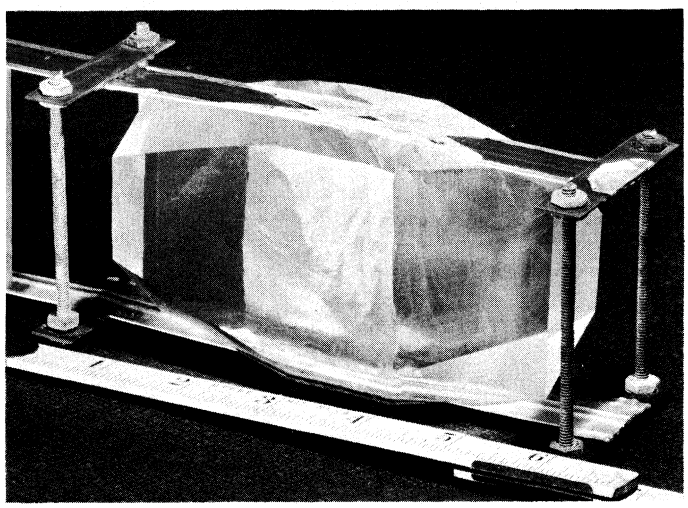


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FIG. 4.— QUARTZ CRYSTAL. WEIGHING 1½ LB., GROWN FROM SODIUM CARBONATE SOLUTION AT PRESSURE OF 6,000 LB. PER SQUARE INCH AND TEMPERATURE OF 360° C.

Direct Measurement Methods.— The most direct method of determining the piezoelectric effect of a crystal body is the measurement of the electric charge generated upon application or removal of a mechanical force. Such measurements are convenient on the piezoelectric ceramics showing high piezoelectric effect and good insulation resistance. The method requires considerable skill when applied to piezoelectric crystals of only moderate piezoelectric effect. In such cases application of an oscillatory force of known magnitude and amplification of the resulting alternating-current piezoelectric signal may be employed.

Other methods depend on the converse piezoelectric effect. A static method uses strain gauges to study the deformation resulting from an applied high direct-current voltage. Small oscillatory displacements resulting from the application of alternating voltage may be detected as frequency modulation if the vibration is applied to the plate of a tuning condenser in a high-frequency circuit.

Resonance Measurement Methods.— The most accurate measurements of piezoelectric constants depend on the electric effects in piezoelectric bodies vibrating near their principal mechanical resonance frequencies. Applied to small crystals or crystal fragments, resonance is employed in the most sensitive test for presence of piezoelectricity. the click test. In this the tester listens to the transients occurring in an oscillator circuit when it is swept over resonances of the crystals.

When the electrical impedance of a crystal is measured as function of frequency, it is found that the apparent capacitance increases to very high values as the resonance is approached. At

this point the impedance is a pure resistance, then becomes inductive. With a further increase of frequency, the impedance becomes once more a pure resistance but at a much higher resistance level, and then it returns to capacitive. This behaviour can be represented by an equivalent electric circuit (fig. 5). In this circuit, C_0 represents the capacitance of the crystal if the piezoelectric effect were suppressed. L_1 and C_1 are related to the mass and elastic compliance of the crystal, multiplied by a factor representing the piezoelectric effect. R_1 represents the mechanical damping of the crystal. The ratio of the inductive impedance to R_1 is given by the mechanical quality factor which is the reciprocal of the mechanical damping factor.

This quality factor may be as high as 1,000,000 in practical quartz crystal oscillators. The ratio of capacitances C_1/C_0 is a direct measure of the strength of the piezoelectric effect involved in the elastic resonance under study. It is found to be related to the piezoelectric d-constants by equations of the type

$$C_1/C_0 = f\mathrm{d}^2\mathrm{Y}/\mathrm{K}\epsilon_0,$$

where Y is Young's elastic modulus, K is the dielectric constant ϵ_0 is the dielectric constant of empty space and f is a numerical factor related to the amplitude distribution of the elastic mode; it is near 0 8 for typical fundamental modes. This capacitance ratio represents the amount of sharing of electric and elastic energy through the piezoelectric effect. The square root of the capacitance ratio is proportional to the electromechanical coupling factor k defined by

$$\mathrm{k} = \mathrm{d}\sqrt{\mathrm{Y}/\mathrm{K}\epsilon_0}.$$

The most convenient way of obtaining the coupling factor and hence the piezoelectric constant is by the measurement of the two frequencies at which the impedance of the crystal is a pure resistance. The frequency of low resistance is the resonance frequency and the frequency of high resistance is the antiresonance. For an elongated bar the product of the fundamental resonance frequency and length is one-half the elastic wave velocity. Extremely accurate values of the elastic modulus, Y, are obtained by the relation

$$\text{wave velocity} = \sqrt{\mathrm{Y}/\text{density}}.$$

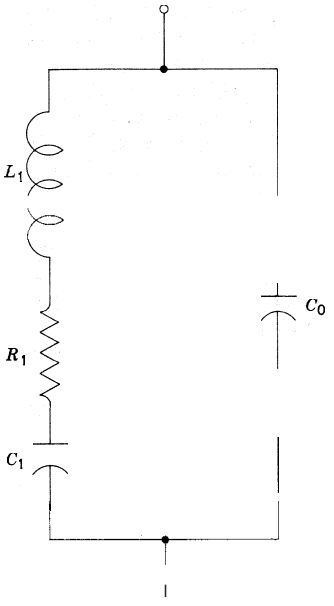

FIG. 5.—EQUIVALENT CIRCUIT OF PIEZOELECTRIC CRYSTAL ELEMENT NEAR ₹ RESONANCE
C_0 is electrical capacitance; L C and R_1 are mechanical mass, compliance and damping load reflected in electrical behaviour through piezoelectric effect.
Resonance frequency is $1/(2\pi\sqrt{LC})$

Table II lists the important piezoelectric operating parameters of some crystals and ceramics. The data for ceramics are only representative, since small variations in composition or processing, either intentional or fortuitous, can cause substantial changes in operating parameters. Only piezoelectric effects of compression or expansion forces, as distinct from shear forces, are considered. The table comprises cases where the electric field and force are parallel as well as those where they are at right angles. For quartz, the same coefficients hold for both cases since $\mathrm{d}_{12} = -\mathrm{d}_{11}$.

Young's modulus is much lower for the water-soluble crystals than for ceramics or quartz, but for calculation of wave velocity this is largely compensated by the lower density of the soluble crystals. The enormous spread in the piezoelectric d-constants is somewhat balanced by the analogous spread of dielectric constants, so that the listed electromechanical coupling coefficients are comprised within one order of magnitude. It is noteworthy that electromechanical coupling coefficients in excess of 0.4 are found only in ferroelectric materials. The ideal piezoelectric would approach the value 1 for this coefficient.

APPLICATIONS

Mechanical Measurements.—The crystals and ceramics listed in Table II are those which have found major application. Minor but continuing use in measurement instruments is made of tourmaline and lithium sulfate. Ethylene diamine tartrate (EDT) and neutral potassium tartrate (DKT) crystals were produced in sizable quantities around 1950 but failed to establish themselves on a competitive basis. Potassium dihydrogen phosphate has found some application for an electro-optic effect closely related to piezoelectricity.

All the methods of observing the piezoelectric effect have become the basis of applications of this effect in the field of electromechanical measurement, electroacoustics, electric voltage sources and frequency controlling devices. The most immediate application is in the measurement of force or pressure. Here, however, a major limitation is encountered as a result of the electric leakage current which gradually neutralizes the voltage generated by application of a force. Piezoelectric effects are therefore not suitable for measurement of constant or slowly changing pressures such as barometric pressure. The compactness and high mechanical resonance frequency of piezoelectrics gives them, however, unique advantages for dynamic pressure studies, as in blast gauges and accelerometers for the analysis of rapidly changing states of motion.

Phonograph Pickups.—Devices translating electric energy into mechanical energy and vice versa are known as electromechanical transducers. Most transducers involve compressional rather than shear piezoelectric effects. The largest use of piezoelectric elements in terms of units manufactured is in phonograph pickups. In these, the piezoelectric element transforms the mechanical energy picked up by the phonograph needle into an electrical signal. In the period from about 1938 to 1958 Rochelle salt phonograph pickup elements supplied approximately nine-tenths of the whole phonograph industry of the United States. Beginning in the early 1950s ceramic piezoelectric elements became increasingly important. They are free of temperature and atmospheric humidity problems and are well adapted to light-weight construction. Major requirements for a phonograph pickup element are high mechanical compliance and high voltage output. In both these respects lead titanate zirconate offers considerable advantage over barium titanate.

In a widely used arrangement, two piezoelectric plates are combined into a sandwich which is subjected to bending forces. The piezoelectric effect used links the field in the thickness direction to elastic stress along the length. The size may be as small as 0.5 X 0.06 X 0.02 in. for the sandwich, and the standard voltage Output is typically one volt for five to ten grams stylus pressure. The two component elements may be connected either in series or in parallel. In either case connections are made so that the outputs of the two elements add when one is compressed and the other is expanded as occurs in bending. An alternative arrangement, in which torque is applied to a combination of two shear-sensitive elements, has been verv successful with Rochelle salt but is not feasible with piezoelectric ceramics. Such a torque-type phonograph pickup cartridge is shown schematically in fig. 6. Torque in the crystal sandwich is caused by the lateral movement of the stylus. A vertical stylus movement in the same arrangement causes bending of the crystal sandwich. This has been used in one type of stereophonic crystal pickup which contains a sandwich of one Rochelle salt "shear" plate and one "expander" plate (see fig. 2). Separate electrical connections from the two plates carry signals proportional, respectively, to the horizontal and vertical excursions of the record groove.

Acoustics and Ultrasonics.—Other applications of piezoelectric transducers are in the fields of sound transmission and reception. They have been especially successful in acoustic undenvater sound devices because piezoelectric solids are much better matched acoustically to water than to air. Thus, comparatively simple matching structures or none at all are required for piezoelectric underwater transducers. While much of the use of piezoelectric crystals has been for military underwater sound purposes, increasing peacetime uses of sound energy in liquids developed after about

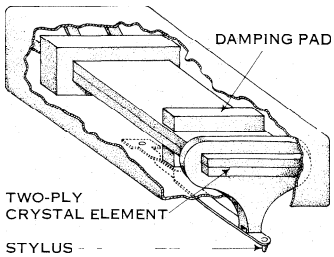

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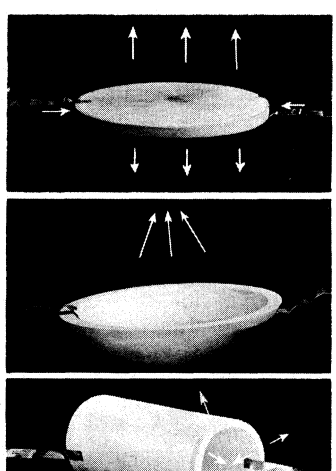
FIG. 6.— SCHEMATIC DRAWING OF ROCHELLE SALT PHONOGRAPH PICKUP

When each half of two-ply crystal element is a "shear plate" (fig. 2), combination is sensitive to torque (lateral stylus movement). Substitution of "expander plate" gives response to bending stress (vertical stylus motion)

1950. Ultrasonic cleaning devices, operating at frequencies from 10 kc. to 100 kc., have been particularly successful. For this frequency range. resonating bars have convenient lengths of 0.5 to 5 in. To obtain reasonably large values of capacitance. bars with the electric field perpendicular to the length direction are usually preferred even when, as in the case of the ceramics, the piezoelectric effect for lengthwise mechanical action is the weaker one. For frequencies above 100 kc. per second, thickness resonance of plates with mechanical and electrical action in the thickness direction is preferred. Fig. 7 shows ceramic thickness vibrators operating about 500 kc. per second. The curved shapes have their electric axes at all points in the radial direction and produce focused compressional waves in the surrounding liquid. This would be very difficult to achieve with piezoelectric single crystal elements which have their axes in parallel directions at every point. The conditions for elastic vibrations of bars and plates are different; the data of Table II refer to bars and are only approximately applicable to plates in thickness vibration.

The principal materials used in underwater sound transducers are ammonium dihydrogen phosphate, barium titanate and lead titanate zirconate. (*See* also ULTRASONICS.)

Frequency Control.— The major application of piezoelectric quartz crystals is for electric frequency control. Quartz combines exceptional chemical and mechanical stability with very unusual elastic properties. While most materials show a steady decrease in the elastic moduli with temperature, some of the elastic moduli of quartz show the opposite trend. By cutting plates from quartz crystals at certain orientations and dimensions, a high degree of compensation for these temperature coefficients can be obtained. The piezoelectric coupling of quartz, while not very large, is entirely adequate to cause a reaction of the quartz crystal on the electric driving circuit. This reaction can force the circuit to oscillate at an exact frequency determined by the quartz crystal. Quartz crystal oscillators have been built to operate at frequencies from 1 kc, per second or less to approximately 100 mc. The largest number are in the communication range from five to ten megacycles. For this range the most important type of quartz crystal oscillator is the AT cut (*see* fig. 3). By applying an electric field in the thickness direction, this plate is excited to transverse vibrations traveling in the thickness direction. To obtain fundamental resonance (one-half standing wave) at eight megacycles, the thickness should be about 0.008 in. The orientation of the AT cut is chosen so as to minimize the temperature dependence of the resonant frequency over a wide operating range, such as −55 to +90° C. Stability within 0.005% may be obtained without temperature control of the crystal.



FROM "INDUSTRIAL AND ENGINEERING CHEMISTRY" (1950); REPRODUCED BY PERMISSION OF AMERICAN CHEMICAL SOCIETY

FIG. 7.—BARIUM TITANATE CERAMIC TRANSDUCERS

Electric drive of transducers at mechanical thickness resonance produces ultrasonic waves in direction of arrows. Bowl concentrates radiation near a point, cylinder along axis

A frequency constant to 1 part per 1,000,000,000 over many months has been obtained through the use of extremely carefully prepared quartz oscillators, maintained at constant temperature. Liquid helium boiling at constant pressure is especially suitable, because at such very low temperatures any gradual changes in elastic properties are suppressed. Such "quartz clocks!! are more constant than the rotation of the earth itself.

Wave Filters.— Closely related to frequency control is the mechanical wave filter application of piezoelectric crystals. In this case the remarkable impedance properties of the crystal near a resonance point are used to provide passage of an electric signal that falls within a prescribed band of frequencies, while other frequencies are rejected. The width of the irequency pass-band is related to the range of frequency at which the crystal impedance is inductive and thus to the capacitance ratio (C_1/C_0) (*see* above, *Resonance Measurement Methods).* In quartz crystals, unless associated with additional inductors, this pass-band is limited to the order of 1% of the centre frequency of the band. Nevertheless: quartz crystal filters are of great importance in separating the voice channels in multichannel telephony, in which carrier frequencies range from 65 to 200 kc. per second. Piezoelectric ceramics are intrinsically less stable than quartz. Nevertheless, modifications of barium titanate and lead titanate zirconate have been found which combine a high piezoelectric coupling coefficient, and hence a high band width, with sufficient stability for intermediate frequency filtering—usually at 455 kc. per second—in radio receivers.

The search for new and improved piezoelectric materials is part of the expanding field of solid state physics. Its practical aim is the development of devices and circuit components of smaller size, greater ruggedness and increased temperature and frequency operating range.

See also ELECTRICITY, CONDUCTION OF.

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PIG, a common name given to the domestic swine of any age. Hog is used collectively with much the same meaning as pig, hog being generally used in the U.S. and pig usually referring to the young animal. Swine is applied to any hoofed animal of the family Suidae, in a broad sense including the peccaries (*see* SWINE).

The origin of the pig is shrouded in mystery. A Chinese scholar estimated his people domesticated swine about 2900 B.C. The pig was used as a scavenger before it was discovered that the flesh was good to eat. Fossil remains of the pig have been found in Europe and India, although not on the American continents. The historic swine that gave rise to the present-day pig may be basically considered as descendants of the European wild boar (*Sus scrofa*), and the Indian wild boar (*Sus cristatus)* probably developed on the Asiatic continent. The Chinese hog was brought to Europe and crossed with European hogs, thereby forming the foundation for present-day breeds. The pig belongs to the class Mammalia. or animals which possess teats for suckling their young.

The pig reproduces by multiple birth, farrowing around 4 to 6 pigs in the wild state. and 8 to 10 pigs in the domesticated state. Pigs are rotund-bodied. short-legged artiodactyl (having an even number of toes) animals of omnivorous habits, having thick skin from which grow short. coarse bristles, a long mobile snout, small tail and feet with two functional and two nonfunctional digits. A mature pig has 44 teeth carries its head low, and eats, drinks and breathes close to the ground.

Swine Population and World Trade.— During the five-year period (1946–50) following World War II. the average annual world swine population nas estimated at 244,900,000. In each of the following years there was a steady increase. until the world swine population reached an all-time high of 373,300,000 head in 1956 (*see* Table I).

TABLE I.—*Estimated* World Hog *Population*

Continent or Country	1946–50 (average)	1956
North America	74,500,000	74,400,000
Europe	59,300,000	95,800,000
U.S.S.R. (Europe and Asia)	13,000,000	?
Asia	58,300,000	102,800,000
South America	33,900,000	43,200,000
Africa	3,900,000	3,900,000
Oceania	2,000,000	2,200,000
Estimated world total	244,900,000	373,300,000

Source: U.S. Department of Agriculture, Foreign Agricultural Service, *Foreign Crops* and *Markets* (April 2, 1956).

Live hogs, except for breeding purposes, are not shipped long distances in world trade because of the excessive shipping space required and the costs involved. Consequently, most hog products entering world trade are shipped either in the dressed carcass, or cured or processed, at much cheaper costs. China normally exports the most live hogs, followed by such countries as Poland, Yugoslavia and Hungary. The greatest total trade in live hogs imported for slaughter is carried on by western Germany, Austria, El Salvador and Italy.

Breeds.—Domestic pigs differ from their wild ancestors and even among themselves with regard to general conformation, colour, size, disposition and other characteristics. Breeds of pigs have been developed to meet certain geographical conditions and to satisfy particular economic wants. A brief description is given of the more prominent breeds of swine throughout the world.

The *Berkshire* is a black pig with white on the face, legs and tip of tail. It originated in England, and is a prominent breed in the United States. The head is short, face dished, ears erect but inclined slightly forward. The body is compact and wide. with well-developed loin and hams. The meat is of excellent quality. The breed is early maturing but not so prolific as most breeds. The boars are used widely in crossing with other breeds for the production of market hogs.

The *Chester White* is white with a pink skin. It originated in the Cnited States, in Chester county, Pennsylvania, hence its name. The Chester White is very prolific, has a quiet disposition, matures early, is a good grazer, a good feeder and possesses good carcass qualities. The breed is found only in the United States.

The *Duroc* breed. formerly known as the Duroc-Jersey, originated in the United States and ranks as one of the leading breeds in numbers. Durocs have good depth of body, good backs, as well as good feet and legs. The breed is red in colour and is noted for prolificacy, hardiness and grazing ability. The mothers produce a good supply of milk. The animals are docile, grow rapidly, and mature boars and sows attain heavy weights.

The *Hampshire* breed originated in England and was later introduced into the United States. The breed is black with a white belt around its body, including the shoulders and front legs. Hampshires possess good growing and fattening qualities. The head is small, with trim jowl, erect ears and smooth, well-set shoulders. They produce a good-quality carcass. The sows are excellent mothers and suckle their pigs well. The breed crosses well with other breeds. The breed is noted for its grazing ability.

The *Hereford* breed originated in the United States. It is red in colour: with white on the head. ears, underline of body and switch of tail. It is sometimes referred to as the "White-Faced" hog, with colour markings resembling those of the Hereford breed of cattle. The Hereford hog is smaller than other common breeds. The body is compact in form, with well-sprung ribs, a medium-arched back and rather short legs. The sows are prolific. The pigs mature at an early age.

The *Landrace* pig. widely distributed in Denmark, Norway, Sweden. Germany and the Netherlands, is white in colour, and so named because the race of pigs was developed on the native land. The Danish Landrace, descriptive of those in the above-mentioned countries, is noted for its length, depth and smoothness of body, with well-developed loins and hams. The head and jowl are trim and refined, the ears large and extending over the eyes. The breed is noted for prolificacy, mothering ability and economy of feed utilization. It produces a carcass of excellent quality with a high percentage of ham, loin and bacon cuts.

The *Large Black* breed is solid black in colour and was developed in England. Large Blacks are exceedingly docile, the ears are large and hang well forward over the eyes. The breed is prolific and the sows are noted for their mothering ability. They produce a rather coarse carcass. Because of their hardiness and early maturity they have proved valuable for crossing with other breeds for market. The carcass qualities of the crossbred pigs are superior to those of pure Large Black breeding.

The *Mangalitza* breed is described because of its prominence in the Balkan states of Hungary, Rumania and Yugoslavia. The breed is either white or has a brownish-black over the body with white on the belly. It differs from other breeds in that it is primarily a fat producer. It is late-maturing, reaching slaughter weight at two years of age or later: The fat forms in lumps and is not distributed through the lean. The lean meat is prepared in sausages or cured. The breed lacks prolificacy, litters of six being average.

The *Poland 'China* pig originated in Butler and Warren counties, Ohio. The breed is popular and rivals the Duroc breed in numbers. The body is black with white feet, face and tip of tail. The ears are drooping. Hogs of this breed are intermediate in type, have good length, are smooth with good width and well-rounded hams. They produce excellent carcasses. The sows are docile, good sucklers and raise pigs that gain rapidly. Mature boars may obtain weights of 1,000 lb. and over.

The *Spotted Poland China,* developed in America, resembles the black Poland China except for numerous white spots over the body. Some Gloucester Old Spots. imported from England into the United States, have influenced the development of the breed. The type of body is similar to that of the Poland China, but the ears are somewhat larger. The sows are prolific and raise good-sized litters.

The *Tamworth* pig originated in England. It is one of the oldest and probably one of the purest of all breeds of hogs. It is strictly a bacon-type breed, producing a maximum of lean meat from its long. fleshy, deep-sided carcass. The breed is red in colour and has a long narrow head, rather long snout and large erect ears often inclined forward. The pigs are good grazers but do not mature so early as some other breeds. This breed is found in small numbers in England, the United States and Canada.

Wessex Saddleback is native to England. The colour is black with a white saddle and white forelegs resembling in type the Hampshire pig found in the United States. The animals are of medium size and are considered to be good grazers and producers of good-quality carcasses.

The *Yorkshire* breed, white in colour, was developed in England and is raised widely over Europe, Canada and the United States. The animals are of the bacon type and are large. long and deep-sided, producing carcasses of excellent quality. The sows produce and raise large litters of pigs. Boars of this breed are widely used in crossing with other breeds for the production of market hogs.

New Breeds in the United States.—During the decade 1946–56, eight breeds of swine were developed at state and federal experiment stations from crossbred foundations of two or more breeds. All were accepted for purebred registration. While dif-

TABLE II.—*New Breeds of Swine Developed in the United States, 1946–56*

Breed name*	Foundation breeds and % blood of breeds	Colour
American Landrace	Danish, Norwegian, Swedish Landrace 100% Landrace	White
Beltsville No. 1	Danish Landrace 75 Poland China 25	Black with white spots
Beltsville No. 2	Danish Yorkshire 58 Duroc 32 Danish Landrace 5 Danish Landrace 5	Red with occasional black spots
Maryland No. 1	Berkshire 38 Danish Landrace 62	Black and white spotted
Minnesota No. 1	Danish Landrace 48 Tamworth 52	Red with occasional black spots
Minnesota No. 2	Canadian Yorkshire 40 Inbred Poland China 60	Black with white spots
Montana No. 1	Danish Landrace 55 Black Hampshire 45	Black
Palouse	Danish Landrace 35 Chester White 65	White

*Breeds have been named from the state or section in which they originated. The Palouse originated in the rich wheat and pea area of Washington.

fering in colour, all but one were derived from crosses with the Danish Landrace as one of the parent breeds. Thus, they have much in common with respect to type, conformation. prolificacy, growth rate, feed efficiency and carcass quality. The breeds are distinguished as being intermediate in type and long bodied, and having moderate depth of body, smooth sides, straight underline, heavily muscled hams and medium length legs. The heads are long and narrow, with light jowls. The ears vary from slightly erect to drooping. Carcass quality is excellent with a high percentage of lean meat and enough fat to produce desirable quality.

BIBLIOGRAPHY.—V. A. Rice, *Breeding and Improvement of Farm Animals*, 3rd ed. (New York, 1942); L. M. Winters, *Animal Breeding*, 4th ed. (New York, 1948); J. A. Greenslade. *Modern Pig Breeding* (London, 1952); G. W. Layley and W. J. Malden, *The Evolution of the British Pig* (London, 1935).

Pedigree Swine Breeding.— A pedigree is a record of an animal's ancestry. similar to that of a family tree. This record may extend back to the beginning of breed history, although for practical purposes it includes only three or four generations back of the individual.

While the pig has been known for centuries. the founding of pure breeds of swine did not take place until the 18th and 19th centuries. Early breeders kept a private record of their breeding operations. As the number of animals increased, types became fixed. well-defined characters established and exchange of animals between breeds increased, it became necessary to protect the purity of breeding stock as well as interests of purchasers of purebred hogs.

Herd books were compiled to record entries for various breeds of purebred swine. The objects were to stimulate the breeding of better pigs; to increase efficiency and economy of production; to maintain uniformity of various characteristics within a breed; and to protect and promote the interest and active co-operation of breeders in the welfare of the swine industry.

The registration of purebred swine varies in different countries. Separate herd books are published by separate breeder associations in some countries, by national pig-breeder associations recording the breeds within a country or under the direction or control of a government agency created for that purpose.

Certain well-defined rules are generally applicable to data for the pedigree. The sire and dam of the animal to be recorded must be purebred and registered. Date of birth, number of pigs farrowed and weaned in the litter, name of the owner of the ancestors at time of mating and identification of pigs are required before a pedigree certificate can be furnished the owner of an animal.

From a breed improvement standpoint, a pedigree is good or bad according to the individual it represents. Regardless of pedigree an animal should not be retained as a breeder unless it meets certain standards, not only of type and conformation as judged by the eye, but also of the individual's inheritance or ability to transmit desirable characters to its offspring. Thus prolific sows that farrow and raise large litters of pigs, that make rapid and economical gains in the feed lot and that produce carcasses of suitable market quality are a credit to any breed, or breeding program.

The swine industry of Denmark has led the world in record-of-performance testing for improvement of swine. Since 1926, when record-of-performance testing of swine was begun in the United States, the value of such a program has been demonstrated. By 1944 the majority of swine associations of the United States were conducting some form of record-of-performance tests for the improvement of their respective breeds. Outstanding animals that meet high standards of production merit are given special notation on the swine pedigree. That the program is a success is attested to by the fact that the demand by breeders for animals of tested strains greatly exceeds the supply.

BIBLIOGRAPHY.—Jay L. Lush, *Animal Breeding Plans*, 3rd ed. (Ames, Ia., 1945); *Pig Breeders' Annual and Year Book of the National Pig Breeders' Association, 1935–36 to 1937–38*, 3 vol. (London, 1935–37); official publications of the United States department of agriculture.

Nutritive Requirements.— The pig is an economical converter of feed into body tissue, the products of which furnish meat and fat for human consumption. Unlike other classes of livestock the pig has a small stomach and requires its food in concentrated form. Pigs grow more rapidly than any other class of farm animals in relation to their weight. Under good feeding and management, an average of 350 to 37 j lb. of feed is required to produce 100 lb. of gain in growing and fattening pigs.

The daily ration of the pig should be properly balanced with respect to proportions of carbohydrates. proteins, minerals and vitamins. Energy which is needed for body maintenance and for gain is furnished primarily by carbohydrates and fat in the ration. Energy is also derived in part from protein metabolism. The excess energy above maintenance requirements is stored as fat in the body. Energy requirements for maintenance vary with atmospheric temperature, increasing as temperature decreases below a critical point. The principal sources of carbohydrates are the grains commonly grown on the farm, namely, corn (maize), wheat. barley, oats, sorghums and rye.

Proteins are essential for growth of muscle. bones and the vital organs, and for body repair. As the pig grows the demand for protein decreases, while relatively larger amounts of carbohydrates are used for fat production. The proportion of protein to carbohydrates may vary from 1 to 4 for 50-lb. pigs to 1 to 7 for pigs weighing 300 lb. Although the grains contain proteins, the latter are not present in sufficient quantity or quality with respect to amino acid make-up. to promote rapid growth. High-protein feeds that possess the essential amino acids necessary to supplement the grain part of the ration are milk, tankage, fish meal, soybean meal, linseed meal. alfalfa meal and similar feeds. Combinations of two or more of the protein-rich feeds improve the quality of the ration.

Mineral and vitamin requirements can be met under ordinary conditions by the proper selection of feeds without recourse to special supplements. Calcium and phosphorus are the two most important mineral elements needed for bone development. Other elements required in small amounts are iodine, zinc. magnesium, cobalt, manganese, potassium: sodium, chlorine. copper and iron. Pasture and hay crops furnish proteins, minerals and vitamins that help correct the deficiencies of these elements in the grain ration. The vitamins known to be needed for the health and growth of the pig are vitamins A, D and the B group: thiamine, riboflavin, niacin, pantothenic, acid and pyridoxine. Research has indicated that supplementing swine diets with vitamin B_{12} and certain antibiotics usually increases growth rate and feed efficiency of pigs.

Water is essential to efficient use of feed. The amount of water consumed at will may increase from about 3.3 lb. daily for a 2j-lb. pig to 12 lb. daily for a 200-lb. pig.

The requirements for the constituents of the ration will vary with the different functions performed, such as growth, fattening. reproduction and lactation. For example. young pigs to 100 lb. weight require a high level of protein in the ration; pigs from 100 to 150 lb. and sows during gestation and lactation require a medium level of protein; whereas pigs weighing from 150 to 225 lb. make efficient gains on a lower level of protein intake.

Care and Management.— Sanitation is essential to good health, rapid growth and development, and profitable pig production. Contrary to general opinion, the pig is a clean animal if given sanitary surroundings. Many pigs are forced to live in an unsanitary environment.

The raising of pigs does not require expensive equipment. The principal needs are (1) good practical houses that provide protection from the elements, freedom from draughts and proper ventilation, (2) dry bedding and (3) prevention of dust to avoid respiratory troubles. Where natural shade is not available, artificial shade is useful to prevent overheating from the sun.

In the selection of purebred animals for the foundation breeding herd, attention needs to be given to strains that are prolific, gain rapidly and utilize feed efficiently. Other considerations are uniformity of type and similarity of colour, markings and conformation. Sows are desired which show quality, length of body, femininity, and a well-developed udder, having two rows of teats with at least six teats in each row, and capable of suckling large litters of pigs. The boar should possess quality, masculinity, good disposition and ability to sire strong, vigorous pigs. A young, well-

developed boar may be bred at eight months of age and mated to 20 to 30 sows during the first breeding season. whereas an aged boar may be mated to 40 to 60 sows during a season.

The period of oestrum (or heat) in the sow is about three days, and mating with the boar should take place the second or third day. If not pregnant, the sow comes in heat every three weeks. The gestation period is 112 days. Much of the success of pig raising depends on the care and management during this period. Suitable feed and ample exercise are important during pregnancy. When practicable, sows and gilts are sorted and fed in separate groups. Gilts may be bred at 8 to 8½ months of age to farrow their first litter when one year old. After that two litters a year may be produced and the sow retained as long as her usefulness continues. The amount of feed is regulated to have the animal in good condition at farrowing time. but not too fat. Accurate breeding dates should be maintained and sows and gilts removed to a cleanly prepared individual farrowing pen three days before they are due to farrow. Providing pens with guard rails helps prevent sows from crushing their young. The use of an electric pig brooder furnishes warmth and prevents chilling of young pigs. The ration of the sow needs to be reduced several days before farrowing. then gradually increased after farrowing so as not to disturb the digestive system of the newborn pigs. Special attention should be given to prevent loss of pigs during the first two weeks of life. when most losses occur.

Newborn pigs depend on the milk of their mothers for the first three weeks. After that they eat supplementary feeds in addition. Pigs are weaned from their mothers at 6 to 10 weeks of age. They should then be well fed and cared for during the growing and fattening period to produce rapid and economical gains. One or a combination of several methods of feeding may be followed, namely, hand feeding, limited feeding, self-feeding or hogging-down crops. Rotation of pastures and placing of pigs on land not occupied by pigs during the previous year will lessen danger of parasite infestation.

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Diseases of Swine.—The most devastating disease of swine, the world over, is hog cholera (swine fever) *(see* SWINE FEVER). This contagious malady affects swine of all ages and breeds and is caused by a virus. Other species are not susceptible.

The virus is present in the blood and excretions even before symptoms appear and may be spread to susceptible swine from these sources either directly or indirectly by man, birds or flies. Feeding uncooked swill, or garbage, that contains infected pork, and purchasing unvaccinated pigs from public markets are especially hazardous.

Methods of prevention are the simultaneous hypodermic injection of graduated quantities of hog cholera virus and anti-hog-cholera serum or the use of live attenuated virus with or without serum. Drugs are ineffective for either prevention or treatment.

Hog cholera should not be confused with African swine fever, another virus disease, although the two appear similar.

Erysipelas is a bacterial disease prevalent in Europe and the United States. The acute form appears much like swine fever; the chronic form is characterized by heart valve lesions, arthritis, unthriftiness, and necrosis of the skin, tail and ears. Some other species, including man, are susceptible, but are less frequently affected. However, in turkeys the disease may cause high mortality. For immunization, live cultures of the causative organism, *Erysipelothrix rhusiopathiae,* are used with specific hyperimmune serum, or killed cultures may be used without serum. The serum has considerable therapeutic value and penicillin is highly effective in treating the acute disease.

Enteritis causes considerable losses in swine. The most widespread and serious form is attributed to *Salmonella choleraesuis,* which commonly occurs with swine fever. Haemorrhagic dysentery, caused by *Vibrio coli,* is another form of infectious enteritis. Transmissible gastroenteritis in baby pigs, caused by a virus, spreads very rapidly and mortality is high. Additional deaths in unweaned pigs may arise from poor sanitation, improper nutrition, chilling, parasitism and genetic weaknesses.

Tuberculosis is contracted by swine from chickens, cattle and man. The chief loss from the disease results from condemnation of heads because of localized lesions in the cervical lymph nodes found during meat inspection. Successful control or eradication depends chiefly upon preventing exposure.

Brucellosis. caused by *Brucella suis,* is characterized by abortions and localized infections, chiefly in the vertebrae, joints and testes. The disease spreads almost exclusively from pig to pig. It may be detected by periodic blood tests. Treatment is ineffective. Man develops a severe form of undulant fever from *Brucella suis.*

Influenza, swine pox. ictero-anaemia and atrophic rhinitis in swine over ten weeks of age, and nutritional anaemia in suckling pigs also cause death losses and impaired health in swine.

Leptospirosis is caused chiefly by *Leptospira pomona,* although other species are incriminated in certain areas of the world. Pregnant sons may abort or farrow small, weak or dead pigs. Swine other than pregnant sows usually have a mild or inapparent infection and mortality is low. The chief source of infection is carrier animals which pass leptospirae in the urine for several months. The disease can be diagnosed by blood tests or finding the organism in the urine. A bacterin made from killed organisms successfully immunizes swine, and antibiotics are effective in treatment. The disease is transmissible to man.

Good swine husbandry emphasizes good breeding, proper nutrition and strict sanitation, all of which help to control diseases.

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Parasites of Swine.—The most serious parasites of swine are roundworms, although protozoa and mites may sometimes be of considerable importance. The U.S. department of agriculture estimated in 1954 that parasites of swine cause an annual loss of $279,826,000 in the United States alone.

Ascaris lumhricoides is the most injurious roundworm of swine. The adult worms are found in the small intestine, where they compete with their host for food. Even more serious are the effects caused by the migration of the larvae. The females lay eggs, which pass out of the body. Infective larvae develop inside the eggs on the ground. These embryonated eggs are very resistant to the effects of heat, cold, sunlight and chemicals, and may remain alive in the soil for more than four years. When they are swallowed by a pig they hatch in the intestine, and the larvae migrate to the liver and lungs, where they undergo some growth. They are then coughed up and swallowed, and finally become adults in the small intestine. The migrations of the larvae damage the liver and lungs, causing pneumonia, difficult breathing, stunting and even death.

Control consists in following a system of sanitation known as the McLean County system, first extensively tested in 1920 in McLean county, Ill. Briefly. the system consists in washing the sows before farrowing and placing them in thoroughly cleaned and disinfected farrowing quarters. After farrowing. the sows and pigs are kept in the houses until the pigs are from two to four weeks old, and are then hauled—not driven—to a clean pasture, where adequate shelter and feed are provided. Even better sanitation can be obtained if the pigs are raised on concrete throughout their lives. With due attention to the details of the system, a high percentage of the pigs which are farrowed can be raised, and the pigs can be marketed four to eight weeks earlier than if kept under average conditions. In addition, the system saves feed and controls many other parasites and infectious diseases.

Piperazine, sodium fluoride or cadmium oxide can be used to remove the adult worms. In treating pigs, these compounds are ordinarily mixed with the feed.

Lungworms are also injurious. They live in the bronchial tubes, where they cause pneumonia and unthriftiness. In addition, they may transmit the virus of swine influenza. Lungworms require earthworms as intermediate hosts before their larvae can develop to the infective stage. Pigs become infected by eating infected

earthworms.

Another roundworm is Trichinella *spiralis*. The tiny adults are found in the intestine, while the larvae occur in the muscles, where they cause the painful and sometimes fatal disease, trichinosis. This disease is serious in man, but swine seldom show symptoms. Swine become infected largely through eating pork trimmings in uncooked garbage or slaughterhouse offal, or by eating dead pigs, rats or other animals which harbour the encysted larvae. Man ordinarily becomes infected by eating uncooked or improperly cooked pork. Human infection can be prevented by cooking pork thoroughly. Infection of swine can be largely prevented by cooking all garbage fed to them.

Other injurious roundworms of swine include whipworms, which attach themselves to the wall of the caecum, and kidney worms, which injure the liver, kidneys and other organs.

The large thorny-headed worm, Macracanthorhynchus *hirudinaceus*, attaches itself to the wall of the small intestine, causing a nodule to form. Its intermediate host is the white grub, which is the larval stage of the May beetle; pigs become infected by eating infected grubs or beetles.

Swine normally are not infected with adult tapeworms. They are, however, intermediate hosts of the pork tapeworm of man, Taenia *solium*. The larva of this parasite occurs in the heart and muscles of swine, and man becomes infected with the adult worm by eating inadequately cooked pork.

Flukes are relatively unimportant, but may be encountered in some parts of the world, especially the Orient. Three of these, the large intestinal fluke, *Fasciolopsis* buski, the lung fluke, Paragonimus *westermani*, and the blood fluke, Schistosoma *japonicum*, also occur in man, and swine may spread them unless proper sanitary precautions are observed.

Lice and mange mites are the principal external parasites of swine. They may cause unthriftiness and low vitality. Lice and mange mites can be eradicated effectively by dipping swine in crude petroleum or in lindane or benzene hexachloride dips. Sprays containing lindane, benzene hexachloride, chlordane or toxaphene can be used. DDT is effective against lice, but not mange mites.

Swine have many intestinal protozoa. Some are harmless, but others cause disease. Coccidiosis is a diarrheal disease caused by Eimeria debliecki and related protozoa. They invade and destroy the epithelial cells of the intestine. The ciliate, *Balantidium* coli, is found in about two-thirds of all swine and also occurs rarely in man. It is usually harmless, but may occasionally invade intestinal lesions started by other micro-organisms. See also Index references under "Pig" in vol. 24. (N. D. L.)

PIGALLE, JEAN BAPTISTE (1714–1785), French sculptor, whose most imposing work is the tomb of the maréchal comte de Saxe in St. Thomas at Strasbourg, was born in Paris on Jan. 26, 1714. He came of a long line of cabinetmakers but he himself turned to sculpture and studied under Jean Lemoyne (1736–39) in Rome where he made copies after the antique. In 1741 he returned to Paris and in 1744 became a member of the Academy, his morceau de *réception* being at the same time perhaps his most famous work, the marble statuette of Mercury tying his sandals (Louvre).

It is possible to maintain that Pigalle, who was of a somewhat serious disposition, was held in check by the tendency in 18th-century France toward femininity and lightness, even frivolity.

Pigalle was an excellent portraitist, at times quite the equal of Houdon. He portrayed, among others, both Voltaire and Diderot and there are by him two busts of Mme. de Pompadour. He died at Paris on Aug. 21, 1785.

See S. Rocheblave, *Jean Baptiste Pigalle* (1919) ; Louis Reau, *Jean Baptiste Pigalle* (1950). (A. K. McC.)

PIGEON is the name applied to birds of the world-wide family Columbidae, found throughout the tropical and temperate zones. There are about 290 species, including the doves which cannot be distinguished from pigeons either by size or by scientific classification. They are gentle, plump, small-billed birds with a skin saddle (cere) between bill and forehead and feathers which are easily pulled out. They strut about with a characteristic bobbing of the head. Because of their long wings and powerful flight muscles, they are strong, swift fliers. Pigeons are monogamous; *i.e.*, they mate for life and the survivor accepts a new mate slowly. The female lays two glossy white eggs in a flimsy nest which barely holds them. The female generally incubates by night, the male by day. The incubation period is 14 to 19 days, but the young are cared for in the nest for another 12 to 18 days. For about a week after hatching the young are fed by pigeon "milk," a secretion rich in protein and fat and proliferated from the glandular walls of the crop in both sexes.

Although the well-known street pigeon (see below) is drab, the majority of pigeon species are tropical and highly colourful. These belong to the fruit pigeon subfamily Treroninae. The green fruit pigeons (Treron) of Africa, Asia and Malaysia are pale green with black flight feathers. The fruit doves (*Ptilinopus*) of the South Pacific islands are more colourful; the superb fruit pigeon (T. superbus) is green with pink and purple on the head and neck. Fruit pigeons and doves are flocking in habit, continually moving about in search of figs and berries. The very large nutmeg pigeons (*Ducula* species) are arboreal and solitary. The green imperial pigeon (D. aenea) is lavender below, metallic coppery-green above, with dark chestnut under the tail and with red feet.

WILLIS PETERSON

DOMESTIC PIGEON OR ROCK DOVE (COLUMBA LIVIA)

The largest pigeons (chicken-sized) are the crowned pigeons (Goura species subfamily Gourinae) of New Guinea's sago swamps; they have maroon body plumage and a large, lacy head crest of blue-gray.

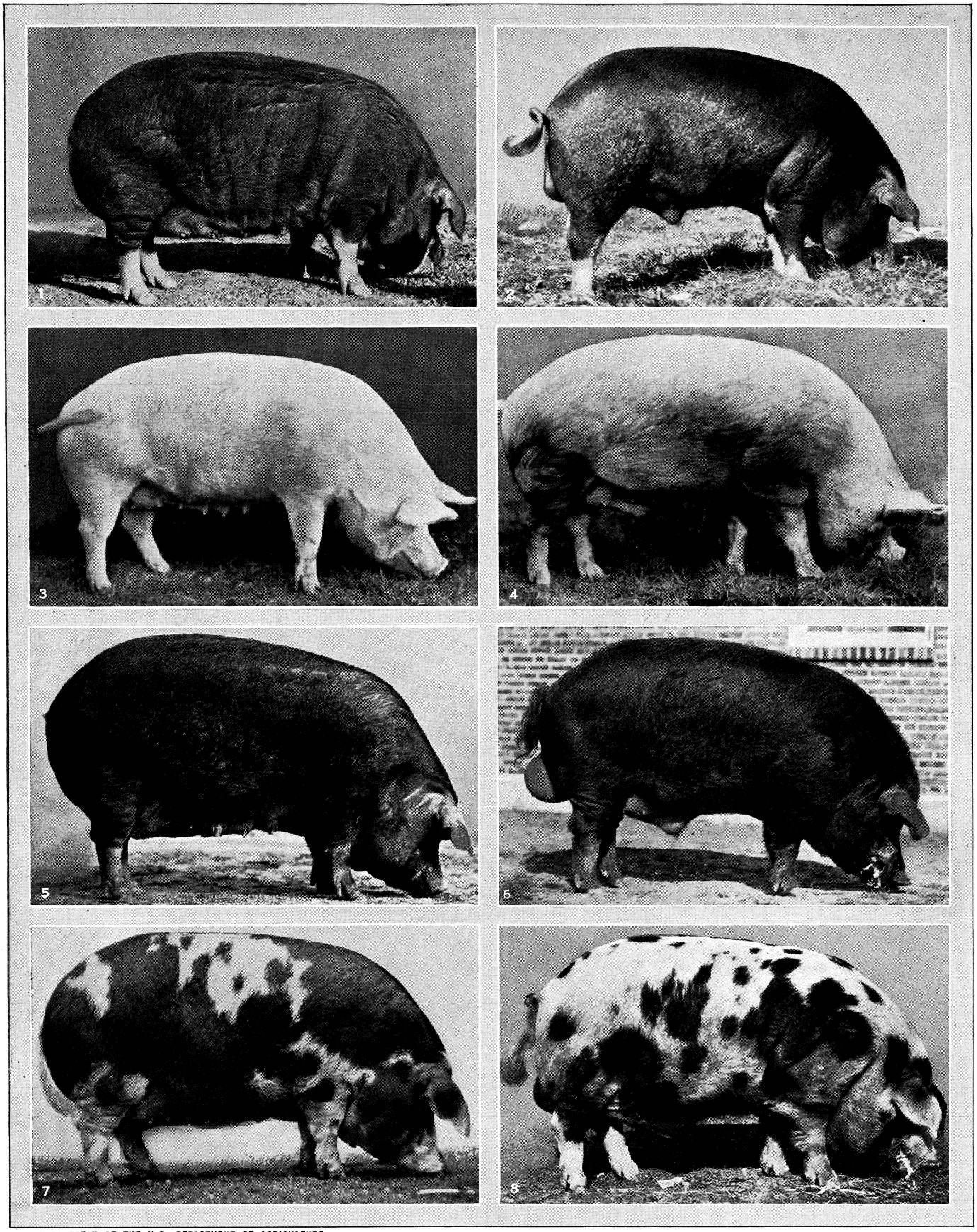
The doves and pigeons of the subfamily Columbinae are seed and fruit eaters. They are found in tropic, temperate and even in boreal regions. The street pigeon or rock dove (Columba livia) is typically dull in colour—gray with white rump and two large black wing bars; this Eurasian species nests above 5,000 ft. in Asia. It has been domesticated since 3000 B.C. with production of numerous colour variants and about 200 named strains—show pigeons, racing pigeons and large food types. Pouters have a large, inflatable gullet; carriers a long bill; runts a massive bill and body; barbs a short bill. Fantails may have 42 tail feathers; owls have diverging throat feathers; frillbacks, the feathers reversed; jacobins, hoodlike neck feathers. Tumblers tumble backward in flight.

The snow pigeon (C. leuconota) breeds at 15,000 ft. in rock crevices on Mt. Everest. Ringdoves or turtledoves (Streptopelia), the size of rock doves or smaller, range throughout the old world to Australia; they are gray and buff with a checkered collar. The name turtledove is also used for the North American mourning dove (*Zenaidura* macroura), with violet and pink on the sides of the neck and a long, pointed tail. The Inca dove (Scardafella inca), gray with a strong scaly pattern, is found in the American tropics with the white-fronted dove (Leptotila verrauxi), which ranges north to Texas. The bleeding-heart pigeon (Gallicolumba *luzonica*) of the Philippines has a splash of red in the middle of the white breast. The European stock dove (Columba oenas) breeds in holes in the trunks (stocks) of trees. The wood pigeon (C. palumbus) is the largest European species.

The passenger pigeon (Ectopistes *migratorius*) of North America, extinct since 1914 with the passing of the last survivor in the Cincinnati (O.) zoo, was colonial and formerly numbered billions. It was destroyed in a few years by market hunters who prevented it from breeding.

See W. M. Levi, *The Pigeon* (1957) ; Charles R. Darwin, *The Variation of Animals and Plants Under Domestication*, 2 vol. (1868). (W. J. BE.)

PIGEON FLYING. Of the many varieties of pigeons man has developed for utility, sport and pleasure, the homing pigeon is

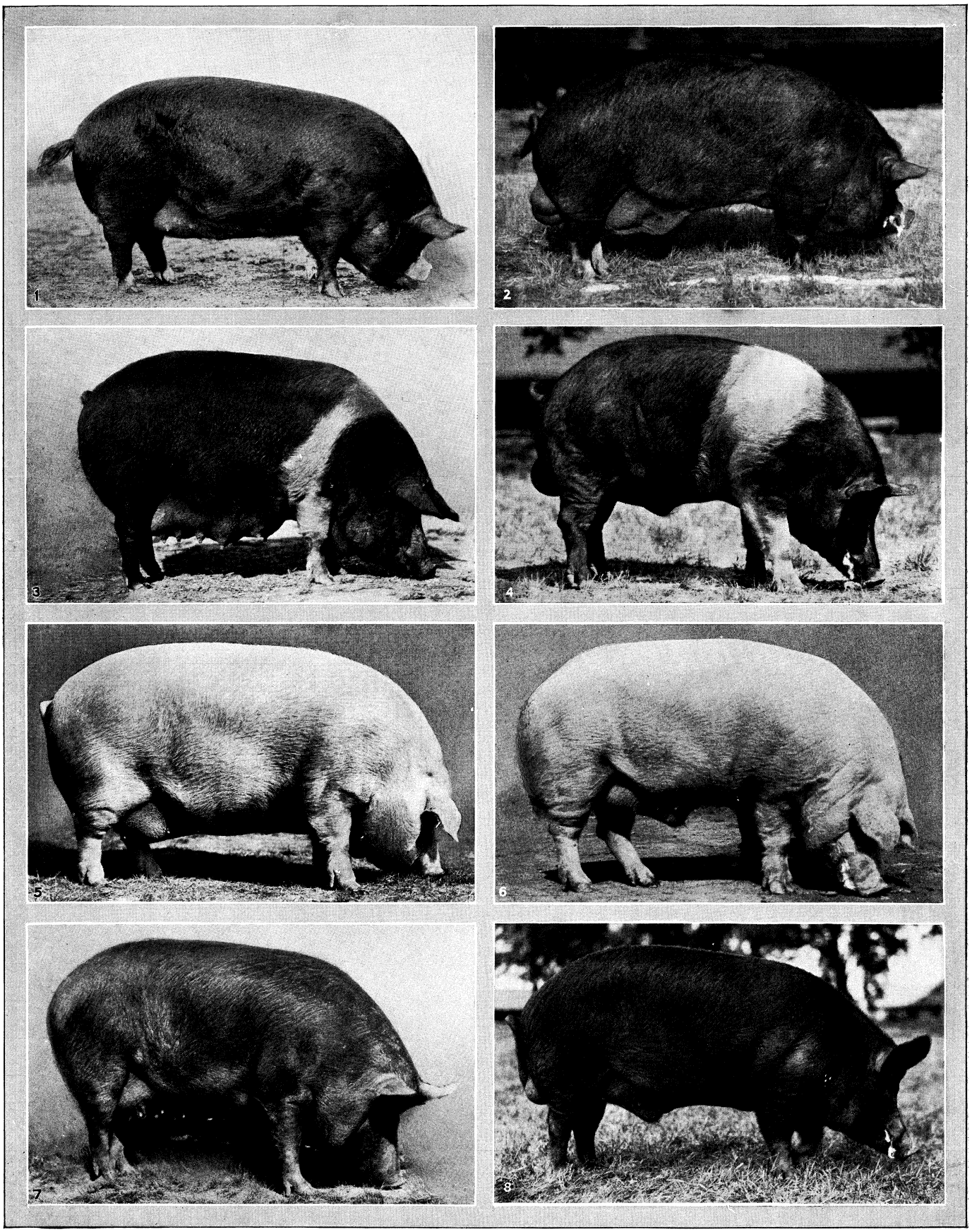


BY COURTESY OF THE U.S. DEPARTMENT OF AGRICULTURE

VARIOUS BREEDS OF PIGS

1. Poland China. Sow
2. Poland China. Boar
3. Yorkshire. Sow
4. Yorkshire. Boar
5. Duroc. Sow
6. Duroc. Boar
7. Spotted Poland China. Sow
8. Spotted Poland China. Boar

PIG



BY COURTESY OF THE U.S. DEPARTMENT OF AGRICULTURE

BREEDS OF PIGS

1. Berkshire sow
2. Berkshire boar
3. Hampshire sow
4. Hampshire boar
5. Chester White sow
6. Chester White boar
7. Tamworth sow
8. Tamworth boar

a specialized variety developed through selective cross-breeding with the objective of developing maximum distance and speed in directed flight. Distinct strains of these pigeons are usually named after fanciers who have devoted generations setting desirable traits of performance and appearance. Pigeon fanciers usually separate their birds into two classes, one for breeding and the other for racing, though the latter are permitted to breed within certain limits.

History. — The earliest record of the domestication of pigeons is from the fifth Egyptian dynasty (about 3000 B.C.). The sultan of Baghdad established a pigeon post system in 1150. Jenghiz Khan used such a system as his conquests spread. Pigeons mere widely used for messenger service during the French Revolution of 1848, and the messages found popular acceptance in both French and Belgian newspapers.

Before 1848 pigeon keepers had been held in disrepute; they became accepted as artisans and the aesthetic worth and usefulness of the pastime became apparent to the populace. In 1819 pigeons were used during interruptions in telegraphic service between Berlin and Brussels.

Pigeons mere used as emergency message carriers in war well into the 20th century. The record flight for a United States army signal corps pigeon was a flight of 2.300 mi.; flights of 1.000 mi. are routine.

Belgium is credited as the home of racing pigeons as a sport. In 1818, the first long-distance race of over 100 mi. was held. while in 1820 a race took place between Paris and Liège, and in 1823 from London to Belgium. The sport gained prominence in Great Britain. the United States and France. Nowhere, however, has it matched the popularity enjoyed in Belgium where most villages have a Societe Columbophile (pigeon club). The annual Belgian Concours National. a race of about 500 mi. from Toulouse to Brussels, was inaugurated in 1881; during the same year the first regular races in Great Britain, from Exeter, Plymouth and Penzance to London. took place.

Loft Construction. — The loft should be on a commanding site, with benefit of the morning sun and located to take advantage of good drainage of wastes. Its location should be accessible to the owner during any type of weather, and afford shelter from wind and rain. An aviary is a part of a loft. usually built of wire netting. open on the sides and roof to afford more sunlight than the loft proper. Perches are arranged on the inner sides of the loft walls and a trap is constructed to permit the pigeons free access into but not out of the loft. A landing board is placed in front of the trap. 4 two-way trap that permits the birds to enter or leave at will is called an open trap. The loft is provided with drinking fountains, bath pans, grit-boxes and sand over wire floors or gravel on concrete floors for sanitation.

Training and Feeding. — All homing pigeons except those reserved for breeding purposes may undergo training continuously from the time they are 28 days of age. This training consists of teaching them to enter the loft through the trap, exercising around the loft and returning to the loft when given liberation at points distant from the loft. The pigeon's desire to return to the loft is a phenomenon not thoroughly understood.

The speed and reliability of the bird's return are reflections of its breeding strain: physical condition. training and treatment. Fog. extremes of heat and cold, rain and adverse winds, or conditions that reduce visibility or oppose the flight of the pigeon. decrease its efficiency. The strength of the bird is improved both by exercise flights within the loft and by training flights that are distant from the loft.

A healthy bird is one that has proper diet, clean drinking water, adequate ventilation and sanitary loft conditions. The diet should include leguminous seeds, cereal grains, green foods and grit. The seeds and grains, fed in a feed mixture, should be clean and of good natural colour and odour.

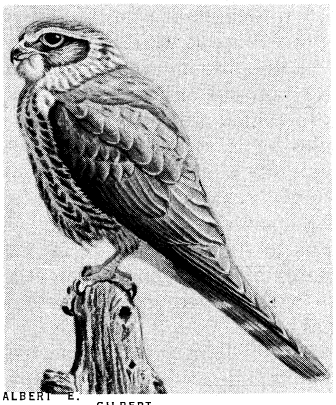
Racing.—At the start of a race the competing birds are banded with a rubber countermark; they are then liberated together by a starter who records the time of release. The birds ascend rapidly, become oriented and head directly toward their loft usually following the line of least resistance.

As the birds enter their home lofts, the rubber countermark is removed from the leg and placed in a pigeon timer that indicates the time of arrival. The distance of the pigeon's flight is divided by the time consumed to determine which pigeon has made the fastest speed. A bird is not considered to have arrived "home" until actually through the trap of its loft.

The training of pigeons for use as a means of communication is similar to training for racing. Messages are attached to the pigeon's leg or back by means of specially designed capsules.

See Carl A. Naether, *Book of the Racing Pigeon (1950)*; A. N. Hutton, *Pigeon Racing* (1958). (H. L. McN.)

PIGEON HAWK, a small falcon (*q.v.*), Falco *columbarius*, which summers from the northern United States north to tree line in North America, and also in Asia and Europe, where it is known as the merlin (*q.v.*). The adult male is about 10 in. long and weighs about 6 oz. In the eastern part of North America it is slaty blue above, heavily streaked below, and with a white-tipped, barred tail. The birds from the arid interior of the country are pale gray above; those from the humid Pacific coast are dark, almost black above. The female, which is about 13 in. long, is brown backed, as are the immature birds.



ALBERT E. GILBERT

PIGEON HAWK (FALCO COLUMBARIUS)

With pointed wings and swift flight, pigeon hawks catch many small birds on the wing, catch dragonflies. which they may eat in the air; they also eat other insects. The species winters as far south as South America.

Some true hawks, such as the sharp-shinned hawk, are sometimes incorrectly identified as pigeon hawks. (A. L. Rd.)

PIGEONITE: see Pyroxene.

PIG IRON. Crude cast iron, run from the blast furnace directly into molds. The molds originally were of sand formed in a way which suggested a nursing litter of pigs. *See* Iron and Steel; Blast Furnace.

PIGMENT, ANIMAL. The vast realm of colour in living forms has, from man's earliest days, incited his wonder and active curiosity. Aside from the universal aesthetic appeal of colour for mankind through the ages, pigmentation holds special attractions for all biologists. Moreover, chromatology (the study of colours) finds applications in medicine, agricultural science, numerous arts and industries and certain military operations.

The physician is often aided in his diagnosis and treatment of diseases by following the visible signs of various metabolic processes as reflected by the colours of tissues and body fluids. The grower has long recognized seasons of ripening or reproductive maturity by viewing the changes in kind or intensity of pigmentation in his products. And the geneticist, pursuing colour expression in successive generations, is in reality studying heritable biochemical operations within the organism. The comparative metabolism of coloured molecules is indeed one of the important realms of investigation in the wide field of biochemistry.

Animal coloration is achieved in two entirely different ways: (1) chemically, by natural pigments (biochromes), coloured molecules which reflect and/or transmit visible light; and (2) physically, by colourless architectural structures (schemochromes), submicroscopic ridges, striations, facets and layers which break up light rays into their component colours. Pigment colours are not substantially changed by physical methods such as grinding or crushing; structural colours, however, are altered and sometimes completely destroyed by such operations. If, for example, a blue feather of a jay is crushed, it appears black: the blue is a structural blue, resulting from the scattering of ordinary light by the delicate organization of a colourless horny subsurface layer; black pigment that lies beneath the scattering layer shows through when this layer is disrupted.

It will be well to consider briefly the schemochromic sources of coloration before discussing the biochromic or molecular origins of true pigmentation. While biochromy, being of molecular foundation, may find conspicuous expression quite independently of the presence of any special minute, optically effective structural units, the reverse is not quite true, for the schemochromic colours are greatly reinforced and intensified by the presence of pigment, whether in underlying or in superimposed strata or occurring within the colour-producing structural layers.

STRUCTURAL COLOURS (SCHEMOCHROMES)

The physical principles of total reflection, interference, scattering and to some extent, diffraction, all familiar in the inanimate world, are encountered also among tissues and tissue products of animals.

Reflection. — Total reflection of light, imparting whiteness to animal structures, often arises from the separation of finely divided structural materials by air spaces just as whiteness is conferred upon snow. Examples of this are seen in white feathers, fur and hair, and in the wings of certain butterflies. Secretions or deposits in animal tissues may also contribute to the whiteness of total scattered reflection, examples being colloidally dispersed fatty or lipoid materials, calcium carbonate in the skeletons of numerous mollusks, crustaceans, corals, echinoderms and protozoans, silica in sponges, proteinaceous materials in various serous membranes, deposits of white pterins in the wings of pierid and other butterflies and silvery aggregates of crystalline guanine or other purine materials (see below) in the covering of numerous invertebrates and in scales of fishes.

Interference. — Disintegration of white light into its spectral components occurs in animal structures chiefly through interference: the incident light penetrates and is reflected back through successive thin-layered films to give striking iridescence, even in diffuse light. Sir Isaac Newton discussed the principle as applying to soap bubbles and other thin films in his book Opticks (1704). The elder and the younger lords Rayleigh between 1919 and 1923, applied Newton's principle to the manifestation of iridescence by various structures of numerous beetles and other animals.

Iridescent interference colours are common in certain animal structures, including: the wing scales of Morpho and other butterflies; the brilliant rainbow hues observed in the feathers of hummingbirds, peacocks, pheasants, etc.; the wing covers of many beetles; the outer skin of reptiles; and nacreous surfaces of pearls and molluscan shells. The lustre of human or other mammalian hair and its iridescent appearance in direct sunlight is due to the same phenomenon, the light being reflected in its disintegrated components by minute transparent scales which surround each individual hair. Pure prismatic refraction of light in animals is probably rare and limited to cases wherein direct beams of light encounter certain microcrystalline deposits. Diffraction by natural gratings or regular fine parallel striations is not uncommon among certain insects, and is conspicuous only when a direct beam of light strikes such structures at an angle. Studies with the electron microscope have confirmed the presence of such natural diffraction gratings in the wing coverings (elytra) of certain iridescent beetles.

Scattering and Diffraction. — Also common in animals is the display of blue colours, arising less frequently from blue pigment than from the scattering of reflected light by finely dispersed colloidal systems above dark layers of melanin deposits. Examples of these structural, so-called Tyndall blues (after John Tyndall, the British physicist who discussed the general phenomenon in 1869) are very numerous. Blue eyes, in which the cloudy tissue of the iris overlies the dark membrane or uvea, may be simulated by placing disks of agar gel or dried collodion film upon a black surface. The blue skin about the head and neck of turkeys, cassowaries and other such birds, or upon the face, buttocks and genital parts of certain primates derives its colour from the scattering of the blue to violet fractions of light by colloidally dispersed materials within the tissue, overlying an absorbing layer of melanin in the dermis. The blues of feathers and of many fishes and reptiles could be added to the many other examples of structural blue.

Two types of structural coloration may act in combination; *e.g.*, diffraction and interference. In other instances, structural and pigmental layers are superimposed. Most of the greens found in the skins of fishes, amphibians and reptiles do not arise from the presence of a green pigment (although there are exceptions to this), but are the result of the emergence of scattered blue light through an overlying layer of yellow pigment. Similarly, the purple hues seen between red and blue areas in the naked skin about the neck and face of cassowaries or turkeys, or in that over the buttocks or genital regions of certain baboons and other primates, are derived from the complementary colour effect of blue-scattering and red hemoglobin.

PIGMENTS (BIOCHROMES)

Chemistry and Physiology. — The visible range of light is selectively affected by reflection from or transmission through particles whose size or whose vibrational frequencies lie between 3,000 and 7,000 Å (angstrom units; 1 Å = 10^{-8} or $\frac{1}{100,000,000}$ cm.). Those physical structures in the biological world which may fractionate white light have already been mentioned: namely, very thin, finely spaced laminations, ridges or striations, all yielding spectral effects; and minute colloidally dispersed particles which scatter incident light, reflecting only the most refrangible rays; that is, blue and violet. The colour of a chemical compound depends upon the selective absorption of light within definite wave lengths, the unabsorbed rays being reflected or transmitted to the eye. This capacity to absorb visible light is due, in turn, to varying kinds and degrees of chemical unsaturation in colour-carrying groups (chromophores) within the molecule. These areas of special molecular activity arise from reduction in the relative speed or frequency of motion of one or more pairs of the compound's many rapidly vibrating electrons. Indeed, sufficient modification in the speed of electronic vibration imparts to the entire molecule a degree of special vibratory motion or chemical resonance. This phenomenon, in the modern view, is the basis of colour manifestation.

If the molecular resonance involves short rapid waves, the shorter visible light waves will be absorbed (*i.e.*, those of the violet and the blue spectral regions) and the compound will therefore appear yellow. Red substances, having slightly longer resonance values, similarly absorb light in the blue and green regions. Blue or green compounds result from cancellation of light in the red or orange realm. Black substances absorb all light equally and completely.

The colours of most chemical compounds are not of spectral purity, but include all of the visible light excepting the absorbed fraction; the commonly observed colour of a substance depends upon the dominant wave length or that of maximum transmission.

There is good ground for the view that colour and chemical reactivity, and hence the potential metabolic value of a pigment to an organism, are parallel expressions of the same underlying molecular property of unsaturation. This is a reason for the careful consideration of the physicochemical attributes of biochromes or pigments and for continued researches regarding their metabolic position in the living organism.

The more important pigments of animals may be arbitrarily grouped into classes whose molecules are without combined nitrogen and others which contain this element.

Of the nonnitrogenous pigments, by far the most important, conspicuous and widely distributed, both in animals and plants, are the carotenoids or polyenes. Chromolipoids, naphthoquinones, anthraquinones and flavones represent other nitrogen-free pigments which occur in animals, but these are limited in distribution, and little is known of their physiological attributes.

In the nitrogenous group are several pigments of most diverse chemical nature and metabolic position. The tetrapyrrolic pigments include both the porphyrin class, present in the blood of many animals, and the bile pigments, occurring in many secretions and excretory products; the dark melanins occur in skin, hair and other parts and represent metabolic end products. Several purines, while usually white or silvery in appearance, are included as pig-

ments because they contribute to the total colour of numerous lower animals; similarly the pterins, which are derivatives of pyrimidine, are frequently white, but may often be yellow or other colours; the lyochromes or flavins, detectable in the tissues of all or nearly all living organisms, are identified with certain important biocatalysts; finally the indigoid derivatives, which are somewhat limited in distribution, are, like the melanins, purines and pterins, end products of metabolism.

In the following treatment are outlined the chemical configuration, colour, source and metabolic features (insofar as the latter are known) of some representative animal pigments.

Carotenoids.—This group of red, orange or yellow pigments, whose number of known compounds is constantly increasing, is of almost universal distribution throughout the living world. Carotenoids are insoluble in water, but may be readily dissolved in alcohol, ether, chloroform and various other organic fat solvents. They are crystalline and in solution exhibit usually two or three absorption bands (but in some cases only one), characteristically in the violet to blue, sometimes extending into the green region of the visible spectrum. They are readily bleached by light and by exposure to atmospheric oxygen, and are unstable also in the presence of mineral acids, their chloroform solutions giving blue coloration upon treatment with concentrated sulfuric acid.

These pigments occur in plant organisms ranging from bacteria, fungi and algae, to the most highly evolved flowering forms. Animals from Protozoa to the highest mammals, including man, contain carotenoids, although the tissues and blood sera of a number of mammals are almost or entirely devoid of these pigments. The livers of some of these species often yield carotenoids, and it is known that the animals depend upon a supply of β-carotene *(see* fig. 1) or its metabolic derivative, vitamin A. Carotenoids are relatively more concentrated in ovaries or eggs, some testes, liver (or liverlike analogue in invertebrates), skin, eyes and milk. Carotenoid pigmentation may be seen in the legs, body fat and eggs of domestic poultry; in similarly coloured wing covers of many insects; and in the milk fat of cattle. In some animals a high degree of specificity exists for the absorption of either the hydrocarbon (carotene) class or the oxygenated (alcoholic or xanthophyllic) type of carotenoid. The horse, for example, absorbs through the intestine only carotenes, from green food containing an ample supply of both kinds of carotenoid. The hen, on the other hand, stores only members of the xanthophyll class; many fishes and marine invertebrates likewise store only xanthophyllic carotenoids, rejecting in the feces or otherwise totally disposing of the carotenes. Other animals, including the frog and man, assimilate and store both classes in depot fat.

Striking displays of carotenoids are found in the skins of many fishes, amphibians and marine invertebrates including sea stars and brittle stars, mollusks, sea squirts, crustaceans, anemones and corals and many marine worms. The blue, green, gray, chocolate, violet and near-black pigments of certain crustaceans, naked mollusks and sea stars are in many instances due to carotenoids in chemical conjugation with protein. Denaturation of the protein by immersion of the specimen in boiling water or in alcohol frees the carotenoid involved and unmasks its colour; hence the familiar red colour of boiled lobsters. Marine animals commonly derive their rich supplies of carotenoids directly or indirectly from the countless microscopic plants or larger seaweeds. Even carnivorous fishes and flesh- or mud-eating invertebrates from the dark depths frequently exhibit rich pigmentation, derived ultimately from supplies of carotenoids long since generated in lighted waters above them.

A yellow condition of the skin known as xanthosis, carotenemia or artificial jaundice, may follow excessive eating of carotenoid-rich foods such as carrots or oranges. The condition, less common in adults than in children, is unaccompanied by pathological symptoms and disappears when excessive carotenoids are withheld from the diet. Hens and female fish mobilize body carotenoids to their eggs during laying (or spawning) season, with an evident loss of the yellow pigment from the skin. Males, however, may continue to exhibit the pigmentation. Derivatives of yellow carotenoids are responsible for the striking red colours observed in the exposed skin covering the legs and toes of the American flamingo (*Phoenicopterus* ruber), the leg joint of the Chilean species (P. *chilensis)* as well as for the pink colours in the plumage of flamingos, roseate spoonbills (*Ajaia ajaja*) and scarlet ibises (Guara rubra). Captive animals of such species gradually lose their pigmentation, both from the skin, which fades, and through the seasonal feather molt, unless a generous supply of carotenoid material is included in the diet.

Naphthoquinones.—These compounds, occurring in many plants, are yellow, orange, red and purple in colour. They are soluble in various organic solvents, and have found considerable use as dyes for fabrics. Their occurrence among animals was long believed to be limited to the sea urchins and sand dollars (echinoids), whose spines, shell and thin skin are often coloured red, purple and, in some instances, green by echinochromes. (See fig. 2.) Some pigments of this class occur also in certain red crinoids or sea lilies. The skull, teeth and other skeletal parts of the sea otter (*Enhydra lutris*) assume a pink to purple coloration as a consequence of the animals' having consumed, over some periods of time, large numbers of sea urchins in their natural habitat. The echinochrome recoverable from the otter's skeleton is chemically similar to the compound obtained from its prey.

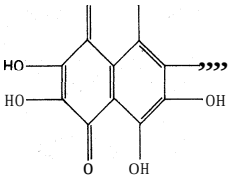


FIG. 2.—ECHINOCHROME

Echinochromes, like quinones generally, are mildly oxidizing and lose their colour when treated with chemical reducing agents. They assume different colours also according to the acidity or alkalinity of their surroundings. The purple colour of sea urchins is consistent with the faintly alkaline condition of the tissues and calcareous shell. The antihemorrhagic factor, vitamin K, is a naphthoquinone of yellow colour. Echinochrome is believed by some investigators to act as a respiratory stimulant for sea urchin eggs, to activate the spermatozoa of certain species of echinoids and to attract the sperm to the eggs. Studies of crystalline melting point, absorption spectra and other properties confirm the existence of a number of chemically different echinochrome compounds. The diverse coloration of various structures of some echinoid species are attributable to the presence of mixtures of several different echinochromes in varying proportions.

Anthraquinones.—A large number of brilliantly coloured compounds which have found wide application as dyes and chemical indicators of acidity or alkalinity are included in this group. Like the naphthoquinones, with which they share a common chromophoric structure, they may be chemically reduced by certain substances.

Cochineal (*q.v.*) is the potassium salt of carminic acid, a red pigment occurring within cells of the fat body of the female cochineal insect, a scale insect that lives upon certain cacti in Mexico and Central and South America. (See fig. 3.) Other species of scale insect store the same or a closely related pigment.

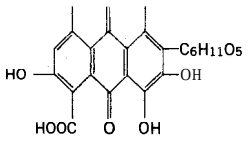


FIG. 3.—CARMINIC ACID

The dye is not confined exclusively to the fat body but is present also in the eggs and in cells of the larvae. It may constitute a considerable proportion of the weight of the adult female insect but is present in lesser amounts in the males.

Carminic acid, chemically extracted from the powdered insect

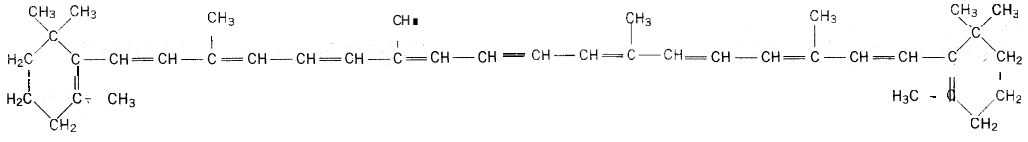


FIG. 1.— 8-CAROTENE

material, imparts a permanent red colour to mordanted wool or silk. Cochineal, largely replaced by aniline dyes, is still applied, however, to the dyeing of certain fabrics, inks and confections.

Kermesic acid, a red dye popular in ancient Greece and Rome, is extracted from the female kermes scale insect *(Lecanium ilicis)*, which thrives upon certain kinds of oak found in Spain. Portugal and Morocco. Yellow-red in water, violet-red in acidic solutions, kermesic acid is employed as a dye, as is carminic acid to which it is chemically allied.

Laccaic acid is isolated from lac dye or lac-lac, the solid exudation or resinous secretion covering the female bodies of certain lac insects living on various plants of southeast Asia *(see* LAC).

While these conspicuous anthraquinones are in all probability derived by the insects from the plants upon which they feed, no information is yet available as to the manner in which the compounds are metabolized, or concerning their possible physiological significance. Anthraquinone pigments have been discovered in red crinoids of the genus *Comatula,* notably *C. pectinate,* thus recalling the assimilation of certain related naphthoquinones by other sea lilies *(see* above).

Flavones.—These compounds occur in a wide variety of plants and in a few insects feeding upon such plants. They impart yellow colours to flowers. The chemical properties of a yellow biochrome isolated from the wings of the butterfly *Melangaria galatea,* correspond closely with those of the plant pigment quercitin. *(See* fig. 4.)

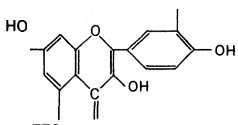


FIG. 4.—QUERCITIN

Flavonelike pigments have been reported in the hypoderm of some strains of the larval silk moth *(Bombyx mori)* and in the cocoons of the Verdi strain. Early studies revealed similar pigments in the hypoderm of a number of true sucking bugs, including not only those parasitizing plants, such as the box elder bug *(Leptocoris trivittatus)* and the small milkweed bug *(Lygaeus kalmii),* but also the Philippine assassin bug *(Eulyes illustris)* which sucks the blood of other insects.

While most of the relatively few animals storing flavones derive the pigment directly from the plant hosts, the carnivorous forms, such as the assassin bug, must obtain their flavones from preying upon herbivorous or perhaps omnivorous species.

The chemically related anthocyanins, the red, violet and blue compounds often seen in blossoms, fruit and leaves of plants, are occasionally encountered in larval and adults of flies and true bugs. None of these classes of pigments has been shown to fulfill a particular physiological function in these animals, though they are believed to be involved in certain biochemical oxidations in the plants which synthesize them.

Tetrapyrroles.—*Porphyrin* Compounds.--Porphin is the parent compound of the class of biologically important nitrogenous, water-soluble pigments called porphyrins. *(See* fig. 5.) They are represented in the green photosynthetic chlorophylls of plants and in animal hemoglobins (*see* BLOOD: *Blood Pigments).*

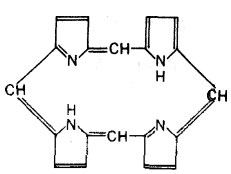


FIG. 5.—PORPHIN

Hemoglobins are present in the red blood cells of mammals, birds, reptiles, amphibians and fishes and in the circulatory fluids of many invertebrates, notably annelid worms and some arthropods, echinoderms and mollusks. These compounds have the unique capacity to combine with atmospheric oxygen in lungs, gills or other respiratory surfaces of the body, and to release it to the tissues. Hemoglobins are responsible for the pink to red colours observed in combs and wattles of birds and in the skin of man and other primates; particularly prominently coloured are portions of the face, buttocks and genital regions of baboons. Hemoglobins are conspicuous also in the blood and muscles of many polychaete worms; they impart red or pink colours to the mouth musculature operating the radula or filelike rasping tongue of many marine snails, also to the mantle, foot, adductor muscle, brain and gills of at least one bivalve—the common edible Pismo clam (*Tivela stultorum*).

The sea cucumbers *Cucumaria miniata* and *Molpadia intermedia* were found by Frederick Crescitelli in 1945 to carry hemoglobin in their red blood cells. H. M. Fox and his associates discussed, in the 1940s and after, the presence of hemoglobins in species of *Daphnia* and other freshwater crustaceans; in certain aquatic insects. notably the midge *Chironomus riparius;* in the pond snail *Planorbis corneus;* and in the echiurid worm *Thalassema neptuni.* Fox emphasized the variability of hemoglobin content in certain *Daphnia* species, depending partly upon the aeration of the habitat, *i.e.,* fading somewhat in aerated waters, but increasing conspicuously in redness in oxygen-poor waters. This ability to elaborate fresh hemoglobin under conditions of unfavourable oxygen supply suggests an important physiological adaptation toward survival. Similar conditions apply to the brine shrimp *(Artemia salina).*

Some parasitic animals seem to derive their supply of the blood pigment from their hosts. This applies to certain copepods that parasitize the gills of fishes and to nematode worms that infest saine and horses. Other examples are the larva of the botfly *Gastrophylus,* parasitic in the stomach of the horse, and the blood-sucking bug *Rhodnius prolixus.*

A singularly interesting discovery in the 1940s was that hemoglobin is present in the bacteria- (*Rhizobium*) harbouring root nodules of peas, beans and other leguminous plants. It is believed that hemoglobin may, in this extraordinary instance, serve as a catalyst for the chemical fixation of atmospheric nitrogen, long known to occur within the root nodules. *(See* also BACTERIOLOGY.)

Other pigments chemically allied to the heme compounds are: cytochrome. the red oxidation enzyme which occurs in minute concentrations in nearly all cells; catalase, an enzyme of similar distribution nhich accelerates the breakdown of hydrogen peroxide; pinnaglobin. a brown compound which serves as a respiratory aid in the mollusk *Pinna squamosa;* chlorocruorin, a green pigment that plays a similar role in the blood of tube-building annelid worms; helicorubin, a red compound encountered in the liver and gut of some snails; and actiniohematin, responsible for some of the beautiful red colours of sea anemones. The physiological functions, if any, of the last two pigments have not been clarified.

Many invertebrates display porphyrin pigments, some showing fluorescence, in their skins or shells. The worm *Thalassema lankesteri,* like its relative *Bonellia,* possesses a bluish-green pigment in its skin and mucus. In acetone solution, the pigment is green and exhibits fluorescence in ultraviolet light; it resembles bonellin in chemical properties and in its absorption spectrum.

Like *Rhodnius,* certain parasitic norms presumably derive their characteristic porphyrin pigments from the heme of their vertebrate hosts. *Tetrathrydium,* a cestode parasite of the hedgehog; *Eustrongylus,* a red nematode in the dog; and *Taenia solium,* infesting the muscles of the pig, are believed to store porphyrin derivatives.

Uroporphyrin and conchoporphyrin have been recovered from the shells of many mollusks, and coloured oyster-pearls yield traces of free and metalloporphyrins. Higher proportions of metalloporphyrins, apparently involving lead or zinc, in ratio to metal-free porphyrins, seem to apply to green pearls, whereas pink pearls have been found to possess both less total porphyrin and lesser proportions combined with metallic elements.

Various porphyrins occur in secretory and excretory products of animals, and some kinds, prominently so-called phorbides derived from plant chlorophylls, have been extracted from ancient natural deposits such as coal, petroleum and muds from long-buried strata of the ocean floor. Ooporphyrin is responsible for the red flecks upon the eggshells of plovers and other birds. The remarkable African touraco (*q.v.*) secretes a copper salt of uroporphyrin III into its quill feathers. This red pigment (turacin) is readily leached from the feathers by water containing even traces of alkali, giving a magenta red solution. Neutralization or mild acidification precipitates the pigment. The green plumes of the same bird owe their colour to. the presence of turacoverdin, an oxidized derivative of turacin. There is some ground for the belief that in various lower animals certain porphyrins may be involved in activating pituitary hormones, including those concerned with the period of sexual heat.

Bilins.—Among the metabolic breakdown products of heme or

allied pigments is a series of yellow, green, red or brown nonmetallic tetrapyrroles typified by the simplest member, a colourless synthetic called bilane (*see* fig. 6).

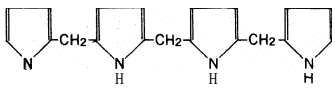


FIG. 6.—BILANE

Small quantities of the red compound bilirubin ($C_{33}H_{36}O_6N_4$), its green oxidation product biliverdin ($C_{33}H_{34}O_6N_4$) and various other chemically homologous compounds occur in normal tissues and may be conspicuous in excretory and secretory materials under some circumstances.

The bile pigments, though first identified in mammals, are by no means confined to them. Various members of the bilichrome series are encountered in invertebrates and among lower vertebrates,

Pterobilin is a blue pigment observed in the wings of many pierid butterflies and other insects, and their larvae exhibit or excrete allied compounds. Certain leeches, nourished by the blood of vertebrates, contain blue-green. red or brown bile pigments in their blood, probably as a result of the breakdown of ingested hemoglobin. A violet bilichrome, haliotiviolin, has been recovered from the shell of the abalone *Haliotis cracherodii.* Two related bilichromes, aplysioviolin and aplysiorhodin, occur in the purple ink of the sea slug *Aplysia punctata.* And the blue coral *Heliopora caerulea* yields a blue pigment, helioporobilin.

Many fishes, notably among the needlefishes and sculpins (Cottidae), bear strikingly blue-green skeletons. The green pigment in the bones and scales of the needlefish *Belone belone* is closely related to or identical with biliverdin. The California needlefish (*Strongylura exilis*) likewise owes the blue-green colour of its skeleton to a very similar bile pigment and, among the mackerels and tunas (Scombridae), commercial catches of the skipjack *Katsuwonus pelamis* yield rare individuals whose endoskeletons. particularly the skull and vertebrae, are green or blue-green, because of the presence of an insoluble salt of a pigment closely resembling biliverdin in its chemical and spectral properties. Thus, contrary to the impressions of some commercial dealers, the green colours persistent in the bones of some species do not reflect the presence of copper or another poisonous substance.

Oocyan. a pigment responsible for the blue or blue-green colours in the eggshells of gulls and various other wild birds, is regarded by R. Lemberg to be biliverdin. The dark green pigment of the emu egg has been proved to involve biliverdin, accompanied by minor amounts of bilirubin.

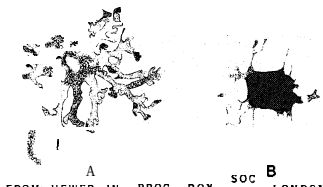
A green bilichrome once called uteroverdin, originating outside of the liver and found in hemorrhagic placental areas in dogs, is also biliverdin. The conspicuous yellow colour of horses' blood plasma arises in part from relatively high concentrations of bilirubin, which pertain after the animal fasts but which return to average values after it feeds.

Although the bilin pigments are in all probability derived largely from the metabolism of heme precursors, there is evidence that bilirubin, accompanied by iron salts, promotes the synthesis of new hemoglobin when injected into humans, dogs or rabbits afflicted with secondary anemia.

Melanins.—Dark colours, indicating the presence of melanin pigment, are observed in feathers; in mammalian hair and eyes; in the skin and scales of numerous fishes! amphibians and reptiles; in the ink of cephalopods; and in various tissues of invertebrates. Melanin is also found in skin moles of man and in black tumorous growths of many vertebrates. It is an end product of metabolism, formed as a result of oxidation and polymerization of tyrosine (*see* fig. 7) or similar phenolic compounds. This oxidation by dissolved atmospheric oxygen is catalyzed by a copper-containing enzyme tyrosinase. Chemically reversible yellow, orange or red stages in the successive oxidation are followed, if uninterrupted, by an intensely black end product.

Some white or albino animals may lack the power to elaborate either the enzyme tyrosinase in its active form or some intermediate compound necessary for pigmentation. Completely white or red variants of the sea anemone *Metridirrm senile,* for example, fail to develop melanin in their tissues as do broun variants of their species. But upon death or upon grinding of the tissues of such an albino animal, the macerated material blackens rapidly with the formation of melanin.

Pale yellow, tawny, buff, ruddy, brown and black colours of hair are due to melanin in various phases of formation or in relatively finely divided condition. That dark,. light-absorbing sublayers of melanin intensify structural blues or iridescent colours has been mentioned



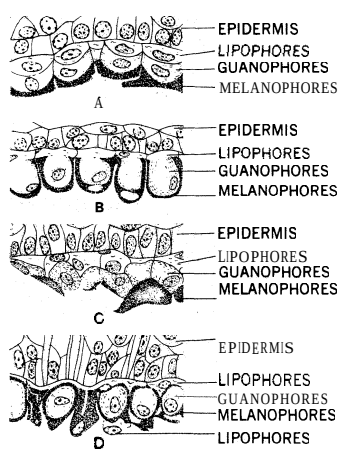
A B

FROM HEWER IN PROC ROY SOC LONDON (1923)

FIG. 8.—FROG MELANOPHORES (A) expanded (skin is darkened green); (B) contracted (skin becomes pale)

Many fishes, lizards, amphibians, cephalopods (octopus, squid) and shrimps possess in their skin dark melanoid pigment in specialized cells called melanophores (fig 8). Within the boundaries of these cells the pigment granules may become dispersed. making the skin dark, or may aggregate into a small mass at the centre, rendering the skin pale. (*See* fig 9) These rapid pigmentary changes may be induced by certain chemicals or by physical stimuli; when alarmed, such animals often display colour changes adapted to concealment.

In at least one of the crestfishes. *Lophotus,* much melanin is stored within a special glandular sac, from where it may be expelled in forcible jets through a post-anal opening by muscular contractions.



FROM W. J. SCHMIDT IN "ARCH. MIKR. ANAT." (1920)

FIG. 9.—DIAGRAM SHOWING SKIN OF TREE FROG DURING COLOUR CHANGE As cells of component layers expand and distribute pigment, skin colour changes from (A) bright green to (B) dark green to (C) lemon yellow to (D) gray

Black or brown melanins or melanoproteins are to be observed in many invertebrate animals. Certain of the worms, many crustaceans and many classes of mollusks exhibit melanism in the skin.

The red intermediate compound, formed during the transformation of tyrosine to melanin (*see* fig. 7) is hallachrome, which is encountered also in the marine worm *Halla parthenopaea.* It is green in alkaline solution. Hallachrome may be reversibly oxidized and reduced. Its original precursor may be either tyrosine or tryptophane.

Red or yellow uranidines. found in sponges, corals, jellyfishes, sea cucumbers, annelid worms and tunicates, are believed to be chemically related to the melanins. Urochrome, the principal yellow pigment of urine, is considered to be a modified melanin. In certain diseases, melanin precursors cause urine to darken as oxidation occurs on standing (melanuria, alkaptonuria).

Black melanin recovered from the wool of hybrid Downs-Dorset

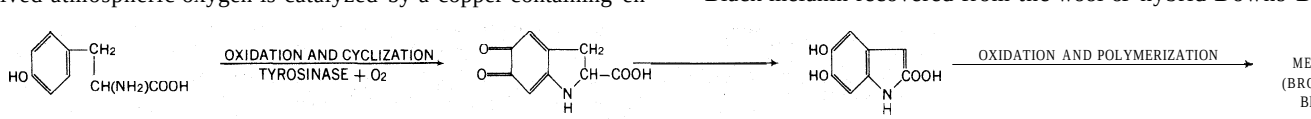


FIG. 7.—TYROSINE (COLOURLESS) CONVERTED TO MELANIN PIGMENT

sheep was originally assigned by R. A. Gortner the empirical formula $C_{105}H_{173}N_{23}SO_{38}$, but there are variations in the elementary composition of melanins from different sources. They are extractable in very dilute alkali, soluble also, when fresh and undried, in very dilute acid solutions. Melanin, soluble in cold ethylene chlorhydrin, is bleached by such oxidants as hydrogen peroxide (which indeed is often applied to growing hair to create a blond effect), chlorine, chromate or permanganate..

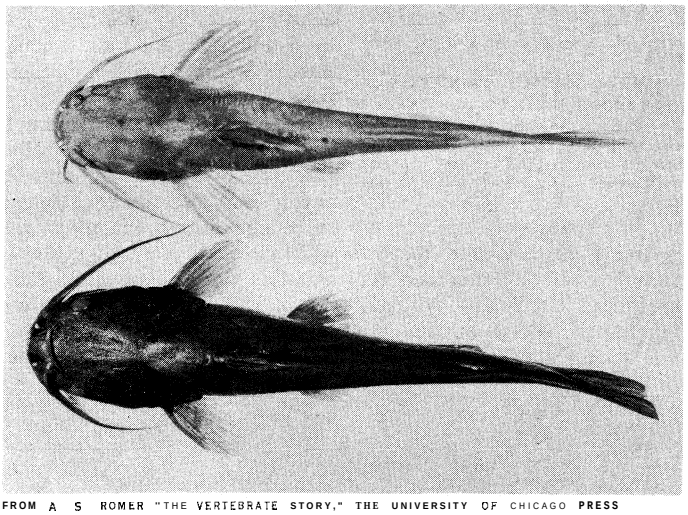
The degree of melanization depends upon relative concentrations of copper and of the copper-containing enzyme tyrosinase. Dark mammalian hairs contain higher traces of combined copper than do pale hairs. Minimal traces of copper are required for melanistic pigmentation of the hair (*e.g.*, of rats); should the daily intake of copper fall substantially below the threshold value of a fraction of a milligram per animal per day, the new pelages emerge successively less dark.

In an individual strand of human hair, the cortex, beneath the outer layer of cuticular cells, surrounds the central medullary column or pith. Ellipsoidal or spherical microgranules of melanin are randomly distributed within the dried cortical cells, imparting pale buff, brown or black colours, depending upon relative numbers, sizes and depth of hue of the individual microgranules. Melanin occurs in the medulla of some mammalian hairs; this medullary melanin may assume the status of a colloidally dispersed stain rather than microscopically identifiable particles. Human red hair. unlike other hair, human or nonhuman, yields a unique, iron-rich pigment. A similar substance has been obtained from red poultry feathers, and is reminiscent of certain reddish melanin derivatives.

All human skin, except in albinos, contains greater or lesser amounts of melanin. In fair-skinned races the corium or deeply lying skin layer contains but little of the pigment, whereas in the darker races, dermal deposits of it are heavy and are fortified by numbers of smaller melanocytes in the upper skin layer or epidermis. Samples of human skin, photographed by electron microscopy have been found to contain minute particles of melanin pigment in the form of microspherules (0.2 to 0.3 μ in diameter) or rodlets (from 0.1×0.4 μ to 0.18×0.6 μ). On exposure to sunlight, man's epidermis undergoes gradual tanning, or increase of melanin pigment, which helps to protect underlying tissues from injurious sunrays. See also SKIN.

Amphibians and fishes, maintained for protracted intervals upon black backgrounds, have been found to augment greatly the numbers of melanophores in the epidermis. Animals thus darkened gradually lose their integumentary melanin after transferral to containers with pale inner surfaces. (See fig. 10.)

There are some remarkable instances of rapid darkening of the skin through melanization. The relatively sudden appearance and rapid enlargement of black skin moles, which are actually malignant, melanotic areolae, is well known. Among the fishes, the Tasmanian whitebait (*Lovettia* sealii) was observed by M. Blackburn in 1950 to exhibit rapid integumentary blackening upon entering the postspawning stage. There is a great increase in numbers of melanophores with successive stages of sexual ripeness, notably in the males; and individuals of both sexes, after spawning, show extensive darkened areas of the skin. In dying individuals the skin may become completely black.



FROM A S ROMER "THE VERTEBRATE STORY," THE UNIVERSITY OF CHICAGO PRESS

FIG. 10.—COLOUR CHANGE IN CATFISH PRODUCED BY DIFFERENT ENVIRONMENTS
(Above) fish taken from light container; (below) fish from dark container

In the very young downy chick of the American flamingo, the pudgy little legs are covered with delicate, naked skin, bright red or pink in colour due to the rich supplies of blood hemoglobin. It has been observed by Étienne Gallet (1950) and by D. L. Fox (1957, 1958) that the colour of the chick's leg skin deepens gradually, becoming black at the end of about the eighth day. when the chick is ready to leave its nest for the first time, hence is no longer to be protected from direct sunlight by the hovering parents.

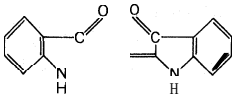


FIG. 11.—INDIGO

Indigoid Derivatives.—Like melanins, the indigo compounds are excretory products of certain animals, but in contrast to melanins, their distribution as pigmentary compounds is relatively limited. Unlike the dark, sombre melanins, many indigoids are red, green, blue or purple.

Indigo.—Also called indigo-blue or indigotin, this occurs as a glucoside in many plants of Asia, the East Indies, Africa and South America. (*See* fig. 11.) It has long been used as a blue dye. While the pigment itself does not occur in the tissues of healthy animals, certain chemical derivatives of it are found in secretory and excretory products.

Hallachrome.—This red pigment in the epidermis of a marine worm has been discussed. The compound, as well as the chromogen of human melanuria, which is probably a derivative of 5, 6-dihydroxy indole, may be generated from the breakdown of either of the common amino acids, tyrosine or tryptophane.

Tyrian *Purple.*—A purple of the ancients, Tyrian is 6,6′-dibromindigo. It is generated in the presence of light, probably through the influence of an enzyme. from a colourless precursor secreted by the so-called adrectal or hypobranchial gland in several species of snails of the genera *Murex* and *Purpura*. This red-violet dye has long been employed commercially in certain countries. Its physiological use to the animals producing it is obscure; in all probability it is an excretory product.

Purines.—The purine compounds are hardly to be classed as true pigments, since they are usually white crystals. They often contribute, however, to the colour scheme of lower vertebrates and invertebrates. The position of purines as excretory products is amply illustrated by the large amounts of solid white uric acid and guanine in the excrement of birds, and of uric acid in that of reptiles. Uric acid has also been found in the yellow sheets of mucus excreted by sea anemones, and urates are present in small amounts in the urine of man and of the higher apes. (Pathological deposition of sodium urate in the joints is a factor responsible for gout [*q.v.*].)

The brilliant whiteness of some anemones, notably the white variant of *Metridium* senile, results partly from microcrystalline deposits of uric acid in the tissues. These crystalline aggregates are especially noticeable in the mesenteries. Other purines, such as xanthine, have been reported as occurring in the wings of pierid butterflies. Mention has already been made of the notable deposition of guanine crystals in the leucophores or iridocytes of fishes, contributing a whiteness or often a brilliant silvery appearance to extensive areas of the skin. Purine compounds constitute part of the complex nucleic acids which abound in the nuclear material of all cells: it is therefore presumed that they play an indispensable part in cell metabolism. The purine compound hypoxanthine exercises a specific stimulating and accelerating effect upon the growth of embryonic tissues of the chick.

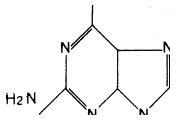


FIG. 12.—GUANINE

Some fishes vary the quantities of deposited guanine (fig. 12) in

proportion to the lightness of the background upon which they are living. Studying the effects of the albedo (ratio of reflected to incident light) upon the black and white pigmentation of fishes' skins, F. B. Sumner in 1944 demonstrated that the greenfish or opaleye *(Girella nigricans)* kept in white-walled containers became very pale during a four-month period. These fishes stored about four-fold the quantity of integumentary guanine as did the skins of fish kept in black-walled aquariums. The skins of the fish in the latter group, intensely black in colour, yielded more than twice the total quantity of melanin. This was a unique demonstration of two alternative, very different biochemical reactions. catalyzed in opposite mays by the total light entering the eyes of the fishes, *i.e.*, high albedo stimulating the deposition of guanine while depressing the formation of the end product melanin; and low albedo exerting the opposite effects. *(See* fig. 10.)

Pterins.—Closely related to the purines, and formerly classed among them, are the so-called pterins, which derive their name from their notable appearance in, and primary chemical isolation from, the wings of certain butterflies. Pterins are encountered as white, yellow, orange or red granules in association with the wing material. They contribute the yellow colour to the body-covering of many wasps.

Pterins are soluble in aqueous solutions, often more so in the presence of ammonia, and insoluble in the usual organic solvents. Leucopterin is a white compound obtained from the white butterflies *Pieris brassicae* and *P. napi,* and has been found accompanied by other pterins in other species. Xanthopterin (fig. 13) is a yellow pigment responsible for the yellow colour in the wings of *Gonepteryx rhamni* and other butterflies, and in the abdominal skin of wasps *(Vespa* species). It occurs also in human urine, and therefore has been called uropterin. This compound has been effective in preventing nutritional anemia in rats and in young salmon.

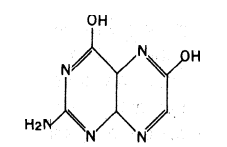


FIG. 13.—XANTHOPTERIN

In butterflies, the colourless compounds guanopterin and mesopterin may be accompanied by chrysopterin, an orange compound, or by a red homologue, erythropterin; the latter imparts conspicuous red colours to the wings of several species. A red pigment in the eyes of the fruit fly *Drosophila melnnogaster,* of great interest and usefulness to geneticists, is believed to be related to the pterin class. Fluorescyanin, a blue-fluorescing pterin in the scales of many fishes. biochemically resembles some of the B vitamins.

Certain pterins and their derivatives are believed to deter the growth of some tumours (in experimental mice), while others have reportedly been effective in reducing pain, whether induced experimentally or incidental to neoplastic diseases.

Lyochromes (Flavins).—This class of yellow, greenly fluorescent, water-soluble pigments is widely distributed in plant and animal tissues, although their presence in but very small amounts usually renders their colour inappreciable in animals. Although synthesized by bacteria, yeasts and green plants, the lyochromes, notably lactoflavin (riboflavin), identical with vitamin B_2, is not manufactured by animals, which thus depend upon plant material for their ultimate supply of this important factor. Lactoflavin (fig. 14) is an enzyme capable of combining with molecular oxygen, whereupon the yellow colour develops. It may then release oxygen for intracellular oxidation processes, with simultaneous loss of colour. The colour is restored by fresh supplies of oxygen.

Blood, milk, eggs, liver, kidney and muscle contain appreciable quantities of lactoflavin. A nutritional lack of this ehzyme leads to impairment of cellular respiration, retardation of growth of young mammals, and cataract development in mice, chickens and monkeys. The compound is not stored in quantity and is a normal excretory product. It has been encountered in somewhat concentrated amounts in the Malpighian tubules of insects, which obtain it from fresh vegetable material. The larvae of mosquitoes responsible for carrying yellow fever fail to develop normally, or to complete their metamorphosis if deprived of flavin and purine.

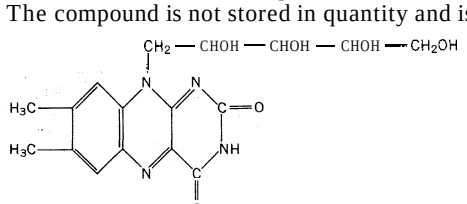


FIG. 14.—LACTOFLAVIN

MISCELLANEOUS PIGMENTS

There are many animal colouring matters whose constitutions remain unknown. Of these, only a few of the more conspicuous examples will be mentioned.

Chromolipoids.—These are yellowish, reddish or brown fat soluble pigments often encountered in the fat droplets of eggs and other cells and in other lipoid-rich tissues. They have often been mistaken for both melanins and carotenoids. Chromolipoids are believed to be derived from partially oxidized fatty acids, phospholipids or other lipoid compounds, perhaps in ways similar to those in which commercial fats may gradually become discoloured on being heated or after long standing in air.

Hernocyanin. — This compound is the respiratory catalyst encountered in the plasma of molluscan and crustacean blood. It is colourless in the reduced condition, but assumes a blue colour upon exposure to oxygen, with which it combines. During the circulation of the blood, the oxygen carried in combination with hemocyanin is released to the tissues requiring it. Chemically, hemocyanin is composed of a large protein compiex bound to copper, whose presence is responsible for the blue colour of the oxidized molecule.

Wide differences in molecular weight have been found in hemocyanins from the blood of various species; in certain crustaceans, the value has been given as 360.000 and represents lower limits. *Limulus,* the horseshoe crab, carries a hemocyanin having a molecular weight of about 1,300,000; *Octopus* 2,000,000; and the land snail *Helix* as high as 5,000,000.

The blue oxyhemocyanins of various mollusks and arthropods commonly exhibit a broad spectroscopic band of light absorption in the yellow to orange region. The fact that hemocyanins possess only about one-fourth the oxygen-combining capacity of the commoner hemoglobins explains in part why species endowed with hemocyanin are subject to relatively depressed metabolic activities, *e.g.,* as in certain bottom-dwelling snails, or are extremely sensitive to asphyxia as are squids.

Hemerythrin.—Hemerythrin is an iron-containing proteinaceous pigment present in the blood of certain bottom-dwelling marine worms and of the brachiopod *Lingula,* serving as *a* reversible oxygen carrier as do hemoglobin, chlorocruorin and hemocyanin. The blood containing hemerythrin is pale in the reduced condition, becoming red or reddish-brown when oxygenated.

Vanadium **Chromogen.**—This compound is the pale-green pigment within the blood cells (so-called vanadoycytes) of sea squirts belonging to the families Ascidiidae and Perophoridae. The vanadocytes are rounded, mulberry-shaped cells, varying but little in shape or size among different species. The diameter is about that of the disc-shaped red blood cells or erythrocytes of mammals, about eight microns. Within each vanadocyte are about eight to ten relatively large, apple-green bodies containing the pigment.

Actiniochrome.—This red or violet pigment in the tentacle tips and mouth opening of various sea anemones is not to be confused with either the carotenoid or the heme classes of pigment. Insoluble in ether, chloroform and in most other common fat solvents (except acetone) it may be extracted from the fresh tissues with glycerol, to which it imparts its red colour with the display of several characteristic absorption bands; one of these has its maximum in the yellow region, another is located in the blue range. The physiological significance of actiniochrome is unknown.

Adenochrome.—This red pigment, occurring in high concentrations in the branchial heart tissues of *Octopus bimaculatus,* is readily soluble in dilute ammonia or other alkalis, conferring thereto a wine-red colour. Even dilute acidification causes complete precipitation of the coloured material as purple flocs. Adenochrome, insoluble in alcohol, ether, chloroform, dioxane and glacial acetic acid, dissolves slightly in trichloroacetic acid or in dilute pyridine. Readily precipitable from aqueous alkaline solutions by the ad-

dition of alcohol and subsequently dried, the resulting mauve or purple powder fails to melt at 300° C., but chars at higher temperatures.

Aphin.—The hemolymph of numerous coloured species of aphids yields a series of yellow, orange and red compounds, referred to by A. R. Todd and his associates as aphins. Fresh insects treated with hot water yield protoaphin, a water-soluble pigment crystallizable as pale-yellow needles. This protoaphin is convertible, through the action of oxidizing enzymes in freshly crushed insects, into a secondary, yellow derivative, xanthoaphin, which, on further oxidative changes is altered to yield chrysoaphin; and this, in turn. is similarly convertible to erythroaphin. Each of these aphins exhibits a characteristic crystalline habit, colour and fluorescence corresponding with successive phases of oxidation.

The aphin molecule is without combined nitrogen, halogens. sulfur or methoxy groups. Erythroaphin seems to possess phenolic hydroxyl groups; its ready chemical reduction and its reoxidation by atmospheric oxygen suggest the likelihood of a quinonoid structure..

Although protoaphin, the primary pale-yellow water-soluble aphin, is easily and extensively oxidizable through an enzyme in the hemolymph, this compound's potential physiological significance in the insect's system remains yet to be clarified.

Other Pigments.— Numerous coelenterates exhibit brilliant pigmentation, the chemical nature of which is as yet imperfectly known. For example, the lasting red pigment in skeletons of red coral (*Corallium rubrum*) and organ-pipe coral (*Tubipora musica*) and the red, orange and yellow colouring matters of many other alcyonarian coral skeletons are chemically obscure.

The large, colourful, poisonous jellyfish *Pelagia noctiluca panopyra* exhibits several pigments. Blue (noncarotenoid) intracellular chromoproteins are present in the heavy, pendulous lips, the exumbrella, gonads and gastric filaments; brown pigments occur in the outer skin of the umbrella and a magenta-coloured chromoprotein is recoverable from the noncellular mesogloeal jelly. Studies on the magenta suggest a melanoid character.

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PIGOT, GEORGE, BARON (1719–1777), English governor of Madras, was born on March 4, 1719, and entered the service of the East India company in 1736. He became governor and commander in chief of Madras in 1755. Having defended this place against the French in 1758–59 and occupied Pondicherry on behalf of the company, he resigned office in Nov. 1163 and returned to England, being made a baronet in 1764. In the following year he obtained a seat in parliament, which he retained until his death; in 1766 he was created an Irish peer as Baron Pigot.

Returning to India in 1775 to occupy his former position at Madras, Pigot was at once involved in a quarrel with the majority of his council, which arose out of the proposed restoration of the raja of Tanjore. The governor was arrested by order of his opponents and was still a prisoner when he died on May 11, 1777. In 1779 the matter was discussed in parliament, and four of those who were responsible for his arrest were tried and fined £1.000 each. Pigot, who left several illegitimate children, was never married, and his barony became extinct.

PIGOU, ARTHUR CECIL (1877–1959), one of the most eminent British economists of the 20th century, was born at Ryde, Isle of Wight, Eng., Nov. 18, 1877, and was educated at King's college, Cambridge! of which he became a fellow in 1902. In 1908 he succeeded Alfred Marshall (*q.v.*) in the chair of political economy at Cambridge, from which he retired in 1943. His most significant and influential work was *The* Economics of Welfare (1920). Based on a carefully guarded set of utilitarian premises, using the techniques of marginal analysis characteristic of neoclassical economics and ordered round the concept of the national income, it inquired into the respects in which the pursuit of individual self-interest may not produce the best results for society as a whole, thus affording scope for various forms of state intervention. In other norks Pigou applied his outstanding powers of analysis and construction to many problems, including those of tariff policy, industrial fluctuation, unemployment and public finance. He served on the Royal Commission on Income Tax (1919–20) and on two committees on the currency (1918–19 and 1924–25). Metaphors in his books bear witness to the important part mountaineering played in his life. He died at Cambridge on March 7, 1959. (D. H. R.)

PIG-STICKING (HOG-HUNTING), the chase and spearing of wild boars from horseback, was an Indian sport adopted enthusiastically by British cavalrymen early in the 19th century. It is believed that the boar was originally merely a substitute target for the bear when that animal became scarce. A further impetus was given pig-sticking in 1816 when England armed the 9th, 12th, 16th and 23rd light dragoons with the lance. Soldiers stationed in India began testing this weapon on wild boars of the kadirs (dry river beds) and rapidly acquired hog-hunting fever. Near Poona, about 1830, a few officers even tried killing pigs with a sabre.

It has been claimed that the jobbing or thrusting spear was also introduced in 1830, yet colour plates in Capt. Thomas Williamson's *Oriental* Field Sports, engraved in 1807, indicate much earlier familiarity nith the jobbing technique. With this type of spear, no longer thrown, many thrills nere had chasing bad-tempered beasts standing 40 in. at the shoulder and weighing up to 358 lb. Equipped nith razor-sharp lower tusks, the Indian boar (*Sus scrofa cristata*) has been knonn to overturn mounted men to attack them. Reaching his prime at 8 years, a boar may live to be 20. Pigs of the jungle average larger than those of the grassy plains and any under 28 in in height are not considered fair game.

Because of the pig's trick of "jinking" (zigzagging) a good hog-horse has to be agile as a polo pony. Arabs, Australian Walers and native Indian ponies proved the best mounts for the sport. A speedy horse might overtake a boar within less than 1 mi. provided the horse had not broken a leg in a porcupine hole, impaled itself on the concealed stake of a cut-down *jhow* (tamarisk), or cut its throat on the cactus fences of Guzerat.

Most hog spears have a shaft of male bamboo and a Bodraj head with oval blade tapering to a point, The Bengal spear, under 6 ft. in length. is weighted with lead at one end and is used overhand for jobbing. The longer Bombay spear is wielded like a lance, an attacking pig being encouraged to spit itself on the point. The Calcutta Tent club fined any member a case of champagne for spearing a boar on his near side or killing a sow. By tradition the head and tusks go to the rider claiming "first spear."

Expert pig-sticking requires strong nerves, keen sight, a firm seat, light hands, a cool head and a lot of luck. The four major methods of hunting include beating a cover, beating on a line ("spears" riding with the line). "ghooming" (riding quietly alone looking for game) and "pugging" (tracking the animal from its feeding grounds). Wuh jata ("There he goes!") is the cry when a boar is sighted.

The Kadir cup competition, established in 1869, was long considered the highest achievement for a hog-hunter.

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PIGWEED, a name applied to various plants, especially lamb's-quarters (*q.v.*) and various species of amaranth (*q.v.*). Winged pigweed (Cycloloma *atriplicifolium*), of the Great Plains region of North America, is closely allied to lamb's-quarters.

PIKA, a small, tailless, rabbitlike mammal (Ochotona), found in northern Asia and the mountains of North America, one species ranging into eastern Europe. The ears are smaller than those of rabbits, and rounded; the hind feet are hardly longer than those of a squirrel and the collarbone is complete. The soles of the feet are hairy and the fur is soft and thick. Pikas inhabit cold and dry regions, usually dwelling in chinks between the rocks or in burrows.

One Himalayan species is found in pine forests and other Asiatic pikas inhabit steppe country. They are very active, often busily gathering food in the daytime. Large piles of vegetation are collected and dried in the sun to make "hay," then stored under rocks for the winter. Their voice is a whistling "bleat." penetrating and ventriloquistic. Pikas are usually coloured much like the rocks among which they dwell, dark gray with a mixture of ochraceous. They are about th size of n guinea g, reaching a length oi about eight inches.

See also RODENTIA.

See J. L. Bouhote, "The Mouse-Hares of the Genus *Ochotona*," *Proc. Zool. Soc.* (1905); A. H. Howell, *North American Fauna*, no. 47 (1924). (J. P. HL.)

I ZEBUI)] ON E Y (1779–1813), U.S. army officer and explorer, was born at Lamberton, N.J., Jan. 5, 1779. His father was nn army officer and young Pike volunteered as n let when only 15 years of age.

In the summer of 1805 Pike, tl a lieutenant, received instructions from Gen. James Wilkinson to lead a exploring party to the headwaters of the Mississippi. He was directed to discover the source of that stream, negotiate peace treaties with the Indian tribes and emphatically assert the legal claim of the United States to the area. With a company of 20 men, Pike started up the Mississippi river from St. Louis in Aug. 1805. Six months later, after traveling more than 2,000 mi. by boat and on foot through wooded marsh lands, the party reached Cass, Leech and Sandy lakes in northern Minnesota. Here they found British traders in undisputed possession of the region and British flags flying over Indian villages. Pike at once explained the American position to the Indians, stating firmly that they now owed allegiance to the United States. He also warned the British traders to respect the laws of the American nation, upon whose soil they were illegally operating. He recommended to the administration at Washington that government agents be appointed to regulate the fur trade and that military posts be erected at strategic sites. Pike erroneously identified Leech lake as the source of the Mississippi.

In July 1806 Pike was dispatched to the southwest with 23 men to explore the Arkansas and Red rivers and, if possible, to obtain information about the adjacent Spanish territory. The alarmed Spaniards attempted to intercept Pike's party but were unsuccessful and Pike pushed rapidly southward. Near the site of Pueblo, Colo., he erected a post and then proceeded to reconnoitre the Arkansas river, ascending that stream as far as Canon City and Leadville, Colo. After building a blockhouse at the eastern entrance of the Royal gorge and leaving two men to guard the horses, baggage and supplies left there, Pike and his men traveled southward until they reached the Sangre de Cristo mountains. After crossing this range. the party emerged upon the vast tableland of northern New Mexico. Here the explorers were apprehended by Spanish officials on the charge of illegal entry into New Mexico. They were forthwith transferred to Santa Fe. N.M., and then to Chihuahua, Mex., for trial. The authorities confiscated Pike's maps, notes and papers, some of which were recovered a century later by the historian Herbert E. Bolton. After considerable delay the Americans were escorted across Texas to the Spanish-American border at Natchitoches, La.. where on July 1, 1807, they were released. The Pike explorations were important because a mass of information about Santa Fe. noting particularly the military weakness of the capital and the lucrativeness of the overland trade with Mexico, was included in Pike's report published in 1810. This report created American interest in the southwest and undoubtedly stimulated the expansionist movement into Texas and the projection of the colourful Spanish-American trade over the Santa Fe trail. Pike saw active service in the War of 1812. attained the rank of brigadier general and was killed in action during the attack on York (now Toronto). Can., on April 27, 1813. A mountain that he discovered in what is now the state of Colorado was later named Pikes peak in his honour. See also references under "Pike, Zebulon Montgomery" in the Index volume.

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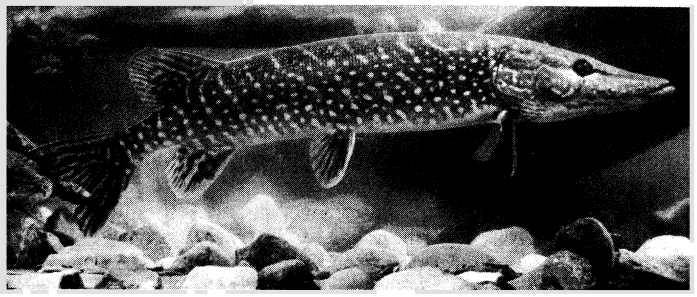
PIKE, fresh-water fishes generally distributed over the rivers and lakes of Europe, northern Asia and North America. They form a small family (Esocidae) of soft-rayed fishes. Pikes, typified by the common or northern pike (Esox *lucius*), are recognized by their elongate, compressed body, which is olive or greenish-gray with lighter spots, and covered with small scales: a long



GENE HORNBECK PROM NATIONAL AUDUBON SOCIETY

NORTHERN PIKE (ESOX LUCIUS), COMMON TO TEMPERATE FRESH WATERS

head; long spatulate snout; and large mouth armed with strong and long teeth in the jaws and broad bands of smaller teeth on the palate and tongue.

The teeth, which point backward or can be depressed, offer no obstruction to any object entering the mouth, but prevent withdrawal. The dorsal and anal fins are placed far back on the tail, thus greatly increasing the propelling po er of the fish. Although pikes lead rather a sedentary life, they are excelled by no other fresh-water fish in rapidity of motion when they dash upon their prey or dart out of reach of danger.

Pikes are the most voracious of fresh-water fishes. Although large specimens will seize muskrats or waterfowl and are said to attack even foxes and small dogs. most of them subsist on small fish, insects and aquatic invertebrates. They are solitary hunters, finding their prey by lying motionless in the water or lurking in a clump of vegetation and. as soon as a victim comes within reach, making a sudden lunge and seizing it.

The common or northern pike occurs in North America from Alaska to British Columbia and eastward to New York. including the Great Lakes and the Ohio valley; it is the only old world species of pike known and is found in Europe north of Greece (but excluding Spain and Portugal) as far as Lapland and in northern Asia. North American waters are also inhabited by other species of the pike family, of which the largest (attaining a weight of over 100 lb) is the muskellunge of the Great Lakes (E. *masquinongy*) Other smaller American pikes are generally called pickerels.

The spawning season of the northern pike varies according to the local climate. It generally occurs from late winter through the spring. Studies indicate the average length at one year of age to be about 20 in and at five years. about 30 in., but specimens are known which have reached a length of more than 4 ft. and a weight of over 50 lb.

Commercial fishermen in North America catch about 100,000 lb. of northern pike a year, mostly with gill nets and pound nets. Anglers take pike by trolling or casting artificial lures, or by fly-fishing, or still-fishing using small fish or frogs as bait.

(L. A WD.)

PIKE PERCH, fresh-water fishes of the perch family (Percidae) identified by having large, strong teeth standing between smaller, weaker ones. These excellent food fish resemble the pike in their elongate body and head, and are dangerous enemies to other fresh-water fishes. In Europe two species occur, the more celebrated being Sander *lucioperca*. It prefers the quiet waters of large rivers and clear, deep lakes, in which it reaches a weight of 25 to 30 lb. The second, S *wolgensis*, is limited to rivers in southern U.S.S.R. and Hungary. In North America the walleyed pike (Stizostedion *vitreum*), of the same family, is sometimes called pike perch. It occurs at least as far west as Nebraska and northern Alberta, as far north as Labrador and as far south as Alabama and Georgia. It grows to a weight of 25 lb. (L. A. WD.)

PIKES PEAK, a famous mountain of the Front range of the Rocky mountains in El Paso county. Colo., U.S. It ranks 32nd in altitude 111.110 ft.) among the 55 Colorado peaks of over 14.000 ft. It is. however, the most widely known mountain in the U.S. by reason of its commanding location and easy accessibility. On its southwestern side, in Teller county, is the famous Cripple Creek gold district. while directly at its eastern base lie Manitou Springs and Colorado Springs (*q.v.*). About 350,000 tourists annually ascend to the summit, a fairly level area of about 60 ac. Ascent may be accomplished by trail, by a cog railway (8.75 mi.) in operation since 1891. or by an automobile toll road (19 mi.) opened in 1916. An average snowfall of about 9½ ft. on the northern and 14 ft. on the southern slopes provides skiing and constitutes the major part of the water supply of Colorado Springs. Timber line is between 11,400 and 12,000 ft.; above it rises nearly 2.500 ft. of bare granite. The view from the summit. which is said to have inspired Katharine Lee Bates to write the familiar hymn "America the Beautiful" in 1893, is magnificent in all directions. Blanca peak (14,317 ft.) and the twin Spanish peaks are visible 100 mi. to the south; Longs peak (14,255 ft.) 100 mi. to the north; the many lofty giants of the Park and Collegiate ranges to the west. On the east is the vast sweep of the Great Plains.

Pikes peak was discovered in Nov. 1806. by Lieut. Zebulon Montgomery Pike (*q.v.*), who abandoned his attempt to climb it because of snow and inadequate clothing. It was climbed by Edwin James and two companions, J. Verplank and Z. Wilson, of Maj. Stephen H. Long's expedition on July 14–15, 1820—the first recorded ascent of a 14.000-ft. peak in the U.S. The mountain was named for James by Major Long but common usage had deservedly bestowed Pike's name upon it by 1859, when it became the focal point of the Pikes peak gold rush.

See Robert *M*. Ormes (ed.), *Colorado Mountain Club's Guide to the Colorado Mountains,* rev. ed. (1955); Harvey L. Carter, *Zebulon Montgomery Pike: Pathfinder and Patriot* (1956). (HY. L. C.)

PILAR (VILLA DEL PILAR), a city of the Ñeembucú department, Paraguay, lies 118 mi. S. of Asunción, on the left bank of the Paraguay river opposite the mouth of the Bermejo. Pop. (1960 est.) 7.136. It is an important river port exporting the agricultural products of Ñeembucú department, between the rivers Paraguay and Paraná.

Pilar has sawmills, distilleries and textile mills, supplies being obtained by road from the northeast where it is linked to the main Asunción-Encarnación highway. Founded in 1778 by Pedro Melo de Portugal, it is the capital of Ñeembucú, which it was originally called. (G. J. B.)

PILATE, PONTIUS, of equestrian rank. was Roman governor of Judaea from A.D. 26 to A.D. 36, when he was recalled. He kept the Roman peace in Palestine, but with little understanding of the people (Josephus. *Ant.* xviii, iii. 1, 2; iv, 1, 2; *Jewish War,* ii, ix, 2–4, Philo. *ad Caium,* 38). One disturbance arose when Pilate used Temple funds for an aqueduct. The reference in Luke xiii, 1, to the massacre of Galilean pilgrims in the act of sacrificing suggests the governor's ruthlessness in putting down riot. It must be said, however. that the post of Roman governor in Judaea was peculiarly difficult, and it was to Pilate's credit that his rule lasted as long as ten years. Both Pilate's part in responsibility for the crucifixion of Jesus Christ and the legal aspects of the trial have been much debated. The early church blamed the Jews and correspondingly tended to exonerate Pilate. The Third and Fourth Gospels, especially, suggest that extraordinary pressure was brought to bear upon the governor by the Jewish priests. Pilate may well have been impressed by the dignity and gentleness of the great Preacher of the Kingdom of God. and may also have given Him opportunity to save Himself (John xviii, 33–38; xix, 9–11 j. There are many stories, all of uncertain value and in many cases legendary, telling of Pilate's later life and of his suicide. Pilate has been canonized in the Abyssinian church (June 25) and his wife Procla, or Procula, in the Greek (Oct. 27).

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PILCHARD (SARDINE), fish of the herring family (Clupeidae) with the fore margin of the dorsal fin situated in advance of the mid-point between the tip of the snout and the base of the caudal fin, with the lower jaw not prominent and with the operculum having grooves radiating toward the suboperculum. One species is known in Europe, *Sardina pilchardus,* which is characterized by a remarkably peculiar arrangement of scales in which alternate oblique rows of small scales are covered by intervening rows of larger ones. This species occurs from Portugal north to the English channel. A subspecies, *S. p. sardina,* occurs from the Canary Islands to the Mediterranean and into the Black sea. Sardines from other parts of the world differ from the European form in having a normal scale arrangement and consequently are placed in another genus. *Sardinops,* of which five species are recognized by some authorities. These are *S. melanosticta* of Japan. *S. caerulea* of the nest coast of North America. *S. sagax* of the west coast of South America, *S. neopilchardus* of New Zealand and southern Australia and *S. ocellata* of south Africa. The differences among these species are so slight that certain authorities recognize only three of them, S. *sagas, S. malanosticta* and *S. neopilchardus.*

Pilchards associate according to size in dense schools or shoals, feed on minute pelagic organisms and grow to be 10 to 12 in. in length. The spawning season varies from species to species; among those of the northern hemisphere it occurs in spring and summer. The eggs are given forth into the open sea and are fertilized there. Suspended near the surface, they drift passively with the currents, hatch within a few days into larvae, which continue to drift passively until they metamorphose into free-swimming fish. Pilchards migrate extensively along the coasts they inhabit, those in the northern hemisphere moving north in summer and south in winter.

Pilchards are utilized for canning and for the manufacture of fish oil and fish meal, which is used for animal feeds. For these purposes about 2,000,000,000 lb. are caught annually in Japan and 1,000,000,000 lb. on the west coast of North America. In the Mediterranean they are used principally for canning. In Cornwall, Eng., considerable quantities are salted. The name sardine is frequently used for other species of small herringlike fishes that are canned. (L. A. WD.)

PILCHER, PERCY SINCLAIR (1866–1899), British engineer and aviation pioneer, was born in Jan. 1866. After six years in the Royal Navy, he qualified and practised as an engineer, and was in 1893 appointed assistant lecturer in naval architecture and marine engineering at Glasgow university. He took up the active study of heavier-than-air flight in 1895, under the influence of Otto Lilienthal, whom he twice visited in Germany. Pilcher built his first glider! the "Bat," in 1895, which he then modified after Lilienthal's ideas, and on which he made many successful glides. His second machine, the "Beetle," was also built in 1895, and his third, the "Gull," in 1896. It was with his fourth glider, the "Hawk" (1896), that Pilcher achieved his most productive flying. It was a monoplane, with rear fin and tailplane and wheeled undercarriage, and was controlled in the Lilienthal manner of swinging the torso and legs from a hanging position between the wings. After gaining valuable experience with this glider, he turned his attention seriously to the problem of powered flying in 1897. By 1899 he had almost completed his first powered machine—for which he had also built the engine—when on Sept. 30, 1899, the "Hawk" broke up in the air when Pilcher was gliding in it at Stanford Park, near Market Harborough. He died of his injuries on Oct. 2.

See *Aeronautical Journal,* vol. i, pp. 1–4 (1897), vol. xiii, pp. 87–89 (1909); P. Pilcher, "Gliding," *Aeronautical Classics, no.* 5 (1910).

(C. H. G.-S.)

PILE. As a textile term, this word indicates the surface of a cloth composed of an infinite number of loops of warp threads, or else of an infinite number of free ends of either warp or weft (filling) threads that stand erect from the foundation or ground

structure of the cloth. There are two general methods of distinguishing between such cloths: (1) When the loops are uncut, the pile is usually termed looped pile. (2) When the same or similar loops are cut, either in the loom during weaving or by a special machine after the cloth leaves the loom, the pile is termed cut pile.

Other names applied to such cut-pile fabrics in which the effect is formed by the warp threads are velvet and plush (*qq.v.*), the former being used to define short-pile fabrics and the latter to define long-pile fabrics. The word velveteen (*q.v.*) is used to distinguish the fabric when the pile is formed of weft or filling threads that have been cut.

Among the loop-pile fabrics may be mentioned Brussels tapestry and imitation Brussels carpeting, as well as Moquettes and the like, In some cases the surfaces of carpets, such as Wilton and Axminster, are formed of cut pile; and again, both looped (uncut pile) and cut pile appear on the surface of the same fabric. Imitation sealskins and several other kinds consist of monocoloured pile, whereas all the above-mentioned carpets have surfaces upon nhich decorative designs appear in both kinds of pile and in several colours.

See CARPET MANUFACTURE; RUGS AND CARPETS. For pile in building see FOUNDATIONS. (T. W.)

PILGRIMAGE, a journey undertaken, from religious motives, to some place reputed as sacred. These journeys play an important role in most pre-Christian and extra-Christian religions: in the Catholic Church their acceptance dates from the 3rd and 4th centuries.

The Pilgrimage in Pre- and Non-Christian Religions.—To the Germanic religions the pilgrimage is unknown. On the other hand, it is an indigenous element, not only in the creeds of Asia, but in those of the ancient seats of civilization on the Mediterranean. The fundamental conception is always that the Deity resides—or exercises a peculiarly powerful influence—in some definite locality; and to this locality the devout repair, either in reverence of their god, or in quest of his assistance and bounty.

One of the oldest homes of the pilgrimage is India. There the devotees tend especially to the Ganges—the hallowed river of Hindu belief. On the Ganges lies Benares, the holy city of Brahmanism: and to look on Benares, to visit its temples. and to be washed clean in the purifying river, is the yearning of every pious Indian. Even Buddhism—originally destitute of ceremonial—adopted the pilgrimage; and the secondary tradition makes Buddha himself determine its goals: the place where he was born, where he first preached, where the highest insight dawned on him, and where he sank into Nirvana. The habit of religious expeditions to sacred places took deep root among the Egyptians, the Jews, and the Greeks; but the pilgrimage attained its zenith under Islam. For Mohammed proclaimed it the duty of every Mussulman, once at least in his life, to visit Mecca; the result being that the birthplace of the Prophet is the religious centre of the Mohammedan world. See ISLAM; CARAVAN; MECCA.

THE PILGRIMAGE UNDER CHRISTIANITY

The pilgrimages of Christianity presuppose the existence of those of paganism; but it would be an error to maintain that the former were a direct development of the latter. For primitive Christianity was devoid of any point by which these journeys of devotion might naturally have been suggested. It was a religion without temples, without sanctuaries, and without ceremonial. The saying of the Johannine Gospel—that God is to be adored neither in Jerusalem nor on Gerizim, but that His true worshipper must worship Him in spirit and in truth—is in complete harmony with the old Christian piety.

The Christian pilgrimage arose from devotion to the memory of Jesus; the faithful repaired to those places which were invested with memories of their Lord's earthly life. Bethlehem and Jerusalem became objects of such visits from the 2nd century; and from references in Eusebius and others, it is evident that the Christians of the 3rd and 4th centuries were in the habit of visiting Jerusalem for prayer; and that men travelled for purposes of prayer implies acceptance of the theory of sanctuaries which it is an act of piety to visit.

THE PILGRIMAGE IN THE ANCIENT CHURCH

The East.—In the passages cited above, Bethlehem and the Mount of Olives figure as the main goal 'of the pilgrim: and on the Mount of Olives the mind must naturally turn to the Garden of Gethsemane and the scene of the Ascension. It may seem surprising that there is no mention of Golgotha and the Sepulchre. But the visitation of these sites was rendered impossible to the Christians by the destruction of Jerusalem and the erection of the town of Aelia Capitolina.

The one holy site in the town of Jerusalem, before the time of Constantine, was the so-called *Coenaculum,* which received its name in later years. It was regarded as the house in which—according to the Acts of the Apostles (xii. 12 *sqq.*)—Mary, the mother of John Mark, lived; and the belief was that there the Lord held the Last Supper, and that there the eleven assembled after the Ascension.

The pilgrimage to Palestine received a powerful impetus from the erection of the memorial churches on the holy sites, under Constantine the Great, as described by Eusebius in his biography of the emperor (iii. 25 *sqq.*). At the order of Constantine, the accumulation of rubbish covering the supposed site of the burial-place of Jesus was removed, and the cave was discovered in which Joseph of Arimathea had laid the body of Jesus; and above this cave and the Hill of the Crucifixion the imposing church of the Holy Sepulchre was built (A.D. 326–336). The churches in Bethlehem and on the Mount of Olives were erected by Helena, the mother of Constantine, who herself undertook the pilgrimage to the Holy Land. These churches were then endowed with new sanctuaries of miraculous powers; and relics of Christ were found in the shape of the Cross and the nails. The result was an exaggerated importance attached to these pilgrimages, a view which led to energetic protests, especially from Gregory of Nyssa, who composed a monograph on the pilgrimages (De *iis qui* adeunt Hierosol.). Jerome, like Gregory, insists on the point that residence in Jerusalem has in itself no religious value: it is not locality, but character, that avails, and the gates of Heaven are as open in Britain as in Jerusalem (***Ep.*** 58, 3).

But Jerome never denied the religious uses of the pilgrimage; he considered it an act of faith for a man to offer his prayers where the feet of the Lord had stood, and the traces of the Birth, of the Cross, and of the Passion were still to be seen (***Ep.*** 47, 2). With the number of the pilgrims the number of pilgrim-resorts also increased. Of Jerusalem alone Jerome relates that the places of prayer were so numerous that it was impossible to visit them all in one day (*Ep.* 46, 9). In the Holy Land the list was still longer: the natives were ready to show everything for which the foreigners inquired, and the pilgrim was eager to credit everything. In her expedition to the East, Paula, the friend of Jerome, visited, among other places, Sarepta and Caesarea. In the first-named place she was shown the tower of Elijah; in the second, the house of Cornelius, that of Philip, and finally the grave of the four virgins. At Bethlehem she saw, in addition to the church of the Nativity, the grave of Rachel; at Hebron the hut of Sarah, in which the swaddling clothes of Isaac and the remains of Abraham's oak were on view (Hieron. *Ep.* 108).

In the West.—While pilgrim-resorts were thus filling the East, their counterparts began to emerge in the West. And here the starting-point is to be found in the veneration of martyrs. Care for the tombs of martyrs was sanctioned by immemorial custom of the Church; but, in this case also, a later age failed to preserve the primitive conception in its purity; and Augustine himself was obliged to defend the usage of the Church from the imputation that it implied a transference of heathen ceremonial to the sphere of Christianity (Contr. *Faust.* xx. 21). The martyrs were the local heroes of particular communities; but there were men whose life and death were of significance for the whole of Christendom—the apostles. Of these Peter and Paul had suffered martyrdom in Rome, and it was inevitable, from the nature of the case, that their graves should soon become a resort, not only of Romans born, but of strangers also. The Roman cemeteries were visited by numerous pilgrims even in the 3rd century. for the earliest *graffiti* in the papal crypt of the Coemeterium Callisti must date

from this period (De Rossi, Roma sotter. i. 253 sqq.; Kraus, Rom. Sott. 148 sqq.).

Pilgrims were drawn to the graves of the saints convinced that there divine succour was certain; hence came the belief in a never-ending series of miracles there performed. Doubt was unknown. St. Augustine observes that, though Africa was full of martyrs' tombs, no miracle had been wrought at them so far as his knowledge extended. This, however, did not lead him to doubt the truth of those reported by others—a fact that is somewhat surprising when we reflect that the phenomenon caused him much disquiet and perplexity. Rho, he asks, can fathom the design of God in ordaining that this should happen at one place and not at another? And eventually he acquiesces in the conclusion that God, who gives every man his individual gift at pleasure, has not willed that the same powers should have efficacy at every sepulchre of the saints (Ep. 78, 3).

THE PILGRIMAGE IN THE MIDDLE AGES

The mediaeval Church adopted the custom of the pilgrimage from the ancient Church. The young Germanic and Romance nations did precisely as the Greek and Romans had done before them, and the motives of these devotional journeys—now much more difficult of execution in the general decay of the great world-system of commerce—remained much the same. They were undertaken to the honour of God, for purposes of prayer, or in quest of assistance, especially health. But the old causes were reinforced by others of at least equal potency. The mediaeval Church was even more profoundly convinced than its predecessor that the miraculous power of Deity attached to the bodies of saints and their relics. But the younger nations—French, English and German—were scantily endowed with saints, while, on the other hand, the belief obtained that the home-countries of Christianity, especially Rome and Jerusalem, possessed an inexhaustible supply of these sanctified bodies.

Pilgrimages were consequently undertaken with the intention of securing relics. At first it was enough to acquire some object which had enjoyed at least a mere connection with the hallowed corpse. One enthusiast took a little wax dropped from the taper; another, a portion of the dust which lay on the grave; a third, a thread from the cloth covering the sarcophagus; still another plucked the flowers which visitors had planted above the tomb Before long, however, these humble trophies failed to content the pilgrims, and they began to devote their efforts to acquiring the actual bodies, or portions of them—frequently by honest means, still oftener by trickery. One of the most attractive works of early mediaevalism—Einhard's little book, *Translatio Marcellini et Petri*—gives a vivid description of the methods by which the bodies of the two saints were acquired and transported from Rome to Seligenstadt on the Main

Far more important consequences, however, resulted from the fact that the mediaeval mind associated the pilgrimage with the forgiveness of sins. This conception of the pilgrimage, as a means of expiation or a source of pardon for wrong, was foreign to the ancient Church. It is quite in accordance with the keener consciousness of sin, which prevailed in the middle ages, that the expiatory pilgrimage took its place side by side with the pilgrimage to the glory of God. The pilgrimage became an act of obedience; and, in the books of penance (Poenitentialia) which date from the early middle ages, it is enjoined as an expiation for many of the more serious sins, especially murder or the less venial forms of unchastity. The place to be visited was not specified; but the pilgrim, who was bound by an open letter of his bishop to disclose himself as a penitent, lay under the obligation, wherever he went, to repair to the churches and—more especially—the tombs of the saints, and there offer his prayers. On occasion, a chain or ring was fastened about his body, that his condition might be obvious to all; and soon all manner of fables gained currency: how, here or there, the iron had sprung apart by a miracle, in token that the sinner was thereby absolved by God.

As the system of indulgences (*q.v.*) developed, a new motive came to the fore which rapidly overshadowed all others: pilgrimages were now undertaken to some sacred spot, simply in order to obtain the indulgence which was vested in the respective church or chapel. In the 11th century the indulgence consisted in a remission of part of the penance imposed in the confessional, in return for the discharge of some obligation voluntarily assumed by the penitent. Among these obligations, a visit to a particular church, and the bestowal of pious gifts upon it, held a prominent place; and during the whole period of mediaevalism, the number of pilgrims was perpetually on the increase.

The Pilgrim Resorts.—The most important places of resort both for voluntary and involuntary pilgrimages, were still Palestine and Rome. On the analogy of the old Itineraria, the abbot Adamnan of Iona (d. 704) now composed his monograph De *locis* sanctis, which served as the basis of a similar book by the Venerable Bede (d. 735). His authority was a Frankish bishop named Arculf, who resided for nine months as a pilgrim in Jerusalem, and visited the remaining holy sites of Palestine in addition to Alexandria and Constantinople. Of the later itineraries the *Descriptio* terrae *sanctae,* by the Dominican Burchardus de Monte Sion, enjoyed the widest vogue. This was written between the years 1285 and 1295; but books of travel in the modern tongues had already begun to make their appearance. The initiative was taken by the French in the 12th and 13th centuries, and the Germans followed in the 14th and 15th; while the Book of *Wayes* to Jerusalem of John de Maundeville (c. 1336) attained extreme popularity, and was translated into almost all the vernacular languages.

As a result of this steady increase in the number of pilgrims, the old arrangements for their accommodation were found deficient. Consequently hospices arose which were designed exclusively for the pilgrim. Those on the Alpine passes are common knowledge. The oldest, that on the Septimer pass, dates from the Carolingian period, though it was restored in 1120 by the bishop Wido of Chur: that on the Great St. Bernard was founded in the 10th century, and reorganized in the 13th. To this century may also be assigned the hospice on the Simplon; to the 14th those on the St. Gothard and the Lukmanier. Similarly, the Mediterranean towns, and Jerusalem in particular, had their pilgrim-refuges. Service in the hospices was regularly performed by the hospital-fraternities—that is to say, by lay associations working under the authorization of the Church. The most important of these was the fraternity of the *Hospitale* hierosolymitanum, founded between 1065 and 1075; for hence arose the order of St. John, the earliest of the orders of knighthood. (See ST. JOHN OF JERUSALEM, KNIGHTS OF.) In addition to the hospital of Jerusalem, numerous others were under its charge in Acre, Cyprus, Rhodes, Malta, etc. Associations were formed to assist pilgrims bound for the East; one being the *Confrérie* des *pèlerins* de Terre-Sninte in Paris, founded in 1325 by Louis de Bourbon, count of Clermont (afterwards first duke of Bourbon).

But since, in the middle ages, the Holy Land was no longer held by a Christian Power, the protection of the pilgrims was no less necessary than their sustenance. This fact, after the close of the 11th century, led to the Crusades (*q.v.*), which in many respects are to be regarded as armed pilgrimages. For the old dream of the pilgrim, to view the country where God had walked as man, lived on in the Crusades—a fact which is demonstrated by the letters of Bernard of Clairvaux, with the songs of Walther von der Vogelweide and other Crusaders. And, since the strongest motive in the pilgrimage was the acquisition of indulgences, unnumbered thousands were moved to assume the Cross, when, in 1095, Urban II. promised them plenary indulgence. The conquest of Jerusalem, and the erection of a Christian empire in Palestine, naturally swelled the influx of pilgrims. And though in 1187 the Holy City again fell into the hands of the infidel, while in 1291 the loss of Acre eliminated the last Christian possession in Palestine, the pilgrimages still proceeded. It was not till the Reformation, the wars of the 16th century, and the loss of Rhodes, Candia and Cyprus to the Turks, that any appreciable alteration was effected. When Ignatius de Loyola (*q.v.*) set sail in 1523 from Venice to Palestine, only some thirteen souls could be mustered on the pilgrim-ship, while eight or nine others sailed with the Venetian state-vessel as far as Cyprus. A considerable number had aban-

doned their pilgrimage and returned home on the news of the fall of Rhodes.

For pilgrimage overseas, as it was styled, the permission of the Church was still requisite. The pilgrims made their journey in grey cowls fastened by a broad belt. On the cowl they wore a red cross; and a broad-brimmed hat, a staff, sack and gourd completed their equipment. During their travels the beard was allowed to grow, and they prepared for departure by confession and communion. Of their hymns many are yet extant ("Jerusalem mirabilis," "In gottes namen faren wir," etc.). Ships belonging to the knights of St. John and the Knights Templars conducted the commerce with Palestine, and the pilgrims formed themselves into unions, elected a "master" and concluded their agreements, as to the outward voyage and return, in common. The expenses of the journey to Palestine were no light matter. In the 12th century they may be estimated at 100 marks of silver (£200) for the ordinary pilgrim. The expenses of the princes and lords were, of course, much heavier. Duke William of Saxony, who was in Jerusalem in 1461, spent no less than £10,000 on his journey. (See Prutz, Kulturgeschichte der *Kreuzzüge,* pp. 106 sqq.; Rohricht, Deutsche Pilgerreisen, p. 42.)

Great as was the number of pilgrims oversea, it was yet far exceeded by that of the visitants to the "threshold of the apostles," *i.e.,* Rome, which received their greatest impetus through the inauguration of the so-called Year of Jubilee.

Of the other pilgrim-resorts, we shall only emphasize the most important. Priority of mention is due to St. James of Compostela (Santiago, in the Spanish province of Galicia). Here the attraction for the pilgrim was the supposed possession of the body of James the son of Zebedee. The first connection of the apostle with Spain is to be traced in the *Poema de aris b. Mar. et xii. apost. dedic.,* which is ascribed to Aldhelm (d. 709) and contains a story of his preaching in that country. The earliest account of the transference of his relics to the Peninsula is found in Notker Balbulus (d. 912, *Martyrol.* in *Jul. xxv.*). But in Spain belief in this cherished possession was universal; and, step by step, the theory won credence throughout the West. In England, indeed, the shrine of St. James of Compostela became practically the most favoured devotional resort; and in the 12th century its visitation had attained such popularity that a pilgrimage thither was ranked on a level with one to Rome or Jerusalem. In France St. Martin remained the chief goal of the pilgrim; while Notre Dame de Sous-Terre in Chartres (with a portrait of the "black Virgin"), Le Puy-en-Velay (dep. Haute Loire), and others, also enjoyed considerable celebrity. In England pilgrimages were made to the tomb of the murdered archbishop, Thomas à Becket, in Canterbury Cathedral. The setting of Chaucer's *Canterbury* Tales gives a vivid idea of the motley company of pilgrims; but it seems probable that Germany also sent a contingent. In addition, Walsingham, Peterborough, St. Davids, Holywell, and St. Andrews in Scotland were much frequented. In lower Germany, Cologne and Aix-la-Chapelle, in Switzerland Einsiedeln, were the principal resorts.

In Italy the church of the Archangel on Mt. Gargano was one of the most ancient centres of the pilgrimage. Later the Portiuncula church at Assisi displaced all other resorts, with the exception of Rome; but in the 15th century it was overshadowed in turn by the "Holy House" at Loretto on the Adriatic. According to an extravagant legend, the house of Joseph and Mary in Nazareth was transported by angels, on the night of the 9th–10th of May 1291 to Dalmatia, then brought to the Italian coast opposite (Dec. 10, 1294), till, on the 7th of September 1295 it found rest on its present site. The pilgrimage thither must have attained great importance as early as the 15th century; for the popes of the Renaissance found themselves constrained to erect an imposing pilgrim church above the "Holy House."

The significance of the pilgrimage for the religious life of later mediaevalism cannot be adequately estimated. The possession of any extraordinary relic was everywhere considered a sufficient claim for the privileges of indulgences; and wherever this privilege existed, there the pilgrims were gathered together. All these pilgrimages, great and small, were approved and encouraged by the Church. And yet, during the whole of the middle ages, the voice of suspicion in their regard was never entirely stilled. Earnest men could not disguise from themselves the moral dangers almost inevitably consequent upon them; they recognized, moreover, that many pilgrims were actuated by extremely dubious motives; and they distrusted the exaggerated values set on outward works. The Roman papacy had no more zealous adherent than Boniface; yet he absolutely rejected the idea that Englishwomen should make the journey to Rome, and would willingly have seen the princes and bishops veto these pilgrimages altogether (Ep. 78). The theologians who surrounded Charlemagne held similar views.

When the abbess Ethelburga of Fladbury (Worcestershire) found her projected pilgrimage impracticable, Alcuin wrote to her, saying that it was no great loss, and that God had better designs for her: "Expend the sum thou hast gathered for the journey on the support of the poor; and if thou givest as thou canst, thou shalt reap as thou wilt" (Ep. 300). Bishop Theodulf of Orleans (d. 821) made an energetic protest against the delusion that to go to Rome availed more than to live an upright life (Carm 67). To the same effect, the synod of Chalon-sur-Saône (813) reprobated the superstition which was wedded to the pilgrimage (c. 13); and it would be easy to collect similar judgments, delivered in every centre of mediaevalism. But, fundamentally, pilgrimages in themselves were rejected by a mere handful: the protest was not against the thing, but against its excrescences.

The Modern Pilgrimage. — The Reformation eradicated the belief in the religious value of visits to a particular locality. It is only pious memory that draws the Protestant to the sites consecrated by ecclesiastical history. On the other hand, while in the Eastern Church things have undergone little change the developments in the Roman Church show important divergences. The Year of Jubilee, in 1525, was unprecedented in its scant attendance, but the jubilees of 1575 and 1600 again saw great armies of pilgrims marching to Rome (see JUBILEE YEAR). Fresh pilgrim resorts sprang up; mediaeval shrines, which had fallen on evil days, emerged from obscurity. The 19th century led to an extraordinary revival of the pilgrimage. Not only did new resorts spring into existence—*e.g.,* La Salette in Dauphiné (1846), and more particularly Lourdes (1858) in the department of Hautes Pyrénées—but the numbers once more attained a height which enables them to compete with the mediaeval figures. The dedication of the church of Lourdes, in 1876, took place in the presence of 30 bishops, 3,000 priests and 100,000 pilgrims. No new motives for the pilgrimage emerged in the 19th century, unless the ever-increasing cultus of the Virgin Mary may be classed as such, all of the new devotional sites being dedicated to the Virgin. For the rest, the desire of acquiring indulgences maintains its influence: but doubting voices are no more heard within the pale of the Roman Catholic Church.

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PILGRIM FATHERS, the name given by posterity to those who settled the first permanent colony in New England at Plymouth, Mass., in 1620. These 102 settlers included 35 members of the English Separatist Church who had migrated to Leiden, Holland. They sought relief from the hard life in Holland and desired civil and religious autonomy within the English government. The remaining majority were a heterogeneous group from England, mostly of the Anglican Church, who came to America for various reasons. These first settlers did not become known as the Pilgrim Fathers until two centuries after their arrival. Contemporaries called them Old Comers while later generations referred to them as Forefathers, and during the colonial period the

people of Plymouth celebrated Forefather's day in their honour. The celebration was revived in 1793, and at that time Rev. Chandler Robbins preached a memorial sermon in which he used a quotation from William Bradford's manuscript which he found copied into old church records. In this quotation, Bradford referred to the "saints" who left Holland as "pilgrimes" and this name struck a responsive chord. In 1819 the Pilgrim society was organized, its efforts dedicated to perpetuating the fame of the Forefathers. In this it was successful. The society promoted a bicentennial celebration in 1820 with Daniel Webster as speaker. His stirring address, which was later published, began: "We have come to this Rock to record here our homage to our Pilgrim Fathers . . . ." From this time on the Forefathers became Pilgrim Fathers in common usage. See also MASSACHUSETTS: History.

See William Bradford, Of Plymouth Plantation 1620–1647, ed. by Samuel Eiiot Morison (1952); George F. Willison, Saints and Strangers (1945), (ed.), The Pilgrinz Reader (1953). (B. K. B.)

PILGRIMS' WAY, THE, a still-traceable road or way from Winchester, in Hampshire, Eng., to Canterbury, in Kent. Along it passed the stream of pilgrims coming through Winchester from the south and west of England and from the continent of Europe by way of Southampton to Canterbury cathedral to view the place of the martyrdom of Thomas Becket, in the north transept, the relics in the crypt where he was first buried after his murder, in 1170, and the shrine in the Trinity chapel which rose above his tomb after the translation of the body in 1220. There were two festivals for the pilgrimage, on Dec. 29, the day of the martyrdom, and on July 7, the day of the translation. The summer pilgrimage naturally became the most popular. In 1538 the shrine was destroyed and the relics of the saint scattered, but the great days of the pilgrimage had then passed. Erasmus gives a vivid picture of the glories of the shrine and of all that the pilgrims saw on his visit with Colet to Canterbury in 1514.

This road, although its name of the Pilgrims' way has for long confined it to the road by which the pilgrims came to Canterbury from Winchester, follows a far older track. Since British and even older times the main direction which commerce and travelers followed across southern and western England to the Straits of Dover and the continent lay from Canterbury along the southern chalk slope of the North Downs to near Guildford, then by the Hog's Back to Farnham. At this point the oldest track went across Salisbury plain toward Stonehenge and so on to Cornwall. From Farnham westward the only portion of this, the oldest track that can now be traced, is a small portion that still bears the name of the Harrow (*i.e.*, hoary, old) road.

PILIBHIT, a municipal town, the headquarters of a district of the same name in Rohilkhand division, Uttar Pradesh, India, about 30 mi. N.E. of Bareilly. Pop. (1951) 46,225. It is a junction on the Northern railway and is connected with Bareilly by a metaled road. The main industry is sugar manufacturing. There is a great mosque on the western outskirts built by Hafiz Rahman Khan (c. 1775), the founder of Pilibhit.

PILIBHIT DISTRICT is on the border between India and Nepal, on the foothills of the Himalayas. Pop. (1951) 504,428. Area 1,352 sq.mi. It is a gentle undulating plain intersected by numerous southward-flowing streams. The north and northwest are a continuation of the Tarai (*q.v.*); the eastern section has undeveloped forest tracts; and the southeastern part is a low lying belt of moist alluvial soil producing grass and tamarisk, with an inhospitable climate. The southern extremities of the district have richer soil akin to that of the Ganges plains, more stable cultivation and a denser population. Among its ancient monuments is an immense fortress near the railway station of Shahgarh (Dhopap). Its main crops are wheat, rice, sugar cane, gram and barley. The only other town of any size in the district is Bisalpur. (B. SI.)

PILKINGTON, FRANCIS (d. 1638), English madrigal composer, the details of whose early life are obscure, took his Mus.B. at Lincoln college, Oxford. He was attached to Chester cathedral about 1604, and a few years later was ordained. His chief works include a book containing 21 vocal pieces and a pavin for the lute and bass viol (1605), The First Set of Madrigals and Pastorals (1614) and The *Second Set* of Madrigals and Pastorals (1624).

PILLORY, an instrument of punishment which consisted of a wooden post and frame fixed on a platform raised several feet from the ground, behind which the culprit stood, his head and his hands being thrust through holes in the frame (as are the feet in the stocks [*q.v.*]) so as to be held fast and exposed in front of it. This frame in the more complicated forms of the instrument consisted of a perforated iron circle, which secured the heads and hands of several persons at the same time, but it was commonly capable of holding only one.

In the statutes of Edward I it is enacted that every pillory or "stretch-neck" should be made strong enough to hold offenders without peril to their bodies. It was customary to shave their heads wholly or partially, as well as the beards of men, and to cut off the hair and even in extreme cases to shave the heads of female culprits.

In 1816 England abolished the pillory except for perjury and subornation, and the perjurer Peter James Bossy was the last to stand in the pillory at the Old Bailey for one hour on June 22, 1830. The pillory was finally abolished in England in 1837. In France the pillory, called *carcan,* was used until 1832. In Germany it was known as pranger. The pillory was employed in the American colonies, and the U.S. federal statutes provided for its infliction until 1839. Delaware, the last state to use the pillory, did not abolish it until 1905. (R. G. CL.)

PILON, GERMAIN (1535–1590), French sculptor of the Renaissance, was born in Paris in 1535. He was perhaps a pupil of Bontemps and more than once carried out designs by Primaticcio. Starting as a somewhat italianate, mannered sculptor he developed curiously enough in a more realistic (and in a sense, native) direction without, however, carrying French sculpture as a whole with him. The classic foundations had definitely been laid in France. Pilon was the author of the monument for the heart of Henry II (though the design was possibly by Primaticcio), in which the three Graces of marble that support the urn are of great elegance. Pilon was also employed on the tomb of Henry II in St. Denis, France (designed by Primaticcio). The greatest of his portraits is undoubtedly the kneeling figure of Chancellor de Birague (Louvre). Pilon apparently was also a medallist of distinction, although it is disputed whether he merely made the wax models or also cast the medals. Pilon died on Feb. 3, 1590.

See H. Vollmer, Jean *Goujon* und die *französische Renaisanceskulptur* (1923). (A. K. McC.)

PILOTAGE, as it is now understood, may be described as the art of conducting a vessel in or out of harbour, or in the neighbourhood of navigational dangers. The word "pilot" mas formerly used to designate the steersman and later the sailing master; in fact, the art of piloting was divided into two parts: proper piloting, identical with what we now term navigating (see NAVIGATION), and common piloting, identical with the meaning of the word as given above.

See PILOTAGE LAWS.

PILOTAGE LAWS. The present general British pilotage laws are contained in the Pilotage Act, 1913, which Act consolidated and amended the laws of pilotage as they existed under the Merchant Shipping Act, 1894. On the passing of the former Act, the Board of Trade, as the central authority, held inquiries, with the result that pilotage orders were made by it in respect of each District. Each pilotage order defines the limits of the district, names the pilotage authority therefor, states whether pilotage is compulsory or not therein, and empowers the authority to delegate any of its powers or duties to a pilotage committee, on which may sit representatives of both pilots and shipowners. The pilotage authority makes the necessary by-laws for the regulation of pilotage and pilots in its district, but these do not take effect until they are confirmed by the Board of Trade.

The principal pilotage authority is the Corporation of Trinity House, London, exercising jurisdiction in the London district, which extends from Orfordness to Selsea Bill, and in 38 other districts round the coasts of England and Wales. There are, however, about 60 other districts within which other pilotage authorities

have jurisdiction.

Compulsory Pilotage. — A ship, whilst navigating in a district in which pilotage is compulsory, for the purpose of entering, leaving or making use of any port in that district, is required to be either under the pilotage of a licensed pilot of the district, or under the pilotage of a master or mate possessing a pilotage certificate for the district, who is bona fide acting as master or mate of the ship. A ship carrying passengers (other than an excepted ship) is, however, compelled to be under pilotage irrespective of whether the district in which she is navigating is a compulsory one or not. Under the Aliens Restriction (Amendment) Act, 1919, pilotage certificates cannot be granted to aliens, except to masters or mates of French nationality trading to the ports of Newhaven or Grimsby.

The following ships are excepted from compulsory pilotage: (1) Ships belonging to His Majesty. (2) Pleasure yachts. (3) Fishing vessels. (4) Ferry boats. (5) Ships of less than 50 tons' gross tonnage. (6) Ships exempted by by-law. (7) Tugs, dredgers, sludge vessels, barges and other similar craft belonging to or hired by a dock, harbour or river authority. (8) Ships calling at a port in a pilotage district for the sole purpose of taking on board or landing a pilot belonging to some other pilotage district.

The Board of Trade has the power, on the representation of parties interested, to revoke or vary any by-laws in a pilotage district, or require the pilotage authority to make by-laws. The licensing of a pilot by a pilotage authority does not involve any liability on the part of the authority for any loss occasioned by any act or default of the pilot.

Pilot Boats. — All pilot boats regularly employed in any district must be approved and licensed by the pilotage authority for that district, who may appoint or remove the masters thereof. Every pilot boat must be distinguished by the name of her owner and port on her stern, and her number on each bow, and the hull of the boat is usually painted black. When afloat the pilot boat must fly a red and white horizontal flag, known as a pilot flag, in a conspicuous position. A pilot flag must also be displayed by a vessel having on board a licensed pilot for the district, or a master or mate holding a pilotage certificate. The master of a ship subject to pilotage in a district must, under a penalty, display a pilot signal and keep it displayed until a licensed pilot comes on board, and if the master accepts the services of a pilot he must give him facilities for getting on board.

The following persons are liable to pay pilotage dues for any ship for which the services of a licensed pilot have been obtained, *viz.:* (a) the owner or master, or (b) the consignees or agents who have paid or are liable to pay any other charges on account of the ship, and these dues may be recovered in the same manner as fines under the Merchant Shipping Act, 1894. The pilotage dues on foreign ships, subject to compulsory pilotage, trading to and from the port of London, have to be paid to the chief officer of customs and excise in that port, and such a ship may be detained until such dues are paid. It is an offence, punishable by a fine, if a licensed pilot demands or receives, and a master offers or pays, dues in respect of pilotage services at any other rates, whether greater or less, than those which are fixed by by-law.

Under section 633 of the Merchant Shipping Act, 1894, the owner or master of a ship was not answerable to any person for any loss or damage occasioned by the fault or incapacity of any qualified pilot acting in charge of that ship within any district where the employment of a qualified pilot was compulsory by law. Section 1; of the Pilotage Act, 1913, however, reversed this defence of compulsory pilotage, and enacted that the owner or master of a vessel navigating under circumstances in which pilotage is compulsory is answerable for any loss or damage caused by that vessel, or by any fault of her navigation, in the same manner as he would if pilotage were not compulsory. Section 15 of the Pilotage Act, 1913, did not, however, come into effect until Jan. 1, 1918, on which date section 633 of the 1894 Act was repealed. The difference which formerly existed under the Merchant Shipping Act, 1894, between British law and the law of most foreign countries as to the civil liability of the owner or master of a vessel employing a pilot under compulsion of law has therefore been removed since Jan. 1, 1918.

See *The Pilotage Act, 1913; Report of Departmental Committee on Pilotage 1911;* Digby & Cole, *Pilotage Law* (1913). (W.J. T.H.)

UNITED STATES

The power of administering all matters relating to pilotage was acquired by the Federal Government as incidental to the authority conferred on it under the Constitution. The first legislative action of the new Government was in 1789, when it delegated its authority to the several States "until further provision is made by Congress." Further legislation enacted subsequently has restricted the broad powers conferred in 1789, but the power of the Federal Government is exclusive only when it is exercised. State laws regarding pilotage are operative so long as they are not in conflict with Federal laws.

Among the acts of the Federal Government restricting the manner in which the several States may control pilotage are: laws which apply to pilotage on waters that are boundaries between States, permitting the master of a vessel to employ a pilot licensed by either State to pilot the vessel to or from such port; laws which prohibit discrimination in rates or pilotage as between vessels operating solely between ports in the State and those engaged in interstate traffic; laws which provide that all coastwise seagoing steamships shall be under the control and direction of pilots licensed under Federal authority; and laws which prohibit State pilots from levying pilotage on coastwise seagoing steamships.

Number and Appointment of Pilots. — In many States no maximum or minimum restriction is placed by statute on the number of pilots that may be appointed, the number being left to the discretion of the several pilotage authorities. In some cases both a maximum and minimum number are prescribed by law and in other States only a maximum number is mentioned. As a rule pilots are licensed by the local pilotage authority, but in several States they are appointed by the governor. In a majority of the States, pilots are licensed for life and lose their licences only because of negligence, incapacity, misconduct or infirmity. In the remaining States licences are granted for periods of one to four years and are renewable. Several grades of licences are generally issued, the grade varying with the draft of vessel which the holder of the licence is considered competent to conduct.

Qualification of Pilots. — In all States the primary qualification for appointment as pilot is actual experience in piloting vessels. A number of States require that applicants for licences as pilots must have served an apprenticeship of a specified number of years on boats of the pilots' association, either in accordance with the law of the State or by regulation of competent authority.

Authority. — In the United States, a pilot occupies the status of an officer of the ship when on board in the exercise of his duty, and his orders as such must be obeyed by the crew. When the master is on board, the orders of the pilot are considered to be those of the master's. The pilot is subject to the master in the matter of discipline but is not liable to any ship's duty except that of pilot. Once in charge of a vessel at sea. it is the duty of the pilot to stay by the ship until she reaches her destination or some place of safety, unless he is earlier discharged.

Liability of Pilots. — Pilots are generally required to give bond, usually $500, to secure the faithful performance of their duties and for the payment of all damages that may accrue from their negligence, unskillfulness or unfaithfulness. The bond is not required in some States, the amount is not specified in the laws of others and in still others it is fixed. The courts have held that while a pilot is responsible to the owner of a vessel for negligence or default in the performance of this duty, he is not liable for the vessel's loss when he has used his best skill and judgment, although the result shows that his best judgment was wrong.

Compulsory Pilotage. — Pilotage is generally compulsory upon certain vessels, or classes of vessels, approaching or departing from a harbour. Throughout the States, all public vessels of the United States and all steamship> engaged in the coasting trade are exempt from compulsory pilotage. In respect to other vessels or classes of vessels there is wide variation in the laws of the several

States. In the great majority of States compulsory pilotage is prescribed for all vessels, both of domestic and foreign registry, engaged in foreign trade, but not for any class of vessel in the domestic trade. In general the rule is that there has been a tender of the services of a pilot if there has been displayed the customary pilot signal on the usual cruising ground of pilot boats at sea, and there is a visible approach of the boat towards the incoming vessel. If the offer of pilot service is refused, the pilot becomes entitled to full fees or half pilotage, according to the local State law, and the liability for payment is enforceable in admirafty.

Compensation. — In general, pilotage fees are fixed by statute, based on the draught of the vessel. In some cases the rates are prescribed by the local pilotage authorities and the net tonnage of the ship is a factor in determining the pilotage charges. In a number of States where pilotage is compulsory, the full rate is not charged if the services of a pilot are refused. The various statutes commonly provide that pilotage fees are to be paid by and are recoverable from the master or owners of the vessel. In addition to fees for the actual work of pilotage, the statutes of practically every State permit certain extra charges to be made to cover loss of time occasioned by detention of vessel in quarantine or by carrying the pilot to sea when the pilot boat was ready to take him off.

BIBLIOGRAPHY.—For legislation on pilotage in the United States, see the Revised Statutes and the Statutes at Large of the United States, and the statutes of the several States in which pilot service is maintained, particularly Title 46, U.S. Code; Laws of 1909, New York, Ch. 42, Sec. 56; Revised Laws of Mass., 1902, as amended; Civil Code of 1906, California, Sec. 2036. (C. M. A)

PILOT-FISH (*Naucrates ductor*), a pelagic fish of the family of horse-mackerels or Carangidae, well known to sailors from its habit of keeping company with ships and large fishes, especially sharks. It occurs in all tropical and subtropical seas, and is common in the Mediterranean. In summer pilot-fish accompany ships into port as far north as the south coast of England. It accompanies both ships and sharks on account of the supply of food which it derives from them, as does the remora (*q.v.*). All observers agree that, except in confinement, neither the pilot-fish nor the sucking-fish is ever attacked by the shark. The pilot attains to a length of about 12 in. A sharp keel runs along the middle of each side of the tail. The teeth are small, arranged in bands. On a bluish ground colour, five to seven dark-blue or violet crossbands traverse the body from back to belly. The pilot-fish spawns in the open sea.

PILOTY, KARL VON (1826–1886), German painter, the foremost representative of the realistic school in Germany, born at Munich on Oct. 1, 1826, was the son of Ferdinand Piloty (d. 1844), noted as a lithographer. His picture of "Seni at the Dead Body of Wallenstein" (1855) gained for the young painter the membership of the Munich academy, where he became professor. He executed a number of mural paintings for the royal palace in Munich, and for Baron von Schach he painted the celebrated "Discovery of America." In 1874 he was appointed keeper of the Munich Academy, being afterward ennobled by the king of Bavaria. Piloty was a successful teacher, among his pupils being Makart, Lenbach, Defregger, Max and Griitzner. He died at Munich on July 21, 1886.

PILSEN (PLZEŇ), a city of the Plzeň region, Czech., at the confluence of the Radbuza and Mze in a fertile and productive fruit and cereal basin. The vicinity is rich in coal and iron. The staple product is beer, exported to all parts of the world, which is closely followed by iron and steel goods and machinery, mainly from the Skoda factory; spirits, leather goods. paper and earthenware are also produced in large quantities. The town is the trade and transport centre for the whole of southwest Bohemia and its cereal and cattle markets are famous.

Little is known of Pilsen till the 10th century and it did not become a town till 1272 but since then it has figured largely in Bohemian history and was a centre of Catholic resistance during the Hussite wars. Among its sights are the 13th century Gothic church with a tower 325 ft. high and a 16th century Renaissance town hall. Pop. (1950) 124,339.

PILSUDSKI, JOSEPH (1867–193j), Polish soldier and statesman. was born in Nov. 1867 in Zulow (Zulowo), county of Vilna (Wilno) of an ancient family tracing their origin from the Lithuanian Princes of Ginet, and educated at Wilno and Kharkov.

In 1887 Pilsudski was involved in an anti-Tsarist plot and sentenced to five years' penal servitude in eastern Siberia, although the trial clearly established his innocence and his deprecation of terrorist methods. He returned to Wilno in 1892 and formed the Polish Socialist party (P.P.S.). In 1894 he began the Robotnik (The Workman), a secret paper of radical tendencies. He was already a force. His courage, keen sense of humour, attractive personality and good breeding made him the idol of the working classes; he was revered by the intelligentsia for the tenacity of his convictions, for his fearlessness and his iron will.

His activities increased rapidly. Armed resistance against atrocities of the Russian government was introduced into the party program. Armed detachments of workmen protected meetings and demonstrations against the police and military, and bloodshed became frequent. In 1900 Pilsudski and his wife, Marie Tuszkiewicz, whom he had married in 1894, were arrested in the offices of the Robotnik in Lodz and for a year he was kept in a special cell in the notorious "Tenth Pavilion" of the Warsaw citadel. Simulating insanity. Pilsudski was transferred to the St. Nicholas hospital in St. Petersburg, where his friends rescued him on May 13, 1901. He lived in London for some time following his escape and returned to Cracow in 1902.

During the Russo-Japanese war Pilsudski planned an insurrection. Frustrated through lack of munitions, he visited Japan to enlist her support, but again proved unsuccessful. After the Russian revolution of 1905 and the convocation of the Duma Polish revolutionary activities were discontinued, but the Russian Constitutional government continued the policy of its predecessors with regard to Poland. Pilsudski transferred his headquarters to Cracow and Lwow and commenced his activities among the refugees from the Russian provinces of the country. Here the idea of a "private Polish army" was conceived. An officers' school was established in Lwow and branches of the "sharpshooters" (Strzelec) formed throughout Galicia. Foreseeing World War I. Pilsudski hoped for a German and Austrian victory over Russia and a French victory over Germany. When war broke out. he consequently sided with Austria The total strength of his "army" was 3.000 infantry and a squadron of cavalry insufficiently armed and equipped; the remaining 7,000 of his men were despatched to Hungary by the Austrian general command. His brigade took part in numerous battles in ahich it exhibited great bravery and exemplary discipline, while P~lsudskihimself displayed the highest qualities as a leader. He refused. however, to let his legions be used outside of Polish territory. On the collapse of Russia, he turned against Germany and Austria. In July 1916 he resigned the command of the Polish legions in consequence of the abuses of the German and Austrian occupation authorities in Polish territory. At the same time he sought to establish relations with France and Great Britain through his colleagues, Sokolnicki and Gabriel Narutowicz. On Nov. j, 1916, the independence of Poland was proclaimed by the central powers and P~lsudskiaccepted the position of minister of war in the newly formed council of state. Within a short time he formed the semisecret Polish military organization, *i.e.*, *Polska Organizacia Wojskowa* (P.O.W.), which spread through Poland and helped disarm Germans and Austrians in 1918.

When the Polish legions in Russia, commanded by General Musnicki, proclaimed P~lsudskitheir spiritual leader, and when his own legions refused, in July 1917, to take the oath of "fraternity of arms with Germany and Austria," Pilsudski was arrested by the Germans and imprisoned with his chief of staff General Sosnowski in the fortress of Magdeburg, whence he nas released in 1918 by the German revolutionary authorities. He arrived in Warsaw on Nov. 10 and completed the disarmament of the armies of occupation. The regency council, established by the Germans, resigned in his favour and all military organizations in the country submitted to his command. He was vested with dictatorial powers, and elected unanimously chief of state, while the army conferred

on him the supreme honour of first marshal of Poland.

For Pilsudski's activities during the next years, see POLAND. His own chief interest was centred in the army, with which he was popular, and at the head of which he undertook the campaigns of 1920 in the Ukraine and against the Russian advance on Warsaw. He had, however, many difficulties with other elements in the state and in 1923 he ceased to be chief of state and retired altogether from the army. In May 1926, however, his notorious dislike of the typically Polish parliamentary wrangling and faction recalled him. He put himself again at the head of the army; a military demonstration on May 12 led to fighting in Warsaw and the resignation of the president. The national assembly, convoked by his successor, Maciej Rataj, elected Pilsudski president (May 31); but he refused the honour, and became only minister of war, while his friends Ignacy Mościcki and K. Bartel were elected respectively president and premier. Pilsudski immediately carried through legislation greatly strengthening the position of the president against the parliament; but did not dissolve the latter or establish an open dictatorship, although he constantly prorogued it. In September, indeed, he took over the premiership himself; but seldom appeared in the Sejm, even when it was sitting. The elections of March 1928 gave his adherents a majority. Nevertheless Pilsudski, who had been in bad health, resigned the premiership, retaining, however, the ministry of war, chairmanship of the army council and inspectorate-general of the force. This change made little difference to his position in Poland and the vigorous abuse of the Sejm with which he motivated his actions was not actively resented. He was again premier in 1930. For the events of his real, though veiled dictatorship, see POLAND.

PILTDOWN MAN (*Eoanthropus dawsoni*) was the name given to the remains of a supposedly primitive form of man brought to scientific notice in 1912. Apparently fossilized fragments of cranium and jawbone were found in a gravel formation at Barkham Manor, on Piltdown common near Lewes; together with these were fossil remains of extinct animals, which supported an early Pleistocene dating of the site, and worked implements of bone and flint, the latter attributable to a very early human culture (pre-Chellean). In 1926 the gravels were found to be much less ancient than supposed and in 1953 and 1954, as an outcome of more recent discoveries of fossil man and intensive re-examination, the remains were shown to be skillfully disguised fragments of a quite modern human cranium and ape (orang) jaw fraudulently introduced into the shallow gravels, as were the implements and animal bones.

Piltdown man was distinct from Pithecanthropus (Java man), Neanderthal and modern man in its combination of a large modern-looking brain case, devoid of marked eyebrow ridges, and a chimpanzee-like jaw. Sir Arthur Smith Woodward's reasons for accepting this combination as an ancestral form of man were threefold: all the remains were found very close together; the lower jaw and the brain case were of a similar brown colour and apparently in the same state of fossilization; and although the jaw itself was apelike, the molars were worn to a flatness expected in a type of human being and the canine tooth was worn in a way never found in modern apes.

Objections by British, American and French anatomists who regarded the finds as the coincidental mingling of a fossil ape and a fossil man failed to refute these arguments. Nor could it be proved that the jaw would not fit the brain case, for the critical part of the mandible was missing.

In 1915 a find at Sheffield Park two miles away again pointed to an association of simian jaw and sapiens-like cranium.

As long as the remains could be accorded a high antiquity, Piltdown man seemed a feasible alternative to *Pithecanthropus* (at that time known only from rather scanty remains) as an ancestor for modern man. From 1930 onward many more finds of Pithecanthropus, the discoveries of the still more primitive *Australopithecus*, and further examples of Neanderthal man left Piltdown man completely isolated in the evolutionary sequence. It was often supposed that it represented a specialized line which had failed to develop.

In 1949, Kenneth P. Oakley showed, by means of the fluorine dating technique, that the remains were not of great antiquity but that the jaw and brain case were of similar geological age. This provided a new reason for insisting on their association but it made Piltdown man not only morphologically anomalous but also chronologically aberrant. To deny the association meant accepting the existence of a fossil ape at an improbable date and allowing the coincidence of fossil ape and man at two different sites.

This dilemma could only be resolved by supposing that the original discovery was a forgery. The bony remains and the associated fauna were therefore analyzed intensively by anatomical and radiographic examination of the jaw, teeth and cranial fragments and by chemical investigations of the bone and stone implements. The main results showed that the jaw and cranium had differing contents of fluorine, nitrogen, uranium, organic carbon and organic water, and these differences all indicated that the jaw was of relatively recent date and the cranium somewhat older. Carbon 14 dating has confirmed these conclusions. Chemical tests revealed that the fragments had been deliberately stained, some with chromium and others with acid iron sulfate solution—neither chromium nor sulfate occur in the locality—and that although the fauna were of genuine extinct animals they were not of British provenance. X-rays demonstrated that the molar teeth were similar to those of the orang. The peculiar dental wear was the result of artificial abrasion to simulate the human mode of flat wear. One of the fragments from the second site was shown to belong to the first skull.

The outcome of this exposure has been to clarify the human sequence of evolution by removing the greatest anomaly in the fossil record. At the same time, a series of new tests has been developed which is valuable for paleontological study.

For scientific papers dealing with all aspects of the exposure, see Bulletin of the British *Museum* (Natural History), vol. 2, no. 3 and 6. For an account of the finds at Piltdown and for a discussion of the authorship of the deception and the tests carried out, see J. S. Weiner, The *Piltdown* Forgery (1955). (J. S. WE.)

PIMA, a tribe of Indians on Gila and Salt rivers in southern Arizona, closely related to the Papago, who adjoin them on the south, and to the Pima Bajo in Sonora. They practised irrigation and lived in permanent though rudely built villages. In their territory are the adobe ruins of Casa Grande and miles of prehistoric ditches. They are divided into five patrilineal totemic groups, make pottery and basketry. They differ much from the other sedentary and agricultural natives of the southwest, the Pueblos. Friendly to the whites, they long withstood the Apache, fought back the hostile Yuman tribes, and sheltered those that took refuge with them. They numbered about 6,750 in 1958. The Piman or Sonoran family, now recognized as a division of the larger Uto-Aztecan one, extended from Arizona to Jalisco, Mexico, and included the Pima, Papago, Opata, Tarahumare, Mayo, Yaqui, Tepehuane, Tepecano, Cora, Huichol and other groups. (A. L. K.)

PIMPERNEL (*Anagallis* arvensis), a small herb of the primrose family (Primulaceae), called also shepherd's clock and poor man's weatherglass, native to Europe and widely naturalized in North America from Newfoundland to the Pacific coast and southward to Mexico. It is a delicate annual with diffusely branching stems, with small, opposite, somewhat clasping, leaves, black-dotted beneath, and scarlet (rarely white) flowers, about one-fourth inch across, usually with a darker centre, opening only in bright sunshine, hence the numerous popular names.

PIN, a peg or bolt of wood or metal used for fastening or support; more commonly a small pointed and headed piece of stiff wire used to secure clothing, papers, etc.

The earliest known pins were made of bronze. Ancient Egyptian tombs have yielded specimens ranging from two to eight inches in length and finished with gold heads or with decorative gold bands circling them at the top. Both the Greeks and the Romans employed pins or brooches similar to the safety pin for fastening clothing such as the tunic and the chlamys.

In medieval Europe, early pins were skewers of wood, bone, ivory, silver, gold and brass. Elaborate metal pins of this type were made by hand and were so costly that only persons of wealth could afford them. The wooden skewer remained the common pin

of the poor until the middle of the 16th century.

Pins of drawn iron wire were made during the 15th century, and by the latter part of that century the manufacture of wire pins was well established, particularly in France. The best quality pins of this period were made of brass. Despite early restrictive legislation in England, the demand for pins in that country was met largely by French makers, a condition that prevailed until about 1626, when John Tilsby, of Gloucestershire, Eng., established domestic manufacture on a firm basis.

Pins of this period were commonly made by coiling a wire, somewhat thinner than that used for the pins, around a spit on a lathe and cutting it into sections of two coils each. These coils were annealed (softened), attached to the ends of pins cut to proper length and pressed in a die to secure them to the pins. The head was then soldered onto each pin and the other end was sharpened, after which the pin mas straightened and blanched.

Machine-made pins were introduced during the early part of the 19th century. Pinmaking machines were patented in England and the United States, and in both countries mechanical production of pins was established on a profitable commercial basis in the 1830s. In the U.S., the improved machines of Dr. John Ireland Howe were the basis for a successful manufacturing company he founded at New York, while Daniel Foote-Taylen, of Birmingham, Eng., profitably applied the patents of Lemuel W. Wright.

Subsequently many machines for making pins were developed. In general, all functioned in the following manner: stiff pin wire was drawn into the machine from a hank wound on a drum and was straightened by rapidly revolving rolls. A pin-length of the wire was gripped by a set of jaws so that the end of the wire extended a little beyond the jaws. This pin-length was struck several times by a header-die to form the head of the pin, and the pin-length was cut off, carried along a shaft and passed over a series of files or cutters to point the end of the pin. The completed pins were cleaned by being rapidly tumbled in sawdust and then treated to give them a thin coating of tin. A sticking device thrust the finished pins through crimped papers. These pinmaking machines were so efficient that advancement to completely automatic manufacturing methods required few innovations in function or design.

(E. L. Y.)

PINACEAE. This family of conifers is composed of trees (rarely shrubs) of north temperate regions in all parts of the world. Many important timber trees are classified here, and wood for paper pulp, oils and resins also derive from the Pinaceae. The trees are much cultivated for ornament. Modern classifications admit nine genera: *Abies* (fir), *Keteleeria, Pseudotsuga* (Douglas fir), *Tsuga* (hemlock), *Picea* (spruce), *Pseudolarix* (golden larch), *Larix* (tamarack, larch), *Cedrus* (true cedar) and *Pinus* (true pine). Fir and true pines extend into lower latitudes at higher elevations, with the latter reaching Central America. The Pinaceae are monoecious (having male and female organs in the same individual) and have needlelike leaves, solitary, in fascicles, or on specialized short branches. The staminate or pollen-bearing cones are solitary or clustered, and consist of numerous spirally arranged scales, each bearing two pollen sacs. The ovulate or seed-bearing cones are compound; the numerous spirally arranged scales are free from the subtending bracts and bear two inverted ovules on their upper side. In the true pines the bract disappears in the mature cone. The embryogeny of the Pinaceae is complex and both simple and cleavage polyembryony occur. Only one of the many embryos thus formed survives to maturity. There are two to many seed leaves, or cotyledons.

See also CONIFERS.,

(R. W. H.)

PINAR DEL RIO, a province and its capital city in the westernmost section of Cuba. The population of the province in 1953 was 448,422; area, 5,212 sq.mi. Low ranges form the backbone of the long, narrow province. The sandy soils of the southern plain produce some of the world's best tobacco. Pine forests have been much exploited. Copper at Matahambre has been mined since 1913.

The city of Pinar del Rio was founded about 1775 and was given the official name of Nueva Filipina in 1800 as the capital of the western jurisdiction of Cuba. Its importance dates from about 1830 with the development of the tobacco industry of the Vuelta Abajo region. The population of the town was 3,000 in 1865 and reached 9,000 in 1900. With completion of the railway from Havana, 110 mi. distant, came the development of the city as a commercial centre of a large rural area. In addition to high-quality cigar tobacco, the region produces sugar cane, rice, pineapples, coffee and livestock.

The city is situated in the hilly pinelands at about 160 ft. elevation near the base of the Sierra de los Organos, whose steep sides of porous limestone give the appearance of giant haystacks. The city is bordered on the east by the arroyo Yagruma, a tributary of the Guamá river. Its industries include the manufacture of cigars, cigarettes and furniture. Since the completion of the Central highway in 1931 with Pinar del Rio as the western terminus, the city grew from 20,000 to a population of 38,885 in 1953.

(D. R. D.)

PINCHBECK. When brass, the familiar alloy of copper and zinc, contains 12% to 15% of the latter metal, its colour simulates that of gold. In 1732, a London clockmaker, Christopher Pinchbeck, introduced a brass containing about 15% of zinc for the manufacture of imitation gold jewellery, and the yellow metal bore his name; hence the use of the term "pinchbeck" for flash or imitation jewellery. *(See* BRASS.)

PINCHOT, GIFFORD (1865–1946), pioneer of U.S. professional forestry and prominent public official, was born at Simbury, Conn., on Aug. 11, 1865. He graduated at Yale in 1889 and afterward studied at the École Nationale Forestière, Nancy, France, and for briefer periods in Switzerland, Germany and Austria. Upon his return he began the first systematic forestry work in the United States, in the Vanderbilt forest, at Biltmore, N.C., in 1892. In 1896 he was made a member of the national forest commission that worked out the plan of U.S. forest reserves, and in 1897 he became confidential forest agent to the secretary of the interior, to examine and report upon the reserves. In 1898 he was appointed chief of the division, later the bureau of forestry, and then the forest service in the department of agriculture, which office he held under presidents McKinley, Roosevelt and Taft until 1910. During the period of his administration the entire forest service system and administrative machinery was built up, and Pinchot's enthusiasm and publicity work did much for the conservation movement in general. He also served as a member of the committee on public lands, 1903, and the inland waterways commission, 1907. In 1908 he became chairman of the national conservation commission, and in 1910 president of the national conservation association. He founded the Yale school of forestry at New Haven, as well as the Yale summer school of forestry at Milford, Pa., and in 1903 became professor of forestry at Yale. His books on forestry included *A Primer of Forestry* (1899) and *The Training of a Forester* (1917, 4th ed. rev. 1937). He was appointed state forester of Pennsylvania in 1920 and began a systematic administration of the forest areas of that state. With Theodore Roosevelt he helped to found the Bull Moose party in 1912. From 1923 to 1927 and from 1931 to 1935 he was governor of Pennsylvania, and in his first term forced a reorganization of the state government and the establishment of a budget system. He was also able, in 1923, to settle an important anthracite coal strike by arbitration. He died in New York, N.Y., Oct. 4, 1946. His autobiography is *Breaking New Ground* (1947).

PINCKNEY, CHARLES (1757–1824), U.S. political leader and diplomat, was born Oct. 26, 1757, in Charleston, S.C. He served as a lieutenant at the siege of Savannah, Ga., was captured by the British at Charleston and was held prisoner until June 1781. After the war, Pinckney served in the Continental Congress (1784–87) where he opposed abandonment of the right of navigation on the Mississippi, supported a more effective revenue system and urged a convention to revise the Articles of Confederation. As a member of the Constitutional Convention of 1787 Pinckney proposed a detailed plan of government generally referred to as the Pinckney plan. The original Pinckney draft disappeared but it contained 31 or 32 provisions that were incorporated into the new federal constitution. Pinckney probably had as large a share in determining the style, form and content of the constitution

as any one individual. He supported the ratification of the constitution in South Carolina, presided over the convention (1790) which remodeled the South Carolina constitution and as governor (1789–92) guided the early steps of adjustment between the state and federal government.

Pinckney began his political career as a Federalist but (1791) transferred his allegiance to the Jeffersonian Republican party. He served that party in the South Carolina legislature (1792–96, 1810–14), as governor of the state (1796–98, 1806–08) and as U.S. senator (1798–1801) and U.S. representative (1819–21). He supported amendments to the state constitution that gave greater representation to the back country and established white manhood suffrage. In 1798 he opposed Federalist policies, thus estranging his cousins Charles Cotesworth Pinckney and Thomas Pinckney (*qq.v.*), and in 1820 bitterly assailed the proposed restrictions on slavery in Missouri.

As U.S. minister to Spain (1801–05), Pinckney negotiated a convention providing for a joint tribunal to settle spoliation claims and the restoration of the right of deposit at New Orleans. He also won Spain's reluctant consent to Napoleon's sale of Louisiana, but the incorporation of West Florida into a United States custom district brought failure to his mission.

Pinckney possessed a genius that dazzled his supporters, who looked upon him as a demigod, and outraged his opponents, who called him a spoilsman and demagogue. He died at Charleston, S.C., on Oct. 29, 1824.

See A. J. Bethea, *The Contribution of Charles Pinckney to the Formation of the American Union* (1937). (F. M. G.)

PINCKNEY, CHARLES COTESWORTH (1746–1825), U.S. soldier, statesman and diplomat, was born in Charleston, S.C., Feb. 25. 1746. With his younger brother Thomas he was educated in England at Oxford university and the Middle Temple, and at the French military academy at Caen.

Pinckney entered public service in 1769 as a member of the South Carolina assembly. He served in the first South Carolina provincial congress in 1775, on the council of safety, as chairman of the committee that drafted the plan of government for the colony and later in both houses of the South Carolina legislature. During the American Revolution he served as aide to General Washington at Brandywine and Germantown, Pa., and later commanded a regiment at Savannah, Ga. He was taken prisoner in 1780 at the fall of Charleston, was sent to Philadelphia, Pa., and exchanged in 1782 and was promoted to brigadier general in 1783.

In the Constitutional Convention of 1787, where he served with his cousin Charles Pinckney (*q.v.*), he opposed religious tests for office, suggested 1808 as the date to end the slave trade and favoured senate ratification of treaties as a check on the executive. He was one of the ablest defenders of the constitution in the South Carolina ratification convention. He was the architect of the provision in the state constitution of 1790 that provided two seats of government, one at Charleston and the other at Columbia, S.C.

When appointed U.S. minister to France in 1796 he was refused recognition by the French Directory and fled to Amsterdam, Holland. He returned to Paris the following year as a member of a commission that included John Marshall and Elbridge Gerry. When one of the group of French negotiators (later referred to in the correspondence as "X, Y and Z") suggested that the U.S. representatives offer a gift, Pinckney is said to have replied, "No! No! Not a sixpence!" (See XYZ CORRESPONDENCE.) The mission was a failure and an undeclared war between France and the U.S. ensued. Pinckney returned home and was commissioned a major general.

The unsuccessful Federalist candidate for vice-president in 1800 and for president in 1804 and 1808, Pinckney spent his later years in successful law practice. He also aided in the establishment of the South Carolina college (1801) and served as president general of the Society of Cincinnati (see CINCINNATI, SOCIETY OF THE) from 1805 until his death on Aug. 16. 1825.

See C. C. Pinckney, *Life of General Thomas Pinckney* (1895). (F. M. G.)

PINCKNEY, THOMAS (1750–1828), U.S. soldier, diplomat and politician, was born Oct. 23, 1750, in Charleston, S.C. With his older brother Charles Cotesworth Pinckney he was educated in England at Oxford university and the Middle Temple, and at the French military academy at Caen. He was admitted to the bar in 1774 in South Carolina and entered military service at the outbreak of the American Revolution. He was engineer at Fts. Johnson and Moultrie and served in the Florida campaign. After being wounded at Camden, S.C., and captured, he was sent to Philadelphia, Pa., and eventually exchanged.

Pinckney's plantation home, Auckland, was burned by British troops in 1779 and his slaves and livestock were carried away. After the war, Pinckney turned to law to recoup his fortune. He served as governor of South Carolina from 1787 to 1789 and as president of the state convention that ratified the federal constitution in 1788.

Pinckney was U.S. minister to Great Britain (1792–96) and envoy extraordinary to Spain (1795). Persona non grata in Britain, he bombarded the foreign office with demands and protests that were generally ignored. Bold, persistent and yet tactful in dealing with Manuel Godoy of Spain, Pinckney negotiated the treaty of San Lorenzo el Real (1796) whereby Spain surrendered all claim to territory east of the Mississippi river and north of 31° N. latitude, granted freedom of navigation on the Mississippi, extended the right of deposit at New Orleans and agreed to a joint settlement of claims and restriction of Indian depredations.

Pinckney was the Federalist candidate for vice-president in 1796 and member of the U.S. house of representatives (1797–1801). State rights in his views, he voted against the Alien and Sedition laws. As a major general in the War of 1812 he saw little active service but was with Gen. Andrew Jackson at the war's end. A scientific planter, Pinckney built dikes to reclaim salt marshes for rice culture, and imported English and Italian cattle to improve his dairy cattle and work oxen. He was a frequent contributor to The Southern Agriculturist. He served as president general of the Society of Cincinnati (see CINCINNATI, SOCIETY OF THE) from 1825 until his death on Nov. 2, 1828.

See C. C. Pinckney, *Life of General Thomas Pinckney* (1895). (F. M. G.)

PIN CLOVER (Erodium *cicutarium*), an annual herb of the geranium family (Geraniaceae), called also hemlock stork's-bill, red filaree and pinweed. It is widespread as a weed in the old world, and is extensively naturalized in North America from Nova Scotia to the Pacific coast, being especially abundant from Texas and Colorado westward to California and Washington, where it is highly esteemed as a forage plant. The larger white-stemmed pin clover, musk clover or filaree (E. moschatus), native to Europe and locally naturalized in the United States, has become abundant in California valleys.

PINDAR (Gr. Πίνδαρος, *c.* 522–443 B.C.), the great lyric poet of ancient Greece, was born at Cynoscephalae, in Boeotia, at the time of the Pythian games (fr. 175, Bergk⁴, 193)[1], which is taken by Bockh to be 522 B.C. He would thus be about thirty-four years younger than Simonides of Ceos. He was the son of Daiphantus and Cleodice (or Cleidice). The clan of the Aegidae—tracing their line from the hero Aegeus—belonged to the "Cadmean" element of Thebes; *i.e.*, to the elder nobility whose supposed date went back to the days of the founder Cadmus. Pindar stood, that is, within the circle of those families for whom the heroic myths were domestic records. He had a personal link with the memories which everywhere were most cherished by Dorians, no less than with those which appealed to men of "Cadmean" or of Achaean stock. And the wide ramifications of the Aegidae throughout Hellas rendered it peculiarly fitting that a member of that illustrious clan should celebrate the glories of many cities in verse which was truly Panhellenic.

Life.—Pindar is said to have received lessons in flute-playing from one Scopelinus at Thebes, and afterwards to have studied at Athens under the musicians Apollodorus (or Agathocles) and Lasus of Hermione. In his youth, as the story went, he was defeated in a poetical contest by the Theban Corinna—who, in reference to his profuse employment of Theban mythology, is

[1] The references are to the edition of Pindar by C. A. M. Fennell (1893–99), and the fourth edition of Bergk's *Poetae lyrici graeci.*

said to have advised him "to sow with the hand, not with the sack." There is an extant fragment in which Corinna reproves another Theban poetess, Myrtis, "for that she, a woman, contended with Pindar" (ὅτι βανὰ φοῦσ' ἔβα Πινδάροιο τοτ' ἔριν) —a sentiment which hardly fits the story of Corinna's own victory. The facts that stand out from these meagre traditions are that Pindar was precocious and laborious. Preparatory labour of a somewhat severe and complex kind was, indeed, indispensable for the Greek lyric poet of that age. Lyric composition demanded studies not only in metre but in music, and in the adaptation of both to the intricate movements of the choral dance (ὀρχηστική).

Several passages in Pindar's extant odes glance at the long technical development of Greek lyric poetry before his time, and at the various elements of art which the lyrist was required to temper into a harmonious whole (see, e.g., Ol. iii. 8, vi. 91, xiii. 18, xiv. 15; Pyth. xii. 23, etc.). The earliest ode which can be dated (Pyth. x.) belongs to the twentieth year of Pindar's age (502 B.C.); the latest (*Olymp.* v.) to the seventieth (452 B.C.)[1]. He visited the court of Hiero at Syracuse; Theron, the despot of Acragas, also entertained him; and his travels perhaps included Cyrene. Tradition notices the special closeness of his relations with Delphi: "He was greatly honoured by all the Greeks, because he was so beloved of Apollo that he even received a share of the offerings; and at the sacrifices the priest would cry aloud that Pindar come in to the feast of the god"[2]. His wife's name was Megacleia (another account says Timoxena, but this may have been a second wife), and he had a son named Daiphantus and two daughters, Eumetis and Protomache. He is said to have died at Argos, at the age of seventy-nine, in 443 B.C.

Piety.—Among the Greeks of his own and later times Pindar was pre-eminently distinguished for his piety towards the gods. He tells us that, "near to the vestibule" of his house (Pyth. iii. 78), choruses of maidens used to dance and sing by night in praise of the Mother of the Gods (Cybele) and Pan—deities peculiarly associated with the phrygian music of the flute, in which other members of Pindar's family besides the poet himself are said to have excelled. A statue and shrine of Cybele, which he dedicated at Thebes, were the work of the Theban artists, Aristomedes and Socrates. He also dedicated at Thebes a statue to Hermes Agoraios, and another, by Calamis, to Zeus Ammon. The latter god claimed his especial veneration because Cyrene, one of the homes of his Aegid ancestry, stood "where Zeus Ammon hath his seat," *i.e.*, near the oasis and temple (Pyth. iv. 16). The author of one of the Greek lives of Pindar says that, "when Pausanias the king of the Lacedaemonians was burning Thebes, some one wrote on Pindar's house, 'Burn not the house of Pindar the poet'; and thus it alone escaped destruction." This incident, of which the occasion is not further defined, has been regarded as a later invention[3].

Better attested, at least, is the similar clemency of Alexander the Great, when he sacked Thebes one hundred and eight years after the traditional date of Pindar's death (335 B.C.). He spared only (1) the Cadmeia, or citadel, of Thebes (thenceforth to be occupied by a Macedonian garrison); (2) the temples and holy places; and (3) Pindar's house. While the inhabitants were sold into slavery, exception was made only of (1) priests and priestesses; (2) persons who had been connected by private ξενία with Philip or Alexander, or by public ξενία with the Macedonians; (3) Pindar's descendants. It is probable enough, as Dio Chrysostom suggests (ii. 33), that Alexander was partly moved by personal gratitude to a poet who had celebrated his ancestor Alexander I. of Macedon. But he must have been also, or chiefly, influenced by the sacredness which in the eyes of all Hellenes surrounded Pindar's memory, not only as that of a great national poet, but also as that of a man who had stood in a specially close relation to the gods, and, above all, to the Delphian Apollo.

Praise of Athens.—During the second half of Pindar's life, Athens was rising to that supremacy in literature and art which was to prove more lasting than her political primacy. Pindar did not live to see the Parthenon, or to witness the mature triumphs of Sophocles; but he knew the sculpture of Calamis, and he may have known the masterpieces of Aeschylus. It is interesting to note the feeling of this great Theban poet, who stands midway between Homeric epos and Athenian drama, towards the Athens of which Thebes was so often the bitterest foe, but with which he himself had so large a measure of spiritual kinship. A few words remain from a dithyramb in which he paid a glowing tribute to those "sons of Athens" who "laid the shining foundations of freedom" (παῖδες Ἀθαναίων ἐβάλοντο φαεννὰν κρηπῖδ' ἐλευθερίας, fr. 55, Bergk[4], 77), while Athens itself is thus invoked: ὦ ταὶ λιπαραὶ καὶ ἰοστέφανοι καὶ ἀοίδιμοι, Ἑλλάδος ἔρεισμα, κλειταὶ Ἀθᾶναι, δαιμόνιον πτολίεθρον (fr. 54, Bergk[4], 76). Isocrates, writing in 353 B.C., states that the phrase Ἑλλάδος ἔρεισμα, "stay of Hellas," so greatly gratified the Athenians that they conferred on Pindar the high distinction of προξενία (*i.e.*, appointed him honorary consul, as it were—for Athens at Thebes), besides presenting him with a sum of money (*Antidosis*, 166).

One of the letters of the pseudo-Aeschines (Ep. iv.) gives an improbable turn to the story by saying that the Thebans had fined Pindar for his praise of Athens, and that the Athenians repaid him twice the sum[4]. The notice preserved by Isocrates—less than one hundred years after Pindar's death—is good warrant for the belief that Pindar had received some exceptional honours from Athens. Pausanias saw a statue of Pindar at Athens, near the temple of Ares (i. 8, 4). Besides the fragment just mentioned, several passages in Pindar's extant odes bespeak his love for Athens. Its name is almost always joined by him with some epithet of praise or reverence. In alluding to the great battles of the Persian wars, while he gives the glory of Plataea to the Spartans, he assigns that of Salamis to the Athenians (Pyth. i. 76). In celebrating (Pyth. vii.) the Pythian victory of the Athenian Megacles, he begins thus: "Fairest of preludes is the renown of Athens for the mighty race of the Alcmaeonidae. What home, or what house, could I call mine by a name that should sound more glorious for Hellas to hear?" (Cf. also Nem. v. 49.)

Pindar's versatility as a lyric poet is one of the characteristics remarked by Horace (Odes, iv. 2), and is proved by the fragments, though the poems which have come down entire represent only one class of compositions—the *Epinicia*, or odes of victory, commemorating successes in the great games. The lyric types to which the fragments belong, though it cannot be assumed that the list is complete, are at least numerous and varied.

Fragments.—(1) Ὕμνοι, Hymns to deities—as to Zeus Ammon, to Persephone, to Fortune. The fragmentary ὕμνος entitled Θηβαίοις seems to have celebrated the deities of Thebes. (2) Παιᾶνες, paeans, expressing prayer or praise for the help of a protecting god, especially Apollo, Artemis or Zeus. (3) Διθύραμβοι, Dithyrambs, odes of a lofty and impassioned strain, sung by choruses in honour of Dionysus. (4) Προσόδια, *Processional* Songs, choral chants for worshippers approaching a shrine. (5) Παρθένια, *Choral* Songs for Maidens.

(6) Ὑπορχήματα, Choral Dance-Songs, adapted to a lively movement, used from an early date in the cult of Apollo, and afterwards in that of other gods, especially Dionysus. To this class belongs one of the finest fragments (84, Bergk[4], 107), written for the Thebans in connection with propitiatory rites after an eclipse of the sun, probably that of the 30th of April 463 B.C. (7) Ἐγκώμια, Songs *of* Praise (for men, while ὕμνοι were for gods), to be sung by a festal company. (8) Σκόλια, Festal Songs. The usual sense of σκόλιον is a drinking-song, taken up by one guest after another at a banquet. But Pindar's σκόλια were choral and antistrophic. One was to be sung at Corinth by a chorus of the ἱερόδουλοι attached to the temple of Aphrodite Ourania, when a certain Xenophon offered sacrifice before going to compete at Olympia. Another brilliant fragment, for Theoxenus of Tenedos, has an erotic character.

(9) Θρῆνοι, Dirges, to be sung with choral dance and the music of the flute, either at the burial of the dead or in commemorative rituals. Some of the most beautiful fragments belong to this class

[1] According to others, his latest poem is the eighth Pythian ode, 450 or 446.

[2] Πινδάρου γένος, in ed. Ald.

[3] A. Schafer, *Demosthenes und* seine *Zeit*. iii. 119.

[4] Compare Jebb, *Attic Orators*, ii. 143.

(106–110, Bergk[4], 129–133). A number of small fragments, whch cannot be certainly classified, are usually given as ἐξ ἀδήλων εἰδῶν, "of uncertain class."

The **Epinicia.**—The ἐπινίκια (sc. μέλη), or ἐπινίκιοι (sc. ὕμνοι), "Odes of Victory," form a collection of forty-four odes, traditionally divided into four books, answering to the four great festivals: (1) Ὀλυμπιονῖκαι (sc. ὕμνοι): fourteen odes for winners of the wild ohve-wreath in the Olympian games, held at Olympia in honour of Zeus once in four years; (2) Πυθιονῖκαι: twelve odes for winners of the laurel-wreath in the Pythian games held at Delphi in honour of Apollo, once in four years, the third of each Olympiad; (3) Νεμεονῖκαι: eleven odes for winners of the pine-wreath in the Nemean games, held at Nemea, in honour of Zeus, once in two years, the second and fourth of each Olympiad; and (4) Ἰσθμιονῖκαι: seven odes for winners of the parsley wreath in the Isthmian games, held at the Isthmus of Corinth, in honour of Poseidon, once in two yeers, the first and third of each Olympiad. The Greek way of citing an ode is by the nomin. *plur.* followed by the numeral, *e.g.*, "the ninth Olympian" is Ὀλυμπιονῖκαιθ'. The chronological range of the collection (so far as ascertainable) is 502 B.C. (Pyth. x.) to 452 B.C. (01. v.).

The general characteristics of the odes may be briefly considered under the following heads: (1) language; (2) treatment of theme; (3) sentiment—religious, moral and political; (4) relation to contemporary art.

Diction.—The diction of Pindar is distinct in character from that of every other Greek poet, being almost everywhere marked by the greatest imaginative boldness. Thus (a) metaphor is used even for the expression of common ideas, or the translation of familiar phrases, as when a cloak is called (01. ix. 97) "a warm remedy for winds." (b) Images for the highest excellence are drawn from the farthest limits of travel or navigation, or from the fairest of natural objects; as when the superlative hospitality of a man who kept open house all the year round is described by saying, "far as to Phasis was his voyage in summer days, and in winter to the shores of Nile" (*Isthm.* ii. 41); or when Olympia, the "crown" or "flower" of festivals, is said to be excellent as water, bright as gold, brilliant as the noonday sun (*Ol.* i. ad *init.*). This trait might be called the *Pindaric imagery of* the *superlative.* (c) Poetical inversion of ordinary phrase is frequent; as, instead of, "he struck fear into the beasts," "he gave the beasts to fear" (Pyth. v. 56). (d) The efforts of the poet's genius are represented under an extraordinary number of similitudes, borrowed from javelin-throwing, chariot-driving, leaping, rowing, sailing, ploughing, building, shooting with the bow, sharpening a knife on a whetstone, mixing wine in a bowl, and many more. (e) Homely images, from common life, are not rare; as from account-keeping, usury, sending merchandise over sea, the σκυτάλη or secret dispatch, etc. And we have such homely proverbs as, "he hath his foot in this shoe," *i.e.*, stands in this case (*Ol.* vi. 8). (f) The natural order of words in a sentence is often boldly deranged, while, on the other hand, the syntax is seldom difficult. (g) Words not found except in Pindar are numerous, many of these being compounds which (like ἐναρίμβροτος, καταφυλλοροεῖν, etc.) suited the dactylic metres in their Pindaric combinations. Horace was right in speaking of Pindar's "nova verba," though they were not confined to the "audaces dithyrambi."

Subjects.—The actual victory which gave occasion for the ode is seldom treated at length or in detail—which, indeed, only exceptional incidents could justify. Pindar's method is to take some heroic myth, or group of myths, connected with the victor's city or family, and, after a brief prelude, to enter on this, returning at the close, as a rule, to the subject of the victor's merit or good fortune, and interspersing the whole with moral comment. Thus the fourth Pythian is for Arcesilaus, king of Cyrene, which was said to have been founded by men of Thera, descendants of one of Jason's comrades. Using this link, Pindar introduces his splendid narrative of the Argonauts. Many odes, again, contain shorter mythical episodes—as the birth of Iamus (01. vi.), or the vision of Bellerophon (01. xiii.)—which form small pictures of masterly finish and beauty. Particular notice is due to the skill with which Pindar often manages the return from a mythical digression to his immediate theme. It is bold and swift, yet is not felt as harshly abrupt—justifying his own phrase at one such turn—καί τινα οἶμον ἴσαμι βραχύν (Pyth. iv. 247).

Religious, Moral and Political Sentiment.—a. The religious feeling of Pindar is strongly marked in the odes. "From the gods are all means of human excellence." He will not believe that the gods, when they dined with Tantalus, ate his son Pelops; rather Poseidon carried off the youth to Olympus. That is, his reason for rejecting a scandalous story about the gods is purely religious, as distinct from moral; it shocks his conception of the divine dignity. With regard to oracles, he inculcates precisely such a view as would have been most acceptable to the Delphic priesthood, viz., that the gods do illumine their prophets, but that human wit can foresee nothing which the gods do not choose to reveal. A mystical doctrine of the soul's destiny after death appears in some passages (as 01. ii. 66 seq.). Pindar was familiar with the idea of metempsychosis (cf. *ibid.* 68), but the attempt to trace Pythagoreanism in some phrases (Pyth. ii. 34, iii. 74) appears unsafe. The belief in a fully conscious existence for the soul in a future state, determined by the character of the earthly life, entered into the teaching of the Eleusinian and other mysteries. Comparing the fragment of the Θρῆνος (114, Bergk[4], 137), we may probably regard the esoteric element in Pindar's theology as due to such a source.

b. The moral sentiment pervading Pindar's odes rests on a constant recognition of the limits imposed by the divine will on human effort, combined with strenuous exhortation that each man should strive to reach the limit allowed in his own case. Native temperament (φυή) is the grand source of all human excellence (ἀρετή), while such excellences as can be acquired by study (διδακταὶ ἀρεταί, *Ol.* ix. 100) are of relatively small scope—the sentiment, we may remark, of one whose thoughts were habitually conversant with the native qualities of a poet on the one hand and of an athlete on the other. The elements of ὑγίεις ὄλβος—"sane happiness," such as has least reason to dread the jealousy of the gods—are substance sufficing for daily wants and good repute (εὐλογία). He who has these should not "seek to be a god." "Wealth set with virtues" (πλοῦτος ἀρεταῖς διδαιδαλμένος), as gold with precious gems, is the most fortunate lot, because it affords the amplest opportunities for honourable activity. Pindar does not rise above the ethical standard of an age which said, "love thy friend and hate thy foe" (cf. Pyth. ii. 83; Isthm. iii. 65). But in one sense he has a moral elevation which is distinctively his own; he is the glowing prophet of generous emulation and of reverent self-control.

c. The political sentiments of the Theban poet are suggested by Pyth. xi. 52; "In polities I find the middle state crowned with more enduring good; therefore praise I not the despot's portion; those virtues move my zeal which serve the folk." If in Pyth. ii. 87, a democracy is described as ὁ λάβρος στρατός, "the raging crowd," it is to be noted that the ode is for Hiero of Syracuse, and that the phrase clearly refers to the violence of those democratic revolutions which, in the early part of the 5th century B.C., more than once convulsed Sicilian cities. At Thebes, after the Persian wars, a "constitutional oligarchy" (ὀλιγαρχία ἰσόνομος, Thuc. iii. 62) had replaced the narrower and less temperate oligarchy of former days (δυναστεία of μετὰ νόμων); and in this we may probably recognize the phase of Greek political life most congenial to Pindar. He speaks of a king's lot as unique in its opportunities (01. i. 113); he sketches the character of an ideal king (Pyth. iii. 71); but nothing in his poetry implies liking for the τυραννίς as a form of government. Towards the Greek princes of Sicily and Cyrene his tone is ever one of manly independence; he speaks as a Greek citizen whose lineage places him on a level with the proudest of the Dorian race, and whose office invests him with an almost sacred dignity. In regard to the politics of Hellas at large, Pindar makes us feel the new sense of leisure for quiet pursuits and civilizing arts which came after the Persian wars. He honours "Tranquillity, the friend of cities" (Ἀσυχία φιλόπολις, 01. iv. 16). The epic poet sang of wars: Pindar celebrates the "rivalries of peace."

Love of Natural **Art.**—Pindar's genius was boldly original; at the same time he was an exquisite artist. "Mine be it to invent

new strains, mine the skill to hold my course in the chariot of the Muses; and may courage go with me, and power of ample grasp" (*Ol.* ix. 80). Here we see the exulting sense of inborn strength; in many other places we perceive the feeling of conscious art —as in the phrase δαιδάλγειν, so apt for his method of inlaying an ode with mythical subjects, or when he compares the opening of a song to the front of a stately building (*Ol.* vi. 3). Pindar's sympathy with external nature was deeper and keener than is often discernible in the poetry of his age. It appears, for example, in his welcome of the season when "the chamber of the hours is opened, and delicate plants perceive the fragrant spring" (*fr.* 53, Bergk⁴, 75); in the passage where Jason invokes "the rushing strength of waves and winds, and the nights, and the paths of the deep" (*Pyth.* iv. 195); in the lines on the eclipse of the sun (*fr.* 84, Bergk⁴, 107); and in the picture of the eruption, when Etna, "pillar of the sky, nurse of keen snow all the year," sends forth "pure springs of fire unapproachable" (*Pyth.* i. 20). The poet's feeling for colour is often noticeable—as in the beautiful story of the birth of Iamus—when Evadne lays aside her silver pitcher and her girdle of scarlet web; the babe is found, "its delicate body steeped in the golden and deep purple rays of pansies" (*Ol.* vi. 55).

Relation to Art.—The spirit of art, in every form, is represented for Pindar by χάρις—"the source of all delights to mortals" (*Ol.* i 30)—or by the personified Charites (Graces). The Charites were often represented as young maidens, decking themselves with early flowers—the rose, in particular, being sacred to them as well as to Aphrodite. In Pindar's mind, as in the old Greek conception from which the worship of the Charites sprang, the instinct of beautiful art was inseparable from the sense of natural beauty. The period from 500 to 460 B.C., to which most of Pindar's extant odes belonged, marked a stage in the development of Greek sculpture. The schools of Argos, Sicyon and Xegina were effecting a transition from archaic types to the art which was afterwards matured in the age of Pheidias. Olympia forms the central link between Pindar's poetry and Greek sculpture. From about 560 B *C.* onwards sculpture had been applied to the commemoration of athletes, chiefly at Olympia.

In a striking passage (*Nem.* v. ad. *init.*) Pindar recognizes sculpture and poetry as sister arts employed in the commemoration of the athlete, and contrasts the merely local effect of the statue with the wide diffusion of the poem. "No sculptor I, to fashion images that shall stand idly on one pedestal for aye; no, go thou forth from Aegina, sweet song of mine, on every freighted ship, on each light bark." Many particular subjects were common to Pindar and contemporary sculpture. Thus (1) the sculptures on the east pediment of the temple at Aegina represented Heracles coming to seek the aid of Telamon against Troy—a theme brilliantly treated by Pindar in the fifth Isthmian; (2) Hiero's victory in the chariot-race was commemorated at Olympia by the joint work of the sculptors Onatas and Calamis; (3) the Gigantomachia, (4) the wedding of Heracles and Hebe, (5) the war of the Centaurs with the Lapithae, and (6) a contest between Heracles and Apollo, are instances of mythical material treated alike by the poet and by sculptors of his day.

Place in Greek Literature.—In the development of Greek lyric poetry two periods are broadly distinguished. During the first, from about 600 to 500 B.C., lyric poetry is local or tribal—as Alcaeus and Sappho write for Lesbians, Alcman and Stesichorus for Dorians. During the second period, which takes its rise in the sense of Hellenic unity created by the Persian wars, the lyric poet addresses all Greece. Pindar and Simonides are the great representatives of this second period, to which Bacchylides, the nephew of Simonides, also belongs. These, with a few minor poets, are classed by German writers as *die universalen Meliker*. The Greeks usually spoke, not of "lyric," but of "melic" poetry (ie., meant to be sung, and not, like the epic, recited); and "universal melic" is lyric poetry addressed to all Greece. But Pindar is more than the chief extant lyrist. Epic, lyric and dramatic poetry succeeded each other in Greek literature by a natural development. Each of them was the spontaneous utterance of the age which brought it forth.

In Pindar we can see that phase of the Greek mind which produced Homeric epos passing over into the phase which produced Athenian drama. His spirit is often thoroughly dramatic—witness such scenes as the interview between Jason and Pelias (*Pyth.* iv.), the meeting of Apollo and Chiron (*Pyth.* ix.), the episode of Castor and Polydeuces (*Nem.* x.), the entertainment of Heracles by Telamon (*Isthm.* v.). Epic narrative alone was no longer enough for the men who had known that great trilogy of national life, the Persian invasions; they longed to see the heroes moving and to hear them speaking. The poet of Olympia, accustomed to see beautiful forms in vivid action or vivid art, was well fitted to be the lyric interpreter of the new dramatic impulse. Pindar has more of the Homeric spirit than any Greek lyric poet known to us. On the other side, he has a genuine, if less evident, kinship with Aeschylus and Sophocles. Pindar's work, like Olympia itself, illustrates the spiritual unity of Greek art.

The fact that certain glosses and lacunae are common to all our mss. of Pindar make it probable that these mss. are derived from a common archetype. Now the older scholia on Pindar, which appear to have been compiled mainly from the commentaries of Didymus (*c.* 15 B.C.), sometimes presuppose a purer text than ours. But the compiler of these older scholia lived after Herodian (A.D. 160). The archetype of our mss., then, cannot have been older than the end of the 2nd century. Our mss. fall into two general classes: (1) the older, representing a text which, though often corrupt, is comparatively free from interpolations; (2) the later, which exhibit the traces of a Byzantine recension, in other words, of lawless conjecture, down to the 14th or 15th century. To the first class belong Parisinus 7, breaking off in *Pyth.* v.; Ambrosianus 1, which has only *01.* i.–xii.; Mediceus 2; and Vaticanus 2—the two last-named being of the highest value. The editio princeps is the Aldine (Venice, 1513). A modern study of Pindar may be almost said to have begun with C. G. Heyne's edition (1773). Hermann did much to advance Pindaric criticism. But August Bockh (1811–21), who was assisted in his commentary by L. Dissen, is justly regarded as the founder of a scientific treatment of the poet. The edition of Theodor Bergk (*Poetae lyrici graeci,* 1878 new ed. by O. Schroder, 1900) is marked by considerable boldness of conjecture, as that of Tycho Mommsen (1864) by a sometimes excessive adherence to mss. A recension by W. Christ has been published in Teubner's series (2nd ed., 1896), also with Prolegomena and commentary (1896); and by O. Schroder (1908). The complete edition of J. W. Donaldson (1841) has many merits; but that of C. A. M. Fennel1 (1879–83; new ed., 1893–99) is better adapted to the needs of English students. The *Olympia* and *Pythia* have been edited by B. L. Gildersleeve (1885), the *Nemea* and *Isthmia* by J. *B.* Bury (1890–92); the *Scholia* by E. Abel (1890, unfinished) and A. B. Brachmann (1903). There is a special lexicon by J. Rumpel (1883). The translation into English prose by Ernest Myers (2nd ed., 1883) is excellent; verse translation by T. C. Baring (1875), and of the *Olympian Odes* by Cyril Mayne (1906), also the edition in the *Loeb Classical Library,* with Eng. trans. by J. Sandys (1915). Pindar's metres have been analysed by J. H. H. Schmidt, *Die Kunstformen der griechischen Poesie* (Leipzig, 1868–72). On Pindar generally, *see* L. Schmidt, *Pindar's Leben und Dichtung* (1862); F. D. Morice, *Pindar* (1879); *A.* Croiset, *La Poésie de Pindare* (1880); G. Liibbert, *Pindar's Leben und Dichtungen* (Bonn, 1882); W. Christ, *Geschichte der griechischen Litterutur* (1898); F. Dornseiff, *Pindars Stil* (1921). Bibliographical information on the earlier literature will be found in W. Engelmann, *Scriptores graeci* (1881); *see* also L. Bornemann, in *Jahresbericht über die Fortschrift der classischen Altertumswissenschaft* (ed. C. Bursian, vol. cxvi., 1904), with special reference to chronological questions and *Pythia,* i., ii., iii. Some considerable fragments of the paeans were discovered in 1906 by B. P. Grenfell and A. S. Hunt, see *Paeans* in *Oxyrhynchus papyri* (pt. v. 1908), and A. E. Housman, in *Classical Review* (Feb. 1908).

(R. C. J.; X.)

PINDARICS, the name by which was known a class of loose and irregular odes in fashion in England during the close of the 17th and the beginning of the 18th century. The invention is due to Abraham Cowley, who, probably in Paris, and perhaps in 1650, found a text of Pindar and determined to imitate the Greek poetry in English, without having comprehended the system upon which Pindar's prosody was built up. Cowley published, in 1656, 1j *Pindarique Odes,* which became the model on which countless imitators founded their pindarics. The erroneous form of these poems, which were absolutely without discipline of structure, was first exposed by Congreve, exactly half a century later. The laxity of these "pindarics" attracted the poets of the unlyrical close of the 17th century, and they served the purpose not only of Dryden and Pope, but of a score of Iesser poets. Although the vogue of these forms hardly survived the age of Anne, something of the vicious tradition of them still remained, and even in the

odes of Wordsworth, Shelley and Coleridge the broken versification of Cowley's pindarics occasionally survives.

PINDARIS, a word of uncertain origin, applied to the irregular horsemen who accompanied the Mahratta armies in India during the 18th century when the Mogul empire was breaking up. Loosely organized under self-chosen leaders, each band was usually attached to one or another of the great Mahratta chieftains. Their special characteristic was that they received no pay, but rather purchased the privilege of plundering on their own account.

The majority of them seem to have been Mohammedans. When the regular forces of the Mahrattas had been broken up in the campaigns conducted by Sir Arthur Wellesley and Lord Lake in 1802–04, the Pindaris made their headquarters in Malwa, under the tacit protection of Sindhia and Holkar. They usually assembled annually in November to set forth over British territory in search of plunder. In one such raid upon the Masulipatam coast they plundered 339 villages, killing or wounding 682 persons, torturing 3,600 and carrying off much valuable property. In 1808–09 they plundered Gujarat, and in 1812 Mirzapur. In 1814 they were reckoned at 25,000 to 30,000 horsemen, half of them well armed. At last the evil became intolerable, and in 1817 the marquess of Hastings obtained the consent of the East India company to the organized campaign known as the Pindari War. The Pindaris were surrounded on all sides by a great army, consisting of 120,000 men and 300 guns, which converged upon them from Eengal, the Deccan and Gujarat under the supreme command of Lord Hasting in person.

Sindhia was overawed and forced to sign the treaty of Gwalior, consenting to aid in the extirpation of the Pindaris, whom he had hitherto protected. The Peshwa at Poona, the Bhonsla raja at Nagpur and the army of the infant Holkar each took up arms, but were separately defeated. The Pindaris themselves offered little opposition. Amir Khan, by far their most powerful leader, accepted the conditions offered to him. His descendant later became Nawab of the state of Tonk in Rajputana. The rest surrendered or were hunted down, the fate of Chitu, one of the most notorious, being to perish in a tiger's den. These military operations were followed by the pacification of Central India under the administration of Sir John Malcolm.

See J. Grant Duff, ***History*** *of the Mahrattas (1826);* Major Ross of Bladensburg, *Marquess of Hastings* **(1893).**

PINDEMONTE, IPPOLITO (1753–1828), Italian poet and author, was born in Verona, Nov. 13, 1753, the son of a rich and cultured nobleman. From 1784–88 he lived in a villa outside the city of Verona and the calm, quiet life there inspired him to write one of his best-known works, *Poesie campestri* (1788). From 1788–91 he traveled extensively throughout Europe, visiting France, England and Germany. The result of his travels was his novel, *Abaritte* (1792) and a poem, "La Francia" (1789), written in commemoration of the opening of the French Revolution, which he had greeted with enthusiasm. His fervour was somewhat dampened later, however, by the destruction of his villa by French and Austrian troops in 1796 and by the Reign of Terror in France. From 1809–22 he published his translation of Homer's *Odyssey,* the first canto of which appeared in 1809, the rest following at intervals thereafter.

One of his best works was "I Cimiteri," a poem he never finished but one which probably inspired Ugo Foscolo's poem "Sepolcri," which was dedicated to Pindemonte. His novel in verse, *Antonio Foscarini e Teresa Contarini,* is also celebrated. Other works include *Arminio,* a tragedy in verse, *Elogi di letterati,* a work of biography and literary criticism, and *Prose campestri,* a companion to his earlier *Poesie campestri.* Pindemonte died at Verona, Nov. 18, 1828.

His brother, GIOVANNI PINDEMONTE (1751–1812), poet, dramatist and politician, was born in Verona, Dec. 4, 1751. At various times during his life he held high positions with governments of several of the Italian states, but he spent much time in exile in France, sometimes because of his own misconduct, sometimes because of the fall of the government he was serving.

He wrote lyric poetry, which is not highly regarded, and 10 tragedies modeled after Shakespeare. He died in Verona, Jan. 12, 1812.

PINDUS, the ancient name for the mountains which separate Thessaly from Epirus, often used by modern geographers in a somewhat extended sense. The folded Alpine chains are continued down the western coast of the Balkan peninsula, where in the north they form the Dinaric Alps. In the neighbourhood of Scutari (Skadar), however, the direction of the coast line undergoes a marked change, associated with a change in the trend of the mountain folds.

In the extended sense the name Pindus is applied to the chain of fold mountains which extends from the Šar Planina, in the latitude of Scutari, southwards to about the latitude of the Gulf of Arta, and thus includes most of the mountains of Albania. As a rule massive limestones are less developed in the Pindus than in the Dinaric region, so that the karstic type of landscape is less frequent and less repellent than in the north, the prevailing types of rocks being often schists, grits and greenish eruptive rocks, especially serpentines.

The range rises to a maximum height of about 8.000 ft., and in places the original forests, mainly of oak and beech, have been preserved.

PINE, the name of an English engraver and his two sons, both painters.

JOHN PINE (1690–1756) operated a print shop in London, and thus was able to publish books illustrated with his own engravings. It is not known where he learned his art, although he may have studied under Bernard Picart. His first important publication, which is also one of the finest examples of his work, was a group of engravings of the ceremonies attending George I's revival of the order of the Bath (1730). His other productions include a copy of the Magna Carta; an edition of Horace and a part of one of Virgil; copies of the tapestries celebrating the defeat of the Spanish armada that hung in the house of lords; and several maps of London. In 1749 his friend William Hogarth depicted him as the friar in his painting "The Gate of Calais," and from that date Pine was known, to his considerable irritation, as Friar, or Father Pine. He died May 4, 1756.

ROBERT EDGE PINE (1730–1788), his son, was born in London. In 1760 his painting "The Surrender of Calais" won for him first prize for historical subjects in the first exhibition held by the Society of Arts, and three years later he received the same award for his "Canute Rebuking His Courtiers on the Seashore." He became widely known as a painter of portraits, particularly those of contemporary theatrical personalities. His likenesses of David Garrick, painted during this period, are regarded as especially fine. About 1783 he went to the United States, planning to paint the portraits of the leaders of the American Revolution, as well as historical scenes of the important events of the war itself. The plan never materialized, although he did make portraits of a number of contemporary statesmen, including Francis Hopkinson, George Washington, Robert Morris, Benjamin Franklin and John Jay. Many of Pine's works went to the Columbian museum in Boston and were destroyed when that institution burned. He died in Philadelphia, Nov. 18, 1788.

SIMON PINE (d. 1772), another son of John Pine, was a miniature painter at Bath.

PINE, a name given by the ancients to several resinous, cone-bearing trees. Modern botanists restrict the use of the term to members of the genus *Pinus* (Pinaceae), which differs from other pinaceous genera in featuring slender, needlelike leaves, borne in fascicles of two to eight (rarely solitary), growing from a basal membranous sheath. Each tuft represents an abortive branch which springs from the axil of a partially deciduous, scalelike leaf, the base of which remains closely adherent to the stem. The numerous staminate catkins are arranged in dense spirals about the bases of young shoots of the season; the two-celled sessile anthers release an abundance of pollen through longitudinal slits; the ovuliferous flowers are composed of several spirally arranged bracts each subtending a scale with two basal ovules. The fruit of the pines, a cone, requires two or rarely three seasons to mature. It is composed of numerous woody, armed or unarmed scales spirally arranged about a woody central axis, each bearing two-

winged, or rarely wingless, seeds. The cones of several species open at maturity to release their seeds, others remain closed for several seasons; still others require the heat of a forest fire to open them in appreciable quantities. In such instances vast amounts of viable seed are accumulated through the years, which, when released, completely reseed burned-over areas.

The pines, which comprise about 90 species. are widely distributed over the north temperate zone, in the southern portions of which they are chiefly confined to the mountains. In Central America a few are found within the tropics. In more northern regions they frequently form extensive forests which are seldom invaded by other trees. One species. ***P. sylvestris,*** is native to Great Britain and about 55 are indigenous to North America. Pines are botanically soft woods. but commercially they may be designated as soft pines (easily worked) or hard pines (more durable and harder to work). Their soft or hard straight-grained, resinous and often durable woods are suitable for many purposes, and some are among the most esteemed of timber trees.

This article considers first North American pines and second Eurasian pines.

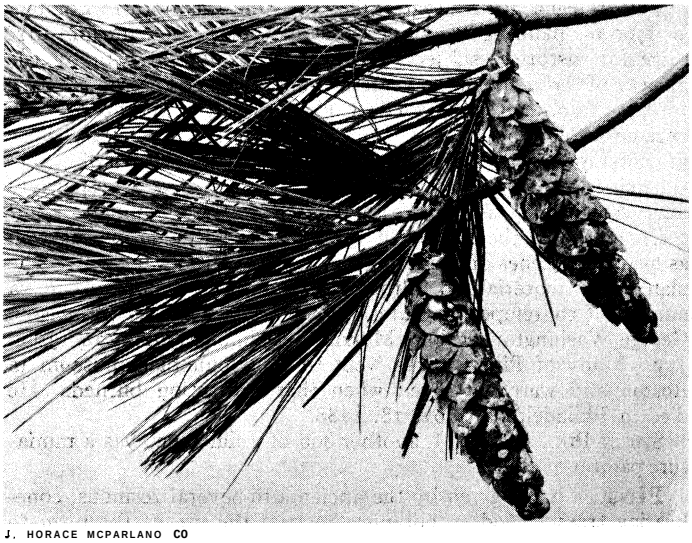
NORTH AMERICAN PINES

The 55 or more species and major varieties of pine native to North America, including Mexico, may be grouped in two sections, the soft pines and the hard pines.

Soft Pines

The soft pines have soft, close-grained wood, with thin. nearly white sapwood; the sheaths of the leaf clusters fall off early (deciduous); the leaves contain a single fibrovascular bundle, and, excepting those of the nut pines, are in five-leaved clusters. There are 17 species, only one of which, the eastern white pine, is found east of the Great Plains, the others occurring in the Rocky mountain region, on the Pacific coast and in Mexico.

American soft pines are divided into four groups whose botanical designations and features are set forth below.



J. HORACE MCPARLANO CO

WHITE PINE (PINUS STROBUS) FOLIAGE SPRAY WITH CLOSED CONES

White Pines.—The eastern white pine ***(P. strobus)***, known also as Weymouth pine, because of its large size and the soft, even grain of its white wood, is one of the most valuable of North American timber trees. It once formed extensive forests from Newfoundland to Manitoba, from Minnesota to Maine and southward in the mountains to Georgia, but it has been cut intensively so long that by the second half of the 20th century very few old trees remained. On deep rich soil ***P. strobus*** may attain a height of 200 ft., and a trunk diameter of 4 to 6 ft. Its wood is durable for indoor use, especially uhen protected by paint, its smooth, easily worked grain rendering it a favourite wood for the carpenter and joiner. The western white pine ***(P. monticola)*** grows in the mountains of the northwestern United States and British Columbia, has light-brown wood and is extensively cut for lumber, especially in Idaho, the total cut in one year exceeding 188,000,000 bd.ft.

Soft Pines

Group	Leaves	Cones
White pines *P. strobus* P. *monticola* *P. lambertiana*	in clusters of 5, 4″ to 6" long	Long stalked, with thin, unarmed scales; seeds long winged
Stone pines *P. albicaulis* *P. flexilis* *P. ayacahuite*	in clusters of j, about 3½″ long	short stalked, with thick, unarmed scales; seeds short winged or wingless
Foxtail pines *P. aristata* P. *balfouriana*	in clusters of j, about 2″ long, persistent for many years	short stalked, the scales armed on the back with a small, often deciduous prickle; seeds long winged
Nut pines *P. cembroides* *P. quadrifolia* *P. monophylla* *P. edulis*	in clusters of 2 to 4, or solitary, about 2″ long	short stalked, few scales, the scales greatly thickened, unarmed, short winged or wingless

The sugar pine (P. *lambertiana)* of California is the largest of known pines, often 200 to 220 ft. tall and with a trunk diameter of 6 to 8 ft., or occasionally to 12 ft. Its crown is pyramidal, with horizontal or slightly drooping branches, and bears slender, bright-green needles 2 to 4 in. long. The pendent cones are 4 to 6 in. in diameter when open, sometimes to 24 in. long, and bear large, edible seeds. It is lumbered extensively, the cut after World War II exceeding 170,000,000 bd.ft. annually.

Stone Pines.—Stone pines are typically timber-line species, and are more important as protectors of valuable watersheds than for the timber they produce. The whitebark pine ***(P. albicaulis)***, so called because of its chalky-coloured bark, extends along the mountains of the Pacific slope from British Columbia to the Sierra Nevada of California and eastward through Idaho to Montana and Wyoming. Limber pine ***(P. flexilis)*** is essentially a Rocky mountain tree. The Mexican white pine ***(P. ayacahuite)*** attains its northern limits in the southwestern United States.

Foxtail Pines.—This group attains its name from the fact that the leaves persist on the branches for 10 to 15 years or more and simulate the bushy aspect of a fox's tail. Bristlecone pine ***(P. aristata)*** is a tree of the southern Rocky mountains, while foxtail pine (P. *baljouriana)* is found on the coast and Sierra Nevada ranges of California. Both are small alpine trees. Needles of the former have superficial resin canals from which resin is exuded upon the surface of the leaf.

Nut Pines.—Some authorities recognize but one species, ***P. cembroides,*** and classify the other forms as varieties of this species. The single-leaf pifion ***(P. monophylla)*** features one and sometimes two needles in a fascicle. This tree occurs sporadically through northern Mexico and the southwestern United States. The Parry piiion (*P. quadrifolia)* is the four-needle pifion of southern California and northern Lower California. Nut pine (P. *edulis)*, the most widely distributed tree of the group, like the Mexican pifion has needles in clusters of two and three. The seeds of the group are very large and tasty and are sold in the markets as "pine nuts."

Hard Pines

The hard pines have usually heavy, coarse-grained, mostly dark-coloured wood, with pale, often thick sapwood; the sheaths of the leaf clusters are persistent, except in the Chihuahua pine ***(P. leiophylla)***; the leaves have two fibrovascular bundles, and are arranged mostly in three-leaved and two-leaved clusters. There are some 24 species about equally divided in number between the region east of the Great Plains and the region extending from the

Rocky mountains to the Pacific coast.

The group of yellow pines with the leaves ordinarily in three-leaved clusters includes several of the most valuable trees of North America. Among these are the longleaf pine (P. *palustris*), the slash pine (P. *caribaea*), the loblolly pine (P. *taeda*), the pitch pine (P. *rigida*) and the pond pine (P. *rigida* var. *serotina*) of the southern states, and the ponderosa or western yellow pine (P. *ponderosa*). the Arizona pine (P. *ponderosa* var. *arizonica*) and Jeffrey pine (P. *jeffreyi*) of the Pacific states. Other representatives of this group are the Monterey pine (P. *radiata*), the knob-cone pine (P. *attenuata*), the digger pine (P. *sabiniana*), and the Coulter pine (P. *coulteri*) of California and Oregon, and also the Chihuahua pine (P. *leiophylla*) of the Mexican border.

The group of hard pines with leaves usually in two-leaved clusters also comprises several important trees. Among these are the red or Norway pine (P. *resinosa*). the gray or jack pine (P. *banksiana*). the spruce pine (P. *glabra*). the shortleaf pine (P. *echinata*), the Virginia pine (P. *virginiana*), the sand pine (P. *clausa*) and the table-mountain pine (P. *pungens*), of the region east of the Rocky mountains. Here belong also the lodge-pole pine (P. *contorta* var. *latifolia*), found from Nen Mexico to Alaska. Another representative of the two-leaved group is the bishop pine (P. *muricata*). The rare Torrey pine (P. *torreyana*), confined to the California coast, is a five-needle pine, a condition rare among yellow pines.

Longleaf pine (P. *palustris*) is the most notable yellow pine of the southern states; it abounds on sandy soils from the Carolinas and Florida westward to Louisiana and Texas. The most marked feature of the tree is its long tufted foliage—the leaves, of a bright-green tint, springing from long white sheaths, being often a foot in length. The tall columnar trunk, sometimes 120 ft high, furnishes one of the most valued pine timbers of the United States; close-grained and resinous, it is very durable and polishes well; it is largely employed in construction work, and large quantities are exported, especially to Great Britain and the West Indies. This tree is the chief lumber-producing pine of the southern United States; it also yields large quantities of tar and turpentine.

Loblolly pine (P. *taeda*), a tall tree with straight trunk and spreading top, covers great tracts of the pine barrens of the southern states, but also frequently spreads over deserted arable lands that have been impoverished by long and bad farming; hence. the woodsmen call it the "old-field" pine, while, from the fragrance of its abundant resin, it is also known as the frankincense pine. It is a fine species 80 to 100 ft. high, having sometimes a girth of 6 or 8 ft. The timber of this pine, though soft and brittle. is much used for lumber and pulpwood, but the forests of it are of no importance to the naval-stores industry because of the poor quality of the derived oils and turpentine. The shortleaf (P. *echinata*) and slash (P. *caribaea*) pines are two other very important timber trees in the south. The latter extends over the Florida keys to several islands in the Caribbean.

Ponderosa and Other Hard Pines.--Ponderosa, western yellow or bull pine (P. *ponderosa*), which grows from 150 to 200 ft. high, with a massive trunk 5 to 8 ft. in diameter, is noted for its soft, easily worked wood which is much softer than most other yellow pines; it is the most widely distributed American pine, being found in the mountain forests of western North America from British Columbia to South Dakota (Black hills) and south to Texas and Mexico. It is the chief lumber pine of the Pacific states where it is second in importance only to the Douglas fir (*q.v.*). The similar Jeffrey pine (P. *jeffreyi*) is confined to California and Lower California. The Coulter pine (P. *coulteri*) is remarkable for its enormous cones (sometimes 1 ft. long, 6 in. in diameter. and weighing more than 4 lb.); the scales end in long hooked points curving upward; the leaves are long. rigid and dark green. Closely related to this is the digger pine (P *sabiniana*) of California, the cones of which are 7 to 9 in. long and 5 to 6 in. in diameter, also with hooked scales; the large nutlike seeds are eaten by the Indians; the tree sometimes attains a height of 80 ft. and a trunk diameter of 4 ft. The beautiful Monterey pine (*P. radiata*), found sparingly along the California coast, is distinguished by the brilliant colour of its foliage. The Torrey pine (P. *torreyana*), with leaves 12 in. long, found only in a narrow strip some 8 mi. in length, along the coast near San Diego, Calif., and on Santa Barbara Island, is the least widely distributed of all known pines.

The pitch pine (P. *rigida*), found from the coast of Massachusetts southwestward throughout the Appalachian region, is a tree of from 40 to 50 ft. in height, with rugged trunk, occasionally 3 ft. in diameter; the short dark-green leaves are in thick tufts, contrasting with the pale-yellowish, usually clustered cones, the scales of which are furnished with small curved spines. Large quantities of a low grade tar and pitch have been obtained from this species. The tree is one of the few that will flourish in salt marshes.

Pine Lumbering in the United States

The various native species of pine, several of which form forests of vast extent, constitute the chief source of softwood (coniferous) lumber produced in the United States. Commercially, the lumber cut from the various kinds of pine is known as white, yellow, ponderosa, sugar and lodgepole pine, and is classified under these descriptive names in the census of manufactures. White-pine lumber includes that produced from the eastern white or Weymouth pine, the western white pine, the gray or jack pine and the Norway or red pine, the two last named belonging botanically with the yellow pines. Prior to 1900 the eastern white pine was one of the chief lumber-producing trees in North America, but the original forests have become so depleted that the tree now contributes only a minor fraction of the lumber marketed as white pine. The lumber from the eastern white, the gray and the red pine is mostly cut in the northern border states from Maine to Minnesota. Western white-pine lumber is practically all produced in Idaho and Washington.

Yellow-pine lumber is cut mainly in the southern states; 70% of the total is produced in five states: Mississippi, Louisiana, Alabama, Texas and Georgia, which rank in the order named. The kinds of pine furnishing yellow-pine lumber all belong to the pitch-pine group, and include the longleaf, loblolly. shortleaf, sand, slash. pitch, spruce, pond, table-mountain and Virginia pine, the longleaf, shortleaf, loblolly and slash pines ranking among the most important.

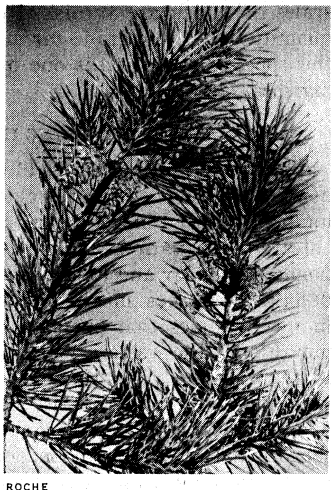
Ponderosa-pine lumber, mainly cut from P. *ponderosa*, with some cut from P. *jeffreyi*, is produced chiefly in Oregon, 32%; California, 25%; Washington, 14%; and Idaho, 12%.

Sugar-pine lumber, cut from a single species (P. *lambertiana*) and produced commercially only in California (97.5%) and Oregon (2.5%), commands the highest average price at the mill of any pine lumber cut in the United States. Lodgepole-pine lumber is produced in small quantities in the Rocky mountain states: Wyoming contributing 48%; Colorado, 42%; Montana, 5% and Utah, 4% of the total footage.

EURASIAN PINES

P. **sylvestris.**—The Scots pine (P. *sylvestris*) of northern Europe is typical of the two-needled pines. When grown under optimum conditions it is one of the finest of the group and is a very picturesque forest tree. Attaining a height of 70 to 120 ft., it is conical in youth, acquiring a mushroom crown in maturity; has a straight trunk 2 to 4 ft. in diameter; fiery red-brown bark; and gnarled. twisted boughs densely clothed with blue-green foliage at the extremities. The leaves are rather short, curved and often twisted. In May or June the staminate cones fill the air with sulfurlike pollen and pollinate the purple carpellate cones, which are at first sessile and erect but become recurved on lengthening stalks. Fertilization occurs the next summer and the carpellate cones mature in the autumn of the following year. Scots pines seldom shed their seeds until the third year. P. *sylvestris* occurs in varying abundance from Finland and Sweden to the mountains of Spain and the higher slopes of Etna, and longitudinally from the shores of the North sea to Kamchatka. U.S.S.R. Abundant in the Scandinavian peninsula. it is the fir (*fur*, *fura*) of the old Norsemen, and still retains that name in Great Britain, although it is a true pine. It grows vigorously on lower ground in Lapland

and occurs up to 3,000 ft. in south Norway. The great forests from which Norway-pine timber is chiefly derived are on the lower slopes of the southeastern dales; in the higher altitudes it dwindles to a mere bush. It furnishes the yellow deal of the Baltic and Norway. In Germany, both on the mountains and the sandy plains, woods of Scots pine *(kiefer)* are frequent and widely spread, while vast forests in the U.S.S.R. and Poland are chiefly composed of this species. In Asia it abounds in Siberia and on the mountains of the Amur region, U.S.S.R.; in the European Alps it occurs at a height of 5.600 ft., and in the Pyrenees it is found at still higher elevations. In Great Britain natural forests of Scots pine of any extent are found only in the Highlands, chiefly on the slopes of the Grampians.



ROCHE

SCOTS PINE (PINUS SYLVESTRIS) FOLIAGE WITH CLOSED CONES

The heartwood of the finer kinds of Scots pine is of a deep broanish-red colour, abounding in the resin to which its durability is probably due. It is as lasting as oak, and is well adapted to both indoor and outdoor construction. The quality of the timber depends greatly on the soil and position in which the trees are grown. The rapidity of growth is still more variable: in Great Britain full maturity is attained in from 70 to 120 years, but in Norway the trunk increases much more slowly; H. Schubeler states that a tree felled in the Alta district (about 70° latitude), measuring 2 ft. 10 in. in diameter. showed 400 annual rings.

P. sylvestris is subject to many insect depredations: the pine chafer *(Hylurgus piniperda)* is destructive in some places, this beetle's larvae feeding on the succulent shoots, especially in young plantations; the fir ueevil *(Hylobius abietis)* eats away the bark, and numerous lepidopterous larvae devour the leaves; the pine sawfly is injurious in some seasons. Removal of all dead branches from the trees and the ground beneath is recommended, as most of these Insects lay their eggs in the decaying parts of the bark and among the dead leaves.

In common with other pines, **P.** *sylvestris* is subject to the attacks of various fungi. *Trametes radiciperda* attacks the roots and penetrates to the stem, causing rotting of the wood. The disease is difficult to eradicate, as the mycelium of the fungus travels from root to root in the soil. Rotting of the wood at the base of the trunk is also caused by *Agaricus melleus,* which spreads in the soil by means of its long, purple-black, cordlike mycelial strands known as rhizomorphs. Much damage is often caused by species of Peridermium, which often invade the soft portions of the inner bark to such an extent as to "ring" the stem or branch. or to cause an abnormal formation of turpentine which soaks into the wood and stops the upward passage of water.

Plantations in England are generally ready for final cutting in from 60 to 70 years, and many are cleared at a much earlier stage of growth, especially when protected from injury by pests. In England P. *sylvestris* is largely employed as a "nurse" for oak trees. Its conical growth when young affords protection from the wind while allowing sunlight to reach the seedling oaks. Its dense foliage renders it valuable as a shelter tree for protecting land from the wind; it stands the sea gales better than most conifers. but will not flourish on the shore like some other species.

This pine is planted for ornament and sparingly naturalized in the eastern United States. It has proved of value also in afforesting treeless areas, such as occur in western Nebraska.

Large quantities of turpentine are extracted from this pine in Sweden and the U S.S R by removing a strip of bark, terminating in a deep notch cut in the wood. into which the pitch runs and from which it is scooped as it accumulates; but the product is not equal to that of the silver fir and other species. Tar is prepared from P. *sylvestris,* chiefly obtained from the roots.

P. **pumilia.**—Closely allied to the Scots pine, and perhaps to be regarded as a mere alpine form of that species. is the dwarf P. *pumilio*—the *krummholz* or *knieholz* of the Germans—a recumbent bush, generally only a few feet high, but with long zig-zag stems that root occasionally at the kneelike bends where they rest upon the ground. The foliage much resembles that of the Scots pine. but is shorter, denser and more rigid; the cones are smaller but similar in form. Abounding on the higher slopes of the Bavarian and Tirolese Alps. it is a favourite shelter for the chamois; the hunters call it the "latschen," from its recumbent, straggling habit.

P. **laricio.**—*P. laricio,* the Corsican pine, is one of the noblest trees of this group. growing to a height of 100 or even 150 ft., with a straight trunk and branches in regular whorls, forming in large trees a pyramidal head; the slender leaves, of a dark-green tint, are from 4 to 7 in, long; the cones, either in pairs or several together, project horizontally, and are of a light-brown colour. This pine abounds in Corsica, and is found in more or less abundance in Spain. southern France. Greece and many Mediterranean countries. The tree is of very rapid growth, but produces good timber, much used in southern dockyards. and very durable, though less strong than that of P. *sylvestris;* the heartwood is of a brownish tint. In southern France it has been planted with success on the drift sands of the Bay of Biscay, though it does not bear the full force of the sea blast as well as the pinaster.

P. **nigra.**—The black or Austrian pine (P *nigm)* derives its name from the sombre aspect of its dark-green, sharp, rigid, rather long leaves The tree. up to 100 ft. tall, displays a deeply fissured bark and light-brown branches. This species, widely cultivated for ornament, is native to Europe and western Asia.

P. pinaster.—The cluster or pinaster is an important species from its vigorous growth in the sand drifts of the coast, for the purpose of binding which it has been grown more extensively and successfully than any other tree, especially on the dunes of the Bay of Biscay. Growing to a height of from 40 to 80 ft., the deeply furrowed trunk occasionally reaches a diameter of 3 ft. or more at the base, where. like most sand trees, it usually curves upward gradually, a form that enables the long taproots to withstand better the strain of the sea gale; when once established, the tree is rarely overthrown even in the loosest sand. The branches. with their thick covering of long. dark-green leaves, curve upward like the stem, giving a massive rounded outline to the tree: the ovate cones are from 4 to 6 in. long, of a light, shining, brown hue, with thick scales terminating in a pyramidal apex: they are arranged around the branches in the radiating clusters that give name to the tree. The pinaster grows naturally on sandy soils around the Mediterranean from Spain to the Levant. On the drift sands of France, especially in the Gironde. forests have been formed mainly of this pine; the seeds, sonn at first under proper shelter and protected by a thick growth of broom sown simultaneously, vegetate rapidly in the sea sand, and the trees thus raised have, by their wind-drifted seed. covered much of the former desert of the Landes with an evergreen wood. These forests of pinaster, apart from the production of timber in a once treeless district. have a great economic value as a source of turpentine. In England the cluster pine has been largely planted on sandy districts near the sea, and has become naturalized in Purbeck and other wild tracts in the southern counties.

P. **pines.-This** is the stone pine of Italy; its spreading, rounded canopy of light-green foliage, supported on a tall and often branchless trunk, forms a striking feature of the landscape in that country, as well as in some other Mediterranean lands. The reddish-brown, shining. roundly ovate cones with pyramidal scale apices have been prized from the ancient days of Rome for their edible seeds (pignons), which are still used for food. They ripen the fourth year and are kept in the cone until required; otherwise their abundant oil soon turns rancid.

P. **griffithi.**—Similar to P. *pinea* is *P. griffithi,* the Himalayan or blue pine, which differs chiefly in its longer cones and drooping, glaucous foliage. It grows in Kumaon, Bhutan and on some of the

Nepal ranges at 7,000 to 12,000 ft., where it attains large dimensions; however, it is absent from the moist climate of the Sikkim Himalayas.

P. cembra.—*P. cembra,* the stone pine of central Europe and Siberia, abounds on the Alps, the Carpathians and the Siberian ranges, groning at altitudes of 4 000 to 6.000 ft. in Switzerland. The oily seeds, like those of P. *pinea,* are eaten by the inhabitants of the Alps and Siberia, and yield a fine oil used for food and in lamps P *cembra* grows slouly, is remarkably even-grained and is used by the Swiss wood carvers in preference to any other.

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PINEAPPLE. Cultivated varieties of pineapple belong to the species *Ananas comosus.* This and other species are members of the family Bromeliaceae and. with one exception, are indigenous to tropical and subtropical America. The exception is Spanish moss, which is native to the west coast of Africa Earliest written records of pineapple are references to it by Columbus. Gonzalo de Oviedo y Valdes and Sir Walter Raleigh, who found pineapple growing in the West Indies where it was used for food and for wine making.

In a remarkably short time after it was first seen by Europeans, the pineapple was carried to many parts of the norld. The Portuguese apparently were responsible for much of its early dissemination. They introduced it to St. Helena shortly after they discovered that island in 1502.

Soon after they carried it to various parts of Africa and to Madagascar and by about 1550 to India. Before the end of the 16th century cultivation of the plant had spread over most of the tropical areas of the world, including some of the islands of the South Pacific. Crowns from fruits carried on board ship for food during voyages were probably the propagating material. They can remain viable. even when detached, for long periods, certainly for as long as these voyages required.

The pineapple plant resembles agave or some yuccas in general appearance. It has from 30 to 40 stiff succulent leaves closely spaced in a rosette on a thick fleshy stem. With commercial varieties, a determinate inflorescence forms about 1j to 20 months after planting on a flower stalk several inches in length. The originally separate lavender flowers. together with their bracts. each attached to a central axis core, become fleshy and fuse to form the pineapple fruit which ripens five to six months after flowering begins.

BY COURTESY OF DOLE HAWAIIAN PINEAPPLE COMPANY

A RIPE PINEAPPLE READY FOR PICKIN=

Fruits of commercial varieties range from three to six pounds in weight. Most varieties are self-incompatible and therefore do not normally produce seed, though they will do so uhen crossed with certain other varieties.

There are many varieties of pineapple, but those of greatest commercial importance are the Smooth Cayenne in Hanaii, the Queen group in Australia and South Africa and the Red Spanish in Cuba and Puerto Rico.

When pineapple is planted on plantations, an asphalt-impregnated mulch paper is first laid on \\ell-tilled soil in rows, with the edges covered to anchor the strips of paper. Mulch paper is commonly laid on five-foot centres and the pineapple propagating pieces are inserted through the paper into the soil, so spaced as to give a population of 15,000 to 20,000 plants per acre In many areas the soil is fumigated with DD (a mixture of dichloropropene and dichloropropane) at the time the mulch paper is laid.

Such fumigation is necessary to kill nematodes parasitic on the roots of the pineapple plants.

Pineapple culture, particularly in Hawaii, makes use of many agricultural chemicals. One of the important uses is in controlling weeds in the spaces between strips of mulch paper. Cultivation for weed control has been practically eliminated by the use of chemicals in many areas where pineapple is grown Chemical insecticides like DDT and Malathion are used to control harmful insects

Chemical fertilizers are employed and the kind, amount and timing of the application varies immensely with the soil and weather. On some of the plantations in Hawaii need for fertilization is determined by frequent chemical analysis of representative plants in the field. By this method, even with fluctuating weather and differing soils. proper adjustments of fertilization to the measured needs of the plants permits a condition of balance in plant nutrition favouring the development of fruit of uniformly high quality.

Total world production of pineapples for all purposes ordinarily averages 1,750,000 tons annually. of which an estimated 45% is produced in the Hawaiian Islands Other areas of substantial production include Brazil, Mexico, Republic of the Philippines, Cuba and Formosa. Hawaii also produces approximately 60% of the world's total supply of canned pineapple products, practically all sold in the other U.S. states. Other areas which produce substantial quantities of canned pineapple products for sale in the United States are the Philippines, Cuba and Puerto Rico. Pineapple canned in Australia, Malaya and South Africa is exported principally to Great Britain.

Except in those countries where it is grown, trade in fresh pineapple is limited Exceptions are the Azores, which produce fresh pineapple for export to the European continent and Great Britain, and Mexico, Cuba and Puerto Rico which export to the United States.

Since highest quality is not developed except when the pineapple fruit is allowed to become fully ripe on the plant, fresh-fruit quality is impaired by long shipment.

For this reason, much pineapple fruit is processed so that it can be transported to parts of the world where it cannot be grown Fresh, ripe fruits are peeled and cored, usually mechanically, and the cylinders are examined for freedom from blemishes. The most common style of cut for packing in cans is slices, but "chunks," wedge-shaped pieces about 1 in. by ½ in., and "tidbits," somewhat smaller than chunks, are also packed. All styles of cut are packed in cans by grades; sirup is then added and the cans are sealed and heat-processed. Some packers also preserve fruit in cans or in cartons by freezing. Shredded pieces of fruit. commonly called "crushed," are canned for use in flavouring ice cream and for pie mix.

Pineapple juice is canned for beverage use and may be either heat-processed or concentrated and frozen. (R. L. CG.)

PINE BEETLE, the name applied to certain bark- and timber-boring beetles (family Scolytidae) that attack pines and other coniferous trees. They are of particular importance in western North America, where they damage a great deal of timber. Some of the most important western species are *Dendroctonus ponderosa, D. brevicomis, D. barberi* and *D monticolae.* *See* BEETLE; ENTOMOLOGY: *Principles of Insect Control.* (R L. WL)

PINE BLUFF, a city of Arkansas, U.S., and seat of Jefferson county, is located S.S.E. of Little Rock. at an altitude of 216 ft on south bank bluffs overlooking the Arkansas river. Originally settled in the 1820s as Mount Marie, it was renamed Pine Bluff for its forest of giant pines in 1832, and was chartered in 1835. During the American Civil War, the city was the scene of an engagement on Oct. 25, 1863, when a Confederate force under Gen. John S Marmaduke was repulsed by a Union brigade under Col. Powell Clayton. The city is the seat of Arkansas Agricultural, Mechanical and Normal college (1873), Arkansas Vocational Technical school and the state industrial school for boys.

Pine Bluff's diversified industrial products include electric transformers, mechanical cotton pickers, planters, kraft board and paper, nensprint, locomotive and car castings, brake shoes, lumber

and wood products, cotton cloth, paper bags, fabricated steel buildings, food products, cottonseed oil, chemicals and archery supplies. The cotton exchange handles 250,000 bales in a normal year. There is an ample supply of natural gas, hydroelectric power and water in the vicinity for industrial use. For comparative population figures *see* table in ARKANSAS: *Population.*

(Jo. A. T.)

PINEL, PHILIPPE (1745–1826), French physician, ranks as the great pioneer in the humane treatment of the insane and as one of the founders of modern psychiatry. He was born at St. André, Tarn, France, on April 20, 1745, and took his doctor's degree at Toulouse in 1773. He went to Paris in 1778 and for some time supported himself by translating scientific and medical works and by teaching mathematics. In 1798 he published *Nosographie philosophique,* a learned work on the classification of diseases. which gave him much reputation. He decided to devote himself to psychiatry after having been profoundly moved by the case of a friend who went mad, ran into the woods and was devoured by wolves.

He held in succession the posts of chief physician to the famous mental hospitals, the Bicêtre and the Salpêtrière, and it was at the former institution that he took the bold and unprecedented step of removing the chains from the patients, some of whom had been restrained in this way for 30 or 40 years. He did away with the old violent methods of treatment, such as bleeding, purging and blistering, and advocated simple psychological management.

Pinel's *Traite' médico-philosophique sur l'aliénation mentale ou la manie* (1801) is one of the great classics of psychiatry. He died in Paris on Oct. 25, 1826. (W. J. Bp.)

PINE NUT, the common name for the edible seed of numerous species of pines found in North and South America, Europe and Asia. *See* NUT; PINE. *Nut Pines;* PIÑON.

PINERO, SIR ARTHUR WING (1855–1934), English dramatist, was born in London on May 24, 1855. A. W. Pinero was engaged in 1874 as an actor at the Theatre Royal, Edinburgh, and came to London in 1876, to play at the Globe theatre. Later in the year he joined the Lyceum company, of which he remained a member for five years. The first piece of his to see the footlights was £200 *a Year,* played in Oct. 1877, at the Globe.

The first play to make a hit was *The Money Spinner* (Theatre Royal, Manchester. Nov. 1880); but in *The Squire* (St. James's theatre, Dec. 1881) he attempted serious drama, and gave promise of the qualities of his later work. In 1883 and 1884 Pinero produced seven pieces, but the most important of his works at this period were the successful farces produced at the Court theatre. *The Magistrate* (March 1885), which ran for more than a year; *The Schoolmistress* (March 1886); *Dandy Dick* (Jan. 1887), revived in Feb. 1900; *The Cabinet Minister* (April 1890), and *The Amazons* (March 1893). Two comedies of sentiment, *Sweet Lavender* (Terry's, March 1888) and *The Weaker Sex* (Theatre Royal, Manchester, Sept. 1888), met with success. and *Sweet Lavender* has enjoyed numerous revivals. With *The Profligate* (Garrick, April 1889) he returned to the serious drama which he had already touched on in *The Squire.* Out of deference to the wishes of John Hare the play was fitted with the conventional "happy ending," but the original denouement was restored, with great advantage to the unity of the play, in the printed version. *The Second Mrs. Tanqueray* (St. James's, May 27, 1893) dealt with the converse of the question propounded in *The Profligate,* but with more art and more courage. The piece aroused great discussion. and placed Pinero in the front rank of living English dramatists.

His later plays include *The Notorious Mrs. Ebbrmith* (1895), *The Benefit of the Doubt* (1895), *The Princess and the Butterfly* (1897), *Trelawney of the Wells* (1898), *The Gay Lord Quex* (1899), *Iris* (1901), *Letty* (1903), *A Wife Without a Smile* (1904), *His House in Order* (1906), *The Thunderbolt* (1908), *Mid-Channel* (1909), *Preserving Mr. Panmure* (1911), *The Widow of Wasdale Head* (1912), *Playgoers* (1913), *The Big Drum* (1915), *Mr. Livermore's Dream* (1917), *The Freaks* (1918), *A Seat in the Park* (1922), *The Enchanted Cottage* (1922). *A Private Room* (1928), *Dr. Harmer's Holidays* (1930), *Child Man* (1930) and *A Cold June* (1932). He also wrote (1918) Monica's *Blue Boy,* a pantomime, performed to music by Sir Frederic Cowen. He was knighted in 1909. Pinero died Nov. 23, 1934.

PINEROLO, city and episcopal see of Piemonte, Italy, in the province of Torino. Pop. (1951) 19.281. It is built on a hillside just above the valleys of the Chisone and the Lemina, at a height of 1.234 ft. above the sea, 24 mi. by rail S.W. of Turin.

Until 1696 it was strongly fortified with a citadel on Santa Brigida, a castle on S. Maurizio, and city walls constructed by Thomas I of Savoy. It has a cathedral (St. Donatus), the palace of the princes of Acaia and other buildings of some interest. Pinerolo was bestowed on the bishops of Turin by Otto III in 996, but in 1078 the countess Adelaide made it over to the Benedictine abbey of Santa Maria, in whose possession it remained until 1159. Thomas I of Savoy captured the castle in 1188, and in 1246 the commune formally recognized the supremacy of Savoy. Passing in 1295 into the hands of Philip, son of Thomas III, Pinerolo became his residence and capital, a distinction which it retained under Amadeus VIII of Savoy.

Francis I of France obtained possession of the town in his descent into Italy, but Emmanuel Philibert received it back from Henry III in 1574. A second occupation by the French occurred under Cardinal Richelieu. The French language was imposed on the people, great fortifications were constructed, and the fortress (Pignerol) was used as a state prison for such men as Nicolas Fouquet, De Caumont and the "man in the iron mask." Victor Amadeus bombarded the place in 1693, and ultimately compelled Louis XIV to relinquish his hold on it, but before the withdrawal of the French troops the defenses were demolished. In 1748 the town was made a bishop's see.

PING-PONG: *see* TABLE TENNIS.

P'ING-TUNG (Japanese HEITO) a town in Taiwan (Formosa), lies 14 mi. N.E. of Kaohsiung in an intensively cultivated alluvial basin of which rice and fruits are the chief products. Its major function is as the market centre for this agricultural area. Sugar milling is a major industry.

P'ing-tung was settled nearly 200 years ago and thus did not benefit from city planning under the Japanese administration (1895–1945). It is a typical market town with numerous light industries including rattan weaving, small machine shops and woodworking shops. A military airbase is located nearby. It serves as the seat of the P'ing-tung *hsien* (country) government. Pop. (1956) 103,433. (N. S. G.)

PINGUICULA. A genus of carnivorous plants of the family Lentibulariaceae and thus related to *Utricularia* (*q.v.*) and *Genlisea.* It contains about 30 species, widely distributed in the northern hemisphere and along the Andes to Patagonia in South America, always in wet situations with acid soil. The plant consists of a rosette of leaves and simple scapes bearing attractive purple or yellow flowers with entire corollas, bilaterally symmetrical and provided with a nectar-secreting spur. The trapping mechanism consists of numerous stalked mucilage glands on the upper surfaces of the leaves which are usually ovate in form, with upturned margins. The digestive glands, also numerous, are sessile and depressed to the level of the leaf surface. Only very small flies, etc., can be caught, and experimental attempts to study the digestive powers of the plant by placing larger bits of food (fibrin, etc.) caused decay of the leaf. Larger insects always escape. The glands are of simple structure, much like those of *Byblis.* It was shown by Charles Darwin that the leaves are capable of movement, which, however, is not rapid or of great amplitude. When an insect is caught near the margin, the latter folds over the prey, causing for the time being a greater contact of glands with the body. After some time the margin again unfolds, the process occupying some days, but varying with the temperature. Darwin recorded a cycle of reaction within 24 hr. The response takes place when inanimate objects are placed in suitable positions on the leaf surface. Small leaves, such as those of heaths, and pollen and small seeds were thought by Darwin to be of probable use to the plant, since all contain nitrogen. The leaves of *Pinguiczrla* have been used by the Lapps, the Welsh and the peasants of the Italian Alps for the curdling of milk, producing "taettemaelk" (ropy- or long-milk), as it is called in Norway.

See Charles Darwin, *Intectivorous Plants* (1900); F E Lloyd, *The Carnivorous Plants* (1942). (F. E. L.; X.)

PINK, the common name for plants of the genus Dianthus of the pink family (Caryophyllaceae; q v.). There are about 300 or more species, natives of the old world. but found chiefly in the Mediterranean region. They are mostly short herbaceous perennials, many of which are tufted or mat-forming hardy evergreens, often with very showy flowers; some annual forms exist. Four species grow mild in Great Britain: the Deptford pink (D. *armeria*), the maiden pink (D. *deltoides*), the Cheddar pink (D. *cāesius*) and the proliferous pink (D. *prolifer*). Two others, the grass or garden pink (D. *plumarius*) and the clove pink or carnation (D. *caryophyllus*), are more or less naturalized in Great Britain, and a fen species are sparingly naturalized in the United States. The carnation (*q.v.*) and picotee of the florist are modifications of the clove pink. The sweet-william is derived from the Eurasian D. barbatus. All of these are widely grown in American and British gardens, being of relatively easy culture. Fine modern varieties of both the greenhouse and hardy types of carnation are largely grown commercially.

Both annual and perennial *Dianthus* species (best treated as biennials, however) may be grown from seed sown in the spring in ordinary moist garden soil in a sunny location. The perennials will bloom the following summer and may be increased by cuttings or diversion of dumps.

The term pink is also applied to a number of other plants: related plants in the genera Silene and Lychnis; sea-pink or thrift (*Statice* armeria) and the related genus *Limonium,* both of the leadwort family (*Plumbaginaceae*); moss pink, Phlox *subulata* (see PHLOX); and swamp pink. Helonias *bullata.* (N. TR.)

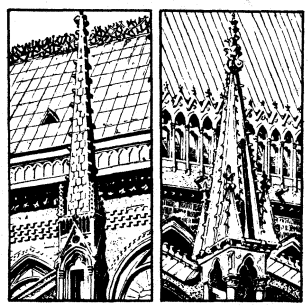
PINKERTON, ALLAN (1819–1884), U.S detective, was born in Glasgow. Scot., Xug. 25, 1819. In 1842 he emigrated to Chicago, Ill., and in 1843 he moved to Dundee, Kane county, Ill. There he ran down a gang of counterfeiters and was then appointed a deputy sheriff of Kane county in 1846 and immediately afterward of Cook county. nith headquarters in Chicago. There he organized a force of detectives to capture thieves who were stealing railway property. Pinkerton's North Western Police agency. established in 1850 and later renamed Pinkerton's National Detective agency. became one of the most famous organizations of its kind. In 1861 Pinkerton organized a system of obtaining military information in the southern states. and from this system he developed the federal secret service. One of his detectives. James McParlan. from 1873 to 1876 lived among the Molly bfaguires (*q.v.*) in Pennsylvania and, secured evidence which led to the breaking up of the organization. Pinkerton died in Chicago on July 1, 1884. He published *The* Molly *Maguires* and *the Detectives* (1877); *The* Spy of the Rebellion (1883), in which he gave his version of President-elect Lincoln's journey to Washington in Feb. 1861; and *Thirty* Yeurs a Detective (1884).

BINKNEY, WILLIAM (1764–1822), U.S. lawyer and statesman. was born in Annapolis, Md., on March 17, 1764. He was admitted to the bar in 1786. and from 1788 to 1792 practised in Harford county. In 1788 he was a member of the state convention which ratified the federal constitution for Maryland (1788–92), and in 1795 of the house of delegates (where in 1788 and 1789 he defended the right of slave owners to free their slaves), and from 1792 to 1795 of the state executive council. From 1796 to 1804 he was commissioner to England to determine the claims of U.S. merchants under the Jay treaty of 1794. In May 1806. with James Monroe, then minister at London, he was commissioned to treat with the British government concerning the capture of neutral ships in time of war; from 1807 to 1811, after Monroe's return to the United States, he nas resident minister in London. He was elected to the Maryland senate in Sept. 1811 and later was attorney general of the United States, until 1814. In Aug. 1814 he was wounded at Bladensburg. He served in the federal house of representatives Jan.–April 1816. and from 1816–18 was minister plenipotentiary to Russia and special minister to Naples. He was a member of the committee nhich drew up the Missouri compromise. He was a member of the U.S. senate from 1820 until his death. at Washington. Feb. 25, 1822.

See William Pinkney (1810–83), ***The*** Life of *William* Pinkney (1853); Henry Wheaton, *Some* Account of the *Life, Writings* and Speeches of William Pinkney (1828).

PINNACLE, in architecture, is a vertical ornament, usually tapering, crowning an architectural member. A pinnacle is distinguished from a finial (*q.v.*), which is only a single ornament, by its greater size and complexity and. from a tower (*q.v.*) or spire (*q.v.*), by its subordinate architectural role. Thus a tower may be decorated with pinnacles, each one capped by a finial.

Simple pinnacles were used on Romanesque churches, especially to mask the abrupt transition from square tower to polygonal spire, but they were far more prominent in developed Gothic architecture and decoration where they were used to give vertical emphasis and to break up hard outlines. They not only appeared at every major corner, flanking gables, and atop parapets and buttresses, but also increased in size and were elaborated with finials, crockets, tracery, colonnettes, small gables and even subsidiary pinnacles. Some of the most striking pinnacles crown the piers of flying buttresses where, although primarily decorative, they enhance the stability of the buttresses by their additional weight. Representative buttress pinnacles are those of the early 14th century around the choir of Notre Dame at Paris and the magnificent 80-ft. pinnacles at Reims cathedral (13th century) with the spirelet and subsidiary pinnacles supported on the slender columns of a niche containing the statue of an angel with outstretched wings.



PINNACLE LEFT. NOTRE DAME, PARIS. RIGHT: REIMS CATHEDRAL

In England, pinnacles were especially developed during the Decorated period (*q.v.*) and played an important part in tower design, as at Salisbury cathedral (mid-14th century). Notable pinnacled buildings from different periods of the Gothic Revival are Horace Walpole's Strawberry Hill (1748), the Houses of Parliament (begun 1840) and the Woolworth building in New York (1911–13). (Js. S. P.)

PINOCHLE (also spelled pinocle, penuchle, binocle), a card game widely played in the U.S. in several variants. According to one account. it was invented in the 17th century by a Swedish schoolmaster. Gustave Flaker, who called it Flakernuhle. This story is probably folk etymology. Though pinochle is popularly regarded as a European game, there is no evidence that it was played there before the late 1860s, at which time it was flourishing in the U.S. It was probably developed by Germanic immigrants out of bézique (*q.v.*), with which its earliest-known form is almost identical.

The idea of all pinochle games is to meld (Ger., announce) certain scoring combinations of cards and to win tricks containing counting cards. A pack of 48 cards is used, containing duplicates in each suit of the ace. ten, king, queen, knave. nine, which rank downward in that order. When won in a trick an ace counts 11; a ten. 10; a king, 4; a queen, 3; a knave, 2; a nine, nothing.

Melds.—The following combinations score the number of points indicated, in any pinochle variant.

Sequence or flush (A, K, Q, J, 10 in trumps)	150
Royal marriage (K, Q in trumps)	40
Marriage (K, Q in any other suit)	20
Four aces. one in each suit ("Hundred aces")	100
Four kings, one in each suit ("Eighty kings")	80
Four queens, one in each suit ("Sixty queens")	60
Four knaves, one in each suit ("Forty jacks")	40
Pinochle (♤ Q and ♢ J)	40
Dix (pronounced "deece"), lowest trump	10

The dix is the 9 of the trump suit except when (rarely) a 64-card pack is used, including two 8s and two 7s of each suit, when the 7 of trumps becomes the dix.

Two-hand Pinochle.—Twelve cards are dealt to each player, three at a time. The next card is turned up and fixes the trump suit. The undealt cards are placed over the trump card so as to partly cover it, and become the "stock." If the trump card is a dix, dealer scores 10.

Kondealer leads first. A card led by one player and the card played to it by the other constitute a trick, and is won by the card led unless the opponent plays a higher card of the same suit, or a trump on a plain-suit lead. Any card may be led, and any card played; until the stock is exhausted it is not necessary to follow suit.

Aiter winning a trick, a player may place face up on the table any meld, and score the points therefor, subject to the following rules: Only one meld may be made in a turn. For each meld, at least one card must be taken irom the hand and placed on the table. The same meld may be repeated only with entirely different cards irom those used previously. A king or queen melded in a sequence may not thereafter be used in a marriage.

The winner of a trick map also exchange a dix for the trump card, or may merely show the dix, and score 10.

Cards once melded remain on the table but are available for play as though they were in the player's hand.

After the winner of a trick has had a chance to meld, each player draws a card from the top of the stock, the winner drawing first and then leading to the next trick.

When only one card of the stock plus the trump card remains, there can be no more melding. The winner of the next trick turns up the last card of the stock and then takes it into his hand; his opponent takes the trump card. Melds remaining on the table are picked up. The last 12 tricks are played, and each player must, if able, follow suit to the card led; if a trump is led he must win the trick if he can; and ii he cannot follow to a plain-suit lead he must play a trump if he has one. The winner of the last trick scores 10. The cards in the tricks are counted and added to the player's score in even 10s, a remainder of less than 7 points not counting.

The game is won by the first player to reach 1.000. A player may call himself out in the middle of the play, and ii his score, including his melds and tricks in the current deal, equals 1,000, he wins the game even though his opponent has a higher score; but ii he, has less than 1.000 he loses the game. If both sides pass 1,000 without calling out, game becomes 1,500 points; and so on.

The game with the 64-card pack is the same except that 16 cards are dealt to each player.

Auction Pinochle.— There are three active players, but it is customary for iour to play, the dealer taking no cards. Each player receives 15 cards, dealt in rounds of 4, 4, 4. 3 or 3, 3, 3, 3, 3 at a time; a 3-card "widow" is dealt at the end of the first round of dealing.

The player at dealer's left has the first turn to bid. It is customary to rule that the first bid must be at least 300; in some games the minimum is 250, in others, 200. Each active player in clockwise rotation may bid as long as he overcalls the preceding bid, but if he once passes he may not thereafter enter the bidding. All bids are in units of 10 points.

The bidder (highest bidder) then exposes the three cards oi the widow and adds them to his hand He names the trump suit and places on the table, face up. whatever melds he uishes to show He then buries (discards) anv three other cards face down from his hand; these count as his first trick. He restores the cards melded to his hand and leads a card. No player other than the bidder may meld.

The bidder's two opponents combine in temporary partnership against him. Three cards, one from each hand, constitute a trick, which is won by the highest trump if it contains one, and otherwise by the highest card of the suit led. Of identical cards, the one played first outranks the other. The winner of each trick leads to the next. Each player must follow suit to the card led if he can; when a trump is led he must win the trick if he can. When he cannot follow suit but has a trump, he must play a trump.

The winner of the last trick scores 10. The values of the cards won in tricks are computed, and if the bidder's score for melds plus cards at least equals the amount of his bid, his contract is made. Each opponent (including the dealer) pays him in chips, on the following or a similar schedule:

Ii the bid was 250 to 290, 1 chip; 300 to 340, 3 chips; 350 to 390, 5 chips; 400 to 440, 10 chips; 450 to 490, 15 or 20 chips; 500 to 540, 20, 30 or 40 chips; the values of these bids depend on the custom of the club or group. If spades are trump, payment is double in each case.

If the bidder concedes deieat without leading to the first trick, he is "bete" (beaten; pronounced "bate") and pays each opponent in accordance with the schedule above. If the bidder led to the first trick and then failed to fulfil his contract, he is "double bete" and pays each opponent double.

In most games there is an imaginary extra player called the "kitty," who participates in payment and collection as an opponent of the bidder. In such games, when the compulsory first bid is passed by the other two active players, the bidder may concede defeat without looking at the widow, in which case he pays only a forfeit of one chip to the kitty.

The principal pinochle rules, established by custom, are. The bidder may change his meld, the trump suit or the cards he buries as oiten as he wishes before leading to the first trick, but not thereafter. If he buries a card he melded, and leads beiore correcting it, he loses. Any failure to play according to law forfeits the contract for the side in error There is no penalty for a bid out of turn, or for an insufficient bid or for a bid by a player who has passed, it is merely void. A player who prematurely exposes a card of the widow must pay the value of the highest bid last made to each other player.

Many players simplify the count of cards by valuing aces and tens 10 each, and kings and queens j each; others simplify still iurther by calling aces, tens and kings 10 each. Other cards have no scoring value. The total of points to be taken in tricks is in every case 240 plus the 10 points for last trick.

Partnership Pinochle.— Four play, two against two as partners, the partners being seated alternately. The dealer gives 12 cards to each player, 3 at a time, but turns up his last card to fix the trump; if this card is a dix the dealer scores 10, and if it is any other card each other player in turn to the left may exchange a dix for it. Each player then shows his meld. Partnerships score jointly, but a player may not combine any card with a card from his partner's hand to form a meld. Once shown, the melds are picked up.

The player at dealer's left leads first. The rules of play are as in auction pinochle. If a side fails to win a trick, it loses its count for melds on that deal. It is usual to penalize a revoke by loss of the offending side's entire count for cards.

The first side to amass 1,000 points wins the game; a player may claim game at any time, or the game may continue to 1,500, as in two-hand pinochle (see above).

In many circles partnership auction pinochle is more popular. No trump card is turned, but each player in turn, beginning at dealer's left, has one bid. The high bidder names the trump. The nonbidding side always scores whatever points it makes; the bidder's side scores all it makes if it at least fulfils its contract, but if it falls short, the amount of its bid is subtracted irom its score. Many iorms of partnership auction pinochle have been developed, including firehouse pinochle, check pinochle and others.

See A. P. George, *Auction* Pinnochle (1913) : Albert H. Morehead, The Modern Hoyle (1949) ; E. Culbertson, Card *Games* Complete, ed. by A H. Morehead and G. Mott-Smith (1952).

PIÑON (PINION. PINYON, etc.), a common name for the low-growing nut pines. P. *cembroides* and varieties; of western North America and Mexico. 'The light, soft but brittle wood is sometimes used for lumber, fuel and fencing material; and the † to ¾-in. dark-brown. tasty, nutlike seeds, rich in oils, are used for food. See NUT; PIKE: *Nut* Pines.

PINSK, a town of the Byelorussian S.S.R. (ceded by Poland in 1945), on the Pina river, 196 mi. S.W. of Minsk. Pottery, leather, oil. soap and beer are the chief products. The draining of the marshes around Pinsk was begun by the Russians in 1872. Pinsk (Pinesk) is first mentioned in 1097 as a town belonging to Sviatopolk, prince of Kiev. In 1132 it formed part of the Minsk principality. After the Mongol invasion of 1239–42 it became the chief town of a separate principality, and continued to be so until the end of the 13th century. In 1320 it was annexed to Lithuania: and in 1569. after the union of Lithuania with Poland, it was the chief town of the province of Brest. Pinsk was annexed to Russia in 1795. and restored to Poland in 1918.

PINT: see WEIGHTS AND MEASURES.

PINTA (MAL DEL PINTO, CARATE) is a skin disease characterized by discoloration of infected areas. with loss of colour or the development of a bluish, violet. reddish. black or even yellowish hue At one time believed to be caused by a fungus growth, in 1938 pinta nas demonstrated to be caused by a spirochete. *Treponema carateum* (synonym, T. *herrejoni*), a relative of the agents of syphilis and yaws. The disease is highly prevalent in certain states of Mexico, in parts of Cuba and other West Indian islands, and throughout Central America and most of South America It possibly occurs among the people of the Marshall Islands and other South Pacific island groups. Transmission is from contact between a weeping open lesion and the abraded or ulcerated skin of an uninfected person. Following an incubation period of 7 to 20 days an initial lesion develops and increases in size. In about five months secondary lesions. at first hyperpigmented, later depigmenting. appear over the body, particularly on exposed skin A third stage is distinguished by progressive patchy depigmentation and thickening of the affected areas. During the earlier stages the spirochetes can be recovered from the lesions. Treatment and prophylaxis are similar to those for yaws. See also BEJEL; YAWS. (E. C. F.)

PINTO, FERNÃO MENDES (*c* 1510–1583), Portuguese adventurer and author of an undisputed literary masterpiece, the *Peregrinaçam* (Peregrination) nas born, probably at Montemôr-o-Velho of poor parents. about 1510. He went out to India about

1537 and claimed to have traveled, fought and traded in almost every part of Asia during the next 21 years and to have experienced the most drastic vicissitudes of fortune, having been made "13 times a prisoner and 17 a slave" before returning to Portugal in Sept. 1558. He then married and settled at Almada near Lisbon, where he composed his famous *Peregrination* and where he died on July 8, 1583, having been awarded a pension by King Philip.

The first draft of the *Peregrination* was ready in 1569, but it was not published until 1614. It is hard to tell how far Pinto's editors rather than himself are responsible for some of the more palpable exaggerations. contradictions, errors and omissions. It is known, for example, that Pinto was a Jesuit novice in 1554–56, but he gives no hint whatever of this in his book. The story of his life, which he told the Jesuits on admission to the society, is very different from that depicted in the *Peregrination.* In the latter he portrays himself as a swashbuckling adventurer and in the former as a wealthy and successful trader, which he certainly was when he joined the society. The *Peregrination* is of no geographical value, but it is of great interest as depicting the impression made on an intelligent Portuguese by the civilizations of the far east, and for its thinly veiled criticism of the behaviour of his compatriots in Asia. There is no good critical edition in any language to date, and the existing editions are listed in the following critical studies: G. Schurhammer, *Fernão Mendes Pinto und seine "Peregrinaçam"* (1926); *G.* Le Gentil, *Fernão Mendes Pinto. Un précurseur de l'exotisme au XVIe siècle* (1947); *M.* S. Collins, *The Grand Peregrination* (1949); A. J. Saraiva, *Fernão Mendes Pinto* (1958). (Cs. R. B.)

PINTURICCHIO (BERNARDINO DI BETTO DI BIAGIO; *c.* 1454–1513), Italian painter of the Umbrian school, was born in Perugia. According to G. Vasari he was 59 at his death. which took place in Siena on Dec. 11, 1513; he was thus born about 1454. He is first recorded as a painter in 1481. when he entered the guild at Perugia, but he may have been active before then since he is usually held to have been concerned in the series of panels of the "Miracles of S. Bernardino" (gallery, Perugia), one of which is dated 1473. In this case he may have been a pupil of Fiorenzo di Lorenzo. but by 1481 he was associated with Perugino, whose influence on him was to be permanent. It is generally agreed that Pinturicchio assisted Perugino on some of the frescoes in the Sistine chapel in the Vatican (1481/82), although his name does not occur in the documents. Vasari says that he worked a great deal for Perugino as a young man, receiving one-third of the fees. He was certainly in Rome in the 1480s, working in the Bufalini chapel in Sta. Maria in Aracoeli and also in Sta. Maria del Popolo, where he decorated two chapels and also painted the choir ceiling (this last in 1509). In 1492 he was in Orvieto, where he painted two Evangelists and two Fathers in the cathedral, but they were not liked.

His most important work of this period was the decoration of the suite of six rooms in the Vatican known as the Appartamento Borgia for Pope Alexander VI between 1492 and 1494. These rooms contain representations of Sibyls, Prophets and Apostles; the seven Liberal Arts; seven Saints; the seven Joys of the Virgin; and some extraordinary astrological and mythological references to the Borgia emblem, the Bull. The sixth room was redecorated early in the 16th century. In 1495 Pinturicchio was back in Perugia. where he painted an altarpiece for Sta. Maria de' Fossi (gallery, Perugia). In 1501 he was prior of Perugia for the months of March and April and then he went to Spello, where he decorated the Baglioni chapel in Sta. Maria Maggiore. These frescoes include a self-portrait dated 1501. Another fresco there, representing Christ teaching in the Temple, virtually repeats Perugino's "Christ Giving the Keys to St. Peter" in the Sistine chapel, painted 20 years earlier.

Pinturicchio's last major works, and his most famous, were the 10 scenes from the life of Pope Pius II painted in fresco in the library of Siena cathedral. They were commissioned by Cardinal Francesco Piccolomini, afterward Pius III (the nephew of Pius II), in 1502, begun in 1503 and completed in 1509. Vasari says that the "sketches and cartoons for all the scenes" were made by Raphael, but this view is no longer accepted; nevertheless, it is not now so confidently asserted that Raphael had nothing whatever to do with it as was often thought in the late 19th century. O. Fischel, an authority on Raphael, holds that some participation by him is highly likely, especially as the fresco outside the library, representing the coronation of Pius III, is believed to contain a self-portrait of Raphael. About 1509 Pinturicchio also painted a series of frescoes in the Palazzo Petrucci, Siena, and the fragment of "Penelope" in the National gallery, London, came from it. His last work was the "Way to Calvary" of 1513, now in the Palazzo Borromeo, Milan.

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(P. I. MY.)

PINZÓN, a family of Spanish navigators, of Palos in Andalusia, three members of which—Martin Alonzo, Francisco and Vicente Yáñez, brothers—were associated with Columbus in the discovery of America.

MARTÍN ALONZO PINZÓN, born about the middle of the 15th century, in the expedition of 1492, commanded the "Pinta," on which his brother Francisco was pilot. On Oct. 6, he suggested to Columbus (when already in the longitude of the Bermudas) to change the course of the expedition from due west to southwest; on Oct. 7 this suggestion was adopted, bringing the fleet to the landfall at Guanahani (San Salvador, Watling Island) in the Bahamas (Oct. 12, 1492). On Nov. 21, near the east end of the north coast of Cuba. he left Columbus, making eastward in search of the supposed gold land. On Jan. 6, 1493, he rejoined the admiral. but on the return journey again left him and landed at Bayona in Galicia. He died soon afterward.

VICENTE YÁÑEZ PINZÓN commanded the "Nina" in 1492–93 and remained loyal to Columbus throughout. In after years he made important discoveries on his own account. In Dec. 1499 he sailed with four caravels across the Atlantic to the southwest, and on Feb. 7, 1500, he landed at Cape S. Agostinho, near its most easterly projection (called by him Cape Santa Maria de la Consolación). Proceeding southward a short distance, he then turned north, followed the coast to the northwest, discovered the Amazon estuary, and went as far as what is now Costa Rica. After touching at Haiti, and losing two of his vessels among the Bahamas, Vicente returned to Palos in Sept. 1500. Although he was created governor of the newly discovered lands by Ferdinand and Isabella, he did not take possession. In 1507 he sailed with Juan Diaz de Solís along the east coast of Central America. In 1509, again with De Solís, he coasted the Atlantic side of South America as far as the La Plata estuary, hoping to find an opening westward leading to the Spice Islands. According to Herrera, he reached 40° S., not recognizing the La Plata and turning back about the mouth of the Rio Negro, but this is probably an exaggeration. After 1523 all traces of Vicente are lost.

PIOMBINO, a seaport of Tuscany. Italy, in the province of Livorno (Leghorn). 8 mi. by rail W.S.W. of Campiglia Marittima (which is 53 mi. S.S.E. of Pisa). 62 ft. above sea level, at the southern extremity of the peninsula of the Monte Massoncello. Pop. (1951) 27,365. It is the port of embarkation for Elba, the nearest point of which is about 6 mi. to the southwest. It gives the title of prince to the Buoncompagni Ludovisi family. who, however, no longer own it. Large iron-smelting and tin-plate works are situated there.

PIOTRKÓW, a town of Poland, in Lodz province, 90 mi. southwest of Warsaw and 3 mi. west of the Pilica river. Pop. (1950) 42,300. It is a well-kept town, with numerous gardens, and has flour mills, sawmills, tanneries, agricultural machinery works and breweries. One of the oldest towns in Poland, Piotrków was in the 15th and 16th centuries the place of meeting of the diets, and here the kings were elected. The town was occupied by German troops from 1939 to 1945.

PIOZZI, HESTER LYNCH (1741–1821), English writer, well known as the friend (Mrs. Thrale) of Samuel Johnson. was born on Jan. 16, 1741, her father being John Salusbury of Bobbel,

Carnarvonshire. In 1763 she married Henry Thrale, a rich Southwark brewer, whose house was at Streatham on the south-east corner of Tooting Bec Common. There was very little sympathy between the lively girl and Thrale, who was 13 years her senior, but gradually she drew round her a distinguished circle of friends. She was introduced to Samuel Johnson in 1765 by Arthur Murphy, who was an old friend of her husband's. In 1766 Johnson paid a long visit to Streatham, and from that time was more or less domesticated with the Thrales. *(See* JOHNSON, SAMUEL.) Fanny Burney was another of her friends. She was very sensitive, and sometimes thought that Mrs. Thrale gave herself airs of patronage. Meanwhile, in 1772, Thrale was threatened with bankruptcy. The situation was saved by his wife's efforts, and in the next year Thrale travelled, leaving her in charge of his affairs. He was twice returned for the borough of Southwark, chiefly through her efforts. In 1781 Thrale died, and Dr. Johnson helped the widow with her business arrangements, advising her to keep on the brewery, until she "cured his honest heart of its incipient passion for trade, by letting him into some, and only some, of its mysteries." The brewery was finally sold for £135,000.

Mrs. Thrale had met Gabriele Piozzi, an Italian musician, in 1780. In 1784 they were married. Johnson told Miss Burney that he drove the memory of Mrs. Thrale from his mind, burning every letter of hers on which he could lay his hand. The Piozzis presently left England to travel in Italy. At Florence they fell in with Robert Merry and the other "Della Cruscan" writers ridiculed by William Gifford in his *Maeviad* and *Baviad,* and she contributed some verses to their *Florence Miscellany* in 1785. In 1786 she published *Anecdotes of the lute Samuel Johnson, during the lest twenty years of his life,* which was severely criticized by Boswell. She was ridiculed by "Peter Pindar" in *Bozzy and Piozzi; or the British Biographers, A Town Eclogue* (1786). But though Miss Burney and some others held aloof, the Piozzis found plenty of friends when they returned to London in 1787. Piozzi died at Brynbella, a villa he had built on his wife's Flintshire estate in 1809, and Mrs. Piozzi gave up her Welsh property to her adopted son, and spent most of the rest of her life at Bath and Clifton. She retained her vivacity to the last, celebrating her 80th birthday by a ball to six or seven hundred people at Bath. She died at Clifton on May 2, 1821.

From 1776 to 1809 she kept a note-book which she called "Thraliana." Her well-known poem of the "Three Warnings" is to be found in many popular collections. *Letters to and from the late Samuel Johnson* appeared in 1788; *Observations and Reflections made in the course of a Journey through France, Italy and Germany,* in 1789; and in 1801 she published *Retrospection; or a review of the most striking and important events, characters, and situations . . . which the last eighteen hundred years have presented to the view of mankind* (1801). See *Letters and Literary Remains of Mrs. Piozzi (Thrale), edited with notes and an Introductory Account of her Life and Writings by A. Hayward* (1861); *Piozziana; or Recollections of the late Mrs. Piozzi by a Friend* (1833), the anonymous friend being Edward Mangin (1772–1852); L. B. Seeley, *Mrs. Thrale, afterwards Mrs. Piozzi . . .* (1891), and G. Birkbeck Hill, *Johnsonian Miscellanies* (1897); also Percival Merritt, *The True Story of the So-called Love Letters of Mrs. Piozzi* (1928), which exposes the misrepresentation of the "love letters" to William Conway the actor written when she was an old lady and published in 1843. Copies of these letters are shown to be misleading. *See* also JOHNSON, SAMUEL.

PIPE, a hollow stem of clay, wood or other material with a bowl at one end used for smoking tobacco, opium or other narcotic, or any medicinal substance. *See* PIPE SMOKING and TOBACCO PIPE.

PIPE and **TABOR, a** popular mediaeval combination of a small pipe or flageolet and a small drum. The tabor being fastened to the performer's left elbow, the hands remained free, the right beating the little drum with a stick to mark the rhythm, while the left held and fingered the pipe with thumb and first two fingers. The pipe and tabor are said to be of Provençal origin.

PIPE-FISH, the name given to fishes which, with the seahorses, form the family Syngnathidae of the order Solenichthyes. Pipe-fishes are long and slender, varying from 1–2 in. to 18 in., usually about 6 in. long when full grown, with the body encased in bony rings, and a small, toothless mouth at the end of a long, tube-like snout; the gill-filaments are reduced in number and appear as rounded lobes or tufts. About 100 species are known from warm seas and a few from rivers. Pipe-fishes frequent seaweeds and swim slowly by rapid undulations of the %mall dorsal fin.

PIPE-LINE: *see* PETROLEUM.

PIPER, CARL, COUNT (1647–1716), Swedish statesman, was born at Stockholm on July 29, 1647. In 1689 he was made one of the secretaries of state, and Charles XI recommended him on his deathbed to his son and successor, Charles XII. Piper became the most confidential of the new sovereign's ministers. In 1697 he was made a senator and set over domestic affairs while still retaining his state-secretaryship. In 1698 he was created a count, in 1702 appointed chancellor of Uppsala university and during the first half of the Great Northern War, as the chief of Charles's perambulating chancellery, he was practically prime minister. But he belonged to the school of Bengt Oxenstjerna (*q.v.*) and was therefore an avowed advocate of a pacific policy. He protested in vain against nearly all the military ventures of Charles XII, *e.g.,* the War of Deposition against Augustus of Saxony and Poland, the invasion of Saxony. the raid into the Ukraine. Again and again he insisted that the pacific overtures of Peter the Great should at least be fairly considered, but his master was always immovable. Piper was taken prisoner at Poltava (1709) and died at Schliisselburg on May 29, 1716.

See W. L. Svedelius, *Count Carl Piper* (1869). (R. N. B.)

PIPERACEAE, the pepper family, a large group of tropical herbs, vines and small shrubs with simple leaves having a characteristic pungent taste, the numerous small flowers, lacking both calyx and corolla, crowded in dense spikes. Most of the species belong in two genera, *Piper* with more than 2,000 described species and *Peperomia* with more than 1,200. Six other small genera are usually recognized. The family is of considerable economic importance, yielding as it does pepper (*q.v.*), the product of several species: black and white pepper, derived from the fruits of *Piper nigrum;* long pepper, the product of *Piper officinarum;* and *P. longum,* and Ashanti pepper, the product of *P. clusii.* Cubeb (*q.v.*) is the fruit of *Piper cubeba.* The leaves of *Piper betle* are widely used in the orient for chewing with slices of betel nut *(Areca catechu)* and lime, while kava (*q.v.*) is a stimulating drink widely used in Polynesia prepared from the roots of *Piper latifolium (P. methysticum).* (E. D. ML.)

PIPERAZINE, a colourless solid, when crystallized from alcohol melting at 106° C. and boiling at 146° C. Chemically it is hexahydropyrazine, $C_4H_{10}N_2$; molecular weight 86.14. It is prepared by the action of alcoholic ammonia on ethylene chloride; by the reduction of pyrazine with sodium in alcohol; or by catalytic deamination of diethylenetriamine and of ethylenediamine. Piperazine has been used in the treatment of gout and kidney stones and is the best chemotherapeutic agent in the treatment of infections with the roundworm *Ascaris lumbricoides* and the pinworm *Enterobius vermicularis.* The citrate, phosphate and adipate are used for this purpose.

Diethylcarbamyl methylpiperazine (Hetrazan) is of value against infections caused by the filarial worms *Wuchereria bancrofti, Loa loa* and *Onchocerca volvulus. See* also FILARIASIS; ANTHELMINTICS. (H. W. BR.)

PIPE ROLLS or the Great Rolls of the exchequer are a long series of financial records of the English croun. The first extant Pipe Roll is that for the 31st year of the reign of Henry I. The continuous series begins with the second year of Henry II's reign and the annual succession of rolls is almost unbroken till 1834, when the last relics of the ancient financial system of the English mediaeval kings were swept away. The most plausible explanation of the name Pipe Rolls is that when rolled up and stacked in their presses the rolls looked like pipes. Up to the beginning of the 13th century the Pipe Rolls are the only consecutive series of official records which have survived; it was not until the reign of John that the Chancery records were systematically preserved. Therefore, the value of the Pipe Rolls for the last half of the 12th century can hardly be overestimated. By them the narratives of the chroniclers can be checked, and from them most of our knowledge of the actual working of the legal system in Henry II's reign comes. They are, a mine of informa-

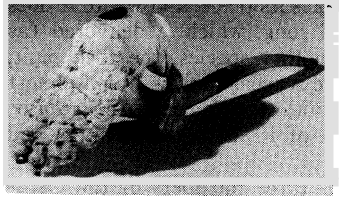
tion about the personnel of the government and the gradual development of the new administrative offices. They are the best authority for the descents of the great families of feudal England. For the historian of English towns they provide a vast mass of material. Calculations as to the amount of the royal revenue have been made from them, but such calculations can only be approximate. since much money was paid directly into the king's privy purse and recorded in no roll that survives.

Consisting of a varying number of skins of parchment about 14 in. wide and a yard long seu-n together at the top. the rolls are not easy to consult. Their matter, too, is not easy reading, nor their method of bookkeeping easy to understand. The accounts are entered county by county, the sheriff being responsible for the account of his shire. Other accounts, known as foreign accounts, appear sometimes on the rolls, accounts of royal manors by their custodians, accounts of escheats, or of towns. The clerks enter debts long after all hope that they may be paid has passed away. The Pipe Roll society, founded in 1883 to print the early Pipe Rolls, had by the middle of the 20th century published the Rolls up to and including that for 1210. In later centuries, the Pipe Rolls lost much of their importance. but interesting matter can be found in the foreign accounts which continue to appear on the rolls. When the escheat rolls begin one great source of foreign accounts is lost to the Pipe Rolls. In this way by a process of splitting off and with the setting-up of new accounting offices the ancient sheriff's account recorded in the Pipe Rolls becomes insignificant and stereotyped. The continuation of the series to 1834 is a remarkable illustration of English administrative conservatism.

(D. M. S.)

PIPE SMOKING. The original source of the idea of smoking must be sought in the sense of smell. This was much keener in primitive man than in man of the more advanced stages. With the pleasure derived from aroma, there was probably a sense of mystery at the sight of the smoke rising up into the air. Thus there was an element of religious ceremony in the burning of pleasant-smelling substances among primitive folk, in whatever part of the world we may be able to study their ways.

The ritual element is enhanced by another circumstance. Herodotus, in the 5th century B.C., described a practice of the Scythians. Mongol people settled in southeastern Europe, between the Carpathian mountains and the Don river. Throwing the leaves of a certain plant (which was probably hemp) upon a fire, they sit around and, inhaling the smoke, "they grow drunk with the fumes as the Greeks do with wine," until they jump up and begin to dance and sing. Herodotus seemed to regard this simply as an orgy; but inhalation was certainly used to produce a supernormal condition of mind in many parts of the world. When Columbus discovered America, he found the habit established of inhaling tobacco, to induce trance, during which visions were seen. which were accepted as divine revelations. The intoxicating vapour at Delphi which inspired the Pythian priestess may have been artificially produced, since no natural source has been found.

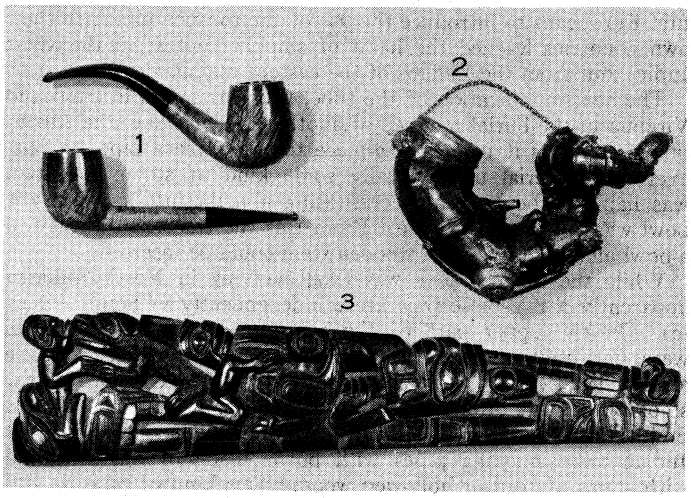


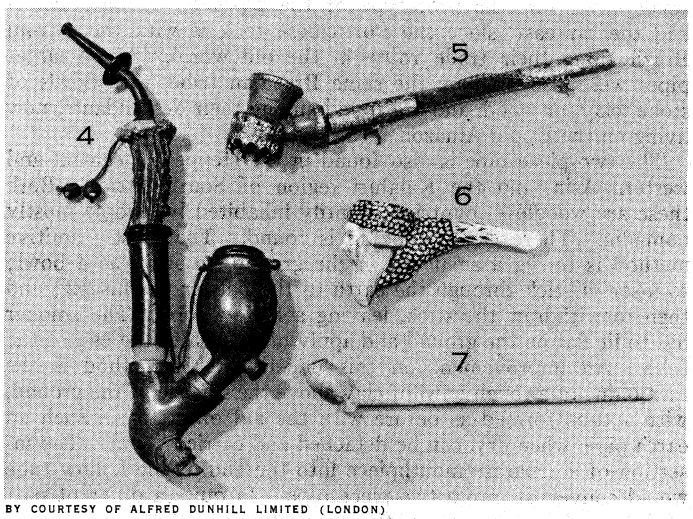
BY COURTESY OF ALFRED DUNHILL LIMITED (LONDON)

FRENCH-CARVED MEERSCHAUM PIPE WITH AMBER MOUTHPIECE

The invention of an implement to concentrate the smoke was an advance. Such an implement is the Y-shaped tube described by G. Fernandez de Oviedo in his *History of the Indies* (1535). The two horns of the "Y" were inserted in the nostrils. and smoke from tobacco burning in a censer was drawn up through the tube. This was the ceremonial method of smoking prevalent in the Antilles when Columbus and his followers reached them, side by side with a common use of the tobacco leaf rolled up and smoked like a cigar. Bernal Diaz, who accompanied Cortez to Mexico, describes the inhalation of tobacco through a tube. But me have much earlier evidence from Mexico. At the ruined city of Palenque, in the southern province of Chiapas, there are the remains of a "Temple of the Cross," which seems to belong to the beginning of the second century A.D. There, on one of two stone slabs on either side of a doorway, is represented a figure of a priest. clad in a jaguarskin cloak and a headdress representing a mythical bird. who is bloning out a smoke offering through a straight tube. This Palenque sculpture is the work of the Mayas, the mysterious race which preceded the Toltecs and the Aztecs in Mexico. Other Maya sculptures portray the straight smoking tube, both as an emblem in one of the hands of Chac, the god alike of rain-and-thunder and of fertility. and as an apparently ordinary implement for smoking. Lionel Wafer, at the end of the 17th century, speaks of a roll of tobacco, 2 ft. or 3 ft. long and as thick as a man's wrist, being lighted by a boy. and the smoke being puffed into the faces of a company who made funnels of their hands and inhaled it.

Whatever the original use of the straight tube (which is found in a variety of materials — bone, wood, cane, stone of kinds not too hard to work. and pottery), the use of it as a pipe for tobacco ages before America was discovered by the early European adventurers is well established. The first modification of the type is that found in the burial mounds of the Muskogee Indians, in the southeastern portion of what is now the United States. The tube is bent up at one end, with a widening of the bowl formed by this end. Pipes on these lines were obviously the model for the clay pipe as known to Europe, which is only natural, since the





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SOME CLASSICAL AND CONTEMPORARY PIPES

(1) Modern briar pipes. (2) Burmese pipe made from bamboo root, with decorative fittings. (3) Pipe carved in slate by Indians of northwestern America. The bowl is sunk in the middle of the top. (4) "Tyrolean" style pipe, manufactured in Bavaria, Ger. The mouthpiece and upper part of the stem are of bone, the lower stem is cherrywood and the bowl is briar. (5) Elaborate Persian pipe with a clay bowl and a bone stem finished in gilt and colour decoration. (6) A china (pottery) pipe of the U.S.S.R. (7) Early 17th-century Elizabethan pipe of clay

first Europeans to introduce the use of the tobacco pipe into their own countries learned the habit of smoking not from the West Indies, but from the Indians of the eastern mainland.

The next modification of the tube, which is found in Ohio and Virginia in the burial mounds of another Indian tribe, the Algonquins, converts it from a one-piece to a two-piece pipe. Whatever the material used, usually some kind of stone, the stem was liable to be broken, necessitating a makeshift stem, if the bowl was to continue in use. From this the transition is easy to a bowl alone, into which a wooden stem could be inserted.

While the tobacco pipe was thus evolving in North America apparently a two-piece pipe arose independently in South America. In the upper part of the southern continent true pipes were not used, though the Y-shaped tube, of which we have already heard, was employed for inhaling snuff. Otherwise cigar smoking was the ordinary form of indulgence in tobacco. But in South Brazil in 1650 the traveller Jan Nieuhoff found a great Indian tribe smoking pipes with bowls made of nutshells and with stems of reed or hollowed wood. This kind of pipe, with a small bowl, was the prototype of the pipes of Turkey, Persia and the far east. since the Portuguese took it with them from Brazil along their trade route in the old world. Much larger pipes were also used by the same Brazilian tribe, with bowls of stone, clay, or wood, and are found among their descendants, now living on the Upper Amazon.

The two-piece pipe is also found in the steppes of central and western Asia, and the Kalahiri region of South Africa. Both these are woodless countries, scantily inhabited by people mostly nomadic. There earth smoking is found. The most primitive method is to dig a small pit in the ground, to serve as a bowl; to insert a stick through the earth to the bottom of this pit; and then to withdraw the stick, leaving a hollow tube. The smoker has to lie flat on the ground and apply his mouth to the end of the tube. An improvement on this uncomfortable method is the fashioning of a rough bowl of clay above the surface of the ground, with a tube formed as before with the aid of a stick. Such an earth pipe, when dry, can be detached and carried about. The insertion of a separate mouthpiece into the end of the hollow tube would convert it into a two-piece pipe. In quite a different part of the world, among some of the North American Indians, a hollow reed stuck into a bowl made of wet clay is said to serve as an emergency pipe.

The credit of the first invention of the pipe cannot be assigned to any one people nor is it certain that smoke proceeded always from tobacco leaf. There is hemp, which, in many parts of the world at least, long preceded tobacco. There are many herbs, such as henbane, ahich were commonly used in Europe, for how many centuries we do not know. Opium smoking, on the other hand. is a late development Early evidence concerning the tobacco pipe comes from America only, for the reason that the tobacco plant is a native of America. The theory that both the plant and the habit of smoking derived originally from Africa and reached the western coast of America by way of the Indian and Pacific oceans, rests on an insufficient basis. Smoking, no doubt, is a custom of great antiquity in Africa; but it is the smoking of hemp, as exemplified notably among the Bushmen of the Kalahiri desert. The evolution in Africa of the pipe for hemp smoking has, so far as we can tell, been from the earth pit, through the simple tube, to the Dakka (hemp) pipe. which is the ancestor of the water pipes of various kinds used for tobacco in the east. Among the Bushmen an animal's horn. generally an antelope's, is used as the water vessel. Among other African tribes oxhorns, gourds, bamboos and wooden stems are to be seen. It was thus the African hemp smokers who gave to the smokers of tobacco this idea of using a pipe in which fumes should be filtered and cooled by passing through water.

See also TOBACCO PIPE.

See A. Dunhill, *The Pipe* (1924); the *British Museum Handbook to the Ethnographical Collection,* 2nd ed. (1925); the *British Museum Guide to the Maya Collection* (1923). (A. D.)

PIPIL, a dialect of the Nahuatl or Aztec language. In southern Mexico, Guatemala and western Salvador there are four groups of Indians who speak a Nahua dialect. related to but more primitive than Aztec. These four groups are: (1) Pipil of Soconusco; (2) Pipil of the upper Motagua valley; (3) Pipil of Escuintla; and (4) Pipil of Salvador. At the time of the Spanish conquest several explanations of the presence of these Mexican Indians in Central America were given by the natives. It was said that the Aztec emperor, Ahuitzotl (1486–1502), sent colonists to spy out the land and prepare for a never accomplished conquest. This tale fails to account for the large and well-built cities occupied by the Pipil. More generally it is thought that they were Toltec (*q.v.*) who either migrated from Mexico with one of the early priest-kings named Quetzalcoatl, or, more probably, fled after the downfall of the Toltec empire in the 11th century. The Spanish historian Juan de Torquemada in support of the last hypothesis has preserved a significant migration legend. Numerous ruined cities are attributed to the Pipil by archaeologists. Of these the most important are Santa Lucia Cazumalhualpa and Baul in Guatemala and Chalchuapa, Cihuatan and Tehuacan in Salvador. These sites yield characteristic stone carvings and pottery types. The modern culture of the Pipil varies from village to village. In general it reflects that of their neighbours such as the Quiché (*q.v.*).

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PIPIT, a subfamily of birds having a great resemblance in habits and appearance to the larks (*q.v.*). They differ. however, in several important characters. They are associated with the wagtails (*q.v.*) in the Passerine family Motacillidae. Pipits, of which over 50 species have been described, occur in almost all parts of the world, but in North America are represented by only two species—Neocorys spraguii, the prairie lark of the northwestern plains, and *Anthus ludovicianus,* the American titlark, which last is nearly allied to the water pipit of Europe, *A. spinoletta.* To English readers the best-known species is the titlark or meadow pipit, *A. pratensis,* a bird abundant on pastures, moors, and uncultivated districts generally; but in some localities the tree pipit, *trivialis* (A. arboreus), takes its place, and where it does so it attracts attention by its loud song, which is delivered (as in all the pipits) on the wing. Another species, the rock pipit, A. *obscurus,* scarcely ever leaves the seacoast and is found almost all round the British Isles. The South African genus Macronyx, remarkable for the extreme length of its hind claw, differs and has brighter coloration.

PIPPIN or PEPIN, the name of three members of the Carolingian family.

PIPPIN I (d. 639), incorrectly called Pippin of Landen, was mayor of the palace of the youthful Dagobert I, whom Clotaire II had placed over the kingdom of Austrasia. He was disgraced when Dagobert became sole king in 629, and had to seek refuge in Aquitaine.

Returning at Dagobert's death (638), he governed Austrasia in Sigebert's name, but died the following year.

PIPPIN II (d. 714), incorrectly called Pippin of Herstal, was son of Adalgiselus (son of Arnulf, bishop of Metz) by a daughter of Pippin I, called in later documents Begga. Toward 678 he placed himself at the head of the great nobles in Austrasia to combat Ebroïn, the mayor of the palace, and Neustria. After some reverses he gained a great victory after Ebroïn's death at the battle of Tertry (687) not far from St. Quentin, which marks the fall of the Merovingians. He appointed one of his grandsons, Theodebald, mayor of the palace of Neustria, reserving for two others (Arnulf and Hugo), the mayoralty of Austrasia.

He made war on the Frisians and defeated their duke Radbod; and part of these people became converts to Christianity. He also defeated the Alamanni, and subdued their country. The only part of Gaul not under his suzerainty was Aquitaine. The plans he had formed for reforming the church and convoking councils

were interrupted by his death on Dec. 16, 714.

PIPPIN III (d. 768), the Short, was the younger son of Charles Martel. Before his death in 741 Charles Martel had divided the Frankish kingdom between his two sons Carloman and Pippin, giving Carloman the eastern part and Pippin the western. Since 737 there had been no king in the Frankish realm; in the diplomas the two brothers bear the title of *majores palatii,* while the chroniclers call them simply *principes*. In 743, however, the mayors decided to appoint a king in the person of Childeric III, who was apparently connected with the Merovingian family. But Childeric was a mere figurehead, and had no power. The two brothers presided over the tribunals, convoked the councils at which the Frankish church was reformed, assembled the host and made war, jointly defeating and subduing Duke Hunald of Aquitaine.

In 747 Carloman unexpectedly abdicated, became a monk, and retired to a monastery near Rome, subsequently founding on Mt. Soracte the monastery of St. Silvester. From the time of the abdication Pippin was sole master; and in 751, after consulting Pope Zacharias, he held an assembly of the Franks at Soissons, took the title of king and removed the feeble Childeric to a monastery. He then got himself crowned by St. Boniface, a ceremony which was new to France and which gave the sovereign immense prestige; henceforth the king of the Franks called himself *Gratia* Dei *rex Francorum*.

Pippin's reign is marked by many important events. He received in France a personal visit from Pope Stephen II, who conferred on him the title of Patrician of the Romans and recrowned him. In return for these honours Pippin, at the appeal of the pope, made two expeditions into Italy, in 754 and 756; and he became the veritable creator of the papal state by conferring on the pope the exarchate of Ravenna, which he had wrested from Aistulf, the king of the Lombards.

Pippin took Septimania from the Arabs, and after a stubborn war of nearly eight years' duration (760–768) succeeded in taking Aquitaine from its duke, Waifer. He also intervened in Germany, where he forced the duke of Bavaria, Tassilo, to become his vassal. In 763, however, Tassilo abandoned Pippin during an expedition against Aquitaine. Pippin made several expeditions against the Saxons, but failed to subdue them. He entered into relations with the eastern empire, exchanging ambassadors with the emperor Constantine Copronymus. During Pippin's reign Frankish institutions underwent some modification. The Frankish assemblies, previously held in the month of March (*champs* de mars), but under Pippin deferred to May (*champs* de *mai*), came to be more numerous, and served the king of the Franks as a means of receiving the gifts of his subjects and of promulgating his capitularies. At the head of the administration was placed the archchaplain, and an ecclesiastical chancellor was substituted for the ancient *referendarius*. Ecclesiastical reform was continued under Pippin. Bishop Chrodegans of Metz uniting the clergy of Metz in a common life and creating canons. Pippin died on Sept. 24, 768 at St. Denis, leaving two sons, Charles (Charlemagne) and Carloman, between whom he divided his kingdom.

See H. Bonnell, Die *Anfänge des karolingischen Hauses* (Berlin, 1866); H. Hahn, *Jahrbücher* des *frankischen Reiches 741–752* (Berlin, 1863); L. Oelsner, *Jahrbücher* des *frankischen Reiches* unter *König Pippin* (Leipzig, 1871); J. F. Böhmer and E. Mühlbacher, *Regesten* des *Kaiserreichs unter den Karolingern*, 2nd ed. (1899); E. Mühlbacher, *Deutsche* Geschichte unter den *Karolingern* (1896). (C. PF.)

PIPSISSEWA (*Chimaphila umbellata*), called also prince's-pine, a plant of the wintergreen family (Pyrolaceae) flowering from June to August in dry woods in North America from Nova Scotia to British Columbia and southward to Georgia and California. It is found also in Europe and Asia. The flowers are flesh-coloured or pinkish, waxy, five-parted and grow in small terminal groups on a three to ten inch stem. The leaves are dark green, shining, evergreen, sharply toothed and appear in whorls or placed oppositely on the stem. The spotted pipsissewa or spotted wintergreen (Chimaphila *maculata*) occurs in small areas from Maine and Ontario to Minnesota and southward to Georgia and Missouri. Its leaves are dark green, and mottled with white veins, sharply toothed and tapering to narrow points.

PIQUA, a city of Miami county, Ohio, U.S., on the Miami river, 28 mi. N.W. of Dayton. The city has grain elevators and blue limestone quarries. Manufactures include textiles, stoves, furniture, blankets and felts. On or near the site of Piqua was one of the principal villages of the Chillicothe division of the Shawnee tribe. A town, Washington, was established there in 1807 and in 1823 it was renamed Piqua after another Shawnee division. It was chartered as a city in 1850. Pop. (1950) 17,447.

PIQUET, a game of cards, probably a development of *ronfa,* a game mentioned by Francesco Berni in 1526. The Spanish name of the game was *cientos* (*centum,* a hundred). Piquet was played in England under the name of cent, probably as early as 1550.

Piquet is essentially a game for two players, although there are variants for three and four. A pack of 32 cards is used, ranking: ace (high), king, queen, jack, ten, nine, eight, seven. Twelve cards are dealt to each player, two or three at a time. The remaining eight cards, the stock, are spread face down. If either player holds carte blanche (a hand with no court card), he announces it and scores 10 points. Nondealer (also called elder, or major) discards from one to five cards and draws an equal number from the top of the stock. If he leaves any of the first five, he may look at them without showing them to dealer. Dealer (also called younger or minor) then discards if he chooses from one card up to the number remaining in the stock and draws an equal number. If he leaves any, he may turn them face up.

After the draw, nondealer announces his best holding (if any) in each of three classes of scoring combinations. The classes are point, sequence and set. Only one player is entitled to score in each class.

Point is the longest suit or, if the long suits in both hands are equal in length, the highest total count in those suits, reckoning ace as 11, court cards 10 each and other cards their pip value. Whoever has the better point scores 1 for each card in the suit. A tie scores for neither.

A sequence is three or more cards of the same suit in consecutive rank: tierce for sequence of three, quart for four, quint for five, etc. The longest sequence is "good," and the holder may also score any additional sequences he holds. Between equal length sequences, that of higher rank is good. Tierce scores 3, quart 4; quint or better scores 10 plus 1 for each card. If there is a tie for best sequence, no sequences are scored.

Sets are three of a kind (trio) or four of a kind (quatorze) of rank ten or higher. A quatorze, counting 14, is good against a trio, counting 3. Between equal length sets, that of higher rank wins. The player with the highest set may count it and any additional set he holds.

A player may sink (conceal) part or all of a combination if he thinks revealing it would aid his opponent's play. Any declared combination that scores must be proved, usually by exposing it, though etiquette varies in this matter. Carte blanche is shown, after the opponent has discarded.

Upon completion of the declarations, play begins, nondealer making the first lead. Each lead requires the other to follow suit if able. The trick is won by the higher card of the suit led. (There is no trump suit.) The winner of a trick leads to the next. For each lead he makes and each trick he wins on an adverse lead, the player counts 1 point. The last trick counts 1 extra point. The winner of a majority of the 12 tricks scores 10 points. If he wins all the tricks he scores 40 for capot.

If by declared combinations a player reaches 30 or more points before his opponent scores a point, he adds 60 to his score for repique. If he reaches 30 in declaring and play (excluding capot) before his opponent scores, he adds 30 for pique.

During declaration and play, the score is kept verbally, each player announcing his new total after each increment. At the end of play the totals are written on paper.

In the early piquet au cent, a game was continued by alternate deals until one player reached 100 points. This game was superseded by rubicon piquet, in which a game is six deals. The winner receives a bonus of 100 for game, plus the difference of the final totals. If the loser fails to reach 100 (regardless of whether the winner also is below 100), he is rubiconed, and the winner

takes 100 plus the sum of the final totals. Modern players prefer the short game of four deals, the first and last counting double.

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PIRACICABA, a city in the interior of São Paulo state, Brazil, 85 mi. N.W. of São Paulo, with which it is connected by rail and all-weather highway. Pop. (1950) 45,782. Piracicaba is the centre of one of São Paulo's most productive agricultural districts, where sugar cane, cotton, coffee, rice and oranges are grown. In the town are sugar mills, brandy distilleries making *caxaça,* cotton gins, rice and coffee processing plants, tanneries, flour mills and a paper manufacturing plant. Nearby, on an area of the purple-coloured *terra roxa* soil, is one of São Paulo state's chief agricultural colleges. (P. E. J.)

PIRANDELLO, LUIGI (1867–1936), Italian dramatist, novelist and Nobel prize winner. was born on June 28. 1867, on a country estate near Girgenti (Sicily). He first went to Rome at the age of 19, staying there until 1891. when he went to Germany and graduated in philosophy at the University of Bonn. He subsequently returned to Rome and taught at the girls' high school until 1923. His first literary essays were in verse, a volume entitled *Mal giocando* published in 1889, followed by a poem *Pasqua di Gea* (1891) and *Elegie renane* (1895). Another Sicilian writer, Luigi Capuana, persuaded him to devote himself to fiction. and in 1901 he published his first novel. *L'esclusa,* in which his somewhat bitter realism already finds expression. Besides the novel, *Il turno,* he began to publish short stories: *Amori senza amore* (1894) *Quando ero matto* (1902) *Beffe della morte e della vita* (1902, 1903), *Bianche e nere* (1904), etc. In 1905 his most celebrated novel, *Il fu Mattia Pascal,* appeared, the story of a man, who having shammed being dead. tries in vain to begin his life anew in a different atmosphere and under another name, Other collections of short stories followed: *Erma bifronte* (1906), *La Vita Nuda* (1910), *Terzetti* (1912). He set forth his artistic creed in two volumes entitled *Arte e scienza* (1908). In 1923 his novel, *I vecchi e i giovani,* describing the drama of Italian life after the Risorgimento, was published in the *Rassegna contemporanea.* Other volumes of short stories appeared between 1914 and 1926, such as *La trappola* (1915), *Un cavallo nella luna* (1918), *Il carnevale dei morti* (1919), *Tu ridi* (1920), and another novel *Uno, nessuno e centomila* was published in the *Fiera letteraria.*

In 1920 he said of his own art:

I think that life is a very sad piece of buffoonery;because we have in ourselves, without being able to know why, wherefore or whence, the need to deceive ourselves constantly by creating a reality (one for each and never the same ior all), which from time to time is discovered to be vain and illusory . . . . My art is full of bitter compassion ior all those who deceive themselves; but this compassion cannot fail to be followed by the ferocious derision of destiny which condemns man to deception.

This despairing outlook attained its most vigorous expression in Pirandello's plays. In his youth he had shown a certain contempt for the drama, but in 1912 he was persuaded by the Sicilian playwright, Nino Martoglio, to dramatize one of his own short stories, *La Morsa,* as a one-act piece. His first three-act comedy, *Se non così* (1917), was produced by Marco Parga at Milan in 1913; and then many plays—dramas and comedies—of which the most celebrated are *Il berretto a sonagli; Liola* (1917); *Così è se vi pare* (1918); *L'uomo, la bestia e la virtù* (1918); *Ma non è una cosa seria* (1918); *Come prima, meglio di prima* (1920); *Sei personaggi in cerca d'nutore* (1918); *L'imbecille; Enrico IV* (1922); *Vestire gli ignudi* (1923); *La vita che ti diedi* (1924); *L'altro figlio; Ciascuno a suo modo; La sagra del signore della nave; La giara.*

Pirandello's dramatic art was at first criticized for being too "cerebral," for not seeing life as it really is and for arbitrarily deforming it. The Roman critics first discovered the real meaning of Pirandello's ideology and the human sense of his plays. His main themes are: the necessity and the vanity of illusion, the multiform appearances, all of them unreal, of what is presumed to be the truth. man is not what he thinks he is, but he is "one, no one and a hundred thousand," accordingly as he appears to this person or to that, and is always different from what he creates himself in his own mind. Hence the supreme catastrophe. when a moral looking glass suddenly reveals to him the image of himself which others see; *i.e.,* what he *is* to others. Most of Pirandello's plays deal with a lower middle class milieu. peopled with clerks, teachers, lodginghouse keepers. etc., from whose modest vicissitudes he draws conclusions of vast human sigpificance. Typical is *Così è se vi pare,* in which he proves that it is impossible t~ know the real truth.

Enrico IV develops in a broader sense; that is, a drama in which we have a man who renounces his changing, empty and vain existence to play the part of a madman, and pretends to believe himself an historical personage. Henry IV. All this might be merely theatrical trickery if it were not seared by a deep anguish, characterizing a philosophy which has destroyed all faith in the absolute, in reality, in any fixed limits outside individual personality.

Pirandello's plays rapidly achieved success throughout Italy and abroad, and were translated into many languages. In 1925 he created an art theatre of his own in Rome, where new Italian and foreign plays are performed. and in the summer of the same year he took his company on a tour to England to'produce his own plays in London (at the New Oxford theatre), to Paris, Basle and 18 theatres in Germany.

Pirandello was awarded the Nobel prize in literature in 1934. He died from pneumonia on Dec. 10, 1936. (S. D'A.)

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PIRANESI, GIAMBATTISTA (GIOVANNI BATTISTA) (1720–1778), Italian draftsman and etcher, whose large prints of the buildings of classical and postclassical Rome and its neighbourhood contributed considerably to Rome's fame and to the growth of classical archaeology and the neoclassical movement in art. He was born in 1720 near Venice and moved to Rome in 1744.

He developed the medium of etching by means of complicated repeated bitings of the copperplate, which resulted in rich textures and bold contrasts of light and shadow. A prolific etcher he created more than 1,000 plates. The "Prisons" *(Carceri)* of *c.* 1745 are his finest early prints; they constitute a climax of late baroque fantastic, visionary architecture. Among his best mature prints are the series Le *Antichitd Romane* (1756), the *Vedute* di *Roma* (appearing as single prints between 1748 and 1778), and the views of the Greek temples at Paestum (1777–78). His unparalleled accuracy of depiction, his personal expression of the structures' dramatic and romantic grandeur, and his technical mastery made these prints the most original and impressive representations of architecture to be found in western art.

Piranesi died in Rome in 1778

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PIRANO (PIRAN), a former seaport of Istria, Italy. 22 mi. S.W. of the city of Trieste by rail, in 1954 incorporated into Yugoslavia. Pop. (1956 est.) 3,574.

Pirano has picturesque Venetian walls and buildings. On the coast nearby are extensive salt pans. The Venetians defeated the fleet of Frederick Barbarossa off Pirano in 1177. It surrendered to Venice in 1283 and was incorporated with Austria, together with the rest of Istria, in 1813. Under an agreement between Italy and Yugoslavia in Oct. 1954, Pirano continued under Yugoslav control, the former zone B, in which it was located, becoming part of the republic of Slovenia. It was the birthplace of the violinist

Giuseppe Tartini. Near Pirano is the favourite seaside resort of Portorose.

PIRASSUNUNGA, a city of the state of São Paulo, in southeastern Brazil. about 6j mi. N.N.W. of Campinas. The population was 12,546 in 1950.

A railway junction, the city manufactures bricks, cotton textiles and rum.

PIRATE and **PIRACY.** Sir J. Fitzjames Stephen in his *Digest of Criminal Law* defined piracy as follows: "Taking a ship on the High Seas or within the jurisdiction of the Lord High Admiral from the possession or control of those who are lawfully entitled to it and carrying away the ship itself or any of its goods, tackle, apparel or furniture under circumstances which would have amounted to robbery if the act had been done within the body of an English county." (Cf. *A. G. for Hong-Kong* v. *Kwok-a-Sing,* 1873, L.R. 5 P.C. 179.) Piracy, being a crime not against any particular State but against all mankind, may be punished under international law in the competent court of any country where the offender may be found or into which he may be carried. But, whilst the practice of nations gives to every one the right to pursue and exterminate pirates without any previous declaration of war (pirates holding no commission or delegated authority from any sovereign or state), they may not be killed without trial except in battle. Those who surrender or are taken prisoners must be brought before the proper tribunal and dealt with according to law.

Following the sinking of merchant vessels at sight by German submarines in the World War, by the Washington Treaties (1921–22) between the United States, the British Empire, France, Italy and Japan, attacks upon, and destruction of, merchant vessels upon visit and search by any person in the service of any Power were declared acts of piracy, and such persons may be brought to trial before the civil or military authorities of any Power within the jurisdiction of which he may be found. It was held by the Federal District Court of New York, in the suits brought against the Cunard Steamship company for damages arising out of the sinking at sight of the "Lusitania" by a German submarine, that such sinking was an illegal act. See *The Lusitania* (1918) 251 Fed. 715; *Scott's Cases,* 784–90. (X.)

HISTORY

It is impossible to say at what period in the world's history piracy began. References to this form of robbery occur in early literature. It was rampant in the Mediterranean in the days of the Roman republic, and it is recorded that Julius Caesar, when a young man, fell into the clutches of a gang of sea-robbers who held him prisoner until ransomed, and that after his release he returned with some soldiers who captured his late gaolers and crucified the whole crew. Amongst the early pirates of which records still exist are the Phoenicians, while there are numerous references to sea-rovers in the Odyssey. Out of the dim North, the Vikings (*q.v.*) are known to have come south to plunder the coasts of Britain, Ireland and France, in A.D. 789 and onwards. For many centuries the north-west coast of Africa was the headquarters of the Barbary pirates (*q.v.*) or Moors, as they were commonly called, who had their chief strongholds at Algiers, Salé and Tripoli. From these harbours they sailed out to harry passing ships, or plunder the opposite coast of Spain, carrying back their Christian captives to sell as slaves. In spite of numerous punitive attacks, these fierce sea-robbers were not finally stamped out until 1830. All through the Tudor reigns piracy was rampant around the British isles, particularly in the south of Ireland and in the Scilly isles, where safe retreats existed for the pirate and where receivers of plunder were to be found willing to buy the goods that the pirate had to offer.

As in the case of the land thief, the sea thief could not exist without a market for his ill-gotten goods. It would be useless for a pirate to seize a well-laden merchant ship, if he had nowhere he could dispose of his prize. Sir William Monson in his book *Naval Tracts,* records how he was sent in 1605 to search for pirates in the Shetlands and Hebrides. But it was in Ireland where he found what he looked for. At Broad Haven he met with an Irish gentleman, of the name of Cormat or Cormac, whose house he describes as being the "well-head of all pirates." Here the Irishman lived in great style and trafficked with the pirate captains, many of whom were the lovers of his daughters.

As life became more difficult for the pirates in the home waters, they migrated further afield, where they could practise their calling with less interference. Thus piracy spread to the far-off West Indies, and the coast of New England, and eventually to the Red sea and Madagascar. For many years the latter island was the happy haunt of the pirates, where they lived in security, married native women, and reigned as petty kings. From here they were able to lay heavy toll on passing ships sailing between England and the East Indies.

The natural haunts of the pirates were in archipelagos and indented coasts, and there at one time or another such places as the Greek islands, the Indian ocean, the coast of Cilicia, the British Isles, Norway and the West Indies became their lurking places.

In England itself, up to the 16th century, piracy was not uncommon, and it was no unusual event for the inhabitants of the Cinque ports to sally forth in their small ships and plunder any passing vessel, and on more than one occasion the fleet of New Romney attacked and plundered the ships of its rival, Yarmouth.

The West Indies. — The West Indies were well prepared for practical exploration both geographically and historically. Since the 16th century the buccaneers (*q.v.*) had preyed upon the Spaniard, and there were innumerable hiding-places, hidden bays in uncharted islands, where pirates could meet in safety and divide the spoils and prepare for their next adventure. During the 17th century the island of Tortuga, or Turtle island, off the coast of Hispaniola, became a regular pirate republic. Good markets for stolen plunder were to be found on the New England coast, and in Jamaica and at New Providence island, as well as in Ireland and certain places in the west of England.

Much of the piracy in the West Indies and America was the direct outcome of the Spanish policy of forbidding her colonists the right of trading with foreigners, in spite of her inability to supply their needs herself. Naturally the Spanish Americans were only too eager to buy smuggled goods, at very low prices, and were not likely to be very particular to enquire where the goods came from. England and France also tried to insist on their colonists trading exclusively with themselves, at their own prices, which, combined with the almost total lack of policing by the regular navies, led to wholesale buying of smuggled merchandise, procured by irregular methods. It was not until the reign of William III., about 1700, that workable laws were made for trying pirates, and even then it was often difficult to get a jury to condemn a pirate who was looked upon as a public benefactor.. Owing to the difficulty of policing the seas, particularly in distant waters, the custom arose in the reign of Charles I., and continued until that of George I., of granting free pardons to all pirates who would surrender themselves by a certain date. The result was that when things had become too warm for a pirate, he would make his submission to the authorities and receive the royal pardon, and, as soon as ever his booty was spent, resume his old practices. One of the greatest wholesale pardoning of pirates was carried out by Captain Woodes Rogers at New Providence in the Bahamas in 1718. At this time there were more than 2,000 freebooters entrenched in this pirate stronghold, but Rogers dealt so successfully with them that almost all surrendered.

Organization. — The ranks of the pirates were recruited from a type of seafaring man who disliked steady work with its small rewards, and preferred a life of danger, with a prospect of gaining sudden wealth. After every European war ships would be laid up and crews disbanded. There being no honest employment for all these sailors, they were compelled by circumstances to take any employment at sea that offered itself; and as often as not this consisted of signing on in a ship where no questions were asked, and no wages paid, but where every member of the crew took a share of any profits which might accrue from the voyage.

Very often when a pirate captured a merchant ship the crew of the latter were invited to join the pirates. Some would do so

willingly, others only under compulsion. Most pirates when brought to trial pleaded that they had been compelled to join the pirates, and had done so only to save their lives. It often happened that amongst the members of a captured crew there would be some "sea-artist,". as a particularly skilful navigator was called, and he would be compelled to sign on whether he wished to or not. A common source of piracy was the privateer, an armed ship that sailed under a letter of marque, which was apt to drift into piracy, when its legitimate prey was not forthcoming, to supply the prize-money which paid the wages of officers and crew. This fact was pointed out by Cotton Mather (*q.v.*), the New England divine, in one of his "hanging sermons" delivered at Boston to condemned pirates. In one which he preached in 1704 called "A Brief Discourse occasioned by a Tragical Spectacle of a Number of Miserables under Sentence of Death for Piracy," he stated, "the Privateering Stroke so easily degenerates into the Piratical, and the Privateering Trade is usually carried on with an Unchristian Temper, and proves an Inlet into so much Debauchery and Iniquity."

The same view was expressed by Nelson when he declared that all privateers were no better than pirates, although this wide accusation cannot be allowed to include such famous and patriotic privateers as Captain Fortunatus Wright or Commodore Walker. Many a shady privateer was little better than a pirate, and the letter of marque under which he sailed a mere pretence, as in the case of a pirate who plundered Spanish ships in the 17th century, under a commission sold to him by the governor of a Danish West India island, himself a reformed pirate. This document, written in Danish, proved, when translated, to entitle the holder to hunt for goats and wild pigs on the island of Hispaniola and nothing more.

The establishment of a pirate gang usually took one of two forms. The most usual was for a few ringleaders to plot a mutiny on board a merchant ship. At a prearranged signal the mutineers would seize the officers and kill them and any members of the crew who resisted, and throw their bodies overboard.

But many a pirate who eventually rose high in his profession began in a very small way. Often a handful of desperate characters would steal a boat and row or sail along the coast by night, until they surprised the crew of some small schooner, and became masters of her. In this they would venture further afield, until by cunning or force they got possession of a larger ship. The downfall of most pirates was brought about by their utter lack of discipline, for, unless the elected captain was a man of unusual strength of character, as was the famous Captain Bartholomew Roberts. he was unable to keep his crew in order, and sooner or later, disaster overtook them, through careless navigation or at the hands of a better-disciplined hostile ship.

One of the first formalities of a newly created pirate crew was the drawing up and signing of the ship's articles, which would include such rules as the following. taken from those of Captain John Phillips of the "Revenge":

1. Every man shall obey civil Command; the Captain shall have one full Share and a half in all Prizes; the Master, Carpenter, Boatswain and Gunner shall have one Share and a quarter.

6. That Man that shall snap his Arms, or smoak Tobacco in the Hold without a cap to his Pipe, or carry a Candle lighted without a Lanthorn, shall receive Moses's Law (that is 40 Stripes lacking one) on the bare Back.

9. If at any time you meet with a prudent Woman, that Man that offers to meddle with her, without her Consent, shall suffer present Death.

Another matter, considered to be of great importance, was the choice of a flag, whose chief object was to "strike terror into all beholders." The favourite design was a skull and cross-bones; though sometimes a whole skeleton was depicted, holding in one boney hand a rummer or glass of punch, and in the other a sword or dagger. Whenever possible the pirates carried a surgeon, who was treated with a certain amount of respect.

Famous Characters.—The ordinary pirate was merely a criminal who lived for himself alone, and lacked any sense of ambition other than to get rich quickly, and must not be placed in the same category with the Vikings, who although sea-robbers and murderers, worked in large and, to a certain extent, organized bands; as did the Mediterranean pirates in Roman times who formed a highly organized brotherhood of desperadoes. The ordinary pirates boasted that they "declared war upon the whole world" and possessed no honour even amongst themselves.

A few of the most famous pirates may be briefly mentioned. Captain John Avery, *alias* Every, alias Bridgeman, familiarly known as "Long Ben" or the "Arch-Pirate," was born at Plymouth about 1665, took to the sea and rose to mate in a merchant ship; headed a mutiny and was elected captain; proved himself a daring pirate leader, and after much success off the Guinea coast and in the West Indies sailed to the Red sea, where he seized a rich ship of the Great Mogul, reported to have on board 100,000 pieces of eight and the Mogul's young and lovely daughter. He took both to Madagascar where he settled down as a reigning monarch. In 1696 he was at Boston, where he bribed the governor to allow him and his crew to land and dispose of their plunder. He died in poverty at Bideford after being tricked out of his ill-gotten gains by certain merchants of Bristol. Charles Johnson wrote a play called *The Successful Pyrate*, which was acted at Drury Lane, in 1713, and which was modelled on Avery's career.

Bartholomew Roberts was, perhaps, the greatest of all pirates. Born in Wales in 1682, he died fighting in 1722. He was credited with having taken over 400 ships during his career, and was remarkable for his discipline, for being a teetotaler, and allowing no women or gambling aboard his ships.

Edward Teach, *alias* Blackbeard, a picturesque blackguard, was killed on Nov. 22, 1718, in a hand-to-hand combat with Lieut. Robert Maynard, of H.M.S. "Pearl."

Captain Misson, a Frenchman of good family, was unique in combining active piracy with socialistic ideals. He reigned for many years over a Utopian republic in Madagascar.

Two women pirates, Anne Bonny and Mary Read, deserve mention, as both rose high in their ancient dual professions.

The famous Captain Kidd (*q.v.*) may perhaps have been no pirate at all, but the victim or scapegoat of political intrigue.

With the peace of 1815 came a great increase in West Indian piracy, which was assisted by the inability of the Spanish authorities to cope with the pirates while their colonies were seething with revolt. At last the British and American navies combined to root out the evil once and for all in the Atlantic, although piracy lasted in the Greek islands until nearly 1850.

The end of piracy, after centuries, was brought about by public feeling, backed up by the steam-engine and telegraph. The last relic exists to-day in China, where a nest of troublesome pirates still carries on the old trade in spite of the navies of the foreign powers. The Chinese pirates ship themselves as ordinary coolie passengers on a coastal steamer and, at a given signal, produce revolvers and hold up the officers and crew and compel them to navigate the ship to their headquarters at Bias bay, where the ship is plundered and officers and passengers held for ransom.

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(P Go.)

PIRE, DOMINIQUE GEORGES (1910–), Belgian Roman Catholic priest who was awarded the 1958 Nobel peace prize in recognition of his work in establishing shelters for elderly, destitute refugees of World War II. Born at Dinant, Belg., on Feb. 10, 1910, Father Pire in 1928 entered the Dominican order at the monastery of La Sarte at Huy, near Liège. From 1932 to 1936 he studied at Rome, taking a doctorate in theology. He later studied social science at the University of Louvain. During the Nazi occupation of Belgium in World War II he took part

in the Belgian resistance movement, and until 1947 he was a teacher of moral philosophy and sociology at Huy. For his war service he was awarded the Belgian Croix de Guerre with palms and the resistance medal. In 1949 he started his refugee work, founding a number of "European villages" for elderly refugees without distinction of nationality or religion. The money he received with his Nobel prize was used to further this work.

PIRELLI, an Italian family of industrialists who contributed to the development of production and commerce in rubber goods, electric wire and electric cable.

GIOVANNI BATTISTA PIRELLI (1848–1932), born at Varenna, Como, on Dec. 27, 1848, was educated in Milan. In 1872 he started a small rubber factory there, the first in Italy and one of the first in Europe. It pioneered the manufacture of electric cable (1884) and in 1899 began producing automobile tires. In 1902 the company began its foreign expansion by starting a subsidiary factory in Spain. Pirelli died in Milan on Oct. 20, 1932.

His two sons, PIERO (1881–1956), born in Milan on Jan. 27, 1881, and ALBERTO (1882–), born also in Milan on April 28, 1882, joined the business in 1904. Factories were started, under the Société Internationale Pirelli of Basel, Switz., in Great Britain, other European countries, Turkey and the Americas, and eventually the Italian and International Pirelli groups together employed more than 55,000 people. Piero Pirelli, chairman from 1932. greatly assisted the development of the Italian telephone service. He died in Milan on Aug. 7, 1956. His brother, Alberto, who became chairman in 1956, also has been active in economic international law. He was a member of the Supreme Economic committee of Versailles (1919), Italian delegate to the first International Labour office of Geneva (1920–22), served on the League of Nations economic committee (1923–27) and, as a leading negotiator on war reparations and debts, on the Dawes and Young committees (1924, 1929). He became a minister plenipotentiary in 1924 and a minister of state in 1938.

PIRENNE, HENRI (1862–1935), Belgian historian, was born at Verviers on Dec. 23, 1862. He first lectured at the University of Liège, and was professor at the University of Ghent, 1886–1930. His *Histoire* de Belgique, of which seven volumes had appeared in 1932, completely revolutionized the current conceptions of Belgian history and nationality by showing how, from the time of the Germanic invasions, Flemings and Walloons were drawn together by community of tradition and economic interest. Pirenne's works on medieval cities and social conditions include Les anciennes de'mocraties des Pays-Bas (1910, Eng. trans. 1915), Recueil des documents relatifs à l'histoire de l'industrie drapikre en *Flandre* (with G. Espinas, 4 vols., 1906–24) and *Mediaeval* Cities: Their Origins and the Revival of Trade (1925). He was the first president of the "Union Académique Internationale" (1920–23) and received many foreign honours.

PIRKE ABOTH, literally Chapters of the Fathers, a collection of proverbs arranged chronologically and giving a *catena* of Jewish scholars. The treatise belongs to the IVth Order (*Neziqin*) of the Mishnah and deals with the history of tradition. This, the so-called Oral Law (Torah she-be-'a1 *Peh,* Deut. iv, 14; v, 22–33, especially 31; and other passages) supplemented the Written Law (Torah she-be-khefhabh). The Oral Law in Aboth is traced back from Moses, through Joshua, the elders and Prophets, to the Men of the Great Synagogue, a body the existence of which is now merely doubted but which was formerly denied categorically. Through Simon the Just (either Simeon, grandson of Jaddua, High priest, 310–291 B.C., or his grandson. 219–199) and Antigonus of Socho, both survivors of the Great Synagogue, tradition is carried on by five pairs of teachers (*Zūgōth, ζνγόν*) to Hillel and Shammai (30 B.C.). Henceforward the sayings of their disciples and successors are given until ch. iv, which concludes with El'azarhaq-Qappar (end of 2nd century AD.). Chapters iii and iv are not strictly chronological. Chapters v and vi are of later date. Chapter v combines historical. legendary and didactic elements, miracles are explained and a series of things, sayings and qualities are grouped numerically, *e.g.,* ten *Ma'amaroth* or Logoi are said to have created the world; vi is called the "chapter of the acquisition of the Law" and was probably added for liturgical purposes. Aboth is written in simple Hebrew. The aphorisms are of great intrinsic beauty and are of .extreme historical importance not only for Judaism but for the environment of nascent Christianity. The chapters are read, on different occasions, in most Jewish rites.

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PIRMASENS, a town of Germany in the Land of Rhineland-Palatinate, 40 mi. W. by S. of Speyer, on the railway from Bieber-miihle. Pop. (1959 est.) 53,148. The staple industry is the production of boots and shoes; but organs, leather and machines are also manufactured.

Pirmasens owes its name to St. Pirmin, who is said to have preached Christianity there in the 8th century. It originally belonged to the count of Hanau-Lichtenberg, but passed to Hesse-Darmstadt in 1736. From 1794–1816 Pirmasens was French; in 1816 it came to Bavaria. In the fall of 1923 Pirmasens was a centre of the separatist movement. In the ensuing civil war 15 separatists were massacred at Pirmasens. See RHINELAND, THE.

PIRMEZ, OCTAVE LOUIS BENJAMIN (1832–1883), Belgian essayist, one of the intellectual elite who brought about the 19th-century literary revival, was born on April 19, 1832, at Chbtelet, Hainaut. He studied at Brussels university and thereafter spent half his time in travel and half in solitary meditation. Besides a lively and interesting correspondence. he left works of considerable philosophic power and literary value—Feuille'es (1862), *Jours* de Solitude (1869), Heures de philosophie (1873) and *Rémo* (limited ed. 1878; 1880)—although showing the debilitating influence of the prevalent egocentric romanticism. In these he expressed both his desire for spiritual contact with the infinite and his appreciation of the beauty of form. All his thought is conveyed in delicate nuances, pervaded with a melancholy charm. Intensely concerned with writing as an art, he developed a style of great fluidity and clarity and strongly influenced the writers of the *Jeune* Belgique group. He died at Acoz, Hainaut, on May 1, 1883.

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PIRNA, a town of Germany in the Bezirk of Dresden, on the left bank of the Elbe, 11 mi. above the city of Dresden, and on the railway to Bodenbach and Prague. Pop. (1959 est.) 40,984. Pirna, a Slavonic settlement, was for years in the alternate possession of Bohemia and Meissen, but it became permanently united with the latter, and thus with Saxony, in 1405. The most notable edifices are the Gothic parish church, built in the 16th century and restored in 1890, and the old town hall. There are manufactures of glass, machinery, cigars, pottery, slates and enameled goods and cotton spinning and wood sawing. The Sonnenstein, a fortress above the town, was erected in the 16th century.

PIROGUE or **PIRAGUA** (the French and Spanish forms, respectively, of a Caribbean word for this type of vessel; it has at various times taken many corrupt forms, *e.g.,* periagua, *pettiaugua, pettyoagar*), originally the native name of a vessel made by hollowing out the trunk of a tree, a "dug-out"; hence applied to many different developments of this type of vessel used in the West Indies and along the American coast. An early improvement was to split the "dug-out" into two sections and insert a flat bottom of planking to widen it; another form had a lee-board, was decked in at either end, and had two masts.

PIRON, ALEXIS (1689–1773), French dramatist and wit, best known for his epigrams, was born at Dijon, July 19, 1689. He was secretary to a banker and then studied law, but moved to Paris in 1719, where he worked as a copyist, struggling meanwhile to enter the world of letters. After *Arlequin* Deucalion (1722) and other successful pieces written for the popular Théâtres

de la Foire, Piron produced Les Fils *ingrats* at the Comédie Française in 1728. La *Métromanie* (1738), a witty, urbane comedy portraying himself as a young poet intoxicated with literary aspirations, remains his most distinguished play; it was revived at the Comédie Française until well into the 19th century. His tragedies included the moderately successful Gustave Wasa (1733). Having achieved a modest fame, Piron acquired noble patrons and the entree to several literary salons, but continued to live an independent, carefree life and became known for his ready wit and his epigrams. The king vetoed Piron's election to the Académie Française in 1753 because of the licentious Ode *à Priape* which he had written as a young man. However, he was given a royal pension, and took his revenge on the Académie in one of his most celebrated epigrams:

Ci-git Piron, qui ne fut rien,
Pas même académicien.
("Here lies Piron, who was nothing,
Not even a member of the Academy.")

In 1741 he married his mistress, Mlle de Bar; she died in 1751. He died in Paris, Jan. 21, 1773.

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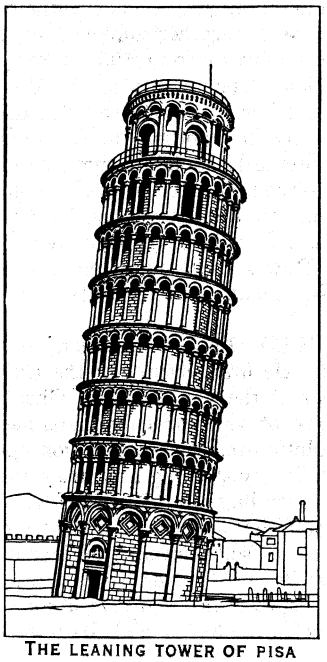
PIROT, a town of south Serbia, Yugoslavia. Pop. (1961) 18,585. It lies amid romantic scenery, and is the seat of a prefecture and a tribunal. The inhabitants are engaged in the manufacture of jewellery, thin cloth, woollen braid and carpets. The latter, woven on hand looms by women and children, are its speciality, and are noted for their excellent quality, designs and colouring. There are several schools, a large mosque and a curious old square leaning tower. The mediaeval fortress is believed to have been built on the site of the Roman fortress Quimedava, on the military road from Old Naissus (Nish) to Philippopolis. Outside the town is an early modern entrenched camp. Pirot, which is strategically important, was captured by the Serbs in the Russo-Turkish War (1877–78) and was ceded to Serbia by the Treaty of Berlin (1878). In the war between Serbia and Bulgaria in 1885 Pirot was occupied by the Bulgarians and held by them till peace was signed. It was again occupied by Bulgaria in 1941.

PIRRIE, WILLIAM JAMES PIRRIE, 1ST VISCOUNT (1847–1924), who controlled the largest ship-building firm in the world, was born of Irish parentage at Quebec, Canada, on May 31, 1847. In 1849 he was brought back to Northern Ireland, and in 1862 became apprenticed to the Belfast ship-building firm of Harland and Wolff. By the time he was 27 he had been made a partner, and was soon left in almost exclusive control. He traveled widely to gain experience in ship design and to study practical shipping requirements, and for many years the largest passenger liners in the world came from Pirrie's yards, notable examples of which were the "Olympic" and "Titanic." Pirrie was also prominent in the development of the diesel engine for marine propulsion. Created a baron in 1906, he became a viscount in 1921. As comptroller general of merchant shipbuilding in 1918, he was mainly responsible for introducing the idea of building "standard" ships. a principle which was to have such economical results in World War II. Viscount Pirrie died at sea on June 7, 1924. (P. DF)

PIRSSON, LOUIS VALENTINE (1860–1919), **U.S.** geologist and specialist in the study of igneous rocks, was born at Fordham, N.Y., on Nov. 3, 1860. Scientific inclinations, manifested in boyhood, led to advanced studies at Yale university and at Heidelberg and Paris. Field work in 1889 with a U.S. geological survey party in Yellowstone park and later in Montana confirmed him in his ultimate specialty, igneous geology. He taught at Yale from 1882 on, after 1897 as professor of physical geology, many of his students achieving distinction as geologists. His bibliography includes more than 60 titles, mostly papers on petrology published in the American Journal of Science, of which he was associate editor for two decades. He wrote significant treatises on the igneous rocks of Montana, Quantitative Classification of Igneous Rocks (with others, 1903), and two influential textbooks: Rocks and Rock Minerals (1908) and Textbook of Geology (with Charles Schuchert, 1915). He died at New Haven, Conn., on Dec. 8, 1919. (F. M. FL.)

PISA, a town and archiepiscopal see of Tuscany, Italy, capital of the province of Pisa, on the Arno, 7 mi. from the sea, and 49 mi. W. of Florence by rail. Pop. (1957 est.) 85,189 (comm.). It retains its mediaeval walls; the citadel now contains barracks. The cathedral, the baptistery, and the famous leaning-tower form a group by themselves at the north-west corner of the town. The two former are built in black and white marble, a characteristic found in Pisan churches elsewhere also. (See SARDINIA.)

The architects of the cathedral were Buschetto and Rinaldo, both probably Pisans. The church is in plan a Latin cross, 311½ ft. long and 252 ft. wide across the transepts inside. The nave, 109 ft. high, has double, the transepts single, vaulted aisles: and at the intersection of nave and transepts is a dome. The columns of the nave and side aisles are ancient. The west front is the finest part of the exterior: the range of arches running round the base is repeated by four open arcades. The three bronze doors were re-made after the fire of 1596; that of the south side (1180) is by Bonanno. The mosaics in the apse were designed by Cimabue, and the splendid decagonal pulpit (restored in 1926: see Per la recostruzione *del pergamo di Giovanni* Pisano, 1926) is by Giovanni Pisano. The baptistery, begun in 1153, is a circle 100 ft. in diameter and is covered with a cone-surmounted dome 190 ft. high on which stands a statue of S. Ranieri. The lowest range of semicircular arches consists of 20 columns, and the second of 60; and above this is a row of 18 windows in the same style separated by as many pilasters. In the interior, which is supported by four pilasters and einht columns. the most striking features are the octagonal font and the hexagonal pulpit, erected in 1260 by Niccola Pisano. The campanile or "leaning tower of Pisa," begun by Bonanno in 1174, is round. The walls at the base are 13 ft. thick, and at the top about half as much; they are constructed throughout of marble. The basement is surrounded by a range of semicircular arches supported by 15 columns, and above this rise six arcades with 30 columns each. The eighth storey, which contains the bells, is of much smaller diameter than the rest of the tower, and has only 12 columns. The height of the tower is 179 feet The tower was 15½ ft. out of the perpendicular when measured in 1829, and 16½ ft. in 1910. There is no reason to suppose that the architects intended that the campanile should be built in an oblique position; it would appear to have assumed it while the work was still in progress. The foundations are not more than 10 ft. deep, and their circumference only that of the tower. The Campo Santo, lying to the north of the cathedral, owes its origin to Archbishop Ubaldo (1188–1200) who made the spot peculiarly sacred by bringing 53 shiploads of earth from Calvary. The building, erected in the Italian Gothic style by Giovanni Pisano in 1278–83, is of special interest for its famous frescoes by various Tuscan artists, including a "Last Judgment" by Francesco da Volterra after Orcagna (1370–71); Benozzo Gozzoli (23 Old Testament scenes, 1468–84), and also for the large collection of Roman sculptures which it contains. Other notable churches are: S. Andrea, S. Pierino, S. Michele in Borgo (11th century), S. Sepolcro, erected by Diotisalvi (c. 1150), S. Nicolò, with a four-storied tower (c. 1230), S. Caterina (1252), S. Francesco (13th century) with frescoes by



THE LEANING TOWER OF PISA
Begun in 1174 and completed in 1350, the campanile is 179 ft. high and leans more than 16 ft. out of the perpendicular

Taddeo Gaddi (in the adjacent monastery is the interesting museum and picture gallery); S. Maria della Spina, an elegant little church of white marble (1325–29); and the Renaissance church of the Tuscan order of St. Stephen from plans by Vasari (after 1562), who also reconstructed the palace of the order.

The main streets of the older part of the town have porticoes. There are wide quays, with fine buildings, on each side of the Arno, but the town, as a whole, is quiet, owing much of its importance to its being the junction for Florence, Lucca, and Volterra, on the main line between Rome and Genoa. The university, founded in 1338, has a natural history and other museums and a botanical garden. There is also an engineering school, a veterinary institute and an agricultural institute. In the vicinity are the royal villa and stud-farm (horses and dromedaries) of San Rossore (the name is a corruption of Lussorio). and the mineral baths of San Giuliano, alkaline-ferruginous, with temperature 91.4° to 105.8° F. At the mouth of the Arno is the seaside resort of Marina di Pisa. also known as Rocca d'Arno, a well-known centre for landscape painters.

The ancient Pisae on the right bank of the Arno was only 2 mi. from the sea, the delta having increased since. It is believed to have been founded from Pisae in Elis and is first mentioned in history as the place at which a Roman army from Sardinia landed in 225 B.C. Being situated on the coast road (Via Aemilia), it was important as a frontier fortress against Liguria, for the fertility of its territory, and its quarries and timber for shipbuilding. Scanty ruins of Roman baths exist near the modern Lucca gate on the north. The older town occupied the same site. (T. A.)

HISTORY

Little is known of Pisa during the barbarian invasions, but it is an ascertained fact that it was one of the first towns to assert its independence of Byzantine rule. During the first years of the Lombard rule the necessity of defending the Italian coast from the attacks of the Byzantines was favourable to the development of the Pisan navy.

Early Wars.—In 1003 we find records of a war between Pisa and Lucca, which, according to Muratori, was the first waged between Italian cities in the middle ages. But the military development and real importance of Pisa in the 11th century must be attributed to the continuous and desperate struggle it maintained against the tide of Saracenic invasion from Sicily. Numerous legends and fables of the old chroniclers serve to attest the importance of Pisa in those days. The Saracens repeatedly attacked the town, but were repulsed, and the Pisans themselves assumed the offensive in Calabria, Sicily, and even in Africa. In 1015 a memorable expedition was undertaken by the united forces of Pisa and Genoa against Mogahid, better known in the Italian clironicles as Mugeto, whom they drove from Sardinia. Again invading the island, he was again attdcked and defeated by the same adversaries, leaving a brother and son, or, as some authorities aver, a wife and son, prisoners in their hands. Sardinia continued to be governed by native "judges" who were like petty sovereigns, but were now subject to the sway of Pisa. This was the primary cause of the jealousy of the Genoese and of the wars afterwards made by them upon Pisa. Meanwhile the Pisans flourished more and more, and continued hostilities against the Saracens. In 1062 their ships returned from Palermo laden with spoil. Thus it is not surprising that Pisa should already have had its awn code of laws *(Consuetudini di* mare), which in 1075 were approved by Gregory VII., and in 1081 confirmed by a patent from the emperor, Henry IV. The oldest of Pisan statutes still extant is the *Breve dei consoli di* mare of 1162.

Commercial Prosperity.—In 1099 the Pisans joined in the second crusade, proved their valour at the capture of Jerusalem, and derived many commercial advantages from it; for within a short time they had banks, consuls, warehouses and privileges of all kinds in every Eastern port. Thus while the commune of Pisa was still under the rule of the marquises of Tuscany, all negotiations with it were carried on as with an independent state officially represented by the archbishop and consuls. The aristocrats were the dominant party, and filled the highest offices of the republic, which, in the 12th century, rose to great power, both on sea and land, by its wars with the Lucchese, Genoese and Muslims. In the years 1113 and 1115 it achieved a still greater enterprise. The Pisan fleet of 300 sail, commanded by the archbishop, Pietro Moriconi, attacked the Balearic Isles, where as many as 20,000 Christians were said to be held captive by the Muslims and returned loaded with spoil and with a multitude of Christian and Muslim prisoners. The former were set at liberty or ransomed, and among the latter was the last descendant of the reigning dynasty. Immediately afterwards, the 14 years' war with Genoa broke out. The two republics contested the dominion of the sea, and both claimed supreme power over the islands of Corsica and Sardinia. A papal edict awarding the supremacy of Corsica to the Pisan Church proved sufficient cause for the war, which went on from 1118 to 1132. Then Innocent II. transferred the supremacy over part of Corsica to the Genoese Church, and compensated Pisa by grants in Sardinia and elsewhere. Accordingly, to gratify the pope and the emperor, Lothair II., the Pisans entered Neapolitan territory to combat the Normans. They aided in the vigorous defence of the city of Naples, and twice attacked and pillaged Amalfi, in 1135 and 1137, with such effect that the town never regained its prosperity. The war with Genoa never came to a real end. Even after the retaking of Jerusalem by the Muslims (1187) the Pisans and Genoese again met in conflict in the East, and it was plain that there could be no lasting peace between these rival powers until the one or the other should be crushed. The greatness and wealth of the Pisans at this period of their history is proved by the noble buildings by which their city is adorned. The foundations of the cathedral were laid in 1063, and its consecration took place in 1118; the baptistry was begun in 1152, and the campanile (the famous leaning tower) in 1174. And all three magnificent structures were mainly the work of Pisan artists, who gave new life to Italian architecture, as they afterwards renewed the art of sculpture.

RIVALRY WITH FLORENCE AND GENOA

The chief authority was still vested in the nobles, who, both in Pisa and in Sardinia, exercised almost sovereign power. They formed the real strength of the republic, and kept it faithful to the empire and the Ghibelline party. The Guelph and popular element which constituted the force and prosperity of Florence was hostile to Pisa, and led to its downfall. Owing to the political and commercial interests binding Florence to the Roman court, the Guelph element naturally prevailed there, while growth of its trade and commerce necessarily compelled that republic to encroach on waters subject to Pisan rule. And, although Pisa had hitherto been able to oppose a vigorous resistance to Genoa and Lucca, it was not so easy to continue the struggle when its enemies were backed by the arms and political wisdom of the Florentines, who were skilled in obtaining powerful allies. The chroniclers ascribe the first war with Florence, which broke out in 1222, to a ridiculous motive. The ambassadors of the rival states in Rome are said to have quarrelled about a lapdog—which merely shows that there were already so many general and permanent reasons for war that no special cause was needed to provoke it. In 1228 the Pisans met and defeated the united forces of Florence and Lucca near Barga in the Garfagnana, and at the same time they despatched 52 galleys to assist Frederick II. in his expedition to the East. Shortly after this they renewed hostilities with the Genoese on account of Sardinia, and war was intermittent down to 1259, when it terminated in the decisive victory of the Pisans and the consolidation of their supremacy in Sardinia. But meanwhile Florence had made alliance with Genoa, Lucca and all the Guelph cities of Tuscany against its Ghibelline rival: the pope had excommunicated Frederick II. and all his adherents; and, as a crowning disaster, the death of Frederick in 1250 proved a mortal blow to the Italian Ghibelline cause. Nevertheless the Pisans were undaunted. Summoning Siena, Pistoia and the Florentine exiles to their aid, they boldly faced their foe, but were defeated in 1254. Soon after this date we find the old aristocratic government of Pisa replaced by a more popular form. Instead of the consuls there were now 12 elders

(*anziani*); besides the podesti, there was a captain of the people; and there was a general council as well as a senate of 40 members. The rout of the Tuscan Guelphs on the field of Montaperti (1260) restored the fortunes of Pisa. But the battle of Benevento (1266), where Manfred fell, and the rout of Tagliacozzo (1268), sealing the ruin of the house of Hohenstaufen in Italy and the triumph of that of Anjou, were fatal to Pisa. For the republic had always sided with the empire and favoured Conradin, whose cruel end struck terror into the Ghibelline faction. The pope hurled an edict against the Pisans and tried to deprive them of Sardinia, while their merchants were driven from Sicily by the Angevins. The internal condition of the city was affected by these events. Owing to the increasing influence of the Guelph and popular side, to which the more ambitious nobles began to adhere for the furtherance of personal aims, the aristocratic Ghibelline party was rapidly losing ground. At this time Count Ugolino della Gherardesca had become the virtual head of the republic, and, in order to preserve its independence and his own sway, inclined to the Guelphs and the popular party, in spite of the Ghibelline traditions of his race. He was supported by his kinsman, Giovanni Visconti, judge of Gallura, in Sardinia; but almost all the other great families vowed eternal hatred against him, and proclaimed him a traitor. In 1274 he and Visconti were driven into exile. Both then joined the Florentines, took part in the war against their native city, and laid waste its surrounding territories. In 1276 the Pisans were compelled to agree to very grievous terms—to exempt Florentine merchandise from all harbour dues, to yield certain strongholds to Lucca, and to permit the return of Count Ugolino. Thus the count again became a powerful leader in Pisa Visconti, however, was dead.

This was the moment chosen by Genoa for a desperate and decisive struggle with her perpetual rival. For some years the hostile fleets continued to harass edch other and engage in petty skirmishes, as if to measure their strength and prepare for a final effort. On Aug. 6, 1284, at the great battle of Meloria 72 Pisan galleys engaged 88 Genoese, and half the Pisan fleet was destroyed. The chroniclers speak of 5.000 killed and 11,000 prisoners; and, although these figures must be exaggerated, so great was the number of captives taken by the Genoese as to give rise to the saying—"To see Pisa, you must now go to Genoa." This defeat crushed the power of Pisa. She had lost her dominion over the sea, and the Tuscan Guelphs again joined in attacking her by land. Count Ugolino had taken part in the battle of Meloria and was accused of treachery At the height of his country's disasters he sought to confirm his own power by making terms with the Florentines, by yielding certain castles to Lucca and by neglecting to conclude negotiations with the Genoese for the release of the prisoners, lest these should all prove more or less hostile to himself. This excited a storm of opposition against him. The archbishop, Ruggieri, having put himself at the head of the nobles, was elected podesti by the Lanfranchi, Sismondi and Gualandi, and a section of the popular party. The great bell of the commune called together the adherents of the archbishop; the bell of the people summoned the partisans of the count. After a day's fighting (July 1, 1288) the count, his two sons and his two grandsons were captured in the palazzo del popolo (or town hall), and cast into a tower belonging to the Gualandi, and known as the "Tower of the Seven Streets." Here they were all left to die of hunger. Their tragic end was afterwards immortalized in the *Divina Commedia.* The sympathies of Dante Alighieri, the Florentine patriot and foe of Rome, were naturally in favour of the victims of an aristocratic prelate opposed to all reconciliation with Florence.

The Florentines were now allied with Lucca and Genoa, and a few of their vessels succeeded in forcing an entry into the Pisan port, blocked it with sunken boats, and seized its towers. In 1293 they secured a profitable peace. They and the other members of the Guelph league were freed from all imposts in Pisa and its port. In addition to these privileges the Genoese also held Corsica and part of Sardinia; and throughout the island of Elba were exempted from every tax They likewise received a ransom of 160 000 florins for their Pisan prisoners.

In 1312 the arrival of the Emperor, Henry VII., gladdened the hearts of the Pisans, but his sudden death in 1313 again overthrew their hopes. He was interred at Pisa, and Uguccione della Faggiuola remained as imperial lieutenant, was elected podestà and captain of the people, and thus became virtual lord of the city. As a Ghibelline chief of valour and renown he was able to restore the military prestige of the Pisans, who under his command captured Lucca and defeated the Florentines at Montecatini on hug. 29, 1315. In 1316, however, he was expelled in an outburst of popular fury. But Pisa's freedom was forever lost. Uguccione della Faggiuola was succeeded by other lords or tyrants of whom the most renowned was Castruccio Castracani, a political and military adventurer of much the same stamp as Lguccione himself. With the help of Louis the Bavarian, Castruccio became lord of Lucca and Pisa, and was victorious over the Florentines; but his premature death in 1328 again left the city a prey to the conflicts of opposing factions. New lords, or petty tyrants, rose to power in turn during this period of civil discord, but the military valour of the Pisans was not yet extinguished. By sea they were almost impotent—Corsica and Sardinia were lost to them forever—but they were still formidable by land. In 1341 they besieged Lucca in order to prevent the entry of the Florentines, to whom the city had been sold for 250,000 florins by the powerful Mastino della Scala. Aided by their Milanese, Mantuan and Paduan allies, they gave battle to their rivals, put them to rout at Altopascio (Oct. 2), and then again excluded them from their port. Thereupon the Florentines obtained Porto Talamone from Siena and established a navy of their own. By this means they were enabled to capture the island of Giglio, and, attacking the Pisan harbour, carried off its chains, bore them in triumph to Florence, and suspended them in front of the baptistery, where they remained until 1848. Then in pledge of the brotherhood of all Italian cities, they were given back to Pisa, and placed in the Campo Santo.

The war was now carried on by the free companies with varying fortune, but always more or less to the hurt of the Pisans. In 1369 Lucca was taken from them by the emperor Charles IV.; and afterwards Gian Galeazzo Visconti, known as the count of Virtù, determined to forward his ambitious designs upon the whole of Italy by wresting Pisa from the Gambacorti. For at this time the conflicts of the Raspanti faction, headed by the Gherardesca, with the Bergolini led by the Gambacorti, had left the latter family masters of the city. At Visconti's instigation Piero Gambacorti, the ruler of the moment, was treacherously assassinated by Jacopo d'Appiano, who succeeded him as tyrant of Pisa, and bequeathed the state to his son Gherardo. The latter, a man of inferior ability and daring, sold Pisa to the count of Virtù, receiving in exchange 200.000 florins, Piombino, and the islands of Elba, Pianosa and Monte Cristo. Thus in 1399 Visconti took possession of Pisa, and left it to his natural son, Gabriele Maria Visconti, who was afterwards expelled from its gates. But even in this century of disaster the Pisans continued to encourage not only commerce, but also the fine arts. In the year 1278 they had entrusted the erection of their fine Campo Santo to Niccola and Giovanni Pisano, by whom the architectural part of it was completed towards the end of the century. In the following year the first artists of Italy were engaged in its decoration, and the celebrated frescoes attributed to Orcagna (*q.v.*) were painted on its walls. Others were afterwards supplied by Benozzo Gozzoli and men of lesser note, and the labour of ornamentation was only discontinued in 1464.

The Victory of Florence.—Meanwhile, in 1406, the Florentines made another attack upon Pisa, besieging it simultaneously by sea and land. Owing to the starving condition of its defenders, and aided by the treachery of Giovanni Gambacorti, they entered the city in triumph on Oct. 9, and sought to "crush every germ of rebellion and drive out its citizens by measures of the utmost harshness and cruelty." Such were the orders sent by the Ten of War to the representatives of the Florentine government in Pisa, and such was then the established policy of every Italian state. Consequently for a long time there was a continual stream of emigration from Pisa. The Medici pursued a humaner course.

In 1472 Lorenzo the Magnificent tried to restore the ancient renown of the Pisan university. To that end he filled it with celebrated scholars, and, leaving only a few chairs of letters and philosophy in Florence, compelled the Florentines to resort to Pisa for the prosecution of their studies. But nothing could now allay the inextinguishable hatred of the conquered people. When Charles VIII. made his descent into Italy in 1494, and came to Sarzana on his way to Tuscany, he was welcomed by the Pisans with the greatest demonstrations of joy. And, although that monarch was ostensibly the friend of Florence, they did not hesitate, even in his presence, to assert their own independence, and casting the Florentine emblem, the Marzocco, into the Arno, made instant preparations for war. Between 1499 and 1505 they heroically withstood three sieges and repulsed three attacking armies. But their adversaries always returned to the assault, and, what was worse, yearly laid waste their territories and destroyed all their crops. Soderini, who was perpetual gonfalonier of Florence, and Machiavelli, the secretary of the Ten, urged on the war. In 1509 Florence encamped her forces on three sides of the distressed city, which at last, reduced to extremity by famine, was compelled to surrender on June 8, 1509. Thenceforth the Florentines remained lords of Pisa. But now, mainly owing to the efforts of Soderini and Machiavelli, the conquerors showed great magnanimity. They brought with them large stores of provisions which were freely distributed to all; endeavoured to succour the suffering populace in every way, and gave other assistance to the wealthier classes. Nevertheless, emigration continued even on a larger scale than in 1406, and the real history of Pisa may be said to have ended. In Naples, in Palermo, in all parts of Italy, Switzerland and the south of France, we still find the names of Pisan families who quitted their beloved home at that time. The Florentines immediately built a new citadel, and this was a great bitterness to the Pisans. The Medici, however, remained well disposed towards the city. Leo X. was an active patron of the university, but it again declined after his death. The grand duke, Cosimo I., a genuine statesman, not only restored the university, but instituted the "uffizio dei fossi" or drainage office for the reclamation of marsh lands, and founded the knighthood of St. Stephen. This order played a noble part in the protection of Tuscan commerce, by fighting the Barbary pirates and establishing the prestige of the grand-ducal navy (*see* MEDICI). Under the succeeding Medici, Pisa's fortunes steadily declined. Ferdinand I. initiated a few public works there, and above all restored the cathedral, which had been partly destroyed by fire in 1595. These dreary times are brightened by one glorious name—that of Galileo Galilei.

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(P. V.; L. V.)

PISA, COUNCIL OF (1409). The great schism of the west had already lasted 30 years, and the efforts which had been made to restore unity within the church by the simultaneous resignation of the 2 rival pontiffs had been in vain, when in the spring of 1408, the state of affairs being desperate, the idea arose of assembling a council to effect a union without the co-operation of the popes. The initiative came from those cardinals who had one after the other seceded either from Gregory XII or Benedict XIII.

They were forestalled by the popes, who each summoned a council, the former to Cividale (in Friuli), the latter to Perpignan, so the dissident cardinals sent out antedated letters inviting Christendom to assemble at Pisa on March 25, 1409. Their appeal met with a response in a great part of Italy, France, Navarre, Portugal and England, and in Germany in the states subject to Wenceslas, king of the Romans, the electors of Cologne and Mainz, the margrave of Brandenburg, etc. For a time the number of the fathers exceeded 500.

The day after the opening of the council, proceedings were started against the two popes, who. it was agreed, were to be eliminated. An act of accusation, containing in 37 articles the chief complaints against them, was read out to the people; not only their policy, but their orthodoxy was attacked, and there was even an insinuation of sorcery.

That is, in order to depose them with some show of legality, it was necessary, as a preliminary, to convict them of heresy, and it began to be seen that their tenacity of power, and the ruses by which they evaded the necessity of abdicating, however harmful might be their consequences, did not in themselves constitute a clearly defined heresy. On June 5, 1409, was read the definitive sentence: that as heretics, and therefore separated from the church, Pedro de Luna (Benedict XIII) and Angelo Corrario (Gregory XII) were *ipso* facto deposed from any office; they must not be obeyed, nor assisted nor harboured.

In order to complete their task the cardinals present at Pisa, authorized by delegation of the council, shut themselves up in conclave, and elected one of their number, Peter Philarges, cardinal of Milan, as the new pope, who assumed the name of Alexander V. They had hoped to save the church, but unfortunately the result of their efforts, generous as they were, was that the schism increased in bitterness, and that instead of the unity for which the church craved, three popes continued to flourish. Both the deposed pontiffs protested against the legality of the council of Pisa; each had numerous partisans, and the thesis, constructed rather to meet the exigencies of the case, which attributed to a synod assembled by the cardinals the right of constituting itself judge of a sovereign pontiff, was far from being established. The council was proceeding to occupy itself with reform when it was dissolved by Alexander V (Aug. 1409).

See also CONSTANCE, COUNCIL OF.

PISANELLO, ANTONIO (ANTONIO PISANO, formerly wrongly called VITTORE) (*c.* 1395–*c.* 1455), Italian medalist and painter and one of the leading artists of his age, was born shortly before 1395 in Pisa (hence his appellation Pisanello). It was first as co-worker with Gentile da Fabriano, then as the continuer of his work and finally as his heir that Pisanello painted his most considerable frescoes in the doge's palace in Venice (c. 1415–22) and in St. John-Lateran in Rome (after 1427). However, the only surviving frescoes of Pisanello's are an "Annunciation" at the tomb of Niccolò di Brenzono in S. Fermo in Verona (*c.* 1423–24) and the legend of St. George in the Pellegrini chapel in S. Anastasia in Verona (c. 1433–38). Early panels which are ascribed to him are the four panels of the legend of St. Benedict (one in the Museo Poldi Pezzoli, Milan, three in the Uffizi depot, Florence). They probably date from between 1417 and 1422.

Later, mature panels by Pisanello, which are extant, are: the "Madonna della Quaglia" (Verona museum); "St. Jerome" (National gallery, London), perhaps a contemporary replica of one of Pisanello's works; the portrait of the emperor Sigismund (Kunsthistorisches museum, Vienna; 1432–33); "St. Eustace" (National gallery); the portrait of Margherita Gonzaga (Louvre, Paris; *c.* 1438); the portrait of Lionello d'Este; and the "Madonna with Ss. Anthony and George" (National gallery).

Pisanello's fame and his importance in court circles, for which his art was admirably calculated, rested even more upon his medals than upon his painting. There he had practically no predecessors and with him the art reached its highest point. His work includes the medal of the Greek emperor John VII Palaeologus (1438); dated are: the uedding medal for Lionello d'Este (1444), Sigismondo Pandolfo Malatesta (1445), Cecilia Gonzaga (1447) and Bellotto Cumano (1447). In 1448 Pisanello was invited to Naples to the court of Alfonso of Aragon and there his most mature medals, of the king and also of Inigo d'Avalos, were produced.

Studies for many of his medals are in the Codex Vallardi in the Louvre, as are those for the craftsman's work which Pisanello was commissioned to design at the court in Naples. Drawings for his portraits in paint, frescoes, etc., have also been preserved, and in the uniqueness of their preservation as a whole these drawings are the most important thing Pisanello contributes to the history of art. They reveal the whole body of work in a studio at the

dividing line between the middle ages and the Renaissance, work between the copying of traditional models and free creation from nature. This most delicate but intense early Renaissance naturalism, combined with the beauty of line of late Gothic, is the distinguishing hallmark of Pisanello's art.

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PISANO, ANDREA (c. 1290–*c.* 1347), Italian sculptor and goldsmith, whose chief works were executed in Florence, where he came under the influence of Giotto, and who is recorded as the author of the earliest of the three famous bronze doors of the baptistery, was born about 1290. The baptistery door, completed in 1336, has 20 quatrefoil panels with scenes from the life of St. John the Baptist and 8 with figures of the Virtues. The figures are gilded and set against a smooth bronze surface with appropriate architectural and other features.

On the death of Giotto in 1337, Andrea succeeded as architect of the campanile of the Duomo of Florence, to which he added two stories adorned with panel reliefs. Most of the reliefs on the lower part depicting the arts, sciences and occupations of man and three scenes from Genesis are generally admitted to be the work of Andrea and his studio, though tradition assigned the designs and some of the panels to Giotto. Statues in niches, originally above the reliefs now in the Duomo museum, representing David and Solomon and two Sibyls, have been assigned to Andrea but the authorship is disputed. Two statuettes of Christ and Sta. Reparata also in the museum are generally attributed to him.

In the iconography of the bronze door Andrea was indebted to the mosaics of the baptistery cupola and Giotto's frescoes in Sta. Croce. The plan of the door was influenced by Bonanno's bronze doors in Pisa cathedral, and the quatrefoil appears in French cathedrals, especially at Paris and Rouen. Andrea's style is marked by a simplicity, restraint and skillful arrangement of figures which places him in the front rank of the sculptors of the period. He is last recorded as superintending architect of the Duomo of Orvieto, in which office his son Nino succeeded him. He died about 1347.

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PISANO, GIOVANNI (c. 12jo–after 1314), Italian architect and sculptor, who continued the revival of sculpture begun by his father Niccolb (*q.v.*) whom he assisted in the creation of the pulpit in Siena cathedral and the fountain in Perugia, was born about 1250. His principal works were the planning and sculptural decoration of the facade of Siena cathedral (1284–95), the pulpit in S. Andrea in Pistoia (completed 1301) and the pulpit in Pisa cathedral (completed 1310). This pulpit, reconstructed, was restored to the cathedral in 1926. Other works by Giovanni include statues of the Virgin and Child in Pisa, Padua and Prato, an ivory statuette of the Madonna in Pisa and the monument in Genoa to Margaret of Luxembourg.

The façade of Siena cathedral, consecrated to the Virgin, was the earliest Gothic cathedral facade in Italy. It corresponded in conception to the porches of the French cathedrals but differed entirely in execution. Giovanni placed his statues of seers and prophets proclaiming the Virgin's coming at structural points above the doorways rather than beside them, as was customary in France. Each stdod alone. yet in significant relation to its neighbours. The figures have undergone much restoration and change of position;. some are now in the cathedral museum.

In the architecture of his pulpits Giovanni followed the polygonal design of the earlier pulpits in the baptistery of Pisa and the cathedral of Siena, introducing however Gothic features. In his treatment of individual figures he combines antique and Gothic forms and shows a marked influence from French ivories and, though there is no definite proof, an acquaintance with French cathedral sculpture. On this foundation Giovanni arrived at a highly developed Gothic style in his statues of the Virgin, in the figures on the Siena façade and especially in the Pistoia pulpit. Here the scenes of the life of Christ are characterized by an extreme vivacity. sense of movement and dramatic poner which is reflected in the accompanying reliefs of prophets and statuettes of Sibyls. The latter rival in emotional intensity the Sibyls of Michelangelo in the Sistine chapel.

The same characteristics reappear in the reliefs of the great pulpit in Pisa cathedral but in some scenes, owing, it is thought, to the intervention of assistants, the standard achieved at Pistoia is not maintained. The defect is counterbalanced by the high quality of the supporting column statues representing the Virtues and other subjects where Giovanni returns to the restraint of the classical models which formed the basis of his father's style. It is to this combination of antique and Gothic forms, together with his extraordinary power of expressing emotion, that Giovanni owes his pre-eminent position in Italian Gothic sculpture.

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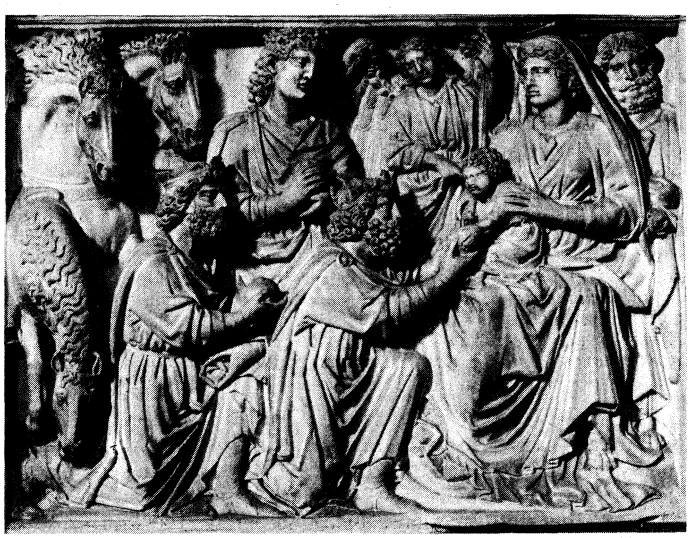
PISANO (DA PISA). **NICCOLÒ** (NICOLA) (*c.* 1220–*c.* 1283), Italian sculptor and architect, to whom was due the rebirth of the plastic arts in Italy, was born about 1220. Although he is usually described in terms which indicate Pisan origin or citizenship, two documents support the view that he was born in Apulia. (He has been known as Nicola de Apulia.) He probably learned the rudiments of his arts in southern Italy, and settled later in Pisa. There he spent most of his life and produced his first great work, the marble pulpit in the baptistery, completed in 12 59.

The pulpit is a hexagon on semicircular arches, with trefoil cusps, supported by seven columns, of which three rest on lions and one has animal and grotesque human figures around the base. The sculpture expresses in outline the Christian scheme of salvation. In the spandrels, the reliefs of kings, prophets and evangelists bear witness to the coming of Christ. In five panels, the Nativity, the Adoration of the Magi, the Presentation in the Temple. the Crucifixion and the Last Judgment are represented, and above the columns statues are placed which personify the Virtues. Niccolb's next work, the magnificent pulpit in Siena



ALINARI

"ADORATION OF THE MAGI." DETAIL FROM THE MARBLE PULPIT OF THE PISAN BAPTISTERY BY NICCOLÒ PISANO

cathedral. completed in 1268, is an enlarged version of its predecessor in Pisa, including a relief of the Massacre of the Innocents. With these pulpits, a new epoch in Italian sculpture began. To features derived from Byzantine, Romanesque and the archaizing classical art of southern Italy, Niccolb added two innovations. He used for Christian subjects the types which he found in antique sculpture; thus, the Phaedra in a relief of the legend of Hippolytus on a sarcophagus in Pisa inspired the figure of the

Virgin in the Adoration of the Magi in the baptistery pulpit. His second innovation was his passage, under the influence of French Gothic sculpture, from the static, impersonal, idealized figures of his early reliefs to the presentation in his later work of his personages as individual human beings in vivid states of action and emotion.

In Siena, Niccolb had among his assistants his son Giovanni (*q.v.*), who also collaborated with him in his last great work, the fountain in the piazza in Perugia. Three basins, rising one above the other, culminate in a bronze group of female figures supporting heraldic animals. These may be the work of Giovanni, whose style may also be detected in some of the reliefs and statues which, on the lower basin, personify the Labours of the Months, the Liberal Arts and other historical and mythical subjects.

The Arca di S. Dominico in Bologna (1267) has been attributed to Niccolb. The design may be his, but the actual carving suggests the hand of a pupil, probably Fra Guglielmo. The holy water basin in S. Giovanni-fuor-civitas in Pistoia may be an early work of Giovanni but is generally accredited to Niccolb. So, too, are the reliefs of a Deposition from the Cross and a Nativity over a side portal in S. Martino in Lucca. Their date is uncertain but they show Niccolb's characteristic style in its Gothic phase, and the Deposition ranks as one of his finest compositions.

Recent research indicates that Niccolb must have been an architect of distinction, although the attribution of important works to him by Giorgio Vasari lacks confirmation. Apart from his works, little is known of Niccolb's life. He died between 1279 and 1284, having, with his son Giovanni, laid the foundations of the great art of later generations. His genius lay in his revolutionary use of classical models and his power to unite antique forms with the spirit of the new northern Gothic sculpture.

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PISAURUM (mod. Pesaro, *q.v.*), an ancient town of Umbria on the Via Flaminia, 26 mi. from Ariminum and 8 from Fanum Fortunae. A Roman colony was founded there in 184 B.C., at the mouth of the river Pisaurus (mod. Foglia; the sea has since receded about half a mile). It was destroyed by the Goths in 539, and restored by Belisarius in 545.

PISCES, the Fishes, in astronomy, the 12th sign of the zodiac, represented by 2 fishes tied together by their tails, and denoted by the symbol X. In Greek legend Aphrodite and Eros, while on the banks of the Euphrates, were surprised by Typhon, and sought safety by jumping into the water, where they were changed into two fishes. This fable, however, as in many other similar cases, is probably nothing more than an adaptation of an older Egyptian tale. The constellation contains only faint stars without any striking grouping. *Piscis australis* or *austrinus,* the southern fish, is a constellation of the southern hemisphere. It contains Fomalhaut, a star of the first magnitude, which is located at a distance of around 24 light-years from the sun. It is thus one of the sun's nearer neighbours. *Piscis volans,* the flying fish, is a southern constellation introduced by John Bayer in 1603. The name is now abbreviated to *Volans.*

PISCICULTURE: *see* FISH CULTURE.

PISCO, a pleasant, muscat brandy, which has been distilled since the 16th century from muscat wines produced in the Ica valley of Peru, 180 mi. S. of Lima. It takes its name from the port of Pisco at the mouth of the Ica river, from whence it was originally shipped in porous earthenware jars to Lima, the vice-regal capital of Peru and all Spanish South America. Distillation was known to the highly developed Incan civilization, probably as early as the 9th century, but distillation of Pisco did not exist before the arrival of the Spanish, who introduced muscat grape vines brought from Spain.

Pisco is distilled from freshly fermented muscat wines. It has the pronounced fragrance and flavour of the muscat grape. The Pisco consumed in Peru is rarely two years old but that which is exported will be three years old or more. It is usually bottled at 80 U.S. proof. Muscat brandies produced in Argentina and Chile and labelled Pisco for home consumption are not as fine as the Peruvian original. Pisco is consumed neat as a brandy but the national cocktail of Peru is the Pisco sour, made with lime juice, sugar and Pisco. (H. J. GN.)

PISEMSKY, ALEXEY FEOFILACTOVICH (1820–1881), Russian novelist, was born on his father's estate in the province of Kostroma, on March 22, 1820, the son of a major who had risen from the ranks. From the gymnasium of Kostroma he passed through Moscow university, and spent over 20 years in the government service. His first novel, *Boyarstchina,* was forbidden by the censor. His principal novels are *Tyufyak* ("A Muff"), 1850; *Tysyacha Dush* ("A Thousand Souls"), 1862; and *Vzbalomuchenoe marye* ("A Troubled Sea"), giving a picture of the excited state of Russian society about the year 1862. His *Corkaya sudbina* ("A Bitter Fate"), depicting the dark sides of the Russian peasantry, obtained for him the Ouvaroff prize. He died at Moscow on Feb. 2. 1881. Pisemsky was a realist, and took an objective view of the unrest among the intelligentsia, which made him very unpopular in Moscow literary society. His best work is his description of the life of the common people. He learned to know them thoroughly when investigating conditions in the Russian interior.

PISHPEK: *see* FRUNZE.

PISIDIA, anciently a region of southern Asia Minor, lying to the north of Pamphylia and to the west of Isauria and Cilicia. To its west the district of Milyas was generally taken as Pisidian, but was on occasion included in Lycia, while to its north the populous and strongly Hellenized area around Pisidian Antioch was sometimes counted as Phrygian and given the name Phrygia Pisidica or Phrygia Paroreius.

Pisidia included some fertile plateaus and high valleys, such as those of the Catarrhactes and Cestrus, which were rich in olives, vines, pastures, timber, resins and iron. But most of the district was composed of the abrupt north-south trending limestone ranges of Taurus, providing refuge for a lawless population, much given to pillage, which resisted stubbornly its successive conquerors: Alexander the Great, King Amyntas of Galatia, and the Roman general Publius Sulpicius Quirinus. At the end of the republic, the population was organized in small tribes, or in groups of villages known as communes, the chief centres of which were Termessus, Sagalassus, Selge and Cremna.

According to Strabo (XIII, iv, 17) the Pisidian language was distinct from those of the nearby Solymi and Lydians. The theocratic rule so characteristie of ancient Phrygia seems to have obtained also in Pisidia, where there is evidence of temples with large estates and servile labour, the most famous being that of Men Ascaenus near Antioch.

On the death of King Amyntas in 25 B.C., the greater part of Pisidia was incorporated in the newly constituted Roman province of Galatia, though it was partly regrouped with Lycia and Pamphylia by Vespasian in A.D. 74. Augustus began its Romanization by founding military colonies, first at Antioch (Colonia Caesareia) and later at Cremna, Comama, Olbasa, Parlais and Lystra. In addition, the Via Sebaste was built forward in two directions from Antioch: one branch joining the highway from Laodiceia to Pamphylia at Comama, and the other running to Iconium and Lystra. The advance of Roman civilization was at first slow, and very little coinage was struck in Pisidia in early imperial times, but in the 2nd century A.D. urbanization proceeded apace, and baths, markets, gymnasiums, temples and porticoes were built even in the little towns of the Milyades. In the following century, however, the Pisidian cities, like those of many other parts of Asia Minor, suffered a serious decline.

On the reorganization of the empire by Diocletian about A.D. 297. Pisidia was included in the Dioecesis Asiana, and in later Byzantine times it fell partly in the Thracesian and partly in the Anatolic theme (province).

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End of the Third Century After Christ, 2 vol. (1950). (WM. C. B.)

PISO, the name of a distinguished Roman plebeian family of the Calpurnian gens which continued in existence till the end of the 2nd century A.D. Nearly 50 of its members were prominent in Roman history, but the following deserve mention.

1. LUCIUS CALPURNIUS PISO CAESOXINUS, Roman statesman, was the father-in-law of Julius Caesar. In 58 B.C., when consul, he and his colleague Aulus Gabinius entered into a compact with P. Clodius. with the object of getting Cicero out of the way. Piso's reward was the province of Macedonia, which he administered from 57 to the beginning of jj, when he was recalled, perhaps in consequence of the violent attack made upon him by Cicero in the senate in his speech *De provinciis consularibus.* On his return Piso addressed the senate in his defense. and Cicero replied with the speech In *Pisonem.* Piso issued a pamphlet by way of rejoinder, and there the matter dropped, Cicero being afraid to bring the father-in-law of Caesar to trial. At the outbreak of the civil war Piso offered his services as mediator, but when Caesar marched upon Rome he left in protest.

Piso did not. however, definitely declare for Pompey, but remained neutral. After the murder of Caesar he insisted on the provisions of his will being carried out, and for a time opposed Antony. Subsequently he became one of his supporters, and is mentioned as taking part in an embassy to Antony's camp at Mutina.

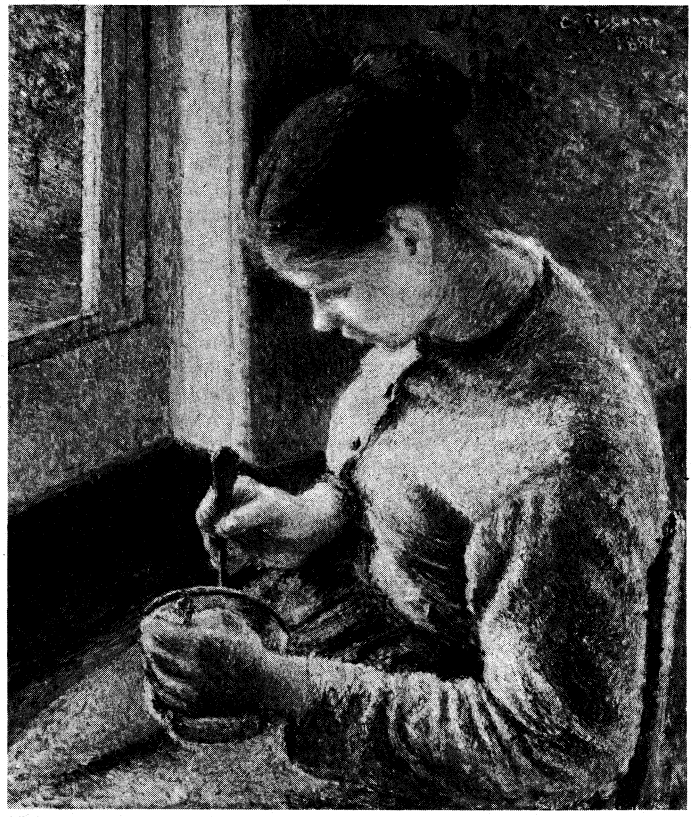
2. LUCIUS CALPURNIUS PISO, surnamed *Frugi* (the worthy), Roman statesman and historian, was tribune in 149 B.C. He is known chiefly for his *lex Calpurnia repetundarum,* which started the system of establishing regular courts for the trial of particular offences in place of the old system of special tribunals being appointed for each case. As praetor (136) and consul (133) Piso fought against the slaves in Sicily.

3. GXAEUS CALPURNIUS PISO, Roman statesman, was consul in 7 B.C. and subsequently governor of Spain and proconsul of Africa. In A.D. 17 Tiberius appointed him governor of Syria, with secret instructions to thwart Germanicus, to whom the eastern provinces had been assigned. The indignation of the people at the death of Germanicus, and the suspicion that Piso had poisoned him, forced Tiberius to order an investigation. Piso committed suicide, though it was rumoured that Tiberius, fearing incriminating disclosures, had put him to death.

PISSARRO, CAMILLE (1830–1903), French painter. the dean of the Impressionist group, was born at St. Thomas in the then Danish West Indies (now the U.S. Virgin Islands) on July 10, 1830; though he lived in France from 1855 till his death, he maintained his Danish citizenship. The son of Jewish parents of Spanish-French extraction, he was sent to Paris at the age of 12 but. having finished school, was called back to help in his father's general store. He devoted all his spare time to drawing and. after some years of struggle between his daily chores and his vocation, ran away in 1852 with a Danish painter. Fritz Melbye, to Caracas. Venez., where he discovered subjects even more tropical and colourful than on his native island. Many of the drawings and watercolours he made there are signed with the Spanish spelling of his name: Pizzarro. Finally his parents let him go back to Paris in 1855 and study painting.

In Paris Pissarro was particularly attracted by the work of Camille Corot whom he visited and who agreed to guide him. When he first exhibited at the Paris Salon. Pissarro's name was accompanied by the legend: "Pupil of Corot." But soon the young man found greater inspiration in the more robust style of Gustave Courbet and began to work exclusively out of doors. A little later Édouard Manet's exciting appearance left its mark on the beginner. Through chance meetings with Paul Cézanne. Claude Monet, Auguste Renoir and their friends. Pissarro became a member of the small Impressionist circle. He was to be the only one who participated in all the exhibitions of the group. from the historic first one in 1874 to the eighth and last one in 1886. In that year he broke with Impressionism and for a while adopted Georges Seurat's divisionist theories and his pointillist technique Eventually he returned to a broader execution. more akin to his former style.

Mainly interested in landscapes and rural life, Pissarro also painted a few portraits of deep insight and some exquisite still lifes. He drew incessantly and made numerous lithographs, etchings, and monotypes. After having spent most of his life outside Paris, in Louveciennes. Pontoise and Eragny, a recurrent eye infection forced him during his last years to work from behind closed windows. He moved to Paris and also traveled each year



BY COURTESY OF THE ART INSTITUTE OF CHICAGO

"LE CAFE AU LAIT" BY CAMILLE PISSARRO. IN THE POTTER PALMER COLLECTION. THE ART INSTITUTE OF CHICAGO

so as to vary his subjects. The work he did then is as fresh, spontaneous and masterly as ever, depicting with admirable truth the peculiar atmosphere, colour, and teeming life of the boulevards. streets and bridges of Paris and the churches and harbours of Dieppe and Rouen.

Pissarro was widely respected for his rare talent, his genuine understanding of nature. his sylvan lyricism and his great humility, as well as for his wisdom and kindness. his profound interest in others (he was the first to encourage Cézanne, Paul Gauguin and Seurat), his humane philosophy tinted with anarchism and his unselfishness. These qualities also appear in the beautiful letters to his eldest son, Lucien, published for the first time in 1943. He died in Paris on Nov. 13, 1903.

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PISTACHIO, the common name for the fruit of *Pistacia vera,* a deciduous tree that produces much prized nuts extensively used as food and for green colouring in confections. Grown in dry lands in warm or temperate climates, the tree is believed to be indigenous to Iran; it is widely cultivated from Afghanistan to the Mediterranean region and to a limited extent in California. The tree has broad-spreading branches but rarely exceeds 30 ft. in height. Each leaf has one to five pairs of thick, aide, leathery, pinnate leaflets; its small fruits are borne in clusters. Usually dioecious, but rarely perfect-flowered (as in a few trees found in Turkey), it is largely wind pollinated The nuts are from one-half to three-fourths of an inch long white and tending to split open at one side. without discharging the kernel. Each nut is enclosed

within a thin, tightly adhering, wrinkled and reddish skin. The kernels are single, solid pieces, with pleasing mild flavour. The principal varieties suggested for cultivation in California are Kerman, Damghan, Lassen, Red Aleppo, and Trabonella. These are interplanted at the rate of about 1 to 20 with Chico No. 23 and Peters used as pollinizers. During a five-year period ending in the early 1950s the United States imported an average of 3,212,800 lb., of which more than 50% were from Turkey. A close relative, *P.* chinensis, the Chinese pistachio, is prized for the bright autumnal colours of its foliage.

See also NUT. (C. A. RD.; J. C. McD.)

PISTIL, the ovule-bearing organ of a seed plant, usually consisting of ovary, style and stigma. See FLOWER.

PISTOIA (PISTOJA), a town and episcopal see of Toscana, Italy, capital of the province of Pistoia, 21 mi. N.W. of Florence. Pop. (1951) 33,526. It is situated on a slight eminence (210 ft.) near the Ombrone, one of the tributaries of the Arno, immediately below the Apennines. It is on the site of the Roman *Pistoriae,* near which in 62 B.C. Catiline was slain and his forces destroyed.

Excavations in the Piazza del Duomo led to the discovery of a large private house (end of 1st century B.C.). During the middle ages Pistoia was the scene of constant conflicts between the Guelphs and Ghibellines; here the great struggle took place which resulted in the creation of the Bianchi and Neri factions (Dante, *Inferno,* xxiv, 121). In 1302–06 it was besieged and eventually taken by the armies of Florence and Lucca, and in 1325 it became subject to Castruccio of Lucca. In 1351 it was obliged to surrender to Florence, and thenceforth shared its fate.

The city is still surrounded by walls, dating from shortly after the siege of 1302–06; while two inner lines of streets represent two earlier and inner lines of wall. A number of skillful artists between 1287 and 1399, made the great silver altar and frontal of the cathedral now in a chapel on the south side. The cathedral (13th century) has a campanile (218 ft. high) porch and façade with small arcades in black and white marble in the Pisan style as in other churches of Pistoia. It contains many fine sculptures—the monument of Cino da Pistoia, lawyer and poet, Dante's contemporary (1337), by Cellino di Nese, surrounded by his scholars, and Verrocchio's monument to Cardinal Forteguerra (1474). The octagonal baptistery is by Cellino (c. 1337). Among the earlier churches the principal is S. Andrea (1166), enriched with sculpture; in the nave is Giovanni Pisano's magnificent pulpit, imitated from his father's pulpit at Pisa. Other churches are S. Giovanni Fuorcivitss (so called because it was outside the line of the earliest, pentagonal, enceinte of the middle ages), with one of the long sides elaborately adorned with small arcades in the Pisan style, in black and white marble, also with sculpture by Gruamons (1162) on the façade. Within are a beautiful group of the Visitation by Andrea della Robbia, and a fine pulpit by Fra Guglielmo of Pisa (1270). S. Bartolomeo in Pantano and S. Pietro Maggiore closely resemble it. San Francesco al Prato is a fine church of the end of the 13th century with interesting frescoes of the school of Giotto.

San Doinenico, a noble church, begun in 1291, contains the beautiful tomb of Filippo Lazari by Bernardo and Antonio Rossellino (1462–67) and other works of art. The Madonna dell' Umilità (1494–1567) and S. Maria delle Grazie have fine Renaissance interiors, by the local architect Ventura Vitoni. The Palazzo del Comune and the Palazzo Pretorio, once the residence of the podestà, are both fine specimens of 14th-century architecture. The Ospedale del Ceppo has remarkable reliefs in enameled and coloured terra-cotta on its exterior. Besides various medallions, there is a irieze of figures in high relief along the whole front—groups representing the Seven Works of Mercy—executed by Andrea della Robbia between 1514 and 1525.

The word '.pistol[n] is said to be derived (apparently through *pistolese,* a dagger—dagger and pistol both being small arms) from Pistoia, where that weapon was largely manufactured in the middle ages. For other possible derivations, see PISTOL AND REVOLVER.

PISTOIA, SYNOD OF, a diocesan synod held in 1786 under the presidency of Scipione de' Ricci (1741–1810), bishop of Pistoia, and the patronage of Leopold, grand-duke of Tuscany, with a view to preparing the ground for a national council and a reform of the Tuscan Church. The synod was attended by 233 beneficed secular and 13 regular priests, and decided with practical unanimity on a series of decrees which, had it been possible to carry them into effect, would have involved a drastic reform of the Church on the lines advocated by "Febronius" (see FEBRONIANISM).

The decrees were issued with a pastoral letter of Bishop de' Ricci (see SACRED HEART), and were warmly approved by the grand-duke, at whose instance a national synod of the Tuscan bishops met at Florence on the 23rd of April 1787. The temper of this assembly was, however, wholly different. The bishops refused to allow a voice to any not of their own order, and in the end the decrees of Pistoia were supported by a minority of only three. They were finally condemned at Rome by the bull *Auctorem fidei* of the 28th of August 1794.

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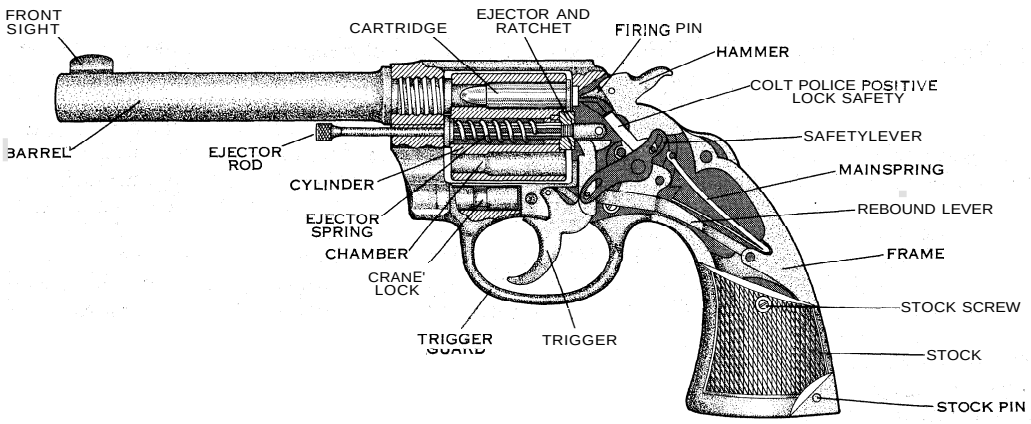
PISTOL AND REVOLVER. A pistol is a small firearm designed for one-hand use, dating from the early 15th century. Tradition ascribes the derivation of the word to two distinct sources, viz., (1) Pistoia, a city in Italy where some claim the weapon originated; and (2) Pistole, an ancient coin to the diameter of which it is said the earliest handguns were bored. (Yet another explanation of its origin is that it derives from "pistallo"—meaning pommel—the common location of the weapon for mounted troops over centuries of use.)

The advantages of a firearm that could be operated by one hand, leaving the other free for the use of an additional weapon, or for defence, must have been apparent from the earliest days of gunpowder, whence it becomes reasonably certain that the pistol evolved simultaneously with its heavier counterpart—the shoulder weapon. Indeed, the most primitive form of small firearm, the "hand cannon," was more a pistol than a musket, but cannot correctly be placed in the former classification since it required one hand to hold it and another to ignite its powder charge. But with the development of the matchlock (c. 1425) it became possible to produce a light and serviceable one-hand piece, and thenceforward the history of the pistol parallels closely that of the corresponding shoulder-arm of the period. (See SMALL ARMS, MILITARY.)

Through the centuries, the pistol has received the attention of untold thousands of inventors. To render it capable of firing more than once without reloading, it has been produced in every conceivable form—as with two, three, four and more barrels—the number limited only by the weight involved, and with countless other devices incorporated. Revolving types are as old as firearms, though the earlier varieties did not embody, as does the revolver of today, a short, many-chambered cylinder positioned behind a single barrel in such manner that the charge in each chamber is brought successively in alignment with the barrel. Instead they were mere sheaves or bundles of tubes of equal length, and were revolved by hand, rather than mechanically as in later specimens. (The latter. in the mid-19th century, acquired the popular designation "pepperbox"—because of the resemblance of the multichambered muzzle to a pepper shaker.) Nevertheless, the true revolver principle (in which cocking the hammer causes simultaneous rotation of the cylinder) is far older than is generally realized. Samuel Colt (*q.v.*), no matter how much the credit due him for improvements he contributed to this type of mechanism. lacks the honour of being its inventor by close to 200 years, perhaps many more. In addition to developing multi-shot varieties, small-arms designers have managed to produce numberless combinations of the pistol with other weapons. Thus



PHANTOM VIEW OF COLT OFFICIAL POLICE MODEL REVOLVER, .38 CALIBRE

we find it incorporated with battle-axes, "holy-water sprinklers," daggers, knives, sabres, whip handles, canes, bludgeons, pocket-books, cigar cases. bicycle handle grips, flashlights, fountain pens and in every other conceivable (and inconceivable) association. Some of the first-named date from the 15th century; the last carries right into the 20th century. The majority of these have been more curiosities than serviceable weapons, but some few have received the stamp of actual (if limited) adoption by the military.

The date of earliest employment of the pistol as a military side-arm is obscure. Pollard tells us that it was adopted by the French cavalry in 1550, and that prior to this period it was "common in Germany." George states that the matchlock pistol was unsuited for military service, and expresses the doubt that pistols were in general use by the military prior to the wheel-lock era, or in England sooner than the opening of the reign of Charles I (1625). He bases this assumption on the absence of any reference to pistols in army records of the reign of Queen Elizabeth (1558–1603).

Thenceforward, however: the pistol held, and holds, a definite if not overly important place among military small arms throughout the civilized world. English-speaking nations, however, were slow to appreciate. the advantages of metallic-cartridge types. Whereas France had adopted, as early as 1853 (for her naval service), a thoroughly satisfactory 12 mm. pin-fire revolver. the United States fought its Civil War (1861–65) almost exclusively with percussion hand-arms. The first delivery of American-made metallic cartridge revolvers to the military took place in 1871. (Some few had been purchased and carried by individuals in the war then terminated, and exactly 200 [Perrin make] secured in France by the federal government.) England also deferred until the late '60s the adoption of a metallic-cartridge weapon, although certain German states (*e.g.,* Bavaria) had preceded England by some years.

Contrary to popular belief, facility in the use of the pistol is not readily acquired, and indeed is infinitely more difficult to gain than in the case of the rifle. Further, the shortness of a pistol barrel, as a result of which a slight twist of the wrist swings the muzzle through a large arc, plus the difficulty of ascertaining at a glance whether certain modern types of pistols are or are not loaded, have resulted in many accidents due to carelessness, and gained for the weapon, among those unfamiliar with it, a reputation for dangerousness far greater than it deserves. In addition, the discovery by the novice that he cannot hit even large targets at close range quickly convinces him that it is a hopelessly inaccurate weapon. Even among the military, its possibilities for wide usefulness as a short-range arm, both of offense and defense, are usually studiously neglected. There remains, nevertheless, an informed and insistent element of military opinion which continues to fight for its more adequate recognition—to the extent, indeed, of the complete replacement of the foot soldier's bayonet with a hand firearm.

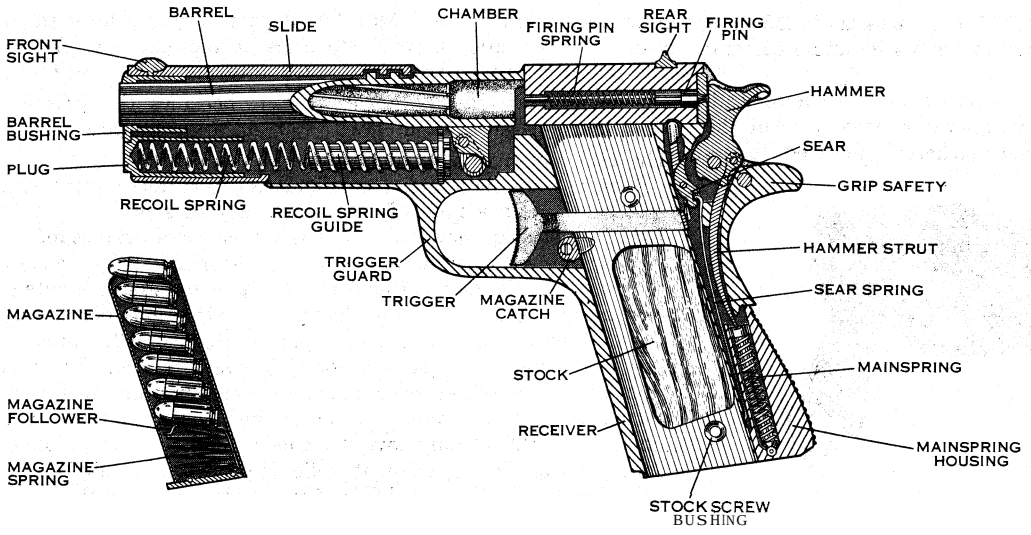
Classification.— So many types of pistols and revolvers exist that it is next to impossible to set up suitable classifications for them. Ignoring for the moment all early specimens (*i.e.*, not handling modern metallic cartridges), there are: (1) revolvers; (2) automatic pistols; and (3) other pistols. Of these the first and third are made in a variety of forms for pin-fire, rim-fire and central-fire ammunition. Automatic pistols, however, are chambered for the last two types only, having been perfected after the pin-fire cartridge was already in its decadence. Considering in turn the three basic classes above named, it is found that a revolver is a weapon embodying an element (cylinder) which revolves, whence comes its name. (By the same token, an arm containing no such component is not a revolver, despite the generally loose application of the term.) Within the cylinder are bored a number of chambers, disposed equidistant from each other and from the axis about which it revolves. Each chamber is designed to contain a cartridge. and each may be brought in line with the barrel, mechanically locked in position and discharged at the will of the operator by pressure on the trigger. Revolving-cylinder rifles (*i.e.*, revolvers in shoulder-weapon form) long enjoyed considerable popularity (especially during the percussion era), even receiving some military recognition, especially in the United States. But apparently no new model of this type has been oifered for sale since 1880–81, as they are not suitable save for low-power ammunition for which other, simpler and less expensive mechanisms are everywhere available.

One widely advertised disadvantage of the revolver is the inevitable escape of some portion of the propellent gases at the junction between cylinder and barrel, and various devices to make this joint more or less gastight (as in the Russian "Nagant" service revolver) have been attempted. The added power thus gained is never worth the complexity of the mechanism required to attain it, however, since the percentage of gas lost, save when the gap becomes truly enormous, is almost negligible.

Revolvers may be classified according to their modes of rotating the cylinder or of extracting the fired case into: single-action, double-action, semiautomatic, automatic-ejecting, hand-ejecting, rod-ejecting, etc. In the single-action arm the acts of cocking the hammer and rotating the cylinder are performed simultaneously by the manual retraction of the hammer, which comes to rest in a rearward position. Thereafter a squeeze on the trigger is required to cause it to fall and discharge the piece. During the percussion era this was the accepted mode of operation (as introduced by Colt, 1536). though certain excellent double-action types such as the Tranter, Webley and Xdams (all British) and the Cooper, Remington and Starr (U.S.A.) also appeared. This type is still produced by Colt in its "Single-Action Army" model and by Sturm. Ruger and others.

Because of the rising interest in shooting muzzle-loading firearms, several percussion revolvers, close copies of Colt and Remington models of 1851–58, are in series production in the U.S.

The double-action mechanism is so designed that the hammer is cocked, and the cylinder rotated. by mere rearward pressure on the trigger, the hammer then falling and discharging the piece when such pressure is continued. To the layman this appears a most suitable design, involving as it does only a single motion, but the spring resistance within the mechanism that must be overcome by finger pressure on the trigger is so considerable, and so variable at different stages in the rearward progress of that member, that none but an expert can do good shooting when firing "double-action" save at the very closest ranges. In the hands of such persons, however, its greater speed of operation (as against the single-action) makes it the weapon of choice. (Most double-action revolvers may be operated either single- or double-action, though some of the cheaper modern types and some of the better



PHANTOM VIEW OF COLT AUTOMATIC PISTOL. .45 CALIBRE (U.S ARMY M1911)

earlier ones will function only on the latter system.)

In the semiautomatic revolver the mechanism is actuated, cocking the hammer and rotating the cylinder. by the energy of recoil, which drives the whole superstructure of the piece (barrel-cylinder assembly) rearward on a horizontal platform built into the lower frame. A "recoil spring," compressed during this movement, then uncoils to force these parts back to their forward (firing) position. The outstanding example of this type is the British Webley-Fosbery arm made in .455 (less often in .38) calibre. Another with practically identical mechanism but far less well known is the .32 calibre pocket model formerly produced by the Union Fire Arms Co. of Toledo, Ohio.

In an automatic-ejecting revolver (first popularized by Smith & Wesson, U.S.A.), the weapon commonly "breaks open" (for loading and ejecting) at a hinge located below and forward of the cylinder and a "spider" operating in the axis of that member automatically lifts out and expels the empty cases after the joint has opened sufficiently to permit this. In hand-ejecting models the cylinder ordinarily swings to one side when released by a latch, its axis remaining parallel to that of the barrel, whereupon a rod running through it and terminating in an ejector spider is manually pushed rearward, so withdrawing the fired cases.

In the rod-ejecting type, an excellent example of which is the Colt "Single-Action Army" model, the cylinder must be rotated, one chamber at a time, to bring the mouths of these successively opposite the tip of a long. slender rod in a housing attached to the side of the barrel, and held in its normal (forward) position by spring pressure. This rod must then be manually pressed down into the chamber, aligned with it to disengage and eject the empty fired case within, the spring then returning it to its forward position. The operation must be repeated for each chamber to be emptied. European practice varies somewhat from that just described, but in all systems of rod-ejection each chamber must be separately and individually cleared of its contained empty case.

Other categories into which revolvers may be differentiated are: hammer and hammerless (concealed hammer) types, the former being far the more common, but the latter (all obviously with double-action mechanisms) widely used in small "pocket" models of .25, .32 and .38 calibre wherein the spur (thumb cocking-piece) of the hammer, if present, might catch in the clothing in an attempt quickly to draw the weapon. Practically all automatic pistols are, strictly speaking, semiautomatic, since in but one or two models (Mauser, Germany), and licensed copies, are they so designed as to permit more than one discharge with each pull of the trigger. But the term "automatic" has gained such wide use that it is perforce employed in this article to designate weapons properly of the semiautomatic class These may be divided into. gas-operated, straight blowback, blow forward, retarded blowback and short-recoil types. Of the first named, but one short-lived example (the "Clair," France) was ever produced. This employed the usual gas port and expansion chamber beneath the barrel, the cartridges (French service revolver type of 8 mm. calibre) being fed into the mechanism through a tubular magazine in the butt of the piece. The straight blowback, numerous models of which are produced in many countries, is. as in shoulder weapons, confined to ammunition of low power and pressure (e *g.*, .22 rim-fire). Walther (Germany) however, did produce, in small numbers. their Model MP, a straight blowback type chambered for the 9 mm. Parabellum, a powerful cartridge used in the Luger and numerous other military automatics.

More powerful ammunition is handled in arms of the retarded blowback type, such as the Luger (Germany), or built on the short-recoil system (Webley, England; Colt, U.S A.). Examples of the much less used blow-forward action are certain early Mannlicher (Austrian) models and the Schwarzlose (Germany). (For descriptions of the modes of operation of these several mechanisms, which duplicate exactly those embodied in machine guns and semiautomatic rifles, see MACHINE GUN.) Magazine capacity of automatic pistols varies from about six cartridges (6.35 mm. calibre) to as high as twelve (some .22 rim-fire models), the average military type holding seven to ten. Most modern military automatics are clip-loaded, but some (*e.g.*, Mauser, Germany; Steyr. Austria) are charger-loaded.

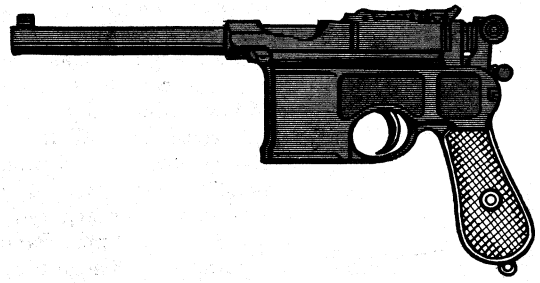
Calibres. — These vary for revolvers all the way from 5 to 15 mm. bore in obsolete pin-fire types, *i.e.*, about .20 to .60 calibre; from 2 mm. ($\frac{4}{100}$ in.) to 46 calibre or more in rim-fire, and from about 5 mm. to .577 calibre in central fire. The smallest sizes (2 mm.) are, of course, mere curiosities, yet capable of firing tiny ball cartridges which will destroy eyesight, if no worse. Among automatic pistols, freak arms, save as produced in tiny calibres, *e.g.*, the 2 mm. Kolibri, Germany, are unusual. The smallest really effective automatic, the German "Lilliput," is of 4.25 mm. (about .21 in.) calibre; the largest, the .45 Colt (U.S.A.) and the .455 Webley (England).

The accuracy of the automatic, save in specimens designed for target work (rare in calibres over .22 rim-fire), is, in average hands, commonly below that of revolvers of comparable weight and size and its construction is such that, except in certain makes which possess "loading indicators" (as the Luger), it is impossible, without opening the mechanism or pressing the trigger, to determine nhether or not it contains unfired cartridges. Further, unless it possesses a "magazine safety," now incorporated in all the better makes, but formerly rare or absent, it remains dangerous even after the removal of the loaded magazine. This is due to the fact that, preparatory to firing. a cartridge must be transferred from magazine to chamber. If now left unfired. the subsequent removal of the magazine leaves the charge in the chamber undisturbed, but all too many persons are forgetful of this and forthwith consider the arm unloaded and treat it as such. The "magazine safety" renders an accident impossible by locking the firing mechanism automatically immediately the magazine is withdraun.

Revolver v. Automatic. — Though devotees of the automatic pistol have, ever since the invention of that type of weapon, predicted the early decline and disappearance of the revolver, there is as yet little evidence to indicate that their forecastings are soon to be fulfilled. The automatic has gained acceptance by the military in many countries. but in others of equal importance the revolver remains in favour. Among civil servants, European police employ the automatic almost exclusively, whereas in the U.S.A. the revolver is practically without competition. Military

revolvers now range in calibre from 7.62 mm. (Russia) to .380 and (formerly) .455 (England); automatics from 7.63 and 7.65 mm. (Germany) to .45 (U.S.A.).

The revolver bullet is commonly an unjacketed missile of lead, hardened perhaps with tin and/or antimony, whereas that of the automatic is usually full metal cased (jacketed), uncased bullets



MILITARY MODEL OF THE MAUSER

being subject to deformation, because of their relative softness, when passing through the mechanism of such an arm. However, .22 calibre automatics use standard *22* rim-fire lead bullet cartridges, not jacketed. Full-jacketed revolver bullets are not unknown, but have never gained much popularity save with law-enforcement agents whose duties may require their firing through heavy doors, automobile bodies, etc. Muzzle velocities in standard revolvers average 600–850 foot seconds, but there has been developed (by Smith & Wesson. U.S.A.) a "Magnum" type in .357 calibre (actual groove diameter of all modern so-called .38 calibre revolvers) with a muzzle velocity exceeding 1.500 ft. per second and a muzzle energy of 800 ft. lb., thus exceeding that of the .44 calibre Winchester (U.S.A.) repeating rifle, model of 1873, to which has probably fallen more medium and large game than to any other firearm ever produced.

In 1956 the same firm (Smith & Wesson) introduced a .44 Magnum revolver, designed around the most powerful handgun cartridge in existence: a 240-grain bullet at 1,570 ft. per second muzzle velocity, with muzzle energy of 1,310 ft. lb. From the standpoint of "stopping power," the .38 or .45 calibre leaden revolver bullet of moderate velocity is more efficient than the high-velocity, automatic pistol missile of small (7.63 and 7.65 mm.) bore as fired by the Mauser and Luger military automatics. Although the latter may exhibit considerably more "calculated" energy on paper, its metal case causes it to penetrate cleanly and its limited diameter results in an almost tiny perforation through the tissues, with little bleeding. By reason of its high velocity it usually passes on through the target to expend most of its energy upon the scenery beyond. The soft-lead revolver projectile tends to "mushroom" (expand) on striking bone or other resistant body structure, tearing ragged holes.

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(C. GD.; J. **T. AM.**)

PISTON: *see* STEAM: *Steam Engine;* INTERNAL-COMBUSTION ENGINES; PUMP.

PITCAIRN ISLAND: *see* PACIFIC ISLANDS.

PITCH, MUSICAL. Pitch is that quality of a musical tone which permits it to be judged by the ear as high or low. It corresponds roughly to the logarithm of the frequency, is somewhat affected by intensity and needs a minimal time for recognition.

As a function of frequency. pitch is closely related to interval. An interval between two tones may be expressed by the ratio of their frequencies. In music theory the octave. with ratio 2:1, is taken as the primary unit of interval. Although a sequence of octaves thus has linear significance, the respective frequencies increase by powers of two. An interval, therefore, is a logarithmic measure of the ratio of two frequencies, to the base two. In occidental music the octave is divided into 12 equal semitones, whence the semitone. with ratio $2^{\frac{1}{12}}:1$, becomes the practical logarithmic measure of interval. For scientific purposes, A. J. Ellis' cent. $2^{\frac{1}{1200}}:1$ is invaluable.

It might seem, therefore, a simple matter to correlate pitch with frequency. With a note of fixed frequency as standard, a note of some other frequency will be a certain number of octaves higher or lower, plus a certain number of semitones or cents. There is no uniform method of designating octaves. In one system the note c' means middle C on the piano, having 256 vibrations per second (v.p.s.) in what is known as philosophical pitch, so called because it provides integral frequencies for C in every octave. But this same note has often been called c, and in contemporary acoustical practice C_4 or C_3. Among musicians the note an octave above middle C is treble C and above it comes C in alt; below middle C comes tenor or viola C, below it 'cello C, pedal C and subpedal C.

The frequency of subpedal C is 16 v.p.s. which is about the lower limit of audibility. The upper limit is between 15,000 and 20.000 v.p.s., some two octaves above the highest note on the piano. Thus the range of frequencies heard by the nvrmal ear is roughly ten octaves. If the ear were to respond uniformly throughout this range, pitch could indeed be correlated with frequency or interval. From experimental data S. Smith Stevens constructed a graph in which subjective pitch is plotted against interval. the logarithm of frequency. His pitch unit is the mel (from melody). which is defined as .001 the pitch of 1,000 v.p.s. The graph is concave until about 1,500 v.p.s., nearly straight, at a 66° angle, from 1,500 to 6,000 v.p.s., after which it becomes slightly convex. From this study, musical intervals, as expressed by frequency ratios, become subjectively larger as the frequency increases, throughout the normal musical range. The peak comes close to the highest note on the piano (4,000 v.p.s.), after which there is a decided drop. Thus pitch is a frequency function which is almost linear at low frequencies (the concave part of the curve), and almost logarithmic at high (the straight part).

Pitch is affected by loudness. A pure tone with constant frequency decreases in pitch as its loudness level increases. Experiments conducted by Harvey Fletcher showed a decrease for all frequencies up to 2.000 v.p.s., after which there was a very slight rise in pitch with intensity. The greatest dip came in the region of 200 v.p.s., about G below middle C. where an increase in intensity from 40 db (decibels) to roo db (from a quiet room level to that of a boiler factory) reduced the heard pitch by almost 10% or 1.7 semitones. For complex tones. the heard pitch seems to be determined by the higher partials. which lie in that part of the range in which the fall of pitch is small. Thus the musician has nothing to worry about. for he does not ordinarily produce pure tones.

A certain time is needed for the ear to perceive a tone as having pitch. With the duration of .001 sec., any frequency is heard as a click. With the duration increased somewhat. the sound appears as a noise of indeterminate pitch. For 1.000 cycles, the threshold for complete pitch recognition is .012 sec., but it increases greatly for lower frequencies. This phenomenon is of little consequence in musical performance. Seldom are staccato notes played as short as $\frac{1}{17}$ sec., the threshold for the lowest G on the piano (50 v.p.s.), and when composers write very rapid notes at a low pitch, they do not desire clarity.

The word pitch is often taken to mean pitch level. the thing the French call "diapason." So long as musical instruments were principally of the stringed type. as in ancient Greece. there was no fixed pitch standard. Even in the Renaissance, instruments were tuned to any convenient pitch. With wind instruments, there was less pitch variation than with the strings. and when these instruments were played in combination it was necessary for them to have some standard, even if it was purely local. The organ has always had a stabilizing effect upon pitch, since its pitch is fixed within narrow limits when it is built.

Alexander J. Ellis attempted to reconstruct the pitch level of old organs by making small-scale models of pipes whose dimensions were known. A safer indication of prevailing pitch is the

compass of the vocal music for a particular time and place, The early scale of the Greeks, for example, was of two-octave extent, from A to *á*. For untrained tenor and bass voices at the modern pitch this range would be too high by approximately a tone. From this it may be concluded that the Greek "diapason" was about a tone lower than ours.

Similar reasoning may be applied to what Arnold Schlick wrote about organ pitch in the early 16th century. He advocated a pedal-board extending from F to *é*, a compass of a 12th, so that the unison plain song melodies might be played on the pedals. But the 12th that mixed male voices can sing with any ease in modem times is A to *é*. Hence Schlick's organ must have been about a major third higher than modern pitch.

Internal evidence shous that at least three different pitches were prevalent in Tudor England. The secular vocal music was at modern pitch, but the church music was sung more than a tone higher and thus should be transposed up a tone. The pitch of the virginals was three semitones lower, but this makes little difference in modern performance.

In Germany in the early 18th century there were two important pitches and tno of lesser moment. The normal pitch was chamber (Kammerton), used by voices, strings, and most woodninds. Choir pitch (Clzorton) was a tone higher than chamber. and was used by organs and trumpets. (The key of D was signally the trumpet key for Bach and Handel.) *Cornett-ton*, the townpipers' pitch, was a semitone higher than *Chorton*, and *tiej* Kammerton, a semitone lower than Kammerton, belonged to oboes.

The tuning fork was invented in 1711 by Handel's trumpeter, John Shore. It helped tremendously to standardize pitches and knowledge of the precise pitches used in various musical centres after that time rested upon a much surer basis than Ellis' measurement of organ pipes Handel's onn fork gave an **A** of 422.5 v.p.s., which is .7 semitone lower than modern pitch, and Mozart's was practically identical

At the Congress of Vienna in 1814 the emperor of Russia presented new and sharper instruments to an Austrian regiment of which he was honorary colonel. This band became noted for the brilliancy of its tone, and another band in 1820 received even sharper instruments. Since opera houses were largely dependent upon military bands for nind players, they were forced to adapt their pitch to a higher standard. And so during Beethoven's lifetime the pitch in Vienna rose close to modern pitch. and by the 1850s had reached 456, .6 semitone higher than that of the 20th century and 1.3 semitones higher than Mozart's pitch.

Meanwhile in England pitch was also rising. In the 1820s Sir George Smart, conductor of the Philharmonic concerts, approved a fork giving 433. But 20 years later, with Sir Michael Costa the conductor. the pitch had risen to 452 4., practically the same as the "sharp Vienna pitch." The "high Philharmonic pitch ' continued to be used for British bands until 1928. In the United States the Steinway pitch of the 1880s nent as high as 458, and this "concert pitch" was still common even 40 years later

A warning voice against rising pitch was raised in 1834 when an international congress of physicists adopted J H Scheibler's 440. But it had no practical effect. In 1858 the French government appointed a joint committee of musicians and physicists to agree upon a lower standard of pitch. Their notable report in Feb. 1859 advocated a "diapason normal," to be set by a tuning fork at 435 v.p.s. (actually 435 4) at 1j° C. (59° F.). At the Vienna Conference of 1885, 435 became International pitch However, it was not until 1896 that England adopted a "new Philharmonic pitch" of 439 at 20° C. (68° F.). The British Standard Concert pitch adopted in 1939 was 440, the standard adopted by the American Federation of Musicians some twenty years earlier.

Controversies continued to rage over the merits of 435 and 440. Many writers consider them equivalent. The pitch of wind instruments rises with temperature. At the frequency for *á* this rise, for flutes and flue organ pipes, is 43 v.p.s. for 1° F. (It is less for other wind instruments.) Thus the rise in temperature from 59° to 68° F. would raise a 435 pitch to 439, the "new Philharmonic pitch." and a temperature of 70° F. would bring it up to 440. But Llewellyn S. Lloyd pointed out that the original French decree was for an absolute pitch—43j, whatever the temperature of the concert hall. It was only the standard tuning fork (whose pitch would *fall* insignificantly with temperature rise) that was to be at 43j at 15° C. However, if a wind instrument has been constructed for a certain pitch level at a specified temperature, the player may find it impossible to adjust its pitch to a level as low as this when playing in a hall with a substantially higher temperature. The British workshop temperature, therefore. is supposed to be held at 68° F., but should be at 72° in the, United States, these temperatures reflecting the difference in concert-hall temperatures for the two countries.

The above term "absolute pitch" is often used in a different sense than to mean a fixed standard. A person who can identify a heard frequency immediately and with great accuracy is said to possess absolute, or perfect, pitch. Some investigators believe that, as a refinement of a widespread ability. it can be improved by training. Albert Bachem rejected this view, calling such a limited ability "pseudo-absolute pitch." His subjects had possessed their uncanny sense of pitch from childhood. with an accuracy that averaged .1 semitone. Although Bachem explained absolute pitch in terms of tone height and "chroma", it remains one of the most puzzling and fascinating things connected with pitch. (J. M. BR.)

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PITCHBLENDE, an amorphous, black, pitchy form of the crystalline uranium oxide mineral uraninite. is one of the primary mineral ores of uranium. containing 50% to 80% of ,that element. Uranium was discovered in pitchblende by AT. H. Klaproth in 1789, and radium by Pierre and Marie Curie and G. Bémont in 1898. Deposits, frequently in association with uraninite or with such secondary uranium minerals, as carnotite. autunite and torbernite. are known in the Belgian Congo, Czechoslovakia, southwestern England, the Northwest Territory and Saskatchewan in Canada, and Arizona, Colorado. Montana. New Mexico and Utah in the U.S. See URANINITE. *See* also RADIUM; URANIUM.

PITCHER, MOLLY (1754–1832), sobriquet of the American Revolutionary War heroine MARY LUDWIG HAYS MCCAULEY who carried water to American soldiers at the battle of Monmouth on June 28, 1778.

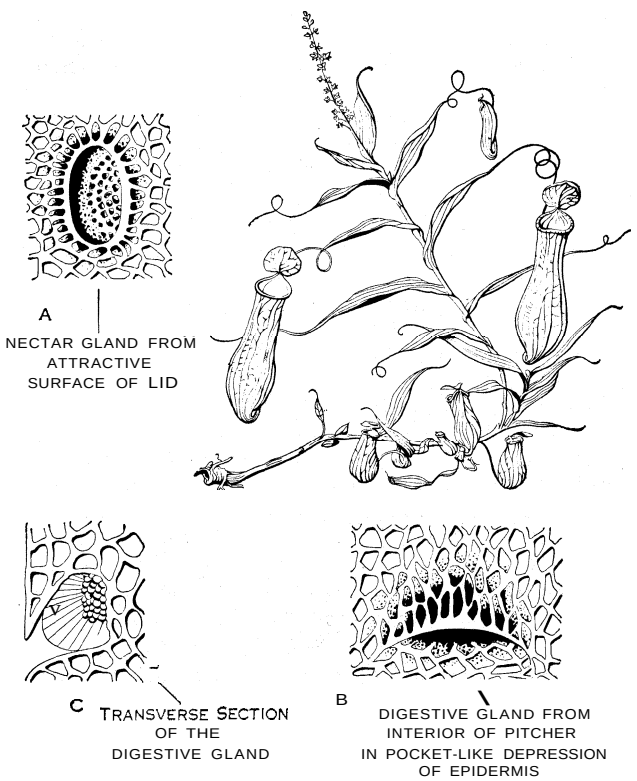
Born or, a farm near Trenton, N.J., on Oct. 13, 1754, the daughter of a German immigrant, John George Ludwig Hass (or Has), she was married in 1769 to John Caspar Hays in Carlisle, Pa. She joined her husband, who was a soldier in the artillery, on the field of battle at Monmouth and not only distinguished herself by supplying water to the troops on the extremely hot day but also was reported to have manned Hays's cannon after he was prostrated by the heat. Molly and her husband returned to Carlisle after the war.

Hays died in 1789 and Molly later was married to George McCauley. but the marriage proved unhappy. In Feb. 1822 the Pennsylvania general assembly recognized her services by awarding an annuity to her. She died on Jan. 22. 1832.

PITCHER PLANTS are certain carnivorous (or insectivorous) plants, the leaves of which bear pitcherlike structures or are as a whole pitcherlike in form. These plants have the usual nutritive mechanism of other green plants: *i.e.*, they are green and manufacture carbohydrates and are capable of absorbing the various other necessary elements from the substrate in which their roots are growing. In addition they have. in common with other insectivorous plants. evolved a mechanism for supplementing their supply of certain elements, particularly nitrogen and to a certain extent potassium and others, which are frequently deficient in the habitat in which they grow. In these plants the mechanism is the "pitcher." described in the following paragraphs.

The plant usually thought of in this connection is the genus *Nepenthes* (family Nepenthaceae). About 60 species are native to tropical Asia, the Philippines. north Australia and Madagascar. The Asiatic islands are especially rich in species. particularly Borneo. They are lax shrubby plants, creeping in the soil or climbing on the surrounding vegetation. While many are jungle plants, some affect relatively drier hillsides. The climbing is done by means of strong tendrils which are elongations of the leaf midrib. These under suitable conditions produce at the apices the pitchers. which stand upright at the hanging ends of the tendrils.

The pitcher is a development of the end of the tendril and is in form either tapering tubular or variously expanded either at the base or upper part; or they may he goblet-shaped. The pitcher usually shon-s a pair of wings, running longitudinally on the ventral aspect of the outer surface which are extensions of the margins of the leaf base. The mouth of the pitcher has a corrugated rim of various dimensions in different species. This rim consists of the outturned pitcher margin flanked by an outgrowth on its inner surface. These two, in maturity, are indistinguishable and form one organ. the peristome. Its surface is very firm, shining and broken into transverse ridges. both primary and secondary in size, parallel to each other and prolonged at the inner edge of the peristome as teeth, beneath each of which is a large nectar gland. Above the mouth is the lid or operculum which is immobile. It varies in size according to the species from a narrow process to a huge heartshaped expansion, overshadowing the mouth. A study of the de elopment of the pitcher, especially in the seedling or in forced small shoots, shows that the inflated portion is a development of the midrib of the leaf. while the wings, which are especially well developed under some circumstances. represent the upwardly extended leaf base. In the mature type of pitcher there is an apparent separation of the nings from the proximal part of the leaf base by the tendril, along which the wings, readily seen in seedling



BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

FIG 1— PITCHER PLANT (NEPENTHES GRACILIS) SHOWING GENERAL HABIT OF GROWTH. AND A, B AND C MINUTE STRUCTURE OF PITCHER PLANT

leaves. are vestigial. The lid has been thought to consist of two fused leaflets, but a more recent vien is that it is a transverse growth.

The short straight or curved process on the back of the pitcher just below the lid represents the organic apex of the leaf.

The size of the pitcher varies widely in different species. from the size of a thimble to that of a pint pot or sometimes even larger. The colour also varies considerably. even in different pitchers on the same plant, according to age. light exposure or soil conditions. It may be yellowish to dark green. variously marked by red. and on the peristome the red colouring forms sharp transverse bands. Some pitchers are merely pale green. They are more or less invested by a rough pubescence of stiff branching hairs, especially when young.

Insects, particularly ants: are attracted to the plant by many deep nectar glands which occur in scattered positions on the stems and leaves, including the tendrils. These insects can hardly escape finding the nectar glands which occur plenteously on the inner surface of the lid in most species. and thus are lured to the mouth of the pitcher. about which the peristome forms a perilous foothold. especially for insects trying to reach the nectar secreted by the large glands found on its inner edge. Even if the surface of the peristome offers no impediment to some insects. as in the case of small ants, there is in most pitchers a curious waxy (glaucous) surface clothing the upper half of the interior of the pitcher. This area has peculiar stomata which appear under low magnification as crescentic cells—guard cells distorted out of position and hiding in each case its companion guard cell beneath it. There is, moreover: no opening. Since the visible guard cells stand a little above the level of the surface in general, they have been interpreted as stumbling blocks to render the hold of insects' feet insecure. In any event the waxy surface crumbles under their feet. and they fall to their doom. This area has been called the "conducting surface." as distinguished from that below it. the "detentive" region, which could be called the digestive region. since the surface here is crowded with digestive glands. each partly covered with a sheltering overhang of epidermis. Of these there may be as many as 6.000 per square centimetre.

In some pitchers there is no waxy surface. though the two kinds of pitchers may occur on the same plant in some species. Insects which have been lured to the mouth of the trap and attempt to obtain nectar from the marginal glands of the peristome or from the underside of the lid, can. on losing ioothold, fall into the trap or pitfall. If they can walk in safety on the peristome, they find it impossible on entering the trap to walk on the waxy surface. They fall into the fluid which, as first secreted, is bland; however, when insects are present the glands are stimulated to secrete a weak acid and a digestive (proteolytic) enzyme. The nitrogenous parts of the insect bodies are digested. leaving the chitinous exoskeletons to accumulate. The products of digestion are absorbed by the walls of this region of the pitcher.

The process is essentially similar to that in the sundews (*Drosera* spp.), *Pinguicula*, and other carnivorous plants.

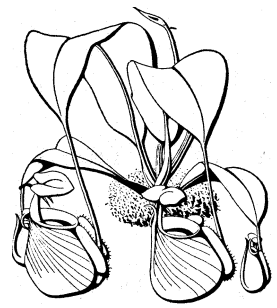
The presence of a digestive enzyme does not preclude the use of the fluid. enriched by insect bodies, by commensal organisms as a nidus for their growth and nourishment. A rich flora and fauna consisting of desmids. diatoms. protozoa and various kinds of insect larvae have been discovered and described. It is held by some that these organisms are protected from the attacks of the digestive ferments by the presence in their bodies of antienzymes, as has been claimed for endoparasites in the animal body.

The small, primitive, monkeylike insectivorous tarsier (*Tarsius* spectrum) is believed to rob the pitchers of their contents. One species of *Nepenthes* (*N. bicalcarata*), has sharp, clawlike hooks, developed from the inner ends of the peristome just beneath the lid (*see* fig. 2).

These have been regarded by some as an adaptation for catching the tarsier if he tries this game on the species. Another species, *N.* intermedia, has projections of similar dimensions in the same situation, but in this case they are too weak to act in such manner.

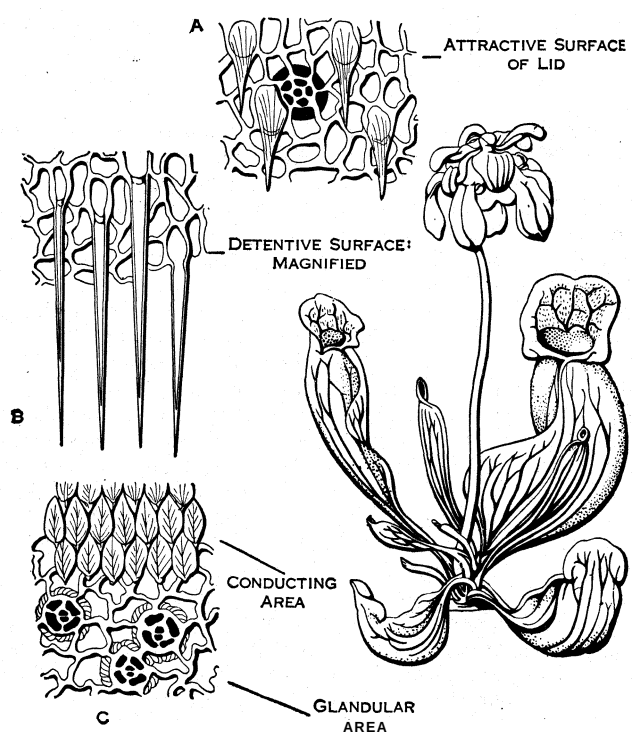
Sarracenia, another genus of pitcher plants (family Sarraceniaceae), is represented by eight or nine species native in eastern United States and Canada. They naturally fall into two groups, distinguished by the posture of the leaves. Two species have recumbent leaves, S. *purpurea* (sidesaddle plant) and *U. psit-*

tacina. The leaf of the former suggests the horn of plenty (see fig. 3). In the other the leaf lies in a nearly prostrate position, and the entrance lies horizontally and is hidden beneath a hood. In other species the leaf is trumpet shaped (slightly curved in S. minor) with the lid either upright or more or less inclined, over the mouth. The colour varies considerably from yellow-green (S. *flava*) to deep green variously masked by red. the intensity of which depends in part upon the situation. whether in bright sunlight or shade. The plant consists of a cluster of leaves springing from strong stolons and is herbaceous. The leaf has a broad sheathing base surmounted by a short stalk widening into the pitcher, which develops from the back (abaxial) part of the leaf base, the edge of which is continuous. On the ventral aspect of the pitcher arises a wing, while from the back of the mouth a laminalike expansion, the lid, arises. The outer surfaces, especially that of the wing leading to the entrance, are supplied with nectar glands which during vigorous growth and for some time during maturity exude nectar which attracts insects to the entrance. The inner surface of the lid and the upper portion of the interior of the pitcher have many glands also; those on the lid and forward edge of the pitcher mouth exude nectar while those within the pitcher are in all probability digestive in function. The



BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

FIG. 2.—PITCHER PLANT (NEPEN. THES BICALCARATA), A PLANT WITH PITCHERS ONLY AT THE END OF THE LEAVES



BY COURTESY OF THE TRUSTEES OF THE BRITISH MUSEUM

FIG. 3.—SIDE SADDLE FLOWER (SARRACENIA PURPUREA): SHOWING LEAVES. THE WHOLE OF WHICH FORM THE PITCHERS; AND A. B. AND C SHOWING THE MINUTE STRUCTURE OF PITCHERS (A AND C FROM S. FLAVA)

lid is armed with strong, downward pointing hairs, and it is a matter of observation that flies attempting to garner the nectar'here almost invariably fall into the pitcher. Below its mouth the surface is smooth and glistening. The upper zone immediately surrounding the pitcher mouth is beset with nectar glands and is usually coloured red in S. *purpurea*. The wide zone below has numerous digestive glands, according to J. S. Hepburn and his associates. Below this occurs a "detentive" zone where the surface bears numerous stiff. straight, retrorse hairs which effectively prevent the escape of insects. The fluid of the pitcher has a ready wetting power so that insects become quickly submersed and drown.

The digestion of the prey is partly by the action of digestive ferments (Hepburn et al.) and partly by bacterial action, in one or two species perhaps wholly.

The chitinous coverings of insect bodies are indigestible, and they accumulate till the leaf dies. Doubtless when this occurs some material is released to the soil and helps to manure it. The accumulated mass of insect bodies offers nutriment to commensal insects which take advantage of the situation to lay their eggs within the pitcher where the larvae live on the putrid mass. Birds often slit open the pitchers and feed on the living larvae. In the fluid a mosquito (*Wyeomyia* smithii) passes its immature stages and is believed to be confined to this habitat. The occurrence of clear fenestrations on the lid (*S.* drummondi), on the lid and back of the upper dorsal part of the pitcher wall (S. *minor*) or on the hood and ventral part of the pitcher wall (*S.* psittacina) is an interesting feature and is seen also in Darlingtonia (*q.v.*). These windowlike areas serve to attract insects.

Cephalotus follicularis (family Cephalotaceae) is a native of southwest Australia. the town of Albany being at about the centre of its restricted range. It has the same habit as *Sarracenia* but is a smaller plant. Its leaves are of two kinds. growing in a rhythmic alternation: the foliage leaves. ovate and acute in form. and pitcher leaves. the latter having very much the form of a loose slipper. as stated by A. G. Hamilton. an Australian student of this plant. The simile is apt if we think of the heel as turned up; this is the lid which overhangs the entrance.

The pitcher is about the size of a thumb and has much the shape of the distal half of a large thumb. The mouth is transversely oval and is guarded by strong, hook-shaped claws pointing inward and downward, graduated in size, the largest being in front. Overshadowing the entrance is the lid which has several white strips (fenestrations) radiating from its base, with green-red strips between. These, we may imagine, give the insect visiting the rim the impression of a way of escape but serve only to deflect him into the inside of the pitfall trap. The inner surface of the lid is lined with striated hairs pointing toward its base and hence toward the pitcher's interior. Within the pitcher is a thickened zone (collar) of the wall which ends abruptly a short distance below in an overhanging shoulder, an impediment to escape. Both on the lid and collar are found many nectar glands. The expanded lower portion of the pitcher is strikingly marked by the presence of two large kidney-shaped patches where the wall is thickened, one on each side and placed obliquely. These are glandular in nature. The epidermis consists of cells with strongly wavy walls, interspersed with curious stomata: the guard cells of which are widely spread and immobile. These stomata are plugged by a soft cellulose wall of a cell below and are probably water-excretory. as experiment has indicated. Here also occur large glands, of a structure similar to others of smaller, graduated sizes, scattered throughout most of the rest of this portion of the pitcher. That these glands secrete a digestive agent seems likely from the work of W. J. Dakin.

The external surface of the pitcher bears wings. One runs along the middle line and is doubled along the outer edge. Another two, one on each side, run obliquely along the sides. Two others, quite low and not readily seen, run from the edges of the lid to the stalk, which is attached to the pitcher near the lid; in this feature Cephalotus differs from the pitchers of all other species. The development of the pitcher shows that it is morphologically upside down.

There are usually produced besides the extreme forms of leaves, foliage and pitcher, intermediate forms which throw light on the morphology of the pitcher.

Genlisea, an aquatic genus with several species in tropical Africa and Brazil, is a relative of *Utricularia* (*q.v.*) (family Lentibulariaceae). It has traps which are of the pitcher type; they are not, however, pitfall traps. but of the lobster-pot type.

Charles Darwin likened them to eel traps. The plants are small and herbaceous. consisting of a cluster of leaves arising from a short stolon. buried in mud. The leaves are of two kinds: foliage leaves. usually near spatulate in shape, and trap leaves of peculiar design. The latter leaf consists of a stalk on which arises a bulbous. hollow enlargement. From its top extends a tube. the extremity of n·hich produces two arms n·hich are twisted like corkscrews. They are ribbon-shaped extensions of the tube folded longitudinally and with the edges of the ribbon fixed and held a certain distance apart by large cells. placed like buttons. The interrupted slit thus left permits the entrance of minute animal forms (small crustaceans. worms. larvae. as in *Utricularia*). The escape of the prey aiter entrance is prevented by numerous sharp, stiff hairs. intermixed with many glands. which may be merely mucilaginous. Both these appendages occur in curved rows. rendering the interior of the arms curiously complicated. Passing down the arms, the prey at length passes into the tube. also lined with long. slender downward pointing hairs so arranged that they form what would be, if large enough. a lobster pot. In this region are digestive as well as mucilage glands, in transverse rows. The prey finally reaches the bulbous expansion. which has two internal ridges carrying numerous digestive glands, and here the process oi disintegration is completed. While no erperimental work has been done to demonstrate the presence of enzymes, the rapid dissolution of the bodies of prey and the analogy with *Utricularia* make it seem fairly certain that such enzymes are produced.

Like *Utricularia, Genlisea* grows only in wet places, partly or wholly submerged, and anchored in the substrate.

See F. E. Lloyd, The *Carnivorous* Plants (1942), in which a full bibliography may be found. (F. E. L.)

PITCHSTONE, a natural glass, generally of composition equivalent to granite, with conchoidal fracture, like glass. and pitchy or resinous lustre, formed by rapid cooling of viscous lava or magma. It may be mottled, streaked. or uniformly coloured in brown, red. green. gray or black. A rhyolite (*q.v.*), the chemical composition, index of refraction, and specific gravity of pitchstone are similar to those of obsidian (*q.v.*). Pitchstone is distinguished from obsidian by a dull, rather than vitreous, lustre. Like obsidian, however, it is translucent on thin edges but is much richer in microscopic embryonic crystal growths (see CRYSTALLITE). The abundance of these tiny crystallites is generally believed to account for the duller appearance of pitchstone. The crystallites assume beautiful and interesting forms such as globular. rodlike, hairlike, stellate, feathery and frondlike. Slightly larger crystal growths (*see* MICROLITE) may also abound.

Most pitchstones occur as dikes or marginal phases of dikes and, therefore, may grade into porphyry (*q.v.*). Pitchstone porphyry (vitrophyre) consists of a glassy base enclosing abundant large crystals (phenocrysts) of such minerals as quartz (see QUARTZ PORPHYRY), alkali feldspar, and plagioclase and fewer crystals of pyroxene. or hornblende.

Pitchstone may reveal evidence of fluid flow by the presence of wavy streaks and trains of crystallites, microlites, phenocrysts and spherulites; and where formed in dikes, the lines and layers of flowage are most conspicuous near the margins of the intrusive body and have assumed an orientation parallel to the dike walls.

Of all the glassy rocks pitchstone is the richest in water, generally carrying 4% to 10% by weight. Most of this water may have been absorbed from the sea or wet sediments into which the pitchstone was intruded. Some lavas and magmas appear to have congealed partly as glass and partly as crystalline material. Water driven out irom those portions undergoing crystallization may have been trapped or taken up by the glassy portions to form pitchstone. Pitchstone is unstable, and its conversion to a very fine-grained crystalline aggregate resembles the devitrification of obsidian.

See also PERLITE. **(C. A. CN.)**

Representative *Analyses* of *Pitchstone* and Related Glassy Rocks

	Obsidian			Pitchstone				Perlite		
	Yellowstone Park	Iceland	Mexico	Scotland	Germany	Madagascar	Iceland	Siberia	Sardinia	New Zealand
SiO_2	74.70	75.28	75.23	73.20	72.42	72.61	68.12	72.78	70.50	74.73
Al_2O_3	13.72	10.22	12.36	10.75	11.26	11.35	12.13	14.15	14.28	10.82
Fe_2O_3	1.01	4.24	0.96	0.95	0.75	1.19	—	0.17	0.75	2.46
FeO	0.62	—	1.24	1.02	—	0.44	1.03	—	1.22	0.58
MgO	0.14	0.25	0.01	0.15	0.28	0.20	*	*	0.49	0.20
CaO	0.78	1.81	1.00	0.76	1.35	1.03	1.63	0.82	1.00	0.80
Na_2O	3.90	5.53	4.00	3.78	2.86	1.88	5.34	4.51	3.62	2.68
K_2O	4.02	2.44	4.62	4.20	3.80	4.00	1.69	2.48	5.28	4.40
H_2O	0.62	0.23	0.73	4.70	7.64	5.13	9.70	4.35	2.86	2.94

*Trace.

PITHECANTHROPUS, the name given to a fossil man (*P. erectus*) discovered by Dr. Eugene Dubois in 1891–92, on the bank of the Solo river. near Trinil. Java. The remains consist of a thighbone. two teeth and the upper part of a skull. The skull is low, with a capacity oi about 800 cu.cm. and with strong superciliary ridges; the teeth are large and the femur is quite human. After 1936 parts of 3 more skulls were found near the original site. In northern China skulls and skeletal remains of about 40 individuals of the closely related Peking man were discovered. Altogether they confirm the restoration based on the original skullcap and indicate that Dubois' fragments belonged to a primitive human being with numerous apelike features. The age of Pithecanthropus is Middle Pleistocene.

See E. Dubois, *Pithecanthropus erectus* (1894), Smithsonian Report of 1898; % Keith, Antiquity of *Man* (1915); F. Weidenreich, "Man or Ape," Yat. *Hist.* Mag., vol. 45 (1940). (J. E. HL.)

PITHOM, one of the "treasure cities" stated to have been built ior Pharaoh by the Hebrews in Goshen during the Oppression (Exod. i. 11). We have here the Hebraized form of the Egyptian Petōm. "House of (the sun god) Etōm," in Greek, Patūmos. capital of the 8th nome of lower Egypt and situated in the Wadi Tumilat on the canal from the Nile to the Red sea. Succoth (Egyptian Thuket) was identical with it or was in its immediate neighbourhood. The site, now Tell el Maskhuta, has yielded several important monuments, including the best preserved of the trilingual stelae of Damus which commemorated his work on the canal.

PITMAN, SIR ISAAC (1813–1897), English educator, inventor of the shorthand system named for him. was born at Trowbridge. Wiltshire, on Jan. 4. 1813. He started in life as a clerk in a cloth iactory, but in 1831 he was sent to a training college for teachers. After 11 years of teaching in elementary schools he opened a private school in Bath. In 1829 he took up Samuel Taylor's system of shorthand and became an enthusiast in developing the art of phonography. a system oi writing shorthand according to sound. In 1837 Pitman drew up a manual of Taylor's system and offered it to the publisher Samuel Bagster. Bagster did not accept the work. but suggested that Pitman invent a new system of his own. The result was his Stenographic Soundhand (1837). Bagster's friendship and active help had been secured by Pitman's undertaking to veriiy the half-million references in the *Comprehensive Bible,* and he published the inventor's books at a low price. thus helping to bring the system within the reach of all. Pitman established at Bath a Phonetic institute and a Phonetic *Journal* for this purpose; he printed in shorthand a number of standard works, and his book Phonography (1840) went through many editions. He was an enthusiastic spelling reformer, and adopted a phonetic system which he tried to bring into general use. In 1894 he was knighted. He died at Bath on Jan. 12. 1897. The Pitman system is described in the article SHORTHAND.

Pitman's biography was written in 1902 by his brother Benn Pitman and in 1908 by Alfred Baker.

PIT PONY. The pit pony is usually a small pony—14 hands high and under—used for hauling the tubs for the conveyance of coal from the working face of the coal seam to a point. variously termed the "flat." "double parting." "station" or "landing." where the tubs are made up into "sets" or trains and conveyed, either by horses or, more commonly. by mechanical haulage, to the shaft bottom. That is to say. the pit ponies ply between the face and flat. bringing the full tubs out from the hewer and serving him with empty tubs. The use of pit ponies has decreased with the extended development of electrically driven haulage underground.

PIT-SHAFT: see COAL AND COAL MINING.

PITT, THOMAS (1653–1726), British East India merchant and governor of Madras, usually called "Diamond Pitt," was born at Blandford, Dorset, on July 5, 1653. From his headquarters at Balasore, he engaged in trade in opposition to the East India Company, whom he opposed also in the law courts. Unable to check him the East India Company took him into its service in 1695, and in 1697 he became president of Fort St. George, or Madras. While in India Pitt bought the fine diamond which was named after him; in 1717 he sold this to the regent of France, Philip duke of Orleans, and it is now the property of the French government. During his stay in England Pitt acquired the manor of Old Sarum, and for a short time he represented this borough in parliament. After his final return from India in 1710 he again became member of parliament for Old Sarum. He died at Swallowfield, near Reading, on April 28, 1726. His eldest son, Robert, was the father of William Pitt, earl of Chatham (*q.v.*); and of Thomas Pitt (d. 1761), whose son became the first Lord Camelford; his second son, Thomas Pitt (c. 1688–1729), having married Frances (d. 1772), daughter of Robert Ridgeway, 4th earl of Londonderry (d. 1714), was himself created earl of Londonderry in 1726.

See Sir C. N. Dalton, ***Life*** of Thomas ***Pitt*** (1915).

PITT, WILLIAM (1759–1806), English statesman, second son of William Pitt, earl of Chatham, and of Lady Hester Grenville, was born at Hayes, near Bromley, Kent, on May 28, 1759, in the year of the pinnacle of his father's glory. Both because of his extreme delicacy and because his father was an early critic of the public school system, he was educated at home under the tutorship of the Rev. Edward Wilson of Pembroke Hall, Cambridge, and the earnest supervision of Chatham himself—a plan which tended to the intensive development of the child's unusual precocity. Before he was ten years old he was a good classical scholar: at 13 he had composed a strange political tragedy *Laurentino*, ***King*** of *Chersonese*. In Oct. 1773, in his 15th year, he went into residence at Pembroke Hall, Cambridge, where his tutor was the Rev. Dr. George Pretyman (he changed his name in 1803 to Tomline), to whom Pitt in later years awarded the bishopric of Lincoln, and at the last bequeathed his papers: and who in return became his pupil's first biographer. Pitt had not been at Cambridge long when he fell seriously ill and was obliged to return home. It was then that the family physician, Dr. Anthony Addington prescribed that generous consumption of port wine which was to become the habit of a life. He returned to Cambridge in July 1774; and in 1776, by the privilege of his birth as the son of a peer, graduated as a master of arts without examination. That year saw the Declaration of American Independence, and the next the battle of Saratoga. On April 7, 1778 Pitt was the witness of his father's last dramatic utterance in the House of Lords. A month later Chatham died. Pitt was left with an income of £300 a year; he began to keep his terms at Lincoln's Inn; was called to the bar on June 12, 1780 and joined the western circuit. At the general election in September Pitt was defeated for the University of Cambridge but was returned for Sir James Lowther's pocket borough of Appleby. He entered parliament on Jan. 23, 1781: he was not yet 22 years old.

Parliament.— Pitt was attached to that section of the opposition which had followed his father, and was now led by Lord Shelburne. His maiden speech on Feb. 26 was made in support of Burke's Bill for economical reform, and produced a series of famous eulogies, Lord North admitting it the best first speech he had ever heard, and Burke, with even greater prodigality, declaring him "not a chip of the old block but the old block itself." A year later, when North's ministry was near its fall, Pitt had the self-confidence to announce in the House of Commons (March 8, 1782) that, should he conceivably be asked to join the new ministry, he would never accept a subordinate position in it; nor did he alter his mind when Rockingham, shortly afterwards offered him certain well-paid but unimportant posts, and even though one of them—the vice-treasurership of Ireland—had been held by Chatham before him.

As a private member Pitt now supported a new version of Burke's reform project, a measure for shortening the duration of parliaments, and another for destroying bribery at elections. On May 7 he presented his own motion for a select committee to inquire into the state of the representation. It was only defeated by 20 votes. Shortly afterwards the death of Rockingham on July 1 provoked a major crisis. The king appointed Shelburne as his successor. Fox, Lord John Cavendish and Burke immediately refused to serve with him; whereupon Shelburne turned to Pitt, who on July 6 accepted the office of chancellor of the exchequer.

The Shelburne Ministry.— The ministry was only to last until the following February. On Jan. 20, 1783, the preliminaries of the Peace of Versailles were signed, and provided the opposition with an easy target. It was essential for Shelburne to obtain more support, and on Feb. 11, by agreement with his chief, Pitt visited Fox to invite him to return to the ministry. Fox replied that he would only serve on the condition that Shelburne resigned the premiership, whereupon Pitt replied "I did not come here to betray Lord Shelburne." The incident is important. It marks the beginning of the ceaseless political warfare between Fox and Pitt; it marks the end of the Shelburne ministry, and the origin of the coalition between Fox and North. Speaking of North's Government only in the previous year, Fox had declared "From the moment when I shall make any terms with one of them, I will rest satisfied to be called the most infamous of mankind," and he had loudly demanded their impeachment: yet he who had poured his blistering scorn upon North's conduct of the war, now joined with North in execrating the terms of the peace. The ministry was defeated (Feb. 21) and two days later Shelburne resigned. For a month the king sought to escape the coalition. But Pitt, who was pressed to accept the Treasury preferred to bide his time, and North could not be lured from Fox. On April 2 the Fox-North coalition under the nominal leadership of the duke of Portland took office.

The Coalition Ministry.—On May 7 Pitt brought forward resolutions for checking bribery at elections, disfranchising corrupt constituencies, and increasing the number of county and London members of parliament. The resolutions were refused by 293 to 149. On June 2 he brought forward another bill which passed the Commons but failed in the Lords, for reforming abuses in public offices: he instanced North's mysterious consumption of stationery, which totalled £1,300 and contained an item of £340 for whipcord.

During September and October Pitt visited France—his only venture outside his own country. In November parliament reassembled and Fox immediately introduced his India bill. Passed in the Commons the measure was defeated in the Lords (Dec. 17) because George III. plainly informed the peers at large through Lord Temple that he should regard anyone who voted for the bill as his enemy. The Government very properly refused to resign. Whereupon the king, on Dec. 19, depending upon a barely literal interpretation of his constitutional rights, but reflecting by accident the wishes of his people, dismissed his ministers and appointed Pitt as first lord of the treasury and chancellor of the exchequer. The coalition had been jockeyed out of office, and it is not surprising that the House received the news of Pitt's appointment with mirth. It is mistakenly generous, however, to suppose that Pitt assumed office from pure altruism and without a certain confidence in the future. The strident Opposition no longer represented its constituency and Pitt knew it, and while they were wasting their breath deriding the "boyish prank," Pitt was converting the electorate—voters who were to be more valuable to him than the voters in the House of Commons. Almost as important, the influence of the City and of the East India Company was on his side. Until the end of March he struggled on, continually defeated in the House, but steadily refusing to resign. Outside his popularity was growing, while the action of the Opposition in threatening to oppose even the votes of supply cast on them the obvious accusation of factiousness. The hostile majority diminished daily until on March 8 Fox's "representation" was carried by only one vote. On March 24 parliament was dissolved. The essential business had been forced

through. At the ensuing election some 160 of "Fox's Martyrs" were rejected. This was the answer to the charge of unconstitutional action: throughout the struggle Pitt had in fact represented the nation. Pitt was himself elected for Cambridge university, which he represented for the rest of his life.

PITT'S FIRST MINISTRY

Finance.—Finance was the first consideration. There was a heavy debt and the fiscal machinery was antiquated. Pitt floated a loan of £6,000,000, offering the tenders to public competition, and funded £6,600,000 of the floating debt. The loss to the revenue which had long resulted from the systematic evasion of the high protective tariffs he countered by a radical reduction of duties—that on tea being reduced from 119% to 12%. To meet the loss he increased the window tax, and many new taxes were instituted to touch the whole people. But he withdrew the tax on raw cotton, and pronounced it as his principle that "manufactures in general ought to be free from taxes."

Pitt, who had been one of the earliest students of Adam Smith, next attempted the establishment of free trade between England and Ireland. The Irish accepted his propositions (Feb. 7, 1785) but in England the measure was met by the organized opposition of vested interest, prejudice, and faction. Pitt was obliged to alter his original scheme, and in that form the Irish, disappointed and inflamed by Fox's subtle tongue, rejected it.

In 1786 Pitt introduced his sinking fund, a measure adapted from a scheme of Dr. Richard Price (*q.v.*). Economically it was undoubtedly mistaken, but it was believed to be a sovereign remedy, and it at least inspired public confidence.

On April 18, 1785, Pitt brought forward a bill proposing to suppress 36 pocket boroughs and to transfer their members to increase the representation of certain towns and counties. £1,000,000 was to be spent upon the purchase of the interests of the various owners. The bill, for which he eloquently pleaded, was rejected by 248 to 174.

India.—Pitt's India Bill, which had been rejected during the first struggle in the spring of 1784, was passed in the summer easily enough. Pitt's bill, unlike Fox's, left the ordinary patronage with the directors of the company while passing to the Crown the political control. Moreover, he had the tact and the wisdom to consult the company and to present as a final draft a measure to which he knew they were prepared to agree. The bill was not without serious defects—especially in its subordination of the governor-general not only to his council, but in all important concerns to the home Government. Warren Hastings resigned at once, and upon his return, his conduct of the Government was called in question. Pitt who had voted against the Rohilla charge (which was not carried) voted in favour of the Benares and the Begum charges. His action decided the issue. The motions were carried, and the impeachment pursued. Pitt has been heavily criticised for his conduct. But the truth that Hastings had been a great administrator could not disguise the fact that here was a patent scandal, which demanded inquiry. Indeed Hastings, through his agent in the House, had himself originated the discussions; and Pitt deliberately chose to support the Opposition in a matter where he honestly believed them to be right, instead of following the usual custom of opposing whatever measure the Opposition proposed.

The Regency Question.—In Nov. 1788 the king's illness provoked a crisis which might have ended Pitt's political career. There was a traditional enmity between the Hanoverian monarchs and their sons, and the whole influence of the prince of Wales (doubly hostile because Pitt would not pay his debts), was directed to the cause of the Whigs. The king being insane it was essential to appoint a regent, and Pitt was inevitably agreed that there could be no other candidate for the office than the prince of Wales. The point at issue lay in the claim of Fox and his party that the prince had a prerogative right to the position. Pitt claimed that he could only become regent by act of parliament, and drew up that act so as to restrain the regent from making peers or granting pensions, while the king's person and household and the patronage of the Crown were to be placed under the direction of the queen. The bill passed the Commons (Feb. 5, 1789) and while it was under discussion in the Lords the king recovered. The situation had been dangerous, for though the resolutions had been carried, there had been much uneasiness among Pitt's followers. Pitt himself believed that he would be unable to retain office and would have to resume work as a lawyer. The London merchants at this time offered him £100,000 in recognition of his conduct, but Pitt replied that "No consideration on earth shall ever induce me to accept it." At the general election of 1790 he obtained an increased majority. In April 1791 by his Constitutional Act he arranged for the division of Canada into Upper and Lower Canada. The following year he accepted the wardenship of the Cinque Ports which carried a salary of £3,000 a year.

Foreign Policy.—The first important act of Pitt's foreign policy—the commercial treaty with France—was complementary to his reorganization of the home finances. The abandonment of useless trade restrictions was plainly to the benefit of both countries and Fox could think of no better ground of attack than to assert that France was the unalterable enemy of England, to which objection Pitt replied that "to suppose that any nation could be unalterably the enemy of another is weak and childish." In 1787 there was trouble in Holland. The Emperor Joseph II. had been for some time preparing a labyrinthine scheme whereby he should consolidate his dominions by annexing Bavaria, whose elector was to be compensated in the Austrian Netherlands. The scheme was agreeable to France who was intriguing for the overthrow of the Dutch stadholder and complete influence in Holland. War was only avoided after full preparations had been made (an expedition for instance was actually prepared for the capture of the Cape) because Prussia, who was opposed to Joseph II.'s policy was at length persuaded to stand with England. Upon Prussia's entry into Holland the Austro-Russo-French intrigue collapsed and the stadholder was restored. In 1789 England was brought into conflict with Spain who had seized the British trading post at Nootka Sound. Again war seemed imminent (over two millions sterling were spent in naval preparations), but Spain, receiving no support in Europe, was obliged to withdraw. Less successful was Pitt's intervention in the Eastern question. Catherine II. of Russia was at war with Sweden and Turkey. The Triple Alliance (of England, Prussia and Holland) had gained a prestige which placed it in a position to work for the maintenance of the balance of power. But though Austria's support was detached from Russia and Gustavus III. made peace with Catherine, the empress was not to be diverted from her ambitions in Eastern Europe. She gained great success in 1791, and Pitt, without adequate means of supporting his policy. determined to prevent Russia from establishing her power in the Black sea. He demanded that Russia should give up Oczakov, but Oczakov meant nothing on earth to the British public, and Catherine perceiving there was no force behind the ultimatum was unmoved by it. Though armament credits had been voted. Pitt was obliged to retire.

Pitt had not at first anticipated that the French Revolution would involve England in hostilities. In the spring of 1792 he was happily discussing finance, prophesying the reduction of 25 millions of debt in the next 14 years. and declaring in support of his vision that "there never was a time when. from the situation of Europe, we might more reasonably expect 15 years of peace than we may at the present moment." He had no intention of interfering in a matter which concerned France alone, and indeed in its original conception he was not unsympathetic to the aims of the Revolution. On Aug. 10th, the French monarchy fell. and the English ambassador was recalled from Paris, and Chauvelin in London could henceforward be only received unofficially. But this was merely a question of diplomatic routine: friendly relations were not strained until the French, having already declared war upon Austria and Prussia. followed the victory of Jemappes by occupying the Austrian Netherlands, threatening Holland. and overturning the treaties which governed the navigation of the Scheldt. England was bound by treaty to support Holland; and. as she had been through the centuries, she was not less insistently bound in this matter by her own interests. The execution of the king, and among the French people a rising tide of truculence swiftly fol-

lowed. On Feb. 1, while Pitt was outlining the provocations which Britain had received from France that country was despatching yet another in the shape of a declaration of war. The remainder of Pitt's life was to be spent in the shade of the revolutionary wars.

War.—The history of the wars with France is discussed under FRENCH REVOLUTIONARY WARS, NAPOLEONIC CAMPAIGNS, NAPOLEON; FRANCE, etc. It is only possible here to estimate generally the part that Pitt played in the organization of Europe. It has long been a current *cliché* to say that Pitt was a great peace minister and a poor war minister. But if Pitt's talents were indeed essentially suited to peace, it is equally true that Napoleon was finally encompassed in disaster by the dogged determination of the English premier, and after his death by the remembered influence of that resolution. To compare him with his father is idle; Chatham had every advantage. His allies were great commanders, his France was effete. But revolutionary France was inspired with a fanatic hope, and England's continental allies proved continually worthless. Year after year Pitt laboured to sustain his coalitions of the Powers; year after year the coalitions melted away before the victorious advances of the French. England, who had no call to be anything but a member of a general European league against France was forced to be the inspiration as well financially as politically of the entire organization.

Home Policy.--At home the war changed entirely the tranquil prospects of national wealth and prosperity. New voices were in the air—voices of political discontent, and shortly the voices too of hunger. Pitt's policy at home at this juncture is of great importance. Because he never again brought forward the question of reform after his failure in 178j, and opposed it whenever it was proposed by others, his sincerity has been openly called in question. His actions certainly demand some.explanation. It is in the first place important to admit that there was as yet no national enthusiasm for reform: the cry had been raised largely in protest against the unconstitutional behaviour of the king, and had been lulled since the declaration of peace; moreover those who had been foremost in urging "economical reform" had no such belief in the necessity of parliamentary reform. A statesman—especially one on whom practically the whole conduct of a Government devolves—can not persist in a measure which has been again and again rejected in one form or another. Pitt had a large majority. But the fact that he remained in office for so long has obscured the truth that he was to a very large extent dependent upon the caprices of that majority. A contemporary political estimate recorded the number of those gentlemen who "would probably support his majesty's Government"—roughly the Court Party—as more than three times the size of Pitt's personal party: and there was a further shifting and entirely independent vote. For all his dominance of the House Pitt was sometimes defeated—over the Westminster petition (see FOX, CHARLES JAMES), over Ireland, over his proposals in 1786 to fortify Plymouth and Portsmouth. The demand for reform was not seriously supported in the House of Commons. More important still it was not as yet properly vocal outside its walls.

In 1792 Tom Paine's *Rights* of Man had been published, suddenly jolting the English Radical movement into a new mind at the moment when the French doctrines were filtering into England in a fashion admittedly designed to provoke dissensions. The circumstances had become altered. Pitt's refusal to support the motion for the repeal of the Test and Corporation Acts in 1789 and 1790 was unintelligibly craven; but when he refused to support Grey in 1792 he had excuse. "The hurricane season" had set in. Pitt allowed himself to be stampeded by a species of panic which was entirely unjustified by the facts. Talleyrand at this time remarked that those curiously deceived themselves who believed that England was on the verge of revolution. He was a more shrewd observer of truth—but it must be admitted that he had the advantage of looking at Britain not only in perspective but also dispassionately. Deceived or not, Pitt declared that this was no time to revise a constitution, and proceeded to punish severely any who should advocate reform doctrines. It was lamentable; it was essentially unjust; and there is but one excuse—the excuse which in sympathy has condoned many shameful persecutions, when things are done in panic which are never justified by the patent facts but are believed to be necessary for profound reasons of State that can only be guessed at.

In 1793, and again in 1795–1801 Habeas Corpus was suspended, and bills for the suppression of sedition followed. There succeeded the trials and transportations of men like Skirving, Margarot, Gerrald, Muir, condemned for nothing more treasonable than advocating parliamentary reform or universal suffrage. Societies for constitutional reform were raided and suppressed. It is unpleasant to find that the records of the confiscated papers of those clubs reveal without exception nothing indicative of revolutionary organization. And yet in 1795 Pitt declared that were he to resign he would lose his head within six months. The circumstances were extraordinary, and it is just to suppose that Pitt was honest: he was not the less grievously wrong.

It was not long before the pain of war was felt in England. Pitt had based his confidence in a short period of war upon the pathetic belief that France would be financially incapable of sustaining a prolonged struggle. But the war advanced, and Pitt's subsidies were swallowed up upon the Continent by allies who made little or no return for them. The nation's debt mounted. The coalition crumbled. More money to buy more allies was needed. In 1795 after a season of bad harvests Pitt had to ask for a loan of 18 millions, and to increase the general taxation. Shortly afterwards followed the legacy duties. In 1797 taxation was increased by two millions; the next year produced the income tax.

Ireland.--One of Pitt's major pre-occupations was still Ireland. He had failed in 1785, but he never ceased to plan for the final consummation of his hopes. In 1793 Pitt forwarded the passage in the Irish House of Commons of the Catholic relief bill; but in 1794 he suffered disappointment when Irish opinion was again alienated by the position he was forced to adopt against the antics of Lord Fitzwilliam, who had been made lord lieutenant as a concession to the Portland Whigs who had entered the ministry in that year. Fitzwilliam and his party were anxious for a broad policy of reform and emancipation; but Pitt had laid down a cautious line of action, and it had been determined that Fitzwilliam should do nothing without the consent of the cabinet. But by "an open breach of a most solemn promise" he proceeded to dismiss the Irish Tory officials, and without authorization to promise widely the immediate prospect of a full emancipation. Fitzwilliam was recalled, and Ireland left to nurse an angry grievance. The whole bungling led directly to the disasters which followed; the state of semi-civil war in 1797 and the rebellion of 1798 and that disaffection which could welcome the French invasion. The union of Ireland and England which he had sought earlier for the mutual benefit of both countries was now imperative as a solution to a state of war. On Jan. 23, 1799, Pitt brought forward his proposals for a union of the two countries. Emancipation was not promised (the hostility of George III.'s eccentric conscience precluded the suggestion) but the hope was held out that this would follow in due course. The bill was pressed through the Irish parliament by Cornwallis, the viceroy, and Castlereagh, the secretary for Ireland. The distribution of titles and money played some part in this and more than a million pounds was expended in compensation to the holders of suppressed rotten boroughs. However open to moral criticism the latter decision may have been, it was essential to the support of the bill and it destroyed an entirely dishonest system of representation. As for the measure of the general corruption, that has at least been over-estimated, and in so far as material persuasion was adopted it must be remembered that bribery in the Irish parliament was a deeply respected tradition. Moreover it must have been patent to the guiding minds in Ireland that the present state of affairs was impossible, and the possible benefits of the union, for instance to trade, were obvious. The bill having passed the Irish parliament in 1800, the first united parliament met in Jan. 1801. Pitt had now to enlarge his policy, and once more the solution of Ireland's troubles was tragically postponed. Pitt had not promised emancipation, but those who had voted for the measure had been led to expect that it must follow. With a secrecy which

was perhaps unwise but understandable in the circumstances Pitt drew up his preliminary suggestions for the abolition of religious tests, the commutation of tithes, and provision for Catholic and dissenting clergy. The plan was opposed in the cabinet, principally by Lord Loughborough, the chancellor, who reported the matter to the king. George was enraged, and adamant against the proposals, and on Feb. 5 accepted the resignation which Pitt had tendered on Feb. 3. Immediately afterwards the situation was complicated by the king's relapse. During his temporary insanity, Pitt retained office until his recovery, finally resigning on March 14. Many bitter things were spoken of him. Once again he was accused of betraying his cause. But he had boldly brought forward his reforms, and his resignation followed upon their veto. Had he pressed his legislation, the king would have persisted inevitably in his opposition: moreover with the war going extremely ill it was not the moment to precipitate a domestic crisis. His promise to George never again to introduce the subject during the reign was sentimental, not necessary, and politically unwise. But he made it because the king had accused him of causing his illness and after all he might reasonably expect that the reign would be shortly finished. That Pitt intended to return to the fullest implications of his project is certain. But he himself had only five more years to live.

1801–1806

Retirement. — Henry Addington, who was called upon to lead the Government, had been universally praised as an expert speaker of the House of Commons; but he was no statesman. Pitt promised to do all he could to support Addington, and generously assisted in the conduct of negotiations for the Peace of Amiens. These terms which Grenville branded as "disgraceful and ruinous" appeared in general "highly satisfactory" to Pitt. Though he had long been anxious to conclude any peace which was at all reasonable, it is difficult to justify him in supporting a peace which recognized the failure of the coalitions to establish the independence of the Netherlands — which had been the ostensible *casus belli.* On the other hand there is evidence that Pitt was conscious of the unstable nature of the peace, and foresaw that a greater struggle was probable. The public supported the peace; and during the discussions a severe vote of censure upon Pitt was rejected, and a counter motion passed by 211 to 52 declaring that he had "rendered great and important services to his country, and deserves the thanks of the house." He retired now from parliament for the space of about a year, living largely at Walmer Castle, where as warden of the Cinque Ports he organized with great diligence and enthusiasm a local volunteer force. The brief interval gave an opportunity too for the examination of his debts. Pitt who had been so astute in public economy was careless of his own. He who had scornfully demanded an explanation of Lord North's expenditure of £340 of public money on whipcord, had himself to account for the grotesque item of £600 for hats. Both thoughtless and generous, Pitt was the victim of swindlers, and in 1800 already owed £45,000 despite the fact that he had received a salary of over £10,000 for many years. He nevertheless refused an offer of £100,000 from the citizens of London, and a gift of £30,000 from the king, though he accepted £11,700 as a loan from a committee of private friends; he was obliged to sell his house Hollwood.

Addington had won a great victory at the general election, but it was not long before his policy began to drift towards perilous courses. When it was clear that a rupture of the peace was imminent, Pitt was approached, but he no longer felt that Addington's policy could receive his honest support, and later negotiations provoked so wide and insistent divergencies of mind upon the personnel of a possible cabinet as to make agreement impossible and even to interrupt an ancient friendship. War broke out again on May 16, 1803. Against the insufficient programme of the ministry Pitt opposed a vigorous policy in a speech (May 23) which provoked the enthusiasm of all parties. But while the cleavage was growing plainer and plainer Pitt yet refused directly to oppose Addington, to whom he had promised his support. The situation was becoming increasingly serious. In the face of the growing danger of invasion the measures of the Government were entirely inadequate, and early in 1804 Pitt was forced into stronger opposition. Complicated once again by a threatened relapse of the king, negotiations for a stronger administration were protracted. The ministry was doomed when a motion of Fox's for a committee of inquiry into the national defenses was powerfully supported by Pitt, and after some days of negotiation he returned as chancellor of the exchequer and first lord of the treasury on May 10.

Second Ministry. — Pitt's second term of office was marked by no great enterprises of governance. The war alone absorbed his energies. The labour and the inspiration of the great European coalition again rested exclusively upon Pitt, and his health, now gravely undermined, was beginning to break beneath the strain when early in April 1805 he suffered the pain of witnessing the public disgrace of his old friend and colleague Dundas (Lord Melville, *q.v.*). The battle of Trafalgar (Oct. 21) destroyed the possibility of invasion, but the year closed in disaster. The capitulation of Ulm (Oct. 20) was succeeded by Austerlitz (Dec. 2). At first Pitt was able to doubt the full implications of the news; but gradually, as dispatches authenticated the reports, he came to realize that the mighty coalition was hopelessly broken. England had saved itself by its exertions, he had remarked at the lord mayor's banquet in the previous November; it would save Europe by its example. And now Napoleon stood without a force to oppose him upon the whole continent; and Pitt, with prophetic accuracy. was brought to the bitter admission that the map of Europe would "not be wanted these ten years." On Jan. 23, 1806, he died, and if his last words were not "My country! How I leave my country!" his thoughts can have been none other.

Constitutional Importance. — The period of Pitt's government covered a supremely important moment of political transition. It was also a period of a not less important crystallization of British constitutional doctrine. It would be wrong to attribute that growth too strongly to Pitt's political acumen. Both the length and the critical instant of his ministry made development natural and inevitable. He was placed in the position of leadership at precisely the tactical moment. The fruit was ripe, but it was the harvest of a century of other men's labours. Pitt was the first Hanoverian minister to appeal definitely from the vote of the House of Commons to the vote of the constituencies, and throughout his career his strength was derived from the public confidence. In his colleagues Pitt appeared to prefer industry to genius. If this was partly because of an exaggerated sense of his own authority. it must also be remembered that the choice was also one of necessity. Pitt did overshadow his colleagues — but it was no difficult task. The result contributed to his general theory that the independence of Government departments was impossible. They must rather be bound together with a corporate policy, responsible to the Crown under a common allegiance to the prime minister. Walpole, who is generally considered the first prime minister. denied the title. and was succeeded by Governments which could only exist under the leadership of duumvirates and triumvirates. Pitt not only claimed the title of prime minister but declared that the office was essential to sane government. In 1803. when negotiations were on foot for a ministry in which the authority should be shared by himself and Addington, he stated that it was "an absolute necessity that there should be an avowed and real minister, possessing the Chief Weight in the Council and the principal place in the confidence of the King; in that respect there can be no rivalry or division of power. It must rest in the person generally called *first minister,* who ought to be at the head of the finances." And if a difference of opinion arose "the sentiments of the minister must be understood to prevail." This view moreover was widely understood by contemporary commentators. In 1794 when Lord Fitzwilliam went to Ireland he was pledged to support the Government "considering Mr. Pitt as the *Prime Minister* without whom no material measure as to *Things* or *persons* is to be concerted or done" *(Carlisle Papers);* and the Glenbervie diary (Dec. 30, 1798) corroborates this language. In everything Pitt laboured to assert the authority of the cabinet, and of the premier within the cabinet. He was the king's

minister; but not the minister of the king's policy. The theory was thrashed out over small details. Pitt claimed, for instance, that the Crown must follow his recommendations in the nominations of bishops, and when the king refused to concur declared that he would take it as a decisive mark of lack of confidence.

Cold, aloof, and sarcastic, supporting a reputation for an almost tiresome integrity, Pitt was not popular except, at a distance, with the people, who saw him as an inspired leader, or with his few intimates, who found him secretly gentle and affectionate. In perspective he has become a man of no little mystery and of unexpected inconsistencies. There seems no good enough reason adequately to explain his changed attitude towards Reform; his treatment of the Reform agitators; his cold indifference to social suffering in England; his support of the Addington ministry in spite of his patent disapproval of its conduct; the lack of a firmer policy during the Fitzwilliam fiasco in Ireland. He remains a statesman: indisputably supreme in debate and tactics and tireless in organization. Because of the failure of the allied cause in the war, it was once popular to assume that Pitt neglected the army and navy, depending solely upon his efforts as an international financier. The assumption is entirely unfair. British naval prestige was at a low ebb at the end of the American war, and it was largely owing to Pitt's interest and to his generous allocations of money that the administration was reformed, and the mastery of the sea re-captured. When Pitt entered office English credit was debased: restoration was effected by his regenerated understanding of finance. In 1783 England was practically outside the concert of Europe, yet in a few years she had become the director of an almost united European policy. A true perception of the future of the Empire was not to come before the 19th century. Yet Pitt's colonial interests were remarkably wide—covering not only the great administrative acts for India and Canada but also the colonization of Australia; the fortification of the West Indies; the defence of Nootka Sound. African settlements were considered, and the territories annexed during the war selected with remarkable discretion.

Actually and theoretically Pitt bridged the distance between the 18th and 19th centuries. He was the source of the emancipation of trade and finance from antiquated restrictions. He was the origin of modern financial theory. Yet, though he warmly supported the abolition of the slave trade, he did nothing to improve the condition of the worker, nothing to promote social emancipation at home. That is perhaps the measure of his position in history. He is revered but not loved.

Pitt was never married. He once professed a tender inclination towards the daughter of Lord Auckland; but the embarrassment of his debts prevented him from a formal declaration of his feelings. His real passion was for his work; and to that he gave his life.

BIBLIOGRAPHY.—The article in the Dictionary of National Biography contains a full bibliography. *See especially* Lord Rosebery's *William Pitt* and the works of Prof. J. H. Rose: *William Pitt and National Revival,* and *William Pzt and the Great War; Pzt and Napoleon;* and *A Short Life of William Pitt. See* also *P.* W. Wilson, *William Pitt, the Younger* (1930).

PITTA, a genus of birds remarkable for their great beauty of coloration. For a long while the pittas were commonly supposed to be allied to the *Turdidae,* but they form a separate family, *Pittidne* of the Passeres. There are about 50 species, divided into a number of genera, confined to the Old World, and ranging from India and North China to Australia, New Guinea and New Britain, with one species in West Africa, the greatest number being found in Borneo and Sumatra. Pittas vary in size from that of a jay to that of a lark, and have a strong bill, a thick-set form, which is mounted on rather high legs with scutellated "tarsi," and a very short tail. In many of the forms there is little external difference between the sexes.

PITTACUS, of Mytilene in Lesbos (650?–570 B.C.), one of the Seven Sages of Greece. About 611, with the assistance of the brothers of the poet Alcaeus, he overthrew Melanchrus, tyrant of Lesbos. In a war (606) between the Mytilenaeans and Athenians for the possession of Sigeum on the Hellespont he slew the Athenian commander Phrynon in single combat. In 589 his fellow citizens entrusted Pittacus with despotic power (with the title of Aesymnetes) for the purpose of protecting them against the exiled nobles. He resigned the government after holding it for ten years. According to Diogenes Laertius, who credits him with an undoubtedly spurious letter to Croesus, Pittacus was a writer of elegiac poems, from which he quotes five lines.

See Herodotus v. 27, 94; Diog. Laët. i. 4; Lucian, *Macrobii,* 18; Strabo xiii. 600, 617–618; Aristotle, *Politics,* ii. 12, iii. 14; T. Bergk, *Poetae lyrici graeci.*

PITTOSPORUM, the most numerous genus of the family Pittosporaceae, comprising about 100 species of evergreen trees and shrubs, native to tropical regions of the old world, chiefly in the southern hemisphere.

Many species are grown as ornamentals in warm regions, as in Florida and California, and as house or greenhouse plants in cooler latitudes. P. *tobira* (Japanese pittosporum) and P. *viridiflorum* (Cape pittosporum) are attractive winter-blooming shrubs; P. *rhombifolium* (Queensland pittosporum) is often planted for avenues; *P. undulatum* (Victorian box), of Australia, is suitable for pruned hedges; P. *eugenioides* (tarata), of New Zealand, is useful in shrubberies; P. *crassifolium* (karo) and *P. undulatum* are planted for seaside windbreaks.

PITT-RIVERS, AUGUSTUS HENRY LANE-FOX (1827–1900), English soldier and archaeologist, son of W. A. Lane-Fox. was born on April 14, 1827. He entered the army, served in the Crimean War, and was one of the founders of the Hythe School of Musketry. General Pitt-Rivers made a collection of weapons and other things which was presented in 1883 to the University of Oxford. When, in 1880, General Pitt-Rivers obtained possession of his great-uncle's estates—practically untouched by the excavator since they had been the battleground of the West Saxons. the Romans and the Britons—he devoted himself to exploring them. His excavations round Rushmore resulted in valuable "finds"; he founded a local museum and published several illustrated volumes. As a scientific archaeologist he attained high rank. He received various honours. including the F.R.S. He married, in 1853, Alice Margaret, daughter of the second Lord Stanley of Alderley, and was the father of a large family; his second daughter became in 1884 the wife of Sir John Lubbock (Lord Avebury). He died at Rushmore on May 4. 1900.

PITTSBURG, a city of Crawford county, Kansas, U.S., was established in 1876 and was named for Pittsburgh, Pa., because of its location in the Kansas coal fields. The city came into being as a direct result of mining and subsequent railroad construction. It is the centre of some of the world's largest strip-mining operations; modern equipment now does work once performed by thousands of European immigrants, who made Pittsburg one of the most cosmopolitan of Kansas cities. Plants producing coal-preparation equipment and clay pipe are among the principal industries. Kansas State college is located in the city. Pittsburg has a council-manager form of government, in effect since 1949. For comparative population figures see table in KANSAS: *Population.* (R. W. *R.*)

PITTSBURGH, the second largest city in Pennsylvania, U.S., and the seat of Allegheny county, is strategically located at the confluence of two major rivers, the Allegheny and Monongahela, nhich drain a watershed of 19,117 sq.mi. west of the Allegheny mountains and unite to form the westward-flowing Ohio. The rivers are normally 710 ft. above sea level and the highest point in the city is 1,365 ft. The climate is relatively free of extremes in temperature and destructive storms. The annual average mean temperature is 52.5° F.; January 31° F. and July 74.3° F. Annual average precipitation is 36.28 in.

The three rivers and minor streams, flowing through narrow valleys, from which rise high hills or precipitous bluffs to rolling plateaus. give the city a spectacular setting. Nearly 300 named bridges and hundreds of lesser ones span the valleys within the county's limits. Two sets of twin tunnels carry high-speed traffic to southern residential districts and to the west, while tubes make possible the limited-access Penn-Lincoln route to the east. Mass transportation is provided by electric street railways, increasingly

supplemented by motor coaches.

Population of the corporate city in 1960 was 604,332. Highly urbanized Allegheny county had a population of 1,628,587 and the tightly knit four-county standard metropolitan statistical area (comprising Allegheny, Beaver, Washington and Westmoreland counties) numbered 2,405,435. Within the metropolitan area are the cities of Aliquippa, McKeesport, New Kensington, Washington and Wilkinsburg (*qq.v.*).

Many new outlying residential communities were built after 1945 and existing suburban areas experienced rapid gronth. In the city a marked trend to apartment dwelling was evident in the latter part of the 20th century.

History.—William Penn was granted the province of Pennsylvania in 1681. The following year the French laid claim, through LaSalle's discovery of the Mississippi, to all the territory drained by its tributaries. In the resulting dispute, the "Forks of the Ohio" were of first importance. The argument was settled, after years of contest and conflict, when Gen. John Forbes and his British and colonial army, after hewing their way across the Allegheny mountains, moved on Ft. Duquesne, built by the French in 1754, to find it in flames and the French in flight. On Nov. 27, 1758, Forbes wrote to William Pitt the Elder that he had named the site "Pittsbourgh" in his honour. After the defeat of Pontiac's Indian forces in 1763, a later settlement with Indian tribes by the Penns and the end of a boundary dispute between Pennsylvania and Virginia, settlers arrived in ever-increasing numbers; they built cabins and stayed, built boats to carry those who pressed on to the west, discovered coal and iron ore in nearby hills and launched the town on its nay to industrial greatness. After the Civil War great migrations from Europe swelled the population and by 1900 the city could boast of 321.616 inhabitants. In 1907 the independent city of Allegheny, largely German in origin, was annexed by legislative enactment.

Immediately after World War II the city entered upon a new, dramatic phase in its history. With strong civic, business and political leadership and mobilized citizen support, and based upon long and patient planning, Pittsburgh set about to build new highways and public works, to raze its blighted areas, to redesign the cleared lands and to rebuild according to a new pattern designed to meet modern needs. Every phase of the city's life—industry, transportation, education, culture, recreation—felt the impact of this new and continuing force which was quickly to become knonn as the Pittsburgh "renaissance."

By Nov. 1958, when the city celebrated its bicentennial. Pittsburgh was no longer a static city; it was a great metropolis in purposeful and directed motion A $2,000,000,000 regional program of public works and rebuilding—public and private—entered its most spectacular phase in the central city in that year and several neighbouring industrial communities mere concurrently moving ahead on ambitious renewal programs. Spear-heading the advance was the Allegheny Conference on Community Development, a citizens' co-ordinating group.

Three notable advances—smoke control, flood prevention and sewage disposal—made possible the city's revival. The ban on smoke, first legislated for the city in 1947 and subsequently extended to all Allegheny county, drastically reduced air pollution. A federal program of dam building for impoundment in the upper reaches of the rivers and their tributaries reduced the stage of maximum flood in the city by ten feet. 4 $100,000,000 sewage-disposal program, joined in by 71 municipalities in Allegheny county, began operation in 1959, heralding major recreational possibilities in the three rivers.

By 1961 the city planning commission had certified 15 areas, comprising 1,442 ac., for redevelopment, and had under study 1 221 ac. in seven additional areas. Rebuilding in nine of these areas was completed or in progress by the urban redevelopment authority. The most spectacular of these projects cleared 36 ac. for a state park and major traffic interchange at the "point" of the "golden triangle." For development by private enterprise, 23 adjoining acres were cleared, and by 1960 six new multistory office buildings and a major hotel—all in a parklike setting—and an underground garage topped by a park had been completed in this once-blighted district.

East of the triangle. in the populous "lower hill." 95 ac. were cleared; the reconstructed section was dominated by a $20 300,000 public auditorium featuring a retractable roof. With a maximum seating capacity of 14.000, the building, completed in 1961, nas designed to accommodate conventions and athletic and cultural programs. Nearby redevelopment was projected on the historic "bluff," permitting expansion of the campus of Duquesne university.

Highlighting a major road program was the 20-mi., $140,000,000 Penn-Lincoln parkuay. a limited-access thoroughfare carrying traffic through the city, along the hlononga hela river and from the triangle to the nest across the new double-decked eight-lane Fort Pitt bridge to and through twin 3,600-ft. tunnels under Mt. Washington. By 1939 the Pittsburgh parking authority had built seven garages nith a capacity of 4,487 cars. One, in the heart of the business district, for subsurface storage under a handsome park, was made possible by gifts to the city totaling $4,000,000 by three Mellon family foundations.

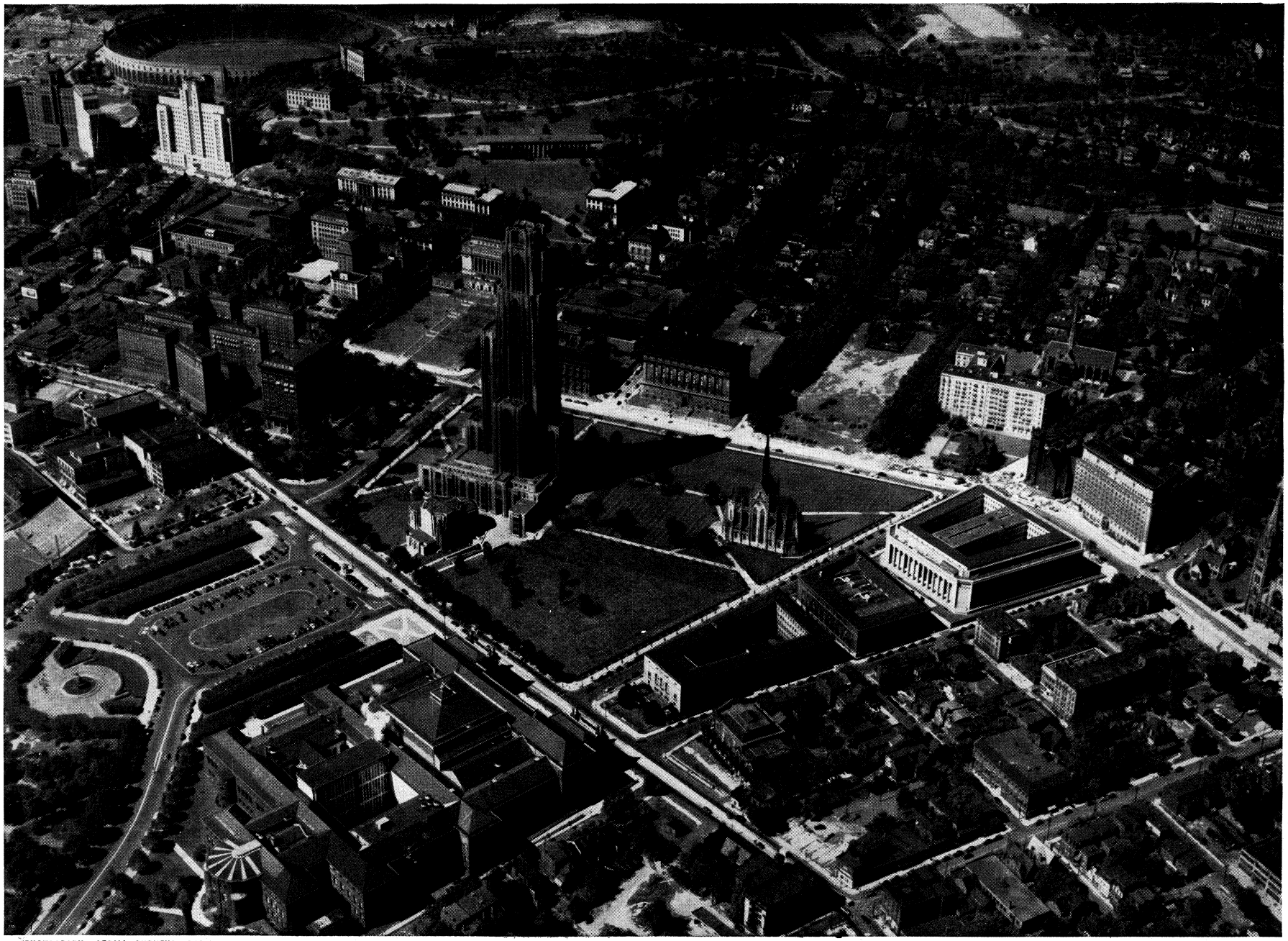
Among major buildings erected after World War II are the 40-story structure shared by the Mellon National bank and the United States Steel corporation, the 30-story Alcoa building, and the Porter; and seven tall structures in Gateway centre, one built by the commonnealth of Pennsylvania. Notable among older governmental buildings is the Allegheny County courthouse (1884), widely known as one of architect H. H. Richardson's masterpieces.

Government.— Pittsburgh nas incorporated as a borough in 1794 and as a city in 1816. By act of legislature (1911) government nas put in the hands of a mayor and council. David L. Lawrence, who resigned as mayor in 1959 after 13 years in office to become governor of Pennsylvania, had served longer than any other in the city's history. The mayor appoints department heads, members of various commissions and three authorities. He names the city treasurer and the city solicitor. The council is the legislative body. Within permissive state legislation, it determines the objects of taxation and fixes the rates, authorizes expenditures and contracts and fixes salaries of city employees. The chief source of revenue is a tax on real estate, the rate on land being twice that on buildings. Other taxes are levied on personal property and personal income, on mercantile activities, on admissions to amusements and on deed transfers.

The school district of Pittsburgh is a distinct governmental entity. Its members, nonsalaried and appointed by the judges of the court of common pleas for six-year terms, comprise the board of public education. Administration is through two departments: education, headed by a superintendent appointed by the board for a four-year term: and business, headed by a manager appointed annually. The chief source of school revenue is the tax on real estate, supplemented by mercantile, per capita and personal property taxes; approximately one-fifth of the cost is provided by state subsidy.

Commerce, Industry and Transportation.— Pittsburgh is a port of entry and a leading transportation centre. The Monongahela and the Allegheny rivers provide a minimum pool depth of 9 ft (with minor exceptions) to Fairmont, W.Va., 128 mi. to the south, and to East Brady, Pa., 72 mi. to the north. The Ohio river connects this system with the Mississippi and the Gulf of Mexico. The total river tonnage in the Pittsburgh engineering district in the late 1950s was greater than that carried by the Panama canal. The city is a major inland exporter of manufactured products to world markets. Greater Pittsburgh airport, accessible by a limited-access highway, was built at a cost of $44,000,000 on 2,450 ac.; its runway facilities accommodate jet transport planes. As the hub of major highways, the city is an important centre for motor freight and of tourist travel. It is served by the Pennsylvania turnpike and other four-lane high−ays.

Pittsburgh's industrial importance, especially in steel, is based upon strategic location and natural resources which originally included abundant timber, clay for bricks and sand for glass. There nere also great deposits of coal, petroleum and natural gas and there continues to be a plentiful supply of water for industrial uses. The district's coal and favourable location with respect to



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THE "CIVIC CENTRE" OF PITTSBURGH

In the left centre is the University of Pittsburgh's 42-story Gothic "cathedral of learning," with the Stephen C. Foster memorial immediately in front. To the right of the "cathedral" is the Heinz Memorial chapel and the Mellon institute (with colonnade). At the upper left is the university's "upper campus," including Pitt stadium, the medical centre and the professional schools. In the lower left is the Carnegie library and museum

PITTSBURGH

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COMMERCE AND INDUSTRY IN PITTSBURGH

1. The compact business district of Pittsburgh known as the Golden Triangle. It is formed by the Allegheny river (right) and the Monongaheia river (left) where they meet to form the Ohio river
2. Night view of the Pittsburgh steel mills

the great iron ore deposits on the Great Lakes gave it early dominance in the steel industry. Despite the development of large steel centres elsewhere, assembly costs of raw materials in Pittsburgh still compare favourably with those of competitors. The district is important in steel fabricating and in machinery manufacture, particularly of mill machinery and heavy electrical equipment.

In Pittsburgh are located some of the largest plants of the U.S. Steel corporation and of Jones and Laughlin, as well as of important independent producers. It is the home of three nidely known companies established by the inventive genius of George Westinghouse — Westinghouse Electric corporation and Westinghouse Air Brake and Union Switch and Signal companies. The city is the seat of Aluminum Company of America and of Gulf Oil corporation. Its ship-building tradition is carried forward by the Dravo corporation. Its pioneering in food processing is recalled by a major plant of the H. J. Heinz company..

Public Health and Housing. — Support for programs of health received impetus from grants of $16,200,000 to the University of Pittsburgh, in the years 1948 to 1958, from the A. W. Mellon Educational and Charitable trust, to establish and support the graduate school of public health. This foundation also made other major grants to the university's health centre. the largest of which was $5,000,000, matched by equal amounts from the R. K. Mellon and Sarah Mellon Scaife foundations. Another notable advance was establishment of a county-wide health department. Within a decade, these tno developments resulted in a virtual revolution in public-health programs. With co-operation of public officials and voluntary agencies a transition to professional status mas effected and forward-looking programs were established. The county has over 40 hospitals, the largest of which is the John J. Kane Memorial hospital for the indigent sick, completed in 1958.

Pittsburgh is traditionally a city of single-family residences and ranks high in percentage of home ownership. After World War II. however, there was a marked increase in the building of three-story walk-up and elevator apartments and of high, so-called "luxury" buildings. Pittsburgh's best-knonn residential district is Chatham Village, a pioneer large-scale, planned garden-homes community, built as a demonstration by the Buhl foundation in 1932–36. The housing authority of the city has built and operates several developments with more than 9,000 dwelling units.

Educational and Cultural Institutions. — Pittsburgh's mid-century surge carried the three universities and two women's colleges to new peaks in endowment, in plant and in enrollment. Largest of the five institutions is the University of Pittsburgh, a private institution chartered in 1787, which receives state aid. It is widely knonn for its 42-story "cathedral of learning" opposite Schenley park. It embraces 22 schools and divisions, operating since 1959 on the trimester plan. Carnegie Institute of Technology, a private school established in 1900, includes an affiliated women's college, a college of fine arts, a college of engineering and science, a graduate school of industrial administration, a school of printing management and a division of humanistic and social studies. Its campus also adjoins Schenley park. Duquesne. a Roman Catholic coeducational university established in 1878, has, in addition to the college, schools of business administration, education, music, nursing, pharmacy and law. The two separate women's colleges are Chatham, a private college chartered in 1869, and Mount Mercy, a Roman Catholic college established in 1929. The Western Pennsylvania School for Blind Children is in Pittsburgh.

Notable research programs in the natural sciences are conducted at the University of Pittsburgh and at Carnegie Institute of Technology. The university's experimental work in physics, biochemistry and biophysics has attracted wide support, as has its health studies, an outstanding achievement being the polio vaccine developed there by Dr. Jonas Salk. Carnegie maintains large research laboratories, especially for metals, petroleum studies and nuclear research. The latter centers about a $2,000,000 synchrocyclotron with a capacity of 450,000,000 ev. Mellon institute, centre for industrial research, and the laboratories of the United States bureau of mines are located in Pittsburgh. Important industrial laboratories include those of Gulf Oil, Westinghouse Electric, United States Steel, Jones and Laughlin, Pittsburgh Plate Glass, Koppers and Union Switch and Signal company.

Carnegie institute is the outstanding cultural centre, with a library of 1.500.000 volumes, a department of fine arts (known for its international exhibitions of contemporary painting), a museum and a music hall. Phipps conservatory uas presented to the city by Henry Phipps in 1893. The Buhl planetarium was dedicated in 1939 in honor of Henry Buhl, Jr., who established the foundation that bears his name. The Pittsburgh Symphony orchestra has been widely acclaimed and the Pittsburgh playhouse, with its school of the theatre, the Civic Light Opera and the Pittsburgh Opera company are more than local in their appeal.

The city has one morning newspaper, the *Post-Gazette* (established as the *Pittsburgh Gazette* in 1786), and one evening paper, the *Press*, established in 1883. Pittsburgh pioneered in the development of radio and KDRA was the world's first broadcasting station. Its television stations include WQED, a pioneering community-sponsored educational outlet.

Parks and Recreation. — City parks include a total area of about 2,000 ac. Most are located on high, rolling land and several afford dramatic views of the industrial valleys below. Overlooking the Monongahela river is Schenley park. Highland park overlooks the Allegheny; in its 425 ac. are found the principal city reservoirs, the municipal zoo and a children's zoo. Also in the eastern portion of the city are Frick and Mellon parks. On high ground on the north side is Riverview park, which contains the Allegheny observatory, once directed by Samuel Pierpont Langley. Supplementing these facilities are North and South parks (each 1,200 ac.), developed by Allegheny county, and six new park sites acquired in 1958. (C. F. Ls.)

PITTSFIELD, a city of western Massachusetts, 7 mi. from the New York state line, in the central valley between the Taconic and Berkshire mountain ranges; the seat of Berkshire county. Pop. (1960) city 57.879; standard metropolitan statistical area (the city and Dalton, Lee and Lenox towns) 73,839. Pittsfield was incorporated as a town of about 1,000 people in 1761 and was named for William Pitt, prime minister of England during the French and Indian Wars. The first land grant in the area was made in 1763 to Col. Jacob Wendell, the great-grandfather of Oliver Wendell Holmes. In 1890 Pittsfield received its charter as a city and changed from the town-meeting to a mayor-council system of local government.

The town was completely dependent on agriculture during its early years. Between 1820 and 1890, however, more than 20 industrial and retail concerns were established. There is a large paper mill which manufactures the paper used for U.S. bank notes and government bonds. Electrical transformers, chemicals, textiles, leather goods, boxes and machine tools are other leading products manufactured in the city.

Pittsfield has an excellent public school system, a local library and a museum. The widely known Berkshire Symphony festival at Tanglewood (10 mi. distant) is held each year. Summer stock theatres at nearby Stockbridge and Williamstown play a prominent part in the cultural activities of Pittsfield's residents.

Social and recreational facilities are abundant and among the best in New England. Parks, bathing beaches, golf courses and numerous ski trails, the best of which is located on nearby Mt. Greylock, provide yearlong entertainment for the area's many tourists and outdoor sportsmen. (P. K. HA.)

PITTSTON, a city of Luzerne county in northeastern Pennsylvania, U.S., on the left bank of the Susquehanna river just below the mouth of its tributary, the Lackawanna river; midway between Scranton and Wilkes-Barre at the entrance to the Wyoming valley. Connecticut Yankees settled there in 1762 and named it for the elder William Pitt, British prime minister and friend of the colonists. They erected frontier Ft. Pittston (1772). Pennsylvanians protested Connecticut's charter claims to this land in three local Pennamite–Yankee Wars (1769–75; 1775–82; 1784–87). During the American Revolution the colonists met the British and Indians in bloody fighting.

The opening of anthracite mines in the 1830s brought people and prosperity to Pittston. It was incorporated first as a borough (1853) and then as a city (1894). With the decline of coal mining the people turned to manufacturing textiles, clothing, furniture, cigars, paper products and automobile parts. For comparative population figures see table in PENNSYLVANIA: *Population.* (J. C. A.)

PITUITARY BODY. The pituitary body (hypophysis cerebri) is an endocrine or ductless gland. Thus, its cells secrete their specific products, the pituitary hormones, directly into blood capillaries. The term hypophysis is derived from the Greek "lying under," descriptive of the gland's anatomical position under the brain. The pituitary plays an extremely important part in the normal functioning of the human body. Since its effects are largely mediated through its control over other endocrine glands, it is described as the "master gland" or "the conductor of the endocrine orchestra."

History. — The name pituitary was given to the gland by Andreas Vesalius (1514–64), who shared the belief advanced by Galen (c. AD. 130–zoo) that it derived from the brain a mucous substance, pituita or phlegm, nhich it secreted into the nose and upper pharynx. Other early workers, including Franciscus Sylvius (1614–72) and Raymond Vieussens (1641–1716), considered that the structure played a part in the elaboration of cerebrospinal, fluid, a viewpoint also expressed by Thomas Willis in 1664. Richard Lower in 1672 was probably the first to ascribe an endocrine role to the gland, for he considered that it removed fluid from the cerebrospinal fluid and secreted it into the blood stream, and not into the nasopharynx.

Modern investigations concerning the structure and function of the pituitary can be said to date from 1886 when the French neurologist Pierre Marie described an association between pituitary tumours and a form of gigantism. Then in 1894 the English investigators G. Oliver and E. A. Schafer demonstrated that pituitary extracts when injected intravenously caused an elevation of blood pressure. In 1896, the U.S. physiologist W. H. Howell showed the substance responsible for the pressor effect was present only in extracts of the posterior lobe of the gland, and in 1906 Sir Henry Dale observed that these extracts also caused contraction of the uterus. The U.S. neurosurgeon Harvey Cushing, in the early part of the 20th century, successfully removed the pituitary from dogs and advanced the knowledge of the pituitary by both experimental and clinical studies that included surgical procedures for the removal of pituitary tumours in man. In 1921, H. M. Evans proved the anterior lobe of the pituitary contained a growth-promoting hormone and some 20 years later he and his associates at the University of California succeeded in isolating this hormone in pure form. Later researches were directed toward isolation and identification of the various hormones, the determination of the cells of origin of these various hormones, and the elucidation of the reciprocal relation of the pituitary and other endocrine glands.

Structure. — Gross Anatomy and Embryology. — The pituitary gland in the human adult weighs about 0.5 g. and measures about 1 cm. in length. 1.5 cm. in breadth and 0.6 cm. in depth. The pituitary of the whale weighs from 10 g. to 60 g.; of the beef, 2.5 g.; of the dog, 0.065 g. and of the cat 0.009 g. The gland is situated in a depression on the surface of the sphenoid bone. This depression, known as the *sella turcica* ("Turkish saddle"), is deep in some species, including man, and quite shallow in others. As is shown in the figure, the gland itself consists of two divisions: a neural division, the neurohypophysis, derived embryologically from the floor of the diencephalon and a glandular division, the adenohypophysis, derived from an outpouching of the roof of the mouth (Rathke's pouch). The neurohypophysis consists of three parts, the median eminence of the tuber cinereum, the infundibular stem and the infundibular process or neural lobe. An extension of the third ventricle penetrates the median eminence and in some species extends into the neural lobe. The adenohypophysis normally loses all connection with the roof of the mouth. In most species. the posterior portion of the developing adenohypophysis becomes so closely applied to the neural lobe that the two cannot be separated, and together form the posterior lobe. The portion of the posterior lobe derived from the adenohypophysis is known as the pars intermedia or intermediate lobe. It is frequently separated from the anterior lobe by the colloid-filled cleft. In certain animals such as the cetaceans, armadillo and beaver and in birds, a discrete intermediate lobe is missing and anterior and neural lobes are separated by a thin layer of connective tissue. A small portion of the adenohypophysis known as the pars tuberalis, extends up the infundibular stem and often encircles it.

Microscopic Structure. — The anterior lobe consists of branching cords of cells supported by a reticulum of connective tissue, and separated by wide vascular channels known as sinusoids. Based on staining properties, the cells are classified into chromophobes and chromophiles. These two cell types are present in almost equal numbers. The finely granular cytoplasm of the chromophobes has a poor affinity for the conventional stains. In about 75% of the chromophiles, the cytoplasm contains granules that are stainable with acidophilic dyes and the cells are known as acidophils, eosinophils or alpha cells. The remaining chromophiles contain granules which stain with basophilic dyes and the cells are known as basophils, cyanophils or beta cells. Chromophiles are situated close to the blood sinusoids and are thought to represent the actively secreting cells of the anterior lobe. Chromophobes tend to be present in the central portion of the cell cords and it is felt that they represent inactive stages. The intermediate lobe is less vascular than the anterior lobe and consists of cells whose cytoplasm stains faintly with basic dyes, as well as cells similar to the chromophobes of the anterior lobe. The pars tuberalis is more vascular than the intermediate lobe and consists of small cells with chromophobic or slightly basophilic nongranular cytoplasm. These cells are frequently arranged in the form of small follicles with a colloid-filled lumen.

The neural lobe resembles the gray matter of the brain rather than a typical endocrine gland in structure. The cells present in greatest numbers are the pituicytes. The neural lobe also contains numerous unmyelinated nerve fibres and a fairly rich blood

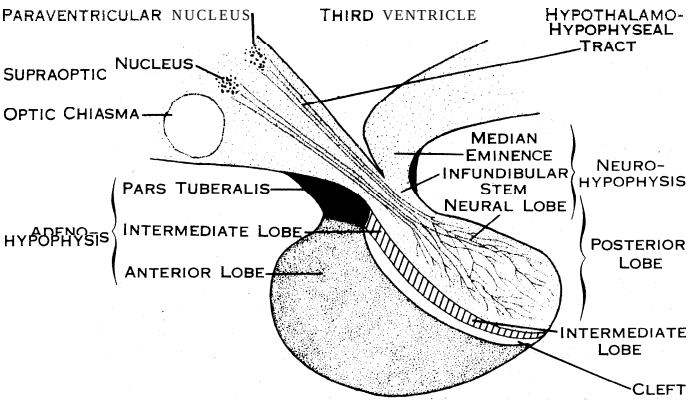

DIAGRAM OF A SAGITTAL SECTION THROUGH THE PITUITARY GLAND

supply. The nerve fibres originate from nerve cells situated in the hypothalamus (the supraoptic and paraventricular nuclei). The fibres sweep down the infundibular stalk and spread out to form a rich network in the lobe. A characteristic of the neurohypophysis is the large amount of intercellular substance which in the course of fixation precipitates into granules known as Herring bodies.

Blood Supply. — The pituitary receives arterial blood from the internal carotid and from the circle of Willis. There is also a venous portal system between the hypothalamus and the anterior pituitary. Venous drainage from the pituitary is into the cavernous sinus.

Nerve Supply. — The neurohypophysis is richly supplied with unmyelinated nerve fibres from the hypothalamic nuclei. It is questionable whether any of these enter the anterior lobe which does receive some sympathetic fibres from the carotid plexus and parasympathetic fibres from the greater superficial petrosal nerves, themselves branches of the facial nerve.

Hormones of the Pituitary Gland.—Anterior Lobe.—A number of hormones have been isolated from the adenohypophysis and the existence of a number of others postulated. The identified hormones all appear to be protein or polypeptide in nature and some have been isolated in pure form. A hormone from one species may be chemically different from that derived from another species. This may explain the occasional failure of a hormone to elicit an effect in a different species. Thus the fact that human and beef growth hormones differ chemically may account for the apparent ineffectiveness of growth hormone prepared from beef when administered to man. Furthermore, species differences can lead to antibody formation (antihormones), which may account for the refractoriness that often develops after extended use of these preparations.

The growth hormone is necessary for normal growth. A type of dwarfism is caused by the absence of this hormone. Excessive growth hormone production results in gigantism in children and acromegaly in adults. (See DWARFISM AND GIGANTISM.) The hormone appears to act directly on the tissues of the body. Prolonged administration to certain species results in the development of diabetes, an effect formerly thought to be due to a separate diabetogenic principle. The thyrotropic hormone (thyrotropin; TSH) stimulates the growth of the thyroid gland and the secretion of the thyroid hormone. In its absence, myxedema may develop, indistinguishable clinically from the true myxedema (*q.v.*) due to a primary underactivity of the thyroid gland. It is possible that exophthalmos (pathological prominence of the eyes) may be the result of excessive pituitary stimulation and that thyrotropin or a closely related substance is responsible for the condition.

The adrenocorticotrophic hormone (corticotropin; ACTH) stimulates the groath of the adrenal cortex and the release of its hormones. In its absence, signs of adrenal insufficiency (Addison's disease) develop. The follicle-stimulating hormone (FSH), the luteinizing hormone (LH) and the lactogenic hormone (prolactin) are sometimes classed together as the gonadotropic hormones. The follicle-stimulating hormone promotes growth of ovarian follicles in the female and stimulates spermatogenesis in the male. The luteinizing hormone stimulates the formation of the corpus luteum from follicles that have ripened under the influence of the follicle-stimulating hormone. The lactogenic hormone causes secretion of milk by mammary glands adequately developed under the influence of the ovarian hormones.

Intermediate Lobe.—The intermediate lobe produces the melanophore-expanding hormone (intermedin) nhich causes darkening in frogs and certain other lower vertebrates, due to a dispersal of pigment in the pigment-bearing cells (chromatophores). In animals in which there is no anatomically distinct intermediate lobe, intermedin is found in the anterior lobe. In the lower vertebrates, the alterations in colour scheme effected by intermedin serve as a protective mechanism. permitting the animal to blend with its surroundings and thus to escape detection. It is not known whether intermedin plays a role in higher vertebrates. Intermedin and the adrenocorticotrophic hormone are remarkably similar in chemical structure, and some investigators believe that they may actually be identical.

Neural Lobe.—In 1928 0. Kamm and his associates separated posterior pituitary extracts into two partially purified fractions, oxytocin (Pitocin), ahich elicited largely oxytocic activity, and vasopressin (Pitressin), which contained largely blood-pressure raising and antidiuretic activities. In 1953 these substances were isolated, identified and subsequently synthetized by Vincent du Vigneaud, who was awarded a Nobel prize in chemistry in 1955 in recognition of this work. Both vasopressin and oxytocin are polypeptides, consisting of eight amino acids each. Vasopressin, whether natural or synthetic, causes an elevation of blood pressure through a direct action upon the smooth muscles of the blood vessels and has an antidiuretic action effected by increased absorption of water by the kidney. Vasopressin also has a stimulating action on the gastrointestinal tract and a slight oxytocic activity. Oxytocin on the other hand causes contraction of the uterus, a fall of blood pressure in birds and an outpouring of milk from the breasts of lactating animals. It also has very slight pressor and antidiuretic activities. The synthesis of vasopressin and oxytocin led to virtual abandonment of the theory at one time fairly widely held that the pressor and antidiuretic activities of neural lobe extracts were elicited by separate hormones.

It is a matter of some dispute as to which of the various pharmacodynarnic actions of neural lobe extracts are of a hormonal nature. It is generally held that the antidiuretic effect, elicited by minute traces of vasopressin, plays an important role in maintenance of nater balance, and it appears probable that oxytocin is responsible for the "let-down" of milk; *i.e.*, the release of milk from the lactating gland initiated by the act of suckling. It has not been established, however, that oxytocin is of physiologic importance in parturition, or that vasopressin plays a role in the regulation of blood pressure.

Considerable controversy surrounds the question as to whether vasopressin and oxytocin exist in the gland as separate entities or whether they are split off from some larger protein molecule in the process of chemical isolation procedures. The latter hypothesis was first advanced by J. J. Abel in 1920 and was supported by the isolation by H. B van Dyke in 1942 of a purified protein, containing pressor, oxytocic and antidiuretic activities in the same proportions in which they are present in the gland. On the other hand the pressor-oxytocic ratio is not constant in all species; furthermore, certain stimuli seem able to release one activity only. These findings. however. would still be consistent with the view that the active principle is elaborated as one large protein from nhich the active polypeptides may be split off and either stored or released according to the body's needs.

Cellular Origin of Pituitary **Hormones.**—*Adenohypophysis.*—The number of hormones isolated from the anterior hypophysis exceeds the number of distinct cell types; hence it is presumed that a single cell type may give rise to more than one hormone. Growth hormone is thought to be secreted by the alpha cells. Tumours composed largely of alpha cells have been demonstrated in acromegaly and pituitary gigantism. Furthermore, in a hereditary strain of dwarf mice alpha cells are lacking. Gonadotropic hormones are thought to arise from beta cells. Thus, castration results in typical changes in these cells, the cells becoming more numerous, enlarged and vacuolated (castration cells). The beta cells also seem to be responsible for the secretion of the thyrotropic and adrenocorticotrophic hormones, though the evidence is not clear cut with respect to the adrenocorticotrophic hormone.

Intermedin is undoubtedly secreted by the cells of the pars intermedia. The distribution of intermedin-secreting cells has not been established in those species in which a discrete pars intermedia is lacking.

Neurohypophysis.—The site of secretion of the active principles of the neural lobe remained a matter of some controversy at mid-20th century. The early view mas that the hormones were elaborated by the pars intermedia and diffused into the neural lobe to form the Herring bodies This viewpoint was rendered untenable nhen it mas shown by E. M K. Geiling that an intermediate lobe is missing in certain species and that in these species. pressor and oxytocic activity are present only in neural lobe extracts arid melanophore-expanding activity only in anterior lobe extracts

Later, the pituicytes were considered to be secretory cells However, considerable evidence exists to support the view adxanced by E Scharrer and B Scharrer that the active principles are actually elaborated by the cells of the hypothalamic nuclei, stream down the stalk and are stored in the neural lobe.

Regulation of Secretion of Hypophyseal Hormones.—Three mechanisms were implicated in the release of hypophyseal hormones: neural, hormonal and neurohormonal.

Adenohypophysis.—As of the mid-1950s it appeared doubtful that the innervation of the anterior lobe plays a role in regulating the secretion of its hormones. Considerable controversy existed as to whether any fibres from the hypothalamico-hypophyseal tracts enter the anterior lobe. Certainly, if such an innervation exists at all, it is too inconstant and slight to assume any major role in the regulation of the activity of the lobe. Furthermore, the parasympathetic and sympathetic nerves to the adenohypophysis appear to be vasomotor rather than secretomotor in nature.

There was considerable evidence of a neurohormonal control of anterior lobe secretion with some unidentified substance being liberated from the hypothalamus bv appropriate stimuli and reaching the anterior lobe cells by way of the hypophyseal portal blood system. It

was also evident that the level of circulating hormones from target endocrine glands has a profound effect on the secretory activity of the pituitary. Thus, injection of thyroid hormone (thyroxin) leads to depression of pituitary thyrotropic hormone while removal of the thyroid or interference with its ability to secrete thyroxin leads to increased secretion of thyrotropin by the pituitary. This action by other hormones on the pituitary may be a direct one on the secretory cells of the pituitary or may be mediated through the hypothalamus and the hypophyseal portal system.

Neurohypophysis.—S. W. Ranson and his associates showed that severance of the hypothalamico-hypophyseal tracts by suitably placed hypothalamic lesions led to degenerative changes in the neurons and to atrophy of the neural lobe with depletion of its hormone content and the development of diabetes insipidus. These findings were interpreted as indicating that the hormones were elaborated in the neural lobe but that their secretion and liberation were controlled by the hypothalamic nuclei. However, the findings were also consistent with the Scharrers' view that the hormones are actually formed in the neurons of the hypothalamic nuclei and merely stored in the neural lobe.

Release of vasopressin from the neural lobe is apparently regulated by osmotic pressure changes in the blood, decrease in osmotic pressure leading to inhibition of the secretion of the hormone and increase in osmotic pressure leading to increased secretion. Release of oxytocin appears to be in the nature of a reflex initiated by external stimuli such as tactile stimuli of the mammary glands. These stimuli apparently pass by afferent neural pathways to the supraoptic nuclei and result in the liberation of oxytocin.

Biological Assay of Pituitary Hormones.—Chemical assay procedures for pituitary hormones were impractical as of the mid-1950s since not all the active principles were isolated and identified and furthermore, they are usually present in small amounts. Recourse must be had, therefore, to biological assay procedures in which the preparation to be assayed is compared quantitatively to a standard preparation of the hormone in question with regard to some specific biological activity. Thus, growth hormone is frequently assayed by its ability to promote growth in the hypophysectomized rat, thyrotropic hormone by its ability to increase the weight of the thyroid or the uptake of radioactive iodine by the thyroid, and follicle-stimulating hormone by its ability to increase the weight of the ovaries of hypophysectomized rats. Methods for assaying posterior lobe preparations include study of the rise in blood pressure in the anaesthetized cat, dog or rat in the case of vasopressin, and the fall in blood pressure in the fowl or stimulation of the isolated rat uterus in the case of oxytocin. In most instances an international standard was developed by the mid-1950s so that results between workers in various parts of the world could be readily compared.

Therapeutic Uses of Pituitary Preparations.—Anterior lobe hormones, with the exception of the adrenocorticotrophic hormone (ACTH) were not widely used in medicine as of the 1950s. In pituitary insufficiency it is easier and more satisfactory to replace the hormones of the target glands, namely, the thyroid, gonads and adrenal cortex, than to administer the appropriate tropic hormone. Adrenocorticotrophic hormone can be used in the various conditions which respond to cortisone, provided the adrenal gland is responsive. Such conditions include acute rheumatic fever, rheumatoid arthritis and various allergic states such as asthma and drug reactions. Because of the rapidity of its action, corticotropin is particularly useful in the acute illnesses. In treatment of chronic conditions, cortisone and similarly acting preparations are usually preferred since they are less expensive and tend to give rise to fewer undesirable side effects.

The most widespread use of commercial posterior'pituitary extracts is during childbirth, either for the stimulation of contractions before birth or for the control of uterine bleeding after birth. Posterior pituitary extracts are also used for the treatment of diabetes insipidus, a disease usually associated with injury to the neurohypophysis and characterized by a greatly increased daily output of urine accompanied by an abnormal thirst. *See* also ENDOCRINOLOGY; HORMONES.

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PIT VIPER, any snake of the family Crotalidae, whose members are poisonous and have the elaborate folding fang apparatus of the vipers. They are distinguished from the true vipers (*q.v.*) by the presence of a sensory "pit" on the side of the face between the nostril and the eye, on each side of the head. The pit vipers take their family name from *Crotalus,* the best-known genus of rattlesnakes. Besides the rattlesnakes (which include also the smaller massasaugas and pygmy rattlers, *Sistrurus*), the pit vipers include the moccasin or cottonmouth and copperhead genus Agkistrodon, which has several species in eastern and central Asia and extreme southeastern Europe in addition to the familiar North and Central American forms; the fer-de-lance group (Trimeresurus), found in eastern Asia and the East Indies as well as in tropical America; and the wholly American bushmaster (Lachesis). Working from the clue supplied by the experiments of Margarete Ros in 1935, which indicated the labial pits of the African rock python to be sensitive to heat radiation, Noble and Schmidt. in 1937, showed that the pit of the pit vipers also is a heat-detecting organ, and presumably an aid in the detection of warm-blooded prey at night. See SNAKES; Rattlesnake; etc.

(K. P. S.)

PIURA, a department in northern Peru, bounded on the north by Tumbes and by Ecuador, on the east by Cajamarca, on the south by Lambayeque and on the west by the Pacific ocean. Area 12,767 sq.mi. Pop. (1958 est.) 598,157. The western half of the department is in the arid coastal desert but the eastern half is in the much dissected, forest-covered Andes, where slopes are very steep but altitude is not great. Emerging from the mountains are two rivers. the Rio Chira in the north, the Rio Piura in the south. The former carries enough water to persist in its flow throughout the year but the Rio Piura only occasionally reaches the sea. Most of the time its water is lost among the sand dunes moving northward from the Sechura desert in the southern part of the department.

The valleys of these two rivers are used chiefly for the production of cotton. The water of the Chira is led into irrigation canals and ditches which keep the plantations of long-staple cotton growing luxuriantly. The cotton along the lower Piura is planted wherever the ground water is close enough to the surface. Cotton fields occupy temporary hollows among the sand dunes and the area is expanded greatly during years of plentiful moisture. The cotton is mostly of the Pima variety, a long, soft staple that brings premium prices. Some rough cotton is produced from bushes that can exist in dry areas where the long staple varieties would perish. Upstream on the Piura irrigated fields are used to grow sugar cane, rice, tobacco, grapes and maize. Cattle are pastured in the mountains and fattened on lowland irrigated pastures. Piura is also important as a producer of petroleum. Oil was discovered in northern Peru in 1864 and has been produced from this region ever since. The chief production comes from the Lobitos and Negritos fields which form a belt about 80 mi. long on either side of Talara, where there is an oil refinery. The smaller Zorritos field is farther north.

The capital of the department is Piura (pop. [1958 est.] 32,147) located on the Rio Piura 164 ft. above sea level and 58 mi. from its port Paita. Piura, the oldest Spanish city in Peru, was founded on a slightly different site by Pizarro in 1532. It is an important cotton market and has numerous cotton gins and cottonseed oil mills. It is accessible by the Inter-American highway and by air as well as by sea through Paita. (P. E. J.)

PIUS, the name of 12 popes.

PIUS I, SAINT, pope from about 140 to 154. Both the very ancient Liberian catalogue and the Muratorian canon say that he was the brother of Hermas, author of the *Shepherd.*

PIUS II (Enea Silvio de' Piccolomini, known in literature as Aeneas Silvius), pope from 1458 to 1464, was born on Oct. 18, 1405, at Corsignano (later called Pienza after him) near Siena, It. He was attracted to Florence by the teaching of Filelfo. He became secretary to Domenico Capranica, bishop of Fermo, and went with him to the council of Basle, where he stayed several years (1432–35), changing masters whenever he could improve his position. He was engaged on various errands, including a long journey to England and Scotland on secret diplomatic business. In 1436 he was back at Basle and obtained a seat in the council and exercised considerable influence. Aeneas took an active part in the council after it was transferred to Florence; and though he still declined to take orders, he was given a position on the conciliar conclave which elected Amadeus of Savoy

as pope under the title of Felix V. In return for his services Felix made Aeneas papal secretary.

A new period of his career opened in 1442, when he was sent by the council to take part in the diet of Frankfurt-on-Main. There he met the German king Frederick III, who made him poet laureate and his private secretary. He ingratiated himself with the chancellor. Kaspar Schlick, at Vienna, one of whose adventures he celebrated in a novel. *De duobus amantibus Eurialo et Lucresia,* in the style of Boccaccio. At this period he also wrote his witty but immoral play. *Chrysis.* In 1446 he took orders as subdeacon and wrote that he meant to reform. "forsaking Venus for Bacchus." Aeneas was useful to Frederick as a diplomatist and managed to give all parties the impression that he was the devoted advocate of each. He took an important part in the diet of Nuremberg (1444) and made his peace with Eugenius in 1445. At the diet of Frankfurt (Sept. 1446) Aeneas modified the hostility of the electors to pope and emperor; and he was present at the conference of Aschaffenburg (1447). The new pope. Nicholas V, made him bishop first of Trieste (1447), then of Siena (1449); and Frederick III made him a prince of the Holy Roman empire. He was made cardinal priest of Sta. Sabina in 1456.

The death of Calixtus III (who succeeded Nicholas V) occurred on Aug. 6, 1458. After a hot fight in the conclave. Aeneas was elected (Aug. 19) and took the title Pius II. with a reminiscence of Virgil's "pius Aeneas." The humanists hailed his election with joy and flocked around to secure a share of the good things, but they were bitterly disappointed. as Pius did not prove himself so liberal and undiscriminating a patron as they had hoped. The fall of Constantinople in 1453 made a deep impression upon Pius, and he never ceased to preach the crusade against the Turk. In June 1459 he opened a congress at Mantua to promote the crusade, but both the French and the Germans were annoyed with him for different reasons. and he received little support, no real session taking place till September. He believed that the decline in the papal influence was due to the usurpation of power by the councils. and he now issued (Jan. 1460) the bull *Execrabilis et in pristinis temporibus inauditus,* in which he condemned as heretical the doctrine that the councils were superior to the popes and proclaimed the anathema against any one who should dare to appeal to one.

While Pius was at Mantua war broke out between the French and Spanish in southern Italy, and a rising of the barons devastated the Campagna. Hurrying back to Rome. Pius succeeded in quelling the disorders. This measure still further alienated the pope from the French. with whom he was at that time negotiating for the abrogation of the Pragmatic Sanction of Bourges. The new king Louis XI sent to Pius saying that he had abolished the Pragmatic Sanction (Nov. 1461), hoping in return to get the kingdom of Naples for his countryman René of Anjou. As Pius continued to support Don Ferrante (Ferdinand I), Louis reasserted the ancient liberties of the Gallican Church. At the same time a serious quarrel with the Germans prevented anything's being done toward a crusade. George of Podebrad, king of Bohemia. was plotting to depose the emperor Frederick III, who was supported by Pius. Diether. archbishop of Mainz, took George's side and replied to Pius' measures by appealing to a general council; whereupon he was declared deposed by the pope (1462). The quarrel with King George, who was accused of supporting the Utraquist heresy, continued with increasing bitterness, but without any decisive result. until the death of Pius. In the meantime the pope did what he could to further the cause of the crusade. The discovery of alum mines at Tolfa gave him an unexpected pecuniary resource; and to stimulate the zeal of Christendom. Pius took the cross on June 18, 1464. He set out for Venice, whence he intended to sail for the east; but he was attacked with a fever and died at Ancona on Aug. 14, 1464.

BIBLIOGRAPHY.—Aeneas Silvius was a voluminous author. His orations and letters were considered models of style. His novel, *De duobus amantibus* (printed at Cologne, *c.* 1468) went into many editions and was much translated (first Eng. trans., *The Goodlie Hiatory of the Ladye Lucres of Scene in Tuskane,* 1560); *see* text ed. by J. I. Dévay (Budapest, 1904) and new Eng. trans. by F. Grierson (London, 1928). His *Chrysis* has been ed. by A. Boutemy (Brussels, 1939) and by I. Sanesi (Florence, 1941). The poems *De miseriis curialium* (Cologne, *c.* 1468) were read throughout Europe. The *Commentarii rerum memorabilium quae temporibus suis contigerunt* (printed in Rome, 1584; Eng. trans.. Northampton. Mass., 1947–51), a history of his times told in an interesting and rational manner, constitutes his most valuable work. Part of the *Cosmographia,* on "Asia," was printed at Venice in 1477; the complete test. "Europe" and "Asia." *ibid.,* 1501–03. The *Historica Bohemica* was printed in Rome in 1475.

See further R. Aubenas and R. Ricard, *L'Église et la Renaissance* (Paris, 1951), being vol. xv of *Histoire de l'Église,* ed. by A. Fliche and V. Martin, with bibliography; L. Pastor, *History of the Popes,* Eng. trans., vol. ii–iii (London. 1891–94); T. Buyken, *Enea Silvio Piccolomini, sein Leben und Werden his zum Episkopat* (Bonn, *1931);* G. Voigt, *Enea Silvio de' Piccolomini als Papst Pius 11 und sein Zeitalter,* 3 vol. (Berlin, 1856–63); W. S. Boulting, *Aeneas Silvius* (London, 1908); C. M. Ady, *Pius 11: the Humanist Pope* (London, 1913); C. Lucius, *Pius II und Ludwig XI von Frankreich, 1461–62* (Heidelberg, 1913).

PIUS III (Francesco Nanni-Todeschini-Piccolomini), pope from Sept. 22 to Oct. 18. 1503, was born at Siena. It.. on May 29, 1439. He was made archhishop of Siena and cardinal deacon of S. Eustachio in 1460 by his uncle Pius II, who permitted him to assume the name and arms of the Piccolomini. He was employed by subsequent popes in several important legations. as by Paul II at the diet of Regensburg (1471) and by Sixtus IV to secure the restoration of the ecclesiastical authority it: Umbria. He opposed the policy of Alexander VI and was elected pope, amid the disturbances consequent upon the death of the latter, through the influence of Cardinal della Rovere (who succeeded him ns Julius II). Pius was a man of blameless life and would doubtless have accomplished much had he lived.

See E. Piccolomini, "Il Pontificato di Pio III," in *Archivio storico italiano,* 5th series, vol. xxxii (Florence, 1903). (X.)

PIUS IV (Giovanni Angelo Medici), pope from 1559 to 1565, was born at Milan. It., on March 31. 1499. After studying law at Pavia and Bologna. he entered the service of Paul III and was eventually made cardinal priest of Sta. Pudenziana by him in 1549. The death of Paul IV and the conclusion of the treaty of Cbteau-Cambrésis (1559) provided an opportunity for a reconciliation between France and Spain preparatory to a final settlement of the problems caused by the Reformation. Pius IV was elected after a protracted conclave (Dec. 25, 1559) as the man to accomplish these aims. He had long agreed with those who saw a need for definite reforms, but was at the same time shrewd, tactful and experienced in affairs. He took prompt action in bringing the Caraffa. his predecessor's nephews, to trial, which resulted in their execution in March 1561; and after this he gave Carlo Cardinal Borromeo a free hand in reforming the administration of the curia. But his greatest achievement was the successful conclusion of the Council of Trent. Despite the peace between France and Spain. many obstacles stood in the way of this. The emperor Ferdinand still hoped for the eventual return of the Lutherans to the church and so remained in favour of some doctrinal concessions in their favour; Philip II of Spain on the other hand was opposed to any change and barely in favour of the council's resuming its sessions at all; and the Roman curia was absolutely against doctrinal change, however small. though willing to discuss the reform of abuses (partly in the hope that any changes in this direction, or toward a restoration of ecclesiastical discipline, would result in an increase in its powers). To reconcile these different interests was not easy; moreover. Pius had his own views, being prepared to concede communion in both kinds and perhaps also clerical marriage where conditions were such as those obtaining in parts of Germany. provided that his own prerogatives were maintained or even enhanced *(see* G. Constant, *Concession à l'Allemagne de la communion sous les deux espèces . . . ,* Paris, 1923). A year was spent in overcoming these differences and the outcome was an almost unmitigated triumph for the papacy. Thanks to the pope's own conciliatory attitude, imperial opposition ceased, while no more than a discretionary power given to the papacy to allow communion in both kicds in certain circumstances marred the appearance of unrelenting opposition to the challenge of the new doctrines. The council was dissolved on Dec. 4, 1563, and its decrees and definitions were confirmed by the pope in the

bull *Benedictus Deus* dated Jan. 26, 1564. Most significant was the exclusive power granted to the pope for interpreting and enforcing these decisions, which task, constituting the third and final period of the Counter Reformation, was to occupy the next 2j years. Yet this apparently complete triumph of the papacy is deceptive. Pius did not long outlive the conclusion of the legal enactment of the Counter Reformation, and his desire for a continued endeavour to reconvert the German Protestants died with him. Increasingly, the papacy found itself committed to an unwelcome degree of support for the policies of Philip II; and although. as a result. Protestant heresy was not only checked but made to retreat, in the next century Rome found itself the enemy of France, so that the diplomatic triumphs of that country involved a defeat for Rome. This process was not continuous, and Pius IV cannot be blamed exclusively for the eventual outcome of his policy; but, in taking the narrow view that to secure the best interests of the church it was only necessary to defend and to enlarge the papal power, he clearly miscalculated. The easy triumph at Trent was not repeated. Only Portugal. Poland and Austria accepted the decrees without reservation; in France, on the other hand, they were absolutely rejected. Pius died on Dec. 9. 1565.

PIUS V, SAINT (Antonio, otherwise Michele. Ghislieri), pope from 1566 to 1572, was born on Jan. 17. 1504, in the Milanese. At the age of 14 he became a Dominican monk, taking the name of Michele. He was appointed inquisitor in Como. where his zeal provoked such opposition as to compel his recall (1550). The chief inquisitor. Giovanni Pietro Caraffa, convinced of his value, straightway sent. him upon a mission to Lombardy and. in 1551, appointed him commissary general of the Holy Office. When Caraffa became pope. Ghislieri was made bishop of Nepi and Sutri (1556), cardinal (1jj7) and finally grand inquisitor (1j58). In this office he was continued by Pius IV. whom, however. he antagonized by his censoriousness and obstinacy. But after the death of Pius IV the rigorists, led by Cardinal Borromeo. had no difficulty in making him pope (Jan. 7, 1566). Retaining his ascetic mode of life, Pius immediately began the work of reform. Decrees and ordinances were rapidly issued; the papal court became a model of sobriety; prostitutes were driven from the city or confined to a certain quarter; penalties were attached to Sunday desecration, profanity and animal baiting; clerical residence was enforced; conventuals were compelled to live in strict seclusion according to their vows; catechetical instruction was enjoined. A new catechism appeared in 1j66, followed by an improved breviary (1568) and an improved missal (1j70). The use of indulgences and dispensations was restricted and the penitential system reformed.

Pius was the avowed enemy of nepotism. One nephew, it is true, he made cardinal, but he allowed him no influence; the rest of his relatives he kept at a distance. By the constitution *Admonet nos* (March 29. 1567) he forbade the reinvestiture of fiefs that should revert to the Holy See and bound the cardinals by oath to observe it. In March 1569 Pius ordered the expulsion of the Jews from the States of the Church. For commercial reasons they were allowed to remain in Rome and Xncona, but only upon humiliating conditions. In Feb. 1571 the Humiliati, a degenerate monastic order of Milan, was suppressed on account of an attempt upon the life of the archbishop, Cardinal Borromeo.

The rules governing the Holy Office were sharpened; old charges. long suspended, were revived; rank offered no protection, but rather exposed its possessor to fiercer attack. None were pursued more relentlessly than the cultured. among whom many of the Protestant doctrines had found acceptance. Princes and states withdrew their protection and courted the favour of the Holy See by surrendering distinguished offenders. Venice delivered Guido Zanetti in 1566; Philip II of Spain, Bartolomé de Carranza in the same year; and Cosimo de' Medici. Pietro Carnesecchi in 1j67 (receiving as a reward the title of grand duke of Tuscany in 1569). In March 1571 the special Congregation of the Index, as distinct from the Inquisition, was estabiished. and hundreds of printers took flight to Switzerland and Germany. The regret of Pius was that he had sometimes been too lenient. He spurred Philip II on in the Netherlands and commanded the utter extermination *(ad internecionem usque)* of the Huguenots; he protested against the tolerance shown by the emperor.

In all this work, Pius confirmed Borromeo's belief that a spiritually minded pope was above all else necessary if the decrees of the Council of Trent were to be put into practical effect. The moral standing of the papacy was raised beyond belief and its effectiveness immensely increased by the obliteration of heresy in Italy; and the morale of the church was much improved by the universal insistence on the Tridentine interpretation of its doctrines. Yet it is open to doubt how much of this improvement was due to Pius' continuous use of the Inquisition. Some at least of the credit belongs to the new generation of higher and lower clergy in the several provinces whose attitude was so different from that of their predecessors.

Moreover, Pius' policy had practical disadvantages. It took too little account of the wishes of secular rulers at a time when their support was essential for the defense of the church against heresy. His attitude toward Elizabeth I of England, whom he declared excommunicate and usurper (Feb. 2j, 1j70) without possessing the means to give force to his judgment, was especially undiplomatic, antagonizing not only England but Spain, France and the Holy Roman empire as well. Much more successful was his organization of a crusade against the Turks, which resulted in the decisive naval victory of Lepanto (Oct. 7, 1571). Pius died on May 1, 1572, and was canonized by Clement XI in 1712.

See C. Hirschauer, ***Pie*** *V, 1566–72* (Fribourg, 1920); C. M. Antony, Saint *Pius* V (London, 1911).

PIUS VI (Giannangelo Braschi), pope from 177j to 1799, was born at Cesena, It., on Dec. 25, 1717. After taking the degree of doctor of laws he went to Ferrara and became the private secretary of Antonio Cardinal Ruffo. in whose bishopric of Ostia and Velletri he held the post of *uditore* until 1753. His skill in the conduct of a mission to the court of Naples won him the esteem of Benedict XIV, who appointed him one of his secretaries and canon of St. Peter's. Raised to the prelature in 1758, he was appointed treasurer of the apostolic chamber by Clement XIII in 1766. On April 26. 1773, he was made cardinal priest of San Onofrio. In the four-month conclave which followed the death of Clement XIV, Spain, France and Portugal at length dropped their objection to Braschi and he was elected to the vacant see on Feb. 15, 1775.

Pius had received the support of the representatives of the three crowns and of the anti-Jesuit party upon a tacit understanding that he would continue the action of Clement, by whose brief *Dominus ac redemptor* (1773) the dissolution of the Society of Jesus had been pronounced. On the other hand the *zelanti*, who believed him secretly inclined toward Jesuitism, expected from him some reparation for the alleged wrongs of the previous reign. In the event. Pius proved unequal to the problems of his age. Not only was the church generally considered to be in urgent need of spiritual and institutional reform. but in addition the papacy was almost completely bereft of either power or influence. The religious orders, the essential medium of its influence in the church, were under attack by the protagonists of the Enlightenment. while its traditional allies, the kings and princes of Catholic Europe! were. now indifferent to its interests, being concerned only with the possibilities for using the national churches in their schemes for administrative reform. The emperor Joseph II inaugurated, in the *Toleranzedikt* of Oct. 1781, a policy whereby non-Catholic minorities received a large measure of religious toleration and an opportunity to enter the public service. This was followed in the next year by the dissolution of a number of religious houses, which was designed to provide the money for converting the secular priesthood into salaried officials of the state and for abolishing private patronage. Further detailed reforms were intended to abolish certain practices, such as an excessive number of festivals and a superstitious reverence for mystical phenomena. not considered in keeping with enlightened belief. Pius intervened in 1782 by a personal visit to Vienna, but even this tactful approach secured no concessions whatsoever. Without wishing for a break with Rome, Joseph yet saw no reason to modify his policy

in the slightest. The church in the Habsburg dominions remained wealthy and influential, but subordinated to the state. The papacy was ignored there as it was in France, where the preliminaries to the French Revolution were taking place.

The church mas not unpopular in France in 1789. At least a substantial minority of the clergy supported the third estate in its demands for constitutional reform. What undermined the church's position arose for reasons quite unconnected with it. The new revolutionary government. at its wits' end for money, turned to the wealth of the church. which it confiscated as a direct backing for its issues of paper currency. It was intended, under the Civil Constitution of the Clergy (1790), to provide for the support both of the secular and of what was to remain of the regular clergy after they had been given the option of renouncing their vows by paying them salaries out of public funds. Other features of the scheme bore a similar resemblance to the designs of Joseph II. Pius took no immediate action. but negotiations were begun to explore the possibilities of modifying the plan. At length. however. when an oath of fidelity to the new constitution was demanded. he denounced the Civil Constitution together with the Revolution itself (brief of March 10, 1791). The French church was completely split. half accepting, half defying the new regime. Pius was on good terms with the allies against France in 1793 and felt that he could rely on them; but in 1796 he saw his territory invaded by Gen. Napoleon Bonaparte. He sued for peace. which was granted on Feb. 19. 1797, at Tolentino; but in the following December a riot in Rome. in which the French general L. Duphot was killed. led to the occupation of Rome itself (Feb. 15, 1798) and the proclamation of a republic. Pius was taken into captivity and died. still a prisoner, at Valence. on Aug. 29. 1799.

The fortunes of the papacy had reached perhaps their lowest point since the middle ages. It was not the only institution to be overwhelmed by the forces unleashed by the French Revolution; but for at least some of its misfortunes Pius himself must be held responsible. He seemed unable to adopt a policy suited to the exigencies of his time. The revolutionary leaders in France, no less than their predecessors the reforming monarchs. were not primarily anticlerical: but the papacy failed to appreciate that the church could not alone expect to be left untouched by the changes that had been set on foot (in France the patriotism of some churchmen was understandably suspect and the wealth of this church offered an obvious answer to the problem of national bankruptcy). Pius VI succeeded in confusing political reaction and religion to such an extent that it may even be asked whether the identification of liberalism with anticlericalism is not the consequence of. rather than an excuse for, his policy.

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PIUS VII (Luigi Barnaba Chiaramonti), pope from 1800 to 1823, was born at Cesena, It., on Aug. 14, 1740. He entered the Benedictine monastery of Sta. Maria at Cesena in 1758, when he took the name Gregorio, and held various teaching appointments in the colleges of his order in Parma and in Rome. He became bishop of Tivoli in 1782 and bishop of Imola and cardinal in 1785. Not surprisingly, a seven-month interregnum followed the death of Pius VI in captivity. The central administration of the church had collapsed, and it was at Venice, under Austrian protection, that the conclave took place which resulted in the election of Cardinal Chiaramonti to the papacy on March 14, 1800.

The situation that confronted the new pope did not call for heroic measures. Europe mas making its peace with the future emperor Napoleon at Amiens; it behooved the pope to do likewise. Nor was Pius himself completely antagonistic to the ideas which had evolved during the French Revolution. He was anti-Austrian in his sympathies and had already (1797) publicly expressed the view that between true democracy and the church there need be no conflict. In the circumstances perhaps any agreement was better than none. Pius then responded to Sapoleon's advances and finally entrusted the detailed negotiations to his very able secretary of state, Ercole Cardinal Consalvi. The concordat of 1801 solved the problem of the conflicting claims to recognition of the constitutional and of the *émigré* bishops, settled the fate of the confiscated church property and laid down the future relations between church and state. Catholicism was declared to be the religion of the great majority of the French people (so admitting the possibility of official sanction for the exercise of other faiths); the hierarchy was to be salaried by the state (so allowing the old church possessions to remain with their new owners); and the dioceses were completely reorganized (so permitting a fresh start to be made with the appointment of bishops). Thus there was re-established in France a church with at least some of the characteristics and privileges of its pre-Revolutionary predecessor. It was not in fact the articles of the concordat itself which were to prove so distasteful to the papacy but the "organic articles" appended to them by the unilateral action of the French government in 1802. These forbade the exercise of any papal jurisdiction in France except with the permission of the government. Pius protested and tried to use the occasion of his formal consecration of Napoleon as emperor in 1804 to have them modified. He was not successful, and from that time onward relations between him and Napoleon rapidly deteriorated. Rome was occupied by French troops in 1808, and Napoleon declared the papal states to be annexed to France in 1809; Pius excommunicated the invaders and was thereupon taken prisoner. Such he remained until the allies invaded France in 1814. During his imprisonment he was brought to assent to a most humiliating concordat at Fontainebleau on Jan. 25, 1813. but he renounced it two months later, and it disappeared with Napoleon in 1814.

The papacy now faced a brighter prospect. Emerging from captivity, Pius appeared in the role of martyr and was received with tumultuous acclamations on his journey back to Rome in May 1814. At the congress of Vienna. Consalvi secured the restoration of the papal states, while the return of the legitimate monarchs promised a welcome relief from the torment of dealing with revolutionaries. Experience had taught Pius to disavou- his earlier liberal leanings, and his policy after 1815 sought to re-establish the church on its old foundations. The territorial changes effected by the congress of Vienna required corresponding changes in diocesan boundaries. and so the opportunity was taken to conclude a series of concordats with the states affected. Consalvi worked to reform the administration. the Jesuits were restored (1814) and recognition was given, after some hesitation, to the new Latin-American republics in revolt against Spain. But at bottom the restored papacy remained in a critical position. It was in no doubt that it should condemn the Revolution and all its works; but the restoration of the status quo *ante,* even where it was possible. had often meant no more than a renewal of the old conflicts which had been all but fatal even before 1789. Thus Francis I of Austria maintained the ecclesiastical institutions erected in the Habsburg lands by Joseph II, while Metternich thought of the pope as just one of a number of Italian princes whose actions required careful watching lest Austrian interests be endangered. Louis XVIII of France affected a support for the church which was shallow, for his actions followed those of his predecessors, jealous of papal interference within their dominions. An attempt to replace the concordat of 1801 with one more favourable to the papacy (1817) was dropped when the French government met with opposition to it in France. From the other flank danger arose out of the discontent felt in Italy against the abolition of the social reforms brought about under Napoleon and, in particular: out of the activities of the Carbonari, a liberal secret society condemned by Pius in 1821.

It was indeed becoming plain that the cure for the ills of the church lay not in concordats of the traditional type with monarchs whose motives were not unmixed and whose own positions were insecure, but in freeing the church from the restraints of the state. To do this it was necessary to bring the national churches closer to the pope and to reassert the absolute supremacy of the pope in spiritual matters. This was the teaching of Joseph de Maistre, and while Pius VII and Consalvi still put their first trust in princes, they gave sufficient encouragement to ultramontanism for it to

become established as a real alternative to Josephism and Gallicanism on the one side and to revolution on the other. Perhaps the foremost need of the church at this time was for a breathing space in which it could think out its future salvation. Pius VII provided this by his consistent refusal to resort to extreme or precipitate action. If his policies frequently proved unfruitful, at least it may be said that. when he died. on Aug. 20, 1823, he left the papacy in a better position than he had found it.

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PIUS VIII (Francesco Saverio Castiglioni), pope from 1829 to 1830, was born at Cingoli. It., on Nov. 20, 1761. He studied canon law at Rome and became vicar-general at Anagni and later at Fano. He was made bishop of Montalto in 1800 and bishop of Cesena and cardinal priest of Sta. Maria in Traspontina in 1816. Appointed grand penitentiary, he was made bishop of Frascati in 1821; and next year he became prefect of the Congregation of the Index. In the conclave following the death of Leo XII. Castiglioni, the candidate of France, was elected pope. on hlarch 31, 1829. He accepted the July revolution in France and was considered to have liberal leanings but was prevented from leaving any impression upon events by his death on Nov. 30. 1830.

PIUS IX (Giovanni Maria hlastai-Ferretti) was pope from 1846 to 1878, the longest pontificate in history. He was born on May 13, 1792, at Senigallia. It., the fourth son of Girolamo Mastai-Ferretti, gonfalonier of Senigallia. and the countess Caterina Solazzi. He first came into prominence as archbishop of Spoleto from 1827 to 1832 at a time of revolutionary disturbance. He was made bishop of the important diocese of Imola in 1832. but it was not until 1840 that he received the hat. as cardinal priest of SS. Piero e Marcellino, the delay being generally ascribed to the disquiet caused by his liberal views. He was not, in 1846. the most prominent liberal candidate likely to succeed Gregory XVI; but it took the conclave only two days to determine his election (on June 16. 1846) and so prevent that of the conservative Luigi Lambruschini. He took the name of Pius in deference to the memory of Pius VII, who had been his friend and who had. like him, been bishop of Imola. The choice was in some sense prophetic, for "Pio Nono," as his predecessor had done. began his career sympathetic to liberal ideas only to learn by bitter experience that they too often incorporated the principles of anticlericalism. In 1846, however, all this lay in the future and Europe was agog to view the unusual spectacle of a liberal pope.

The Revolution of 1848. — The new pope was confronted by a difficult situation. All Europe. save perhaps Metternich. considered that the papal states stood in urgent need of reform. A memorandum drawn up in 1831 by the French, Austrian. Russian and Prussian ambassadors in Rome (with the British representative in Florence subscribing) had suggested that councils should be elected to assist in local government, that a central body, composed partly of elected representatives. should control finance and that the dominant position held by the clergy in the administration and in the judicial system should be terminated. Liberal opinion clung to these measures as absolutely essential throughout the pontificate of Gregory XVI. In addition, the papacy was constantly under attack by Italian nationalists as one of the instruments through which Austria maintained its domination over the peninsula. Pius recognized that the papal administration, if not so corrupt and despotic as its opponents asserted, was inefficient and intolerant; and he was sufficiently Italian to resent Austrian interference. Above all he saw the need for the papacy to possess a greater measure of popular support. Yet he was never a revolutionary. He believed that the interests of the church must always come first, and he appreciated that the conservative Catholic powers such as Austria were entitled to consideration for the practical support that they had given the church in the past. That he should eventually disappoint his revolutionary supporters is not surprising, and Pius himself was early aware of this possibility. A criticism more substantial than that of tergiversation is that he chose to depart from the traditional policies of his predecessors without possessing any definite plans for avoiding the pitfalls that must surround the paths of a pope endeavouring to ally himself with liberalism and nationalism.

Pius wasted no time. He declared a general political amnesty on July 16, 1846. and followed it by a number of practical reforms, including a reorganization of the criminal procedure. Some financial reforms of an administrative character came next. and the censorship was mitigated. Finally came Pius' most daring innovations, the political reforms announced in 1847. The council of ministers became a cabinet of departmental heads of which only the secretary of state was of necessity to be a cleric; it was to be advised by a council of 24 elected members; and a municipal government was established for Rome which included an elected representative body. At the same time, the papacy brought support to the cause of Italian nationalism when Pius ordered the Austrian government to withdraw from Ferrara the reinforcements sent to its garrison there and opened negotiations with Piedmont for a national customs union.

The year of revolutions, 1848. began with revolution in Sicily; soon all Europe was ablaze and Pius was faced with demands, both liberal and nationalist, much beyond what he had been prepared to grant. On March 14 he was compelled to grant a constitution establishing a two-chamber parliament with full legislative and fiscal powers subject only to the pope's personal veto. On March 23 Charles Albert of Sardinia (Piedmont) declared war on Austria. For a time Pius continued to endeavour to steer a middle course, claiming in his allocution to the cardinals of April 29 that he was a disinterested spectator of the revolutionary activities sweeping Italy and that his program of reform was merely the fulfilment of the program long pressed upon the papacy by the powers. In the atmosphere of the time such sentiments were judged as displaying absolute hostility to the national cause. and the papacy was never again able to appear in Italy as anything other than a bulwark of reaction.' To prevent revolution from breaking out in Rome itself. Pius consented to the appointment of popular ministries, but neither Terenzio Mamiani nor his successors Edoardo Fabbri and Pellegrino Rossi were able to control the situation. A steadily deteriorating situation culminated in the assassination of Rossi on Nov. 15. A radical ministry was appointed under Emanuele Muzzarelli and Giuseppe Galletti, and when the Swiss guards were disbanded the pope was a virtual prisoner. On Nov. 24–25, with the aid of the French and Bavarian ambassadors, he fled to Gaeta in the kingdom of Naples. In his absence, elections were held for a constituent assembly; and this. on Feb. 9, 1849. declared the temporal power at an end and a democratic republic to be established. The papacy thereupon issued a formal appeal to the rulers of France. Austria, Spain and Naples, but not Piedmont, for assistance. Although it was generally considered that the pope's restoration could take place only with some sort of undertaking to maintain constitutional government in the papal states and although Louis Napoleon, the newly elected president of France. was in favour of such a policy, Pius held out against any concessions and asserted his determination to exercise his temporal power without any restrictions whatsoever. The upshot of a period of military and diplomatic manoeuvre on the part of France and Austria was the unconditional restoration of papal rule by the French general N. C. V. Oudinot on July 15. The revolution was over, and Pius himself returned to his capital on April 12. 1850.

The *Roman Question.*—It has often been asserted that Pius returned to Rome a changed man, that the former liberal had become a narrow reactionary. That his policy had changed there is no doubt. but his fundamental attitude remained the same. The interests of the church had always been his first concern and he could never be an unconditional ally of nationalism or liberalism. He had been prepared to countenance both while they left the church intact. but experience had taught him that both led to revolution, which he had never been prepared to countenance. Furthermore, political concessions on his part had led to attacks on his

spiritual power, and he considered that it could be protected only by his continued exercise of a temporal authority. Once these two aspects of his dominion had become indissolubly linked. it is easy to see why Pius considered himself obliged to oppose any alteration of his position as a temporal ruler. This is. of course! only to say that the pope can never be a successful temporal sovereign, being unable to make those compromises which statesmanship demands. and that the contradiction inherent in his position does exist. In 1846 Pius had considered that a new departure was necessary to meet the legitimate demands for reform within the papal states and perhaps also those for a change in the Italian system of states; he had experimented and failed and he now considered that he could do no more. But the problems that he had tried to solve remained. and to substitute no policy at all for one that had failed was no answer. The new secretary of state. Giacomo Cardinal Antonelli (*q.v.*), into whose hands diplomacy was now entrusted since Pius recognized his own inadequacies in that field. considered throughout that. in endeavouring to retain the temporal sovereignty untouched, he was fighting a losing battle but had no practical alternative to a policy of inaction. So, not for the first time in history, the papacy was a spectator while events changed the map of Europe.

Most of the administrative reforms carried out immediately after Pius' accession remained, and the papal territories benefited from the general increase in European prosperity after 1850. But constitutional government was never restored: the amnesty granted on the pope's return was so riddled with exceptions as to be worthless; and to all expressions of national sentiment the papacy was utterly hostile. It was not that papal government was tyrannical but that it formed an absolute barrier in the way of Italian unification upon which politically minded Italians were set. So relations with Piedmont. where Count Camillo Cavour became chief minister in 1852, grew steadily worse. What began as a dispute over the terms of a new concordat took on a much more serious aspect when Cavour found it politically expedient to encourage anticlerical feelings during the passage of a law in 1855 dissolving a large number of religious houses. Certain of papal opposition, Cavour began in the same year his plans to achieve Italian unification under the leadership of Sardinia-Piedmont alone. At Plombières in 1858 he agreed with Napoleon III to combine to eliminate Austria irom the Italian peninsula and so to settle the fate of Italy between them. Pius declared his neutrality in the war which broke out in April 1859, fearing that the victory of either of his protectors would leave him at its mercy. The Austrian defeat and the armistice of Villafranca resulted in the pope's losing control over the Romagna but non-here else. Sporadic negotiations for the establishment of an Italian confederacy under the presidency of the pope went on during the winter of 1859–60, but the pope's refusal to contemplate the loss of any part of his dominions brought them to an end. In Jan. 1860 Cavour (who had resigned in protest against the armistice) returned to power. possibly as a direct consequence of the pope's intransigence, and agreed with France to cede Savoy and Nice in return for a free hand everywhere in Italy except at Rome itself. The newly raised papal army was defeated at Castelfidardo on Sept. 18, and the papal states were quickly overrun. French troops protected the Patrimony of St. Peter, which alone of his dominions still remained in the pope's hands.

For ten more years the remnant of the temporal possessions were retained by virtue of the presence of a French garrison at Rome. Cavour himself was favourable toward an agreed settlement of the Roman question on the basis of a continuing papal sovereignty over all the states of the church but with its exercise entrusted to the king of Italy. A start was made to begin negotiations. but then the pope suddenly withdrew. In less than a year. Cavour had died (June 1861). and it was clear that the pope would be able to hold his remaining territories just so long as Napoleon 111 was willing and able to maintain the French garrison in Rome. When the Franco-German War broke out that was no longer possible. On Sept. 20. 1870, Italian troops occupied the city; and in October a plebiscite was held in which an overwhelming majority of the votes cast were for the incorporation of Rome in the kingdom of Italy. Pius remained for the rest of his days a prisoner, as he regarded himself, in the Vatican. He refused any intercourse with the Italian government. so that their relations rested upon a law passed by the Italian parliament in November. The sovereignty of the pope was declared to be untouched by the loss of his dominions. in compensation for which he was to receive an annual sum of money. He was to be entitled to conduct his own diplomatic relations with other powers and to have exclusive authority within the Vatican itself and a small district around it. In the rest of Italy, church and state were to be separated. So, though the papacy did not formally recognize the fact till the concordat of 1929, the Roman question had been settled.

Ultramontanism.—Important as the events just described were for the papacy, the doctrinal developments of Pius' pontificate, which spring directly out of these political disasters, constitute its most significant contribution to papal history. Ultramontanism began with Joseph de Maistre. as a reaction against Gallicanism and against Josephism, seeking to free the church from the chains of secular control by binding it more closely with the papacy. H. F. R. de Lamennais developed it by suggesting that the church would benefit from a general increase in political freedom. Gregory XVI condemned Lamennais's teaching because he saw that freedom might mean freedom to deny religion altogether. Pius IX decided in 1846 to experiment with liberalism, but later became convinced that Gregory XVI had rightly suspected it. Nevertheless, if Italy taught Pius one lesson, developments in France, where the church prospered more under the liberal regime of Louis Philippe than it had under the clerical Charles X, suggested quite the opposite conclusions to the liberal Catholics there. whose spokesman was now Charles de Montalembert. On the other hand, the coming of the Second Empire stimulated the party led by Louis Veuillot. whose ultramontanism was of the older sort. completely divorced from liberalism and seeking freedom for the church in an authoritarian state that would guard it against revolution.

For a period after 1850, Pius' policy took little heed of either brand of ultramontanism. Antonelli followed the paths of Consalvi (*see* above, *Pius VII*) in seeking to procure more favourable concordats with Catholic rulers. Most important was that with Austria (1855), the home of Josephism; and others were concluded with Spain (1851, 1859), with Portugal (1857), with Württemberg (1857), with Baden (1859), with Nassau (1861) and with a number of Latin-American states (1852–62). Such agreements might be politically valuable but were no defense against intellectual anticlericalism; and Pius became increasingly convinced that the real danger to the church lay in the modern secular ideas which the liberal Catholics were endeavouring to incorporate into its doctrines. The events of 1860 finally convinced him that the notion of a "free church in a free state," as dear to Montalembert as it was to Cavour. was a snare. The encyclical *Jamdudum cernimus* (March 18. 1861) denounced not only Piedmontese aggression but all modern political doctrines, which, it said. encouraged non-Catholic religions, allowed all freedom to attack the church in print and sought always to undermine the authority of the church. The Risorgimento not only convinced Pius that liberalism in the church must be destroyed, but also placed the liberal Catholics in the difficult position of appearing to support those who had caused him so much distress. In every way the ground was being cleared for a new departure. The alternative to Montalembert's doctrine was no longer an unconditional attachment to the principles of the *ancien régime* but a new kind of ultramontanism which asserted the necessity of concentrating authority within the church in the hands of the pope. The ground was being prepared for the Vatican council and for the doctrine of papal infallibility.

But first the strong liberal party in the Catholic church had to be defeated. In 1863 Montalembert was invited to address a large Catholic congress at Malines, and he took the opportunity to defend the concept of a free church in a free state and to condemn intolerance in principle, citing as an example the revocation of the Edict of Nantes. Pius was content in reply to point out that on these two points he was running counter to authoritative

pronouncements of Pius VI and Gregory XVI. This was sufficient to deter Montalembert from accepting a second invitation to Malines in 1864; but his supporter F. A P. Dupanloup proved an able substitute. Meanwhile at a congress at Munich. in 1863. J. J. I. von Dollinger had pleaded for the right of a scholar to pursue independent inquiry. It was clear to everyone that the church stood in need of authoritative pronouncements about its relations with the state and with modern society, and discussion began about the possibility of calling an ecumenical council for this purpose. But once again the Roman question intervened decisively in the struggle. On Sept. 15, 1864, the French and Italian governments came to an agreement whereby the French garrison was to be withdrawn from Rome within two years. In fact, it was not finally withdrawn until the outbreak of the Franco-German War, but the conclusion of the September convention was sufficient to decide Pius to take immediate action against liberalism now that the final disaster was threatened. On Dec. 8, 1864, he issued the encyclical Quanta *cura* with, attached to it, the famous Syllabus listing 80 of the "principal errors of our times." As the errors listed had already been condemned in allocutions, encyclicals and other apostolic letters. the Syllabus said nothing new and so could not be contested. Its importance lay in the fact that it published to the world what had previously been preached in the main only to the bishops and that it made general what had been previously specific denunciations concerned with particular events. Thus perhaps the most famous article, the 80th, stigmatizing as an error the view that "the Roman Pontiff can and should reconcile himself to and agree with progress, liberalism. and modern civilisation" sought its authority in the pope's refusal, in *Jamdudum cernimus,* to have any dealings with the new Italian kingdom. On both scores, the Syllabus undermined the liberal Catholics' position. for it destroyed their following among intellectuals and placed their program irrevocably out of court. Though Dupanloup tried to explain away the Syllabus by insisting upon its context and by stressing its purely negative aspect (thus, though the concept of toleration as the final and universal answer was condemned, it did not follow that intolerance was universally valid). the *Syllabus* nevertheless dealt a mortal blow at liberal Catholicism, which ceased after 1864 to be the main issue taxing Catholic contraversialists. While some of Louis Veuillot's followers hoped that at the forthcoming council a positive statement of the orthodox doctrine of the position of the church in society would replace the negative denunciations of the Syllabus, the majority looked upon that battle as won and so turned to the question of defining the pope's infallibility the keystone of the neoultramontane program of centralizing the authority of the church in Rome so as to escape from the control of the secular state. Conversely, the former liberal Catholics ranged themselves in opposition to this project. When the council at last met, on Dec. 8, 1869, everything was ready for a last decisive engagement.

The Vatican Council.—In the doctrine of papal infallibility itself there was nothing new. It had been employed to define, on Dec. 8, 1854, the dogma of the Immaculate Conception (q v.) which asserted that the freeing of the Virgin Mary from all taint of original sin had occurred at the moment of her conception. The pope had previously made extensive inquiries among the bishops and other divines and there was little opposition to such an exercise of his undoubted prerogative. When, however, at a gathering of bishops and other dignitaries of the church in Rome in 1862 and again at another in 1867 it had been suggested that the doctrine of infallibility should be authoritatively defined, Dupanloup had led a successful opposition to the project. It was objected that such a definition was inopportune, tending to widen the breach between the church and modern society, and that it would present a one-sided view of the source of authority in the church; for while the pope possessed powers issuing directly from God, so too did the bishops, for instance, whose ordinary jurisdiction arose, not out of their nomination or institution (whether by the state or by the church). but equally from divine origin; so that the pope's powers ought not to be defined without reference to other aspects of the nature of the church. The criticism that must attach to Pius is that he allowed, even encouraged, the council to put aside discussion on the wider issue. which was its original program, in favour of the narrower definition. This was, of course, precisely what the ultramontane party desired. The ultramontanes, indeed. undoubtedly possessed the backing of by far the greater part of the church. partly because of the reaction engendered by the political misfortunes of the last decade, partly because of the immense prestige enjoyed by Pius as a result of his long and tragic pontificate, but to a larger extent because of the contemporary movement away from intellectualism and in favour of devotional religion. Pius himself was at the front of this movement and received strong support from the Jesuits, whose influence was now most emphatically increasing.

The Vatican council (*q.v.*) opened on Dec. 8. 1869, the day of the feast of the Immaculate Conception, which Pius chose for the majority of the important acts of his pontificate. The opposition, consisting of the German. French and U.S. bishops, was strong enough to prevent a definition of the doctrines and nature of the church on the lines suggested by the Syllabus; but the ultramontane party, led by Archbishops H. E. Manning (of Westminster) and V. A. Dechamps (of Malines) brought forward the question of infallibility, upon which their position was much stronger. Pius intervened decisively to alter the procedure of the council on Feb. 20. 1870. and on April 29. and to make known his personal support for Manning and Dechamps. The outcome was to postpone all deliberation except that upon infallibility. The decisive vote came on July 13 when 451 voted for it. 88 against it and 62 in favour of some amendment. Thereupon the minority left Rome and the final definition was carried on July 18 by 533 votes to 2. Infallibility (*q.v.*) was confined to those occasions upon which the pope made pronouncements ex cathedra; but these pronouncements were to take their authority from God and not from the consent of the church, and no mention was made of any other divine authority existing in the church except that of the pope. There is no doubt that this act secured the triumph of the ultramontane party or that the decisive element in it was provided by Pius himself.

The Prisoner in *the* Vatican.—Pius reigned for a further eight years during which he became further estranged from the Italian government and witnessed a general outbreak of anticlericalism in western Europe. In Germany this culminated in Bismarck's *Kulturkampf,* which Pius condemned in the encyclical *Quod nunquam* of Feb. 5, 1875, leaving the solution of the problem to his successor. Pius died on Feb. 7. 1878, having seen in his long pontificate the creation of the modern papacy. The exact responsibility of Pius for the events of his pontificate is still a matter for controversy. The result is clearer. Church and state were now finally separated, authority in the church was centralized in Rome and the church was ranged in opposition to the dominant political forces of the day. On the last score alone, Pius was condemned by many of his contemporaries; the 20th century. however, was to see nationalism develop into fascism and revolutionary principles into communism. Whether the separation of church and state reinforced anticlericalism or inoculated the church against its effects is less certain. But perhaps the most damaging criticism of Pius is that he assumed almost the sole direction of events while never appreciating their significance. The great events of his pontificate occurred despite him rather than because of him. Thus he condemned in the Syllabus that very separation of church and state which it was the work of the Vatican council, to" which for the first time the secular Catholic rulers were not invited, to secure. At one time or another Pius was served by the leaders of all the important movements of his century, by liberal cardinals like Pasquale Gizzi, by ecclesiastical statesmen like Antonelli and by the saintly Manning, a convert from Protestantism. Yet it is unfair to say that he changed his principles; rather he never possessed any, save in his personal religious life, that were not rather nai've, and so he was always open to be guided by experience. In view, however, of the benefit that has accrued to the church from the loss of the temporal power, it should at least be asked whether it was not Pius' determination to maintain it at all costs that contributed most to the temporal power's being lost.

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PIUS X, SAINT (Giuseppe Melchiorre Sarto), pope from 1903 to 1914, was born of humble parents on June 2, 1835 at Riese in the province of Treviso. It. He studied theology at Padua and was ordained priest in 1858. For 17 years he acted as parish priest at various places in Venetia until his appointment in 1875 as canon of the cathedral and superior of the episcopal seminary at Treviso. He refused the bishopric of Treviso in 1880. but accepted that of Mantua in 1884, at the command of Leo XIII. He was created a cardinal on June 12. 1893, and nominated patriarch of Venice three days later. In Venice his piety, simplicity and readiness to act in harmony with the Italian government made him very popular. Elected in succession to Leo XIII. on Aug. 4, 1903, he took the name Pius in commemoration of Pius IX.

Pius brought the church back from the diplomatic ways of Leo XIII to the paths mapped out by Pius IX's intransigence. Yet it continued to make its presence felt in European politics through the activities of the parish priests and the opportunities afforded to them of influencing opinion in elections. The new pope was the very man to lead this movement. as he came to the papal chair with a long experience as a parish priest and without having held important office in the curia. The real changes introduced by him lay elsewhere. He had little interest in the social reforms supported by Leo XIII, laying his emphasis rather upon the spiritual work of the church in advocating early and frequent communion. He ceased to pursue actively the quarrel with the Italian government, and something like a modus vivendi was reached without either side's formally giving way. It is significant that individual Catholics were allowed to enter Italian politics with a view to combating the parties of the left. But Pius made his most important contribution to the history of the church by his attitude to intellectuals. His own scholarship was entirely theological. and he was utterly opposed to the employment of secular disciplines in subjects affecting the faith. When a body of Catholic intellectuals devoted themselves to a scientific study of the Scriptures and of the history of dogmas and reached conclusions which he considered to be at variance with orthodox belief. Pius took action. In the encyclical *Pascendi* (Sept. 1907) he formally condemned 65 propositions of modernism and denounced all tendencies which aimed at the reform of dogma. It has been claimed that by this action Pius cut the church off from modern scholarship. It is fairer to say that he endeavoured rather to compel the church to conduct its own works of scholarship instead of leaving them to institutions outside its control. A striking example of the new moral attitude of the papacy, as well as the termination of its old concern with diplomacy, is to be seen in Pius' denunciation, at the end of his life. of the powers' recourse to war in 1914 and in his refusal to bless the Austrian cause. Though much of his work was later overshadowed by the changes brought about through World War I, there is little doubt that he confirmed the church in the policies which it had at first adopted of necessity during Pius IX's pontificate. Pius X died on Aug. 20, 1914. He was beatified by Pius XII in 1951 and proclaimed a saint on May 29, 1954—the first pope so honoured since Pius V *(see* above).

See J. Rivière, *Le Modernisme dans l'Église* (Paris, 1930); A. R. Vidler, *The Modernist Movement in the Roinan Church* (Cambridge, New York, 1934); M. Pernot, La *Politique de Pie X* (1906–10) (Paris, 1910).

PIUS XI (Achille Ratti), pope from 1922 to 1939, was born on May 31, 1857, at Desio, It.. near Milan. He was ordained priest in 1879. His exceptional success in his studies pointed to a career of scholarship, and up to the age of 60 he was concerned almost exclusively in directing a number of great libraries. He became an expert in palaeography and in the problems associated with library classification. Benedict XV recognized his great qualities of mind and selected him for the diplomatic service. In 1918 he was sent as apostolic visitor to the new republic of Poland, where he was made nuncio next year. Ratti became a cardinal mith the title of S. Martino ai Monti in 1921 and was elected pope in succession to Benedict XV on Feb. 6. 1922.

One event stands out in Pius' pontificate: the signing. on Feb. 11, 1929, of the Lateran treaty between the papacy and the Italian government. This was more than a recognition of the *status quo,* as the agreement was specifically declared to constitute a final and irrevocable settlement of the Roman question. The papacy recognized the establishment of the kingdom of Italy and received in return recognition of its full sovereignty over the Vatican City State. Further, the permanent neutrality of the Vatican and of the papacy in the military and diplomatic conflicts of the world was announced. In future. the pope would intervene in such affairs not as the head of a sovereign state but as head of the church, interested only insofar as he might work for the preservation of peace. He would attend international conferences only when invited to do so. These provisions were to prove of great value to the papacy in World War II. The pope received financial compensation for his surrender of any claim to the old papal states; significantly, it was less than that proposed by Cavour in 1861. At the same time as the Lateran treaty, a concordat was concluded regulating the position of the church in Italy itself *(see* ITALY: *Religion).* It established the validity of church marriage, which was to precede, for Catholics, the civil ceremony; provided for compulsory religious instruction in school for the children of Catholic parents; and declared Catholicism to be the exclusive religion of the state.

The part played by Pius in these negotiations was considerable and their successiul conclusion owed perhaps most to his appreciation both of the real interests of the church and of the political realities of his age. He was similarly successful in reaching an agreement with the Mexican government, which allowed the church to resume religious services in that country. Another agreement was concluded with the new Nazi government in Germany in 1933, hut this was short-lived. The papacy claimed that the state was not keeping its promises and began increasingly to denounce pagan aspects oi the regime. Holding communism to be the chief enemy oi the church, Pius was favourable to the cause oi Franco in the Spanish Civil War; but developments in 1938 brought a change of emphasis, and Pius denounced the new anti-Semitism of Mussolini and, mith it, all racial theories, so attacking the element common to all branches oi iascism (to which Catholic parties had inclined out oi their opposition to communism). The fulfilment of this new departure. under Pius' successor, was to bring the political views of the church back to the middle policy advocated by Leo XIII. Pius died on Feb. 10, 1939. (I. F. B.)

PIUS XII (Eugenio Pacelli) was elected pope on March 2, 1939. Born on March 2, 1876, in Rome, of a family with legal traditions and long associations with the papal service, he studied philosophy and theology at the Capranica seminary, at the Gregorian university and at the Pontifical Institute of the Apollinare and was ordained a priest in 1899. In 1901 he was taken into the papal secretariate of state, though he was also employed elsewhere—notably in work on canon law. Attached to the Sacred Congregation for Extraordinary Ecclesiastical Affairs in 1909, he became secretary of that department in 1914.

In 1917 Pacelli was raised to the episcopate as titular archbishop of Sardes and made apostolic nuncio in Munich, at the time when Pope Benedict XV mas advancing his proposals for a compromise peace. He stayed in Munich throughout the troubled period of 1918. After the establishment of the Weimar republic he mas appointed first papal nuncio to Berlin, but he did not take up residence there till 1925 because of work connected with negotiating the concordat with Bavaria. In Berlin he was *doyen* of the diplomatic corps and was much taken up with drafting a concordat with the German republic; it mas approved by the Prussian *Landtag* in 1929. In the same year he was recalled to Rome and created cardinal priest, with the title of SS. Giovanni e Paolo. Appointed papal secretary of state early in 1930, he supervised the implementing of the Lateran treaty and concordat between Italy and the Holy See. Soon after Adolf I-Iitler's accession to power in 1933 Pacelli drew up a revised concordat with Germany; but by 1933 the Vatican was complaining about German nonfulfilment oi its terms and also protesting against pagan elements in the Nazi ideology, such as the doctrine of racism and the persecution of the Jews. Before he became secretary of state Cardinal Pacelli was already a traveled man. He employed the following nine years to increase still more his knowledge of the world, \-isitinp Argentina (1934), France (1935, 1937), the United States (1936) and Hungary (1938). After 1935 he held the post of chamberlain of the church! by which he automatically took charge of the Vatican when an interregnum occurred upon the death of Pius XI on Feb. 10. 1939.

The conclave ior the election of the new pope opened on March 1, 1939. Though Pacelli was a popular candidate, no cardinal secretary of state had been elected pope since 1667. He was chosen on the third ballot on March 2 and crowned on March 12.

The pontificate of Pius XII included the most trying period in papal history since the struggle with Napoleon, and the new pope's experience of world affairs stood the Vatican in good stead. Elected when World War II was imminent. his first addresses as pope consisted oi appeals ior peace. Vatican diplomacy n-as then in unusual measure in the hands of the pope himself. who was assisted by the cardinal secretary of state. Luigi Mairlione. Pius tried to halt Hitler's attack on Poland and used what influence he could to prevent the war from becoming general. Italy's declaration of nonbelligerence gave the Vatican an opportunity for unhampered activity, and the pope availed himself of it. He published his first encyclical, *Summi Pontificatus* (dated Oct. 20), on Oct. *27* after the partition of Poland between Germany and Russia. writing warmly of the Poles and condemning the totalitarian principles obtaining alike in Germany and the U.S.S.R. The basic ideas oi his proposals ior peace. outlined in this encyclical, were formulated in a fire-point program in his Christmas message in *1939* and were emphasized in his speech to the College of Cardinals on Dec. 24, *1914.* He stressed the rights of small nations, the protection of minorities, economic co-operation. disarmament and the influence oi religion as the only guarantee oi "just and lasting" peace. In pursuit of this policy the pope sent warm messages to the sovereigns of Belgium and the Netherlands when their countries were attacked.

The entry of Italy into the n-ar on June 10, *1930,* restricted Vatican communications with the rest of the world, but the pope as sovereign of a neutral state was able to carry on relief work on an extensive scale, notably throueh the Vatican organization for information about the missing and prisoners. He held aloof irom the Nazi-Soviet conflict and established "normal" diplomatic relations with Tokyo. A new period of tension began with the Allied landings in Sicily and the bombing oi Rome. During the Nazi reign of terror in the city after the overthrow of Mussolini, substantial numbers of escaped prisoners oi war, Jews and leaders of democratic parties were sheltered by the ecclesiastical power.

On the death of Cardinal Maglione in *1944,* the pope once more took charge of the secretariate of state: his closest assistants were Domenico Tardini, secretary of the Congregation for Extraordinary Ecclesiastical Affairs, and Giovanni Battista Montini, in charge of the Department of Ordinary Affairs. After the war the Vatican found itself in a position oi great, if indirect, power in Italy. The strength of the church was reaffirmed in the general elections of *1948* in which the civic committees of Catholic Action assisted the Christian Democratic majority party in retaining power in the country. Repeated deieats, however, were inflicted on the church in eastern Europe and in the far east, where Soviet Communism was in the ascendant. In Feb. *1939* all concerned in the bringing of the Hungarian primate Joseph Cardinal Mindszenty to trial mere excommunicated, and the pope compared "the long chain of persecution" in "certain dictatorial countries" with the persecution of the church under Nero. In July the Holy See formally excommunicated all members of the Communist party and all those who aided or abetted it, pointing out that Communism was materialist and anti-Christian; that it was not permissible for Catholics to publish, distribute or read books, periodicals, papers or pamphlets which preached the doctrine of Communism, or to write in them; and that those who consciously and freely did so incurred excommunication.

The year 1950 was a jubilee year. and pilgrims flocked to Rome from all parts oi the free world. The pope used the occasion to make a number oi significant pronouncements. In the encyclical *Summi Maeroris,* he deplored the evils of the new "murderous and inhuman weapons" of war but reiterated his severe strictures on the Soviet system and also castigated those who "insidiously" libelled the Catholic Church with "the accusation of wanting a new conflagration"; another encyclical, *Humani Generis,* condemned certain "false opinions" which threatened the ioundations of the Catholic faith. denouncing "lovers oi novelty." those who neglected traditional channels of doctrine, evolutionists, existentialists and people who "tried to reconcile opposing opinions in the field oi dogma itseli"; and on Nov. *1.* Pius solemnly pronounced the dogma of the Corporal .Assumption of the Virgin Mary.

In *1951* at the traditional New Year's reception for the diplomatic corps, the pope spoke of the horror of war and the desire of "an equitable, freely stipulated peace, immune from all unjust conditions and irom all the intolerable burdens" imposed on the peoples of the world.

Pope Pius XII announced that he opposed any system of socialized medicine that conflicted with the moral principles of respect for man and family. With appropriate saieguards against certain medical practices, however, he held that socialized medicine does not conflict with the principles of the Roman Catholic Church, which welcomes any state initiative in the field.

The circumstances under which in France and in Italy a large share of the loyalty of the working class was given to the Communist parties led to a marked increase in the attention given to the problems of pastoral care under modern conditions. The Holy Week liturgy was reiormed to put an increased emphasis on the role of the laity. In his encyclical *Fulgens Corona* Pius XII proclaimed *1954* as a Marian year; it was marked by special ceremonies in commemoration of the definition proclaimed *100* years beiore of the dogma of the Immaculate Conception.

In *1954,* though severely ill most of the year, the pope composed a special prayer at the occasion of the Marian year, in which he invoked the protection of the Virgin Mary for the Catholic Church and asked that all men, in her name, recognize that they are brothers. On June 5 the pope issued an encyclical commemorating the *12th* centenary of the martyrdom oi the English Benedictine missionary St. Boniiace, the "apostle of Germany."

Pope Pius XII's Christmas message, on Jan. *3, 1955,* called on all nations to live in peace and harmony. On April *3,* seemingly fully recovered irom his illness of the previous year, the pope made his first Palm Sunday appearance in two years and took part in the ceremonies opening Holy Week. Pope Pius XII, described as slight and ascetic in appearance and suave and gentle in manner, became noted for his frequent audiences given to pilgrims of all nations, some oi whom he addressed in their own languages—French, German and English. He died on Oct. *9, 1958.* (B. WL.; X.)

PIZARRO, FRANCISCO (c. 1471 or 1475–1541), discoverer and conqueror of Peru. was born at Trujillo in Estremadura, Spain, about 1471 (or 1475). Shortly after the news of the discovery of the new world had reached Spain he was in Seville, and from there found his way across the Atlantic. There he is heard of in 1510 as having taken part in an expedition from Hispaniola to Urabi under Alonzo de Ojeda. by whom he was entrusted with the charge of the unfortunate settlement at San Sebastian. He accompanied Balboa in the discovery of the Pacific.

In 1522 he entered into a partnership with a priest named Hernando de Luque and a soldier named Diego de Almagro for purposes of exploration and conquest toward the south. Explorations were then undertaken down the west coast of South America, in which Pizarro was left for months with but 13 followers on the island of Gallo, without ship or stores. There it was that Pizarro displayed the courage which has made famous the story of himself and his companions. But Pizarro persisted until he had coasted as far as about 9° S. and obtained distinct accounts of the Peruvian empire. The governor of Panamá showing little disposition to encourage the adventurers, Pizarro resolved to apply to the sovereign in person for help, and with this object sailed from Panama for Spain. accompanied by Pedro de Candia, in the spring of 1528, reaching Seville in early summer.

On July 26, *1529,* was executed at Toledo the famous *capitulación* by which Pizarro was upon certain conditions made governor and captain general of the province of New Castile ior the distance oi 200 leagues along the newly discovered coast, and invested with all the authority and prerogatives of a viceroy. One of the conditions mas that within six months Pizarro should raise a sufficiently equipped force oi men, oi whom *100* might be drawn irom the colonies; as he could not make up his due complement he sailed clandestinely irom San Lucar in Jan. *1530.* He was aiterward joined by his brother Hernando with the remaining vessels, and the expedition left Panamá in January oi the following year. The subsequent movements of Pizarro belong to the history of Peru (*q.v.*). After the final effort of the Incas to recover Cuzco irom *1536* to *1537* had been defeated by Diego de Xlmagro, a dispute occurred between him and Pizarro respecting the limits of their jurisdiction. This led to battle; Almagro was defeated *(1538)* and executed; but his supporters conspired, and assassinated Pizarro on June 26, *1541.* ***See*** also references under "Pizarro, Francisco" in the Index volume.

PIZARRO, GONZALO (?1505–1548), explorer, half-brother of Francisco Pizarro, was born at Trujillo in 1505 or 1506. He accompanied the Peruvian expedition in 1531, and received for his services extensive grants in the Potosi mines. In 1539 he was made governor of Quito, and in 1541–42 he led an expedition east of Quito in the course of which Francisco de Orellan explored the Amazon. Two years later he defeated Vela, the new viceroy, and was declared governor of Peru, but in 1548 he was defeated by a Spanish force under Pedro de la Casco, was compelled to surrender and was executed on April 10, 1548.

PLACE, FRANCIS (1771–1854), English radical reformer, a skilled political organizer in the struggle for parliamentary reform. Born on Nov. 3, 1771, in London! he was apprenticed to a leather-breeches maker and ultimately had his own tailor's shop. He was a great admirer of Jeremy Bentham. As a radical politician, in 1814 he took up a campaign to secure the repeal of the Combination acts forbidding trade unions, in which he was finally successful, in 1824. Again in 1825, after a substantial increase in the strength of trade unions, he was able to prevent an effective reinstitution of the acts.

In 1832, together with Joseph Parkes of Birmingham, he framed the placard "TO STOP THE DCKE, GO FOR GOLD" which produced the run on the banks that drove Wellington from office and carried the Reform bill without violence. He died in London,

Jan. 1, 1854.

See Graham Wallas, *Francis* Place, rev. ed. (1918). (D. F. Dd.)

PLACE NAMES: see NAME (IN LINGUISTICS).

PLACENTA. The human placenta is a disc-shaped organ, formed on the inner surface of the wall of the pregnant womb (uterus). Through it the unborn baby (embryo or fetus, *q.v.*) is nourished. Soon after the birth of a child a mass of tissue, called the afterbirth, is expelled from the womb. Its chief constituent is the placenta, but attached to the placenta are the umbilical cord and the thin membranous structures known as the chorion and amnion. Adherent to these structures, which are really accessory portions of the fetus, is a thin layer of the lining of the uterus known as the decidua (decidere, to shed), so-called because it is a castoff portion of the mother's body. The placental portion of the mass is about 8 in. in diameter and about 1½ in. thick, thinning rather abruptly at the edges where it is continuous with the membranous chorion. Its outer or uterine surface is lumpy in appearance and is covered by a thin flaky and fibrous layer of decidua. The inner surface is relatively smooth and translucent except for the branching fetal blood vessels which ramify over this surface from the place where the umbilical cord attaches, which is usually near the centre of the disc. Between the tno surfaces the placental tissue consists of a spongy mass of complexly and finely branched chorionic villi containing the fetal vascular system. Filling the interstices of this spongework is a considerable quantity of maternal blood. trapped there when its circulation was stopped and the placenta separated by the final contractions of the labouring uterus after expulsion of the child.

In cases of spontaneous abortion during the first three or four months of pregnancy the entire conceptus (embryo or fetus and placenta and membranes) is often expelled in one mass without rupture of the membranes. In these cases a thin decidual layer of the mother's tissue more or less completely covers the spheroidal mass. Removal of this reveals the thin outer fetal membrane or chorion, all of which in younger stages, and a large part of which in older stages, is covered by chorionic villi making up the placental area. Cutting through this membrane one comes to a thin liquid-filled space. the chorionic cavity (exocoelom), within which is the transparent inner membrane, the amnion. Within the amnion can be seen the embryo or fetus floating in the faintly straw-coloured amniotic liquor which, with the embryo, completely fills the amnionic cavity. Extending from the belly of the embryo, apparently through the amnionic cavity, toward the placenta can be seen the narrow, twisted umbilical cord.

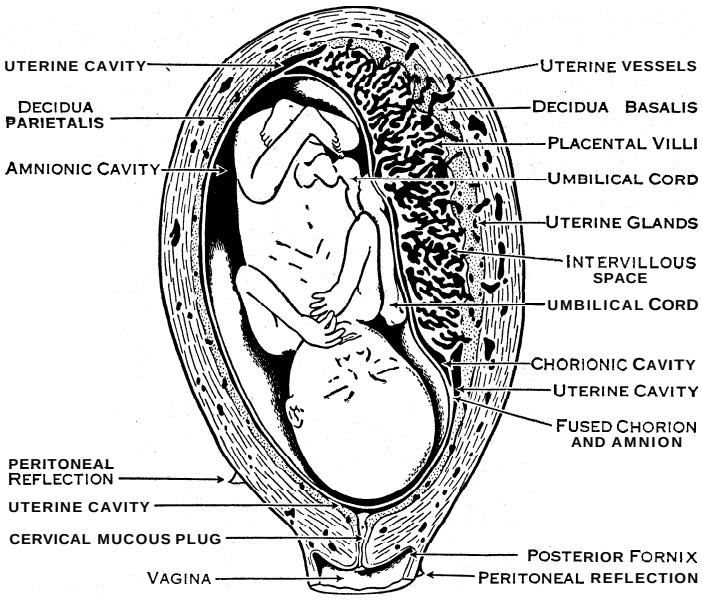

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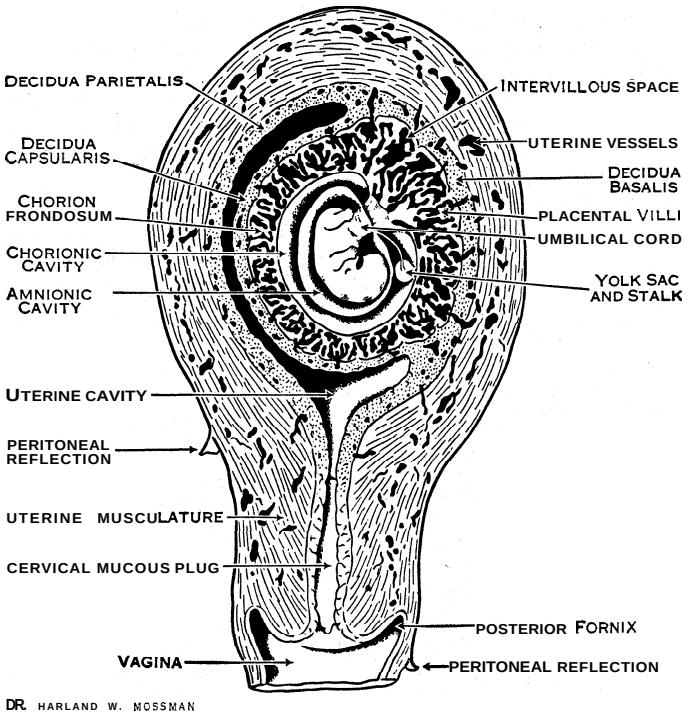
FIG. 2. — IDEALIZED SAGITTAL SECTION OF THE HUMAN UTERUS IN THE FOURTH MONTH OF PREGNANCY

Comparing this with fig. 1, it will be noted that the villi have disappeared from all but the basal side of the chorion, thus giving rise to a disc-shaped placenta; the decidua capsularis has also disappeared, bringing the smooth chorion into contact with the uterine cavity and opposite wall (decidua parietalis). There also has been considerable fusion of the amnion with the chorion, and the umbilical cord has increased greatly in length



DR. HARLAND W. MOSSMAN

FIG. 1. — IDEALIZED SAGITTAL SECTION OF A GRAVID HUMAN UTERUS IN THE SEVENTH WEEK OF PREGNANCY, SHOWING THE RELATIONS OF THE PLACENTA AND FETAL MEMBRANES TO ONE ANOTHER

The entire chorion is covered with villi so that the placenta completely surrounds the embryo. The chorion also is completely separated from the uterine cavity by the decidua capsuiaris, a condition resulting from the embedding of the very early embryo within the lining of the uterus (endometrium)

The umbilical cord contains two arteries and one vein through which the fetal heart pumps its blood to and from the placenta. Lying in the chorionic cavity between the two membranous envelopes is a small balloonlike sac attached by a delicate strand of tissue to the region where the umbilical cord leaves the amnion. This delicate structure, about ⅛ in. in diameter, is the yolk sac or vitelline sac and the tiny strand connecting it to the cord is the yolk stalk containing the minute artery and vein which supplies it with fetal blood. The first blood corpuscles of the embrvo are manufactured in the yolk sac.

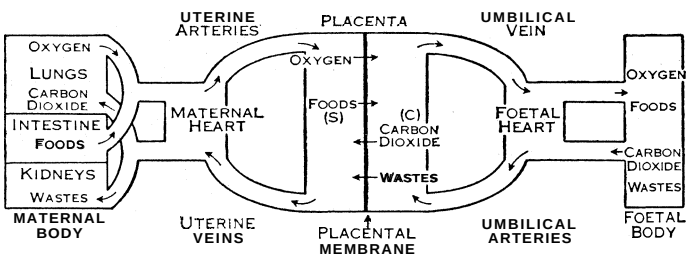
Obviously, all the fetal membranes are structures designed to adapt the developing embryo to the uterine environment. The placenta, especially, is the organ for physiological connection of the embryo or fetus to the mother. The heart of the fetus pumps its blood to the placenta through two large arteries in the umbilical cord. Radiating out from the attachment of the cord on the inner surface of the placenta, these vessels divide into small arteries which penetrate outward into the depths of the organ through the hundreds of branching and interlacing strands of tissue known as villi. These villi are actually outgrowths toward the wall of the womb irom the outer fetal membrane or chorion which surrounds the embryo irom its earliest stages in the uterus. From the beginning of their growth into the mother's tissue they have caused the mother's blood vessels in their vicinity to rupture. Thus the villi become bathed directly in maternal blood. Because of this when the fetal arteries in these villi split into capillaries which ramiiy just beneath the surface of the villi, the fetal blood within them is brought very close to the maternal blood bathing the villi. Since both the fetal blood and the maternal blood are being circulated constantly, and the living tissue separating the fetal blood in the capillaries from the maternal blood bathing the villi is very thin (.02 to .002 mm.), there is provided a mechanism for efficient interchange of dissolved materials between the maternal and fetal blood streams without allowing any opportunity for the blood of one actually to pour across into the blood vessels of the other. Such a mixing of the two bloods would be physiologically highly undesirable and possibly fatal to both the mother and fetus.

Thinking of the placenta in terms of function, then, it can be understood that food materials, oxygen, etc., in the mother's blood are carried to the uterus by the uterine arteries which break up into smaller arteries in the uterine wall and empty into the spaces (maternal blood sinuses) in which the fetal villi lie. There food and oxygen diffuse into the fetal blood in the capillaries of the villi, and nitrogenous wastes and CO_2 diffuse out of these capillaries into the maternal blood to be carried out of the sinuses into the uterine veins and back to the mother's lungs where she eliminates the CO_2 and to her kidneys

where she eliminates the nitrogenous wastes. The purified and enriched blood in the capillaries of the villi of course is collected into ietal veins which carry it back to the inner surface of the placenta and collect at the attachment of the cord to iorm the umbilical vein. This vein enters the cord alongside the two arteries and carries the blood back to the fetus, thus completing the circuit to and from the placenta. The placenta, because of these things! can be said to iunction as a ietal lung, intestine and kidney. It is also true that in last analysis the pregnant woman eats, breathes and excretes ior her unborn baby.

Comparative Anatomy.— Fetal membranes in the ordinary sense (amnion, chorion, yolk sac and allantois) are characteristic of the Amniota (Aves, Reptilia and Mammalia), but a primitive yolk sac is common in many Anamniota (Cyclostomata, Selachii, Pisces and Amphibia). A true chorioallantoic placenta supplied by ietal blood vessels irom the allantois is universally present in all mammals except the Monotremata and Marsupialia. It is, however, present in some species of marsupials and in some viviparous reptiles. A vitelline placenta supplied by yolk sac vessels is present in one iorm or another, at least temporarily. in all marsupials and most placental mammals. The primitive yolk sac of viviparous Selachii commonly forms a placental relationship with the wall of the uterus. In viviparous fishes gestation usually takes place within the ovary and so the vitelline (and often pericardial) net of venous capillaries becomes intimately associated with the ovarian tissue instead of the uterus. In addition to these more common types oi placentation many bizarre and unique structural adaptations ior this purpose have been described in a few species among the "lower" vertebrates and even in some invertebrates.

The evolutionary history of the ietal membranes in general and



DR HARLAND W MOSSMAN

FIG. 3.—SCHEMATIC DIAGRAM SHOWING HOW THE PLACENTA FUNCTIONS BY ALLOWING THE PASSAGE OF NUTRIENTS. OXYGEN. CARBON DIOXIDE AND WASTES THROUGH THE EXTREMELY THIN PLACENTAL MEMBRANE SEPARATING THE FETAL BLOOD IN THE CAPILLARIES OF THE VILLI (C) FROM THE MATERNAL BLOOD IN THE INTERVILLOUS SINUSES (S)

of placentation in particular has been of great interest to biologists for many years. It is a highly complex problem because the structures themselves are very variable and complex anatomically and physiologically; because fundamentally identical types oi placentation occur in widely unrelated groups. *i.e.*, in certain lizards, marsupials and placental mammals; and because the type of placentation in one order of mammals may run almost the whole range from a very primitive condition to a highly coniplex one. Obviously then there are evolutionary series from simple to complex types in several animal groups and these are often rather closely paralleled by similar series in widely unrelated forms. The only tenable conclusion in view of these facts must be that placentation has arisen independently several times in different groups, but that once these adaptations to viviparity have been initiated they have frequently run parallel courses because of parallel physiological conditions to be met and similar structural units or building blocks (chorion, amnion, etc.) to be worked with, inherited from the oviparous ancestors of each.

One extremely interesting and valuable feature of the fetal membranes from the evolutionist's point oi view is the iact that they are relatively "conservative" features. That is, they change less rapidly than other portions of the anatomy of the group. For instance, sea lions, dogs and cats belong to the order Carnivora: yet are very different anatomically. But, except ior size differences and a few microscopic details, the fetal membranes of all three are almost identical. The same can be said of the Artiodactyla, including the cattle, sheep! goats, deer, etc., and of the Primates where only an expert can distinguish between the placenta and membranes of the great apes and man. This conservatism makes it possible to see indications of phylogenetic relationships of species and groups where such extreme anatomical modifications have occurred that it has been diificult on other anatomical grounds to determine with what groups they are affiliated. One such group is the order Edentata, where so much adaptive modification of skeletal ieatures, especially of skull and teeth, has occurred that it is impossible to compare their skulls or dentition profitably with other groups. Xlthough knowledge of the ietal membranes oi this heterogeneous group is fragmentary, enough is known to show that the membranes of the old world scaly anteater or pangolin (family Manidae) closely resemble those of the more primitive hoofed animals such as the pigs (order Artiodactyla); that the new world anteaters and the sloths (Myrmecophagidae and Bradypodidae) have membranes which are much alike and that the sloths show many affinities to the Primates; and that the new world armadillos (Dasypodidae) have many ieatures in the development of their ietal membranes which are very similar to those oi the Rodentia. It seems probable thereiore that these three divisions of the catch-all order Edentata are widely unrelated to one another and that each may be rather closely related to a different order oi less highly specialized forms. *See* also references under "Placenta" in the Index volume.

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PLACENTA AND FETAL MEMBRANES, DISEASES OF, include a number of disorders that may injure the unborn fetus and endanger the health or life of the mother.

Infarction.—This condition. local death of the placenta, is a common degenerative process caused by interference with the maternal circulation to, through or from the placenta. Whether infarction of the placenta causes harm to the baby is determined by the rate and extent of infarction; usually the baby is unaffected.

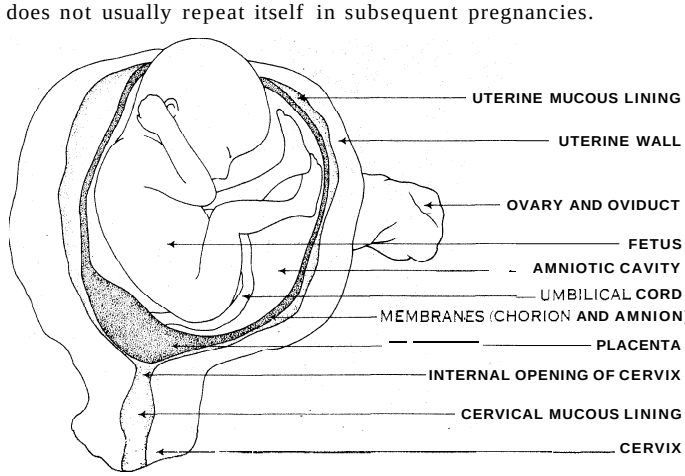
Infection.— Any part of the placenta and its membranes may become infected through either the maternal blood stream or the cervical canal. Tuberculosis, syphilis and toxoplasmosis are infections which may involve the villous structures. Malarial organisms have been found in the intervillous space and malarial pigment in the villi but without inflammatory changes. Up to the early 1960s no specific changes had been found in the placenta with virus infections other than smallpox and chickenpox. Acute bacterial infection is frequently associated with criminal abortion, and occasionally may follow infection of the amniotic sac. Much commoner is the occurrence of inflammation of the membranes following long labour or prolonged rupture of the membranes.

Erythroblastosis **Fetalis.**—This uncommon disease. resulting from immunization of the mother by antigenic substances on the baby's red blood cells (usually the Rh factor), may result in death of the baby and enlargement of the placenta, probably a compensatory phenomenon. See FETAL DISORDERS.

Placenta **Praevia.**—This results from low implantation of the blastocyst close to the cervix; varying amounts of the placenta lie over the cervical opening (see accompanying figure). There may be severe hemorrhage, death of the baby and occasionally death of the mother when the uterus changes late in pregnancy.

Placenta **Accreta.**—In this condition the placenta adheres abnormally to the muscle of the uterus, because of local or complete absence of the decidua. Complete placenta accreta is uncommon. but partial and focal placenta accreta are relatively common. Difficulty in delivering the placenta results, occasionally necessitating removal of the uterus.

Abruptio Placentae.— This sudden separation of the placenta from its uterine attachment is one of the manifestations of toxemia of pregnancy (high blood pressure and poorly functioning kidneys). and usually results in death of the baby. The condition does not usually repeat itself in subsequent pregnancies.



PLACENTA ATTACHED OVER THE INTERNAL OPENING OF THE CERVIX (PLACENTA PRAEVIA)

In this uterus, about 5 months pregnant, the chorion and amnion have been opened to expose the surgically removed fetus lying in its amniotic sac

Premature separation of the placenta may also occur as a result of intrinsic aging of the tissue at the placental site, in the absence of any other maternal disease.

Hydatidiform Mole.—This is an abnormality of the placenta resulting from early death or absence of the fetus accompanied by continued growth of the trophoblast (covering of the villi). It occurs about once in 2,000 pregnancies (in U.S.) and is characterized by a mass of grapelike vesicles filled with gelatinous fluid. It is usually diagnosed about the 14th to 20th week of pregnancy. More than half the patients with these tumours have a subsequent normal pregnancy. In about 16% some of the villi invade the uterine muscle, causing bleeding. In about 2.5% there is development of choriocarcinoma.

Choriocarcinoma.—This is a rare malignant epithelial tumour composed of the two trophoblastic elements, syncytiotrophoblast and cytotrophoblast. Grossly it is hemorrhagic and friable. Most commonly it follows a hydatidiform mole but may follow abortion (once in 14.000) or an apparently normal pregnancy (once in 160.000). Choriocarcinoma spreads rapidly by way of the blood stream, usually producing secondary tumours in the lung. Although rare cures have been reported, this disease is usually fatal.

Chorioangioma.—This commonest true tumour of the placenta usually has no effect on the baby. It consists of an overgrowth of fetal blood vessels. connective tissue and trophoblast.

Others.—Should the blastocyst have implanted deeply all the surrounding villi may persist, resulting in placenta membranacea. The placenta may be partially divided (placenta bipartita, tripartita or multipartita), may be completely divided (as in placenta duplex), or there may be extra lobes (placenta succenturiata).

Placenta circumvallata and its variant, placenta circummarginata, are probably caused by a small blastocyst or its shallow implantation or both. Frequent clinical complications are abortion, intrauterine fetal death. premature placental separation and premature labour. *See* also PLACENTA; EMBRYOLOGY, HUMAN; FETAL DISORDERS; ABORTION; STILLBIRTH; PREMATURE BIRTH.

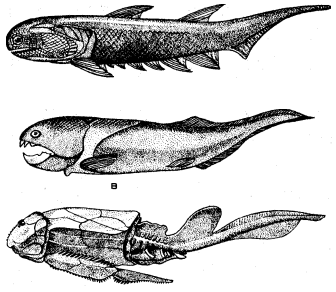
See A T Hertig and H. Mansell in W. A. D. Anderson's Pathology, 3rd ed (1957) (A. T. H.)

PLACERS, the common name given to the alluvial deposits in which gold frequently occurs. They consist of sand and gravel deposited by existing or former streams of water carrying detritus of gold-bearing rocks. Other metals, *e.g.*, tin, are similarly deposited. The gold of the placers consists of grains called gold dust and larger pieces, rounded by attrition, called nuggets. The placer of an ancient stream may be deep lying because covered since its formation with other deposits or even lava. *See* GOLD: *Gold Mining and Refining.*

PLACODERM, a term used for a series of plated-skinned archaic fishes abundant in certain late Paleozoic deposits but now entirely extinct. Members of the class Placodermi had progressed beyond the cyclostomes and ostracoderms in acquiring jaws and paired appendages, although these structures often differed greatly from their homologues in more advanced fishes. As in ostracoderms and bony fishes (Osteichthyes), but unlike sharks and cyclostomes, all the placoderms possessed bony armour. It is possible that some placoderms gave rise to sharklike fishes, but there are no known links with either ostracoderms or bony fishes; most placoderm types were aberrant and destined to speedy extinction. Placoderms first appeared toward the end of the Silurian and flourished during the Devonian. They vanished at the end of that period except for one group, the acanthodians, which lingered until Permian times.

Placoderms may be arranged in two major groups, to the larger of nhich may be applied the term arthrodire in a broad sense. Typical arthrodires were late Devonian marine fishes, best known from shales in the Cleveland (U.S.) region. Many were of large size, *Dinichthys* being estimated to have reached 30 ft. in length. The posterior part of the body was unclad, but head and "chest" regions were covered with bony armour; the two sections of the armour were connected by movable joints (hence the term arthrodire—"jointed-neck"). Small paired fins were present. The early Devonian ancestors of these arthrodires were small, with a flatter body and more extensive armour. Paired fins were absent; instead, long curved bony "horns" extended outward on either side from the shoulder region.

There were numerous variants on the arthrodire pattern. Common in fresh waters were the antiarchs (Antiarcha), such as *Bothriolepis.* In these small fishes there was an armour similar to that of typical arthrodires. As in primitive arthrodires there, were long bone-covered structures extending laterally in the shoulder region, but in antiarchs these were movably articulated with the body, having somewhat the appearance of crustacean appendages. In still other forms found in marine deposits, such as *Gemündina,* paired fins, particularly pectorals, were highly developed and bony armour was reduced; possibly such types were evolving toward the shark condition.



FROM A. S. ROMER, "THE VERTEBRATE BODY," 1ST ED., 1949 REPRODUCED BY PERMISSION OF W. B SAUNDERS COMPANY (A) DATA FROM WATSON; (B) AFTER HEINTZ; (C) AFTER PATTEN

DEVONIAN **PLACODERMS: (A) CLIMATIUS,** AN ACANTHODIAN: **(B) DINICHTHYS, AN ARTHRODIRE; (C)** BOTHRIOLEPIS, AN **ANTIARCH**

Classed among the placoderms, although showing little evidence of relationship, are the Acanthodii. These small fresh-water fishes, such as *Climatius,* are often termed "spiny sharks," but they resemble sharks only in their general proportions and differ markedly from these cartilaginous fishes in a body covering of typical bony scales and head plates, and in the presence of internal bone in some forms. Characteristic is the fact that all fins, paired and median (except the tail) were supported by prominent spines. In some genera additional fins, supported by spinelets, are present as well as the typical vertebrate pectoral and pelvic appendages. (A. S. RR.)

PLAFOND, a card game played in France as early as 1918, was one of the forerunners of contract bridge. Trick values are as in auction bridge. Tricks made but not bid are entered in the honour score at 50 each. There are bonuses of 100 points for a small slam and 200 for a grand slam whether or not these contracts were bid. Undertrick penalties are 100 for each trick (200 if doubled. 400 if redoubled), and the vulnerable feature of contract bridge is not used. Four trump honours in one hand count 100, or 150 if partner holds the fifth; five trump honours, or four aces at no trump, count 200. Additional bonuses are 50 for contract, 100 for game, 400 for rubber. *See* also BRIDGE.

PLAGIARISM, an appropriation or copying from the work of another, in literature or art, and the passing off of the same as original. The Lat. *plagiarius* meant a kidnaper, stealer or abductor of a slave or child, though it is also used in the modern sense by Martial (I. 53, 9). *See* COPYRIGHT.

PLAGIOCLASE, an important group of rock-forming feldspar minerals. *See* FELDSPAR: *The Plagioclases.*

PLAGUE (also called PEST and ORIENTAL PLAGUE) is a term formerly applied to any widespread disease causing a great mortality. but now confined to a specific infectious fever caused by *Pasteurella pestis* (also called *Bacillus pestis* and *Yersinia pestis*). It is primarily a disease of rodents, and epidemics in human beings originate in contact with infected rodents. most commonly rats, or their fleas. The disease in man has three clinical forms: bubonic, characterized by swelling of the lymph nodes (buboes); pneumonic, in which the lungs are extensively involved; and septicemic, in which the blood stream is so strongly invaded by *Pasteurella pestis* that death ensues before the bubonic or pneumonic forms have had time to appear. Plague as spread from rats to man in cronded urban areas is sometimes called murine (rat) or urban plague; plague in desert or rural areas where the human population is sparse but the mild rodent population large and in. fected may be called sylvatic (woodland) or campestral (field).

History of Outbreaks.—Many experts believe, because of the characteristics of the disease in man and the extent of the mortality in mice. that it was true plague that afflicted the Philistines in 320 B.C. (I Sam. v and vi). Another early historical notice of

plague is contained in a fragment of the writings of the physician Rufus of Ephesus, who lived in the time of Trajan (1st–2nd century A.D.), preserved in the *Collections of Oribasius*. Rufus described the buboes called pestilential as specially fatal and found chiefly in Libya, Egypt and Syria. This passage shows the antiquity of plague in northern Africa, which for centuries was considered its home. Not until the 6th century A.D. was Europe afflicted by bubonic plague, as part of a great cycle that lasted 50 years. It spread over the whole Roman world, beginning in maritime towns and radiating inland. In another direction it extended from Egypt along the north coast of Africa. Whether the numerous pestilences recorded in the 7th century were caused by P. *pestis* cannot now be said, but the ones in England chronicled by St. Bede in the years A.D. 664, 672, 679 and 683 may have been this disease, especially since *pestis inguinaria* was again recorded in Rome in A.D. 690. Several infectious diseases were called plague or pest, so retrospective diagnosis must depend on clinical accounts of the buboes, the course and the contagiousness.

In the great cycle of the 14th century, when this disease was known as the Black Death, some plague infections were bubonic and some were pneumonic. The number of deaths was enormous, reaching in various parts of Europe two-thirds or three-fourths of the population in the first pestilence. J. F. K. Hecker calculated that one-fourth of the population of Europe, or 25,000,000 persons, died in the epidemic.

There was no documentary basis until the 20th century for the assumption that the second plague pandemic of the 14th century originated in central Asia and spread to Europe, to India and to China. The Russian archaeologist D. A. Chwolson discovered two Nestorian graveyards near the Issyk-Kul lake, Kirghiz S.S.R., an area long thought to form part of the central Asian plague focus. Inscriptions on three headstones made in 1338 and 1339 stated that the persons interred had died of plague. Chwolson also noted that the number of graves dating back to those years was exceptionally high. This, considered with other known characteristics of those outbreaks, is good evidence that plague existed in central Asia before it ravaged China, Europe and India. China, with its proximity to Mongolia, regularly suffered from plague. It was known there as *ko-ta-wen* (literally, "sore-sore") and in the Hakka dialect of south China as *ta-wun,* which, according to the philological studies of Mahdihassan, means "bubo-epidemic," a connotative descriptive name for plague. Distorted to *ta'un,* it appears in several significant early treatises on plague in Arabic.

The Great Plague of London in 1664–65 was not an isolated phenomenon. Plague had recurred frequently throughout Europe in the 15th, 16th and 17th centuries, but London had been unusually free of it in the preceding years. It was not mentioned in the bills of mortality until the autumn of 1664 (Nov. 2). A few isolated cases were observed in Westminster, and a few in the following winter, which was severe. About May 166j the disease again became noticeable and spread, but somewhat slowly. The total number of deaths from plague in that year, according to the biils of mortality, was 68,596 in a population estimated at 460,000. This number is probably an underestimate, since it is likely that many of the 6.432 deaths attributed to spotted fever were really caused by plague. In December the mortality fell suddenly and continued down through the winter, but in 1666 nearly 2,000 deaths were recorded. From London the disease spread widely over the country, but from 1667 on there was no epidemic of plague in any part of England, though sporadic cases appeared in bills of mortality up to 1679. This disappearance of plague from London has been attributed to the Great Fire, but it also subsided in other cities without such cause. The decline has also been ascribed to quarantine, but effective quarantine was actually not established until 1720. The cessation of plague in England must be regarded as spontaneous.

Epidemics subsided soon after in most of western Europe. In 1666 plague raged in Cologne and on the Rhine and continued there until 1670. In the Netherlands there were instances of plague from 1667 to 1669. but no definite notices of it after 1672. France saw the last of plague in 1668, until it reappeared in 1720 at Marseilles. About 40.000 persons died in the city and 10.000 in the surrounding countryside. The source of infection was a ship arriving from the Levant with plague on board; there had been eight deaths. Quarantine procedures were a farce, and bales of cloth were smuggled into the city. Apparently the infection was circulated solely by human beings and their ectoparasites; there was no mention of deaths among rats. The infection spread by leaps. often of great distances, skipping some areas immediate to Marseilles.

Between 167j and 1684 a new epidemic appeared in north Africa, Turkey, Poland, Hungary, Austria and Germany, progressing northward. Malta lost 11,000 persons in 1675. The plague of Vienna in 1679 caused at least 76,000 deaths. Prague in 1681 lost 83,000 of its population. Dresden was affected in 1680, Magdeburg and Halle in 1682—in the latter town with a mortality of 4,397 in a population of about 10,000. Many north German cities suffered about that time, but in 1683 plague disappeared from Germany, not to reappear until 1707. In Spain it ceased about 1681; in Italy certain cities were attacked until the end of the century, but not later.

It is remarkable that in such a short time plague should totally disappear. Various explanations have been offered: the progress of civilization, in particular the control of infectious diseases by sanitation, hospitalization and cleanliness, and the supervision of the infectious sick were considered important factors. The agrarian revolution brought about a change in domestic housing that led to the exclusion of rats from human dwellings, so that the opportunity for infection was reduced. Another factor may be that, with the abandonment of the old trade routes, commercial activity centred in Amsterdam and London, and the new connections with the far east were by sea, not by land. This reduced the distribution of the disease. These explanations are not'fully satisfactory, but they doubtless cover auxiliary factors. Knowledge acquired in the 20th century leads to the conclusion that the decline at the end of the 17th century illustrates the great natural law of the rise and decline of epidemics. The seeming disappearance again in the middle of the 19th century was merely a phase of the natural history of the disease itself, no more remarkable than the similar prolonged quiescence following epidemics of the 8th century.

During the 18th and the early part of the 19th century, plague continued to prevail in Turkey, the near east, Syria, Egypt and Greece. The cases in Egypt from 1833 to 1845 played a part in the history of the disease, since they were almost the first to be studied scientifically in their home by skilled physicians, chiefly French. Because this outbreak was less severe than the previous ones, the observers were misled to believe that the disease was not particularly contagious.

An outbreak in 1878–79 on the banks of the Volga near Vetlianka, Russia, spread another panic across Europe, and most European governments sent special commissions to study and help control the epidemic. Although the foreign commissioners arrived when the epidemic was over, they learned something of the characteristics of the disease. Subsequent research in southern Russia established the region around the Volga as an old focus of campestral plague.

Once it was a maxim that plague never appears east of the Indus, but during the 19th century it afflicted more than one district of India. In 1815 Gujarat, Kathiawar and Cutch suffered epidemics after three years of severe famine. Again early the next year it struck these same localities and then extended to Sind as far as Hyderabad and southeast as far as Ahmedabad and Dholera. But it disappeared from those parts in 1820 or early in 1821 and was not heard of again until July 1836, when it broke out with violence at the town of Pali, in Rajputana. It spread from Pali to Ajmer-Merwara but died out spontaneously in the hot season of 1837.

In 1823 an epidemic broke out at Kedarnath, in Garhwal, a subdistrict of Kumaun, southwest of the Himalayas. on a high situation. In 1834 and 1836 there were others, and these at last attracted the attention of the government. In 1849 and 1850 and again in 1852 the disease raged and spread southward. In another outbreak in 1876–77 the symptoms of the disease, called *maha murree* or *mahamari* by the Indians, were precisely those of orien-

tal plague, and concurrent deaths of rats were noted.

The third great expansive pandemic is generally thought to have gained momentum in Yunnan province in China, where the rebellion of the Moslems beginning in 1855 and possibly the movements of refugees propagated the disease. Progressing in slow stages, it reached the provincial capital of Yun-nan-fu (modern Kunming) in 1866, and not until 28 years later did it extend to Canton and Hong Kong (May 1894). The number of deaths in Canton has been estimated at 80,000 to 100,000. During the epidemic in Hong Kong the organism that causes plague, *Pasteurella pestis,* was identified on June 20, 1894, by Alexandre Yersin, a fact acknowledged by Kitasato Shibasaburo, who has been claimed to be the discoverer of the inciter of plague.

Ports in south China became plague distribution centres, and between 1894 and 1922 the disease spread throughout the whole world, more widely than during any great foregoing epidemics. Among the many points infected were Bombay in 1896, Calcutta in 1898. Japan and the Philippines in 1897. Australasia, Hawaii. Central and South America in 1899, Cape Town, U. of S. Af.. and San Francisco. Calif., in 1900, Egypt and Singapore in 1901, Bangkok, Thailand, in 1904, Guayaquil, Ecuador, in 1908, Java in 1910, New Orleans, La., and Colombo. Ceylon, in 1914, Galveston and Beaumont, Tex., and Pensacola, Fla.. in 1922. Being at that time a seafaring disease it struck nearly all European ports, causing local epidemics in Glasgow. Oporto, Port., Odessa, Naples and Marseilles. India suffered most. The reported number of deaths between 1896 and 1917 was 9,841,396; the maximum, reached in 1907, was 1,315.892—a rate of 5.16 per 1,000 of the population. Fortunately in the ensuing 25 years the incidence curve turned downward toward greatly diminished prevalence. In 1923 there were fewer than 250,000 deaths; in 1942, 10,577; in 1947, 41,745; in 1948, 9,757; and in 1952, 1,007. Incomplete records for 1954 listed 157 deaths in Burma and 547 in India; those for 1955 showed 720 cases, with 162 deaths. During this period Kenya in Africa had 50 deaths, and Ecuador and Peru had 159. After 1937 no cases were reported from the European part of the U.S S R., an old plague focus.

The usual statements that nothing definite was known about the transmission of plague during the early outbreaks is not entirely correct. Himalayan villagers long ago believed that unusual death among rats preceded outbreaks among human beings, and centuries earlier, in the Israel-Philistine controversies, mice were suspected of being in some way concerned. The discovery of the skeleton of a rat in a Neolithic site in Abu Uba cave near Mt. Carmel, Palestine, and in the Paleolithic site in the desert near Judea attests to the antiquity of this important host of plague in the homeland of the Philistines. Some confusion about this has long prevailed because in Greek and Latin. the languages into which the Bible was first translated, the same word is used for both mice and rats, according to W. P. MacArthur. Avicenna mentions plague in animals, and, according to Nicephorus Gregoras, mice died in 1348 during the Black Death in Constantinople. By that time a highly efficient plague reservoir, the black rat *Rattus* rattus, had become firmly established in Europe. Rat skeletons have been found in excavations at Pompeii, Italy. and votive offerings from the first century found in Roman tombs depict rats. The Justinian plague (AD 542 and after) spread throughout Europe, where outbreaks occurred during the next half-century; these must have arisen from some persisting source through the agency of rats.

The significance of rat mortality was again brought up in the Pali outbreak in India in 183;. From the time of the Canton epidemic, it had been noticed that plague in rats had concurred with plague in man. The relationship was so striking that in 189; Ogata blasanori described the Formosa outbreak as "ratpest." Paul Louis Simond noted the frequency of the disease among those who had recently handled rats and the major role of the rat in its spread. It was reserved for the Plague Research commission to discover, in Bombay in 1905–06, the exact link between rats and human disease As the result of studies of the Indian outbreak made by the advisory committee appointed in 1905 by the secretary of state for India, the Royal society and the Lister institute, the whole epidemiology of plague was elucidated.

Geographic Distribution and Prevalence. — The distribution of plague in man depends almost solely on its distribution and course in rodents. Once this was recognized: measures were taken to stop the transportation of rats and their fleas, and these measures were remarkably successful in confining plague to areas where it prevails in domestic and wild rodents. Transportation of infected rodents and fleas, once responsible for the spread across broad geographic areas, was almost eliminated through well-planned and well-executed efforts. From 1929 to 1951 the only proved instance was on board the S.S. "Ville de Tamatave" in April 1938 at Beirut, Lebanon. Rat-proofing, fumigation of cargoes and general control measures in ports have freed the world of ship-borne plague. A change in the disease itself—away from the ports of warm countries toward the cooler hinterlands—has also contributed.

Asia.—The principal active plague centres in Asia by the middle of the 20th century were in India, China and Burma. There are three endemic centres near the foot of the Himalayas, one in central India comprising the watersheds of the Vindhya, Bhanrer and Maikal ranges and the Mahadeo hills, and three centres in the watersheds of the Western Ghats in Bombay and Mysore, in Hyderabad state, and in the districts of Salem, Nilgiris and Madura. These focuses have been very active. Plague there early in the 1950s was both a rural and an urban problem—it moved from the commercial towns out to villages and flared up where it found a highly susceptible rat population. The epizootics on the warm tablelands were severe, mortality among rats was high and the disease ebbed in a short time. In cooler regions, such as watersheds, the disease was enzootic, persistent and less fatal to rats.

In China, outbreaks varying in intensity were perennial in Hong Kong until 1923. Canton was free from the end of World War I until 1954, but the infection remained entrenched east of Pakhoi, where 62j cases were recorded from Jan. to Sept. 1950. From Kwangtung it spread to other coastal provinces. of which Fu-kien continued to be involved. Another series of outbreaks, preponderantly bubonic, was dispersed along inland routes from Mongolia. Plague also reappeared in Yunnan province about 1938. North Manchuria, infected by human agency from the wild rodent focuses in Outer Mongolia, suffered pneumonic plague epidemics in 1910–11 (more than 60,000 deaths) and a smaller outbreak (10,000 deaths) in 1920–21. Because these did not include the local rat population, they ended as soon as the climate ceased to favour spread of the infection from man to man.

Plague continued in Burma (only 157 deaths in 1954, compared with 2,743 in 1946), Indochina and Thailand (not more than 100 cases a year) and Java (about 2,266 deaths in 1951; 829 in 1952). In Saigon. Indochina, in 1943 an epizootic among domestic mice, more heavily infested with the commonest plague-carrying fleas than mere rats, was responsible for 42 cases of bubonic plague.

Infection among wild rodents in the interior of western Asia was in part responsible for plague invasions of Turkey, Syria, Iran, Iraq and possibly Israel (a few cases in Jaffa and Haifa in 1946 and 1947). Typing of plague bacilli isolated from rats in the port of Istanbul and Adalia, Turk.: and the demonstration of Pesteurella *pestis* in 376 rats in 1941, 1945 and 1947 in Palestine led to the suspicion that the infection also came in by sea.

Europe and Africa.—After World War II. plague appeared in Europe only in Ajaccio, on Corsica; in Taranto, Italy; on Malta; and in the Azores. Information about its real prevalence in the steppes of the southern U.S.S.R. is not available.

North and northwest Africa recorded infection in Egypt (712 cases in 1943–44), Tunisia. Algeria, Morocco (5,000 cases in 1940–45) and French West Africa (639 cases in Dakar in 1944). Central Africa—in particular Cganda. Kenya, Tanganyika and the Belgian Congo—had old campestral focuses, but the incidence of cases was usually less than 400 a year. On Madagascar the outbreaks in ports and along the coast were bubonic, but on the high plateaus the infection tended markedly to secondary lung involvement and on to pneumonic plague. which accounted for 56.2% of all cases seen there in 1946 and for 4 of 17 cases in 1955.

Plague gained a foothold in the Union of South Africa in 1900,

when the South African War necessitated the importation of large amounts of forage from infected South American ports. Until 1912 port areas were involved, but thereafter infected rodents and fleas spread plague to rodents in southwestern Transvaal and northwestern Orange Free State, in the Cape Midland and near Port Elizabeth, U. of S. Af., where cases began to occur after 1919. Human infections numbered 556 from 1919 to 1925, 466 from 1925 to 1931, 687 from 1931 to 1937 and 646 from 1937 to 1949. Nine cases observed in 1955 near the mission station Chitokoloki, on the Zambesi river, about 500 mi. W. of the copper belt, indicated that wild rodent plague was spreading from the Union of South Africa into Northern Rhodesia.

North America and Hawaii.—In the United States, plague was first recognized in San Francisco in 1900. Up to 1904, when San Francisco was declared plague free, 121 persons had been infected, and 113 of them died. Evidence that rats were the source of this outbreak is abundant. The disease broke out again between May 1907 and Nov. 1908, when there were 159 cases and 77 deaths. Plague-ridden rats, as many as 2% of those trapped and examined, were caught in badly infected districts of the city. In New Orleans 30 persons became infected in 1914 and 25 (11 deaths) in 1920. At the same time, Florida and Texas were reporting human plague (total of 41 cases). Between 1924 and 1955 there were no outbreaks of human plague of murine or urban origin.

As the result of a case of plague in a human being in 1903, the squirrel was added to the list of animal reservoirs. A few human infections were later traced to contact with squirrels or bites by their ectoparasites: a small epidemic of pneumonic plague (13 cases) in Oakland, Calif., in 1919 and a similar one in Los Angeles, Calif., in 1924 (31 cases). A human infection was recorded in the Great Basin area in Oregon in 1934. Although the infection is endemic among a large number of rodents throughout rural areas of western United States, it rarely spreads to man. Between 1949 and 1951, seven cases were reported from New Mexico and Arizona, and one was reported in 1956 from California.

Infected prairie dogs have been found in Mexico.

Plague became manifest in Honolulu, Hawaii, in Nov. 1899 and spread to adjacent districts and to Kauai, Maui and some other islands of the archipelago. Between 1899 and 1949, the total of human cases reported was 416. The Hamakua district, Hawaii, has suffered several human infections.

South America.—Plague has been endemic in South America at least since early in the 20th century—in Venezuela, Brazil, Peru, Bolivia, Argentina and Ecuador. Flea-borne bubonic plague has been the commoner form, but in mountainous areas the proportion of pneumonic infections is much higher.

From 1910 to 1951 Venezuela reported 211 cases, 37 of them in Miranda and Aragua. Brazil was more afflicted—between 1899 and 1949, at least 9.248 persons were infected. In Argentina about 7,000 infections were recorded between 1899 and 1940. Bolivia was infected in 1928. Rat epizootics preceded some outbreaks there. Peru has had more bubonic plague than any other South American country (22,254 cases until 1952); it has not been free of plague since 1903. The infection among wild rodents was established in Guayaquil, in Ecuador, as early as 1908 and spread from there to Chimborazo and Loja provinces, causing more than 2,700 human infections between 1909 and 1940, after which a limited number of cases were recorded each year in the mountainous areas.

Causative Organism.—The plague bacillus, identified in 1894 by Alexandre Yersin. is found in the local vesicle of the flea bite, in buboes in ordinary cases, in large numbers in the blood in so-called septicemic cases, and in the sputum in pneumonic cases. On post-mortem examination it is found in great abundance in the lymph nodes, spleen, bone marrow and liver. Outside the body the plague bacillus is not very resistant to heat or to chemicals, but it remains alive in dried sputum for at least three months and in dry flea feces held at room temperature, for five weeks. It is resistant to cold; cultures and organs held in the icebox retain their virulence for months, even up to ten years.

On the whole, the capacity of the bacillus to multiply in the tissues and to cause death of its host—that is, the virulence of the organism—is remarkably stable and vigorous. Test animals (for example, mice) have been fatally infected with as few as three to ten bacilli. Most investigators agree that the virulence of the organisms does not subside in the course of a bubonic outbreak. The mildness of some infections may be explained by greater resistance of certain individuals. not by inherent differences in the causative microorganism. Strains of P. *pestis* secured from man, rats, wild rodents and fleas from every corner of the world are biologically identical and show remarkable homogeneity of virulence and infectiousness. With special laboratory methods certain strains may be rendered avirulent, or they may spontaneously lose their virulence when kept in the laboratory. Unfortunately most of these avirulent strains are somewhat toxic. They are, however, suitable for active immunization and also are used in the manufacture of antiplague serums.

Natural History.—Plague is primarily a disease of rodents, and man enters only accidentally into the usual cycle. This cycle—rodent-flea-rodent—as a rule is enzootic, but under certain environmental conditions it reaches epizootic proportions. In some areas plague-infected rats from ships spread the infection in ports, where it became epizootic in commensal rats. Then it extended from these rodents to peridomestic and field rodents. Independently or as an extension of the infection in urban rodents, plague in wild rodents may affect guinea pigs, hamsters and rabbits; in deserts and other uninhabitable places it uses squirrels, gerbils, hamsters and rabbits as hosts.

Human beings only rarely contract the disease from wild rodents; in the midst of epizootics that have littered pastures with cadavers of plague-infected squirrels, when burrow openings were teeming with infective fleas, rarely if ever has a human being been infected. But spread of the infection among domestic rodents in the vicinity of human habitations creates conditions favourable for outbreaks of human plague. For when an epizootic reduces the rodent population, fleas from the dead animals fail to find another rodent host and thus begin to infest men. At first the cases are sporadic, but under suitable conditions large numbers of persons may be included.

As a rule, at this stage if the infection is bubonic, plague does not spread directly from one person to another. Relatively rarely are there enough bacilli in the blood of human beings to infect the fleas that ingest it. The human flea, Pulex irritans, is a poor transmitter of plague. Under certain circumstances when the bacilli become localized in the lung and are eliminated in large numbers in respiratory discharges, and when environmental and climatic conditions favour aerogenic droplet transmission, the infection spreads from man to man. The pulmonary plagues in Manchuria in 1910–11 and 1920–21 and later in eastern India amply attest to the importance of cool weather and crowding in badly ventilated dwellings as contributory factors in creating pneumonic epidemics. The term epidemic is used loosely to describe bubonic plague, for this relatively seldom spreads from man to man.

Infection may also be acquired at post-mortem examinations and in the course of laboratory accidents, and it was once used with homicidal intent (in Calcutta in 1933, described by Wu Lien-teh and his colleagues in 1936).

Rodents carrying plague fall into two main groups: (1) the Muridae, the rats, of which certain species living in close association with man are responsible for maintaining endemicity and for large outbreaks; and (2) the Sciuridae, Cricetidae, Jaculidae, Caviidae and Leporidae, the wild rodents: responsible for maintaining campestral and sylvatic plague.

Murine or Rat Plague.—Natural plague has been observed in a great variety of the order Rodentia, but of numerous species of the Muridae family only three of the subfamily Murinae (the typical rats and mice) are of universal importance in plague. The rats largely responsible for propagating plague are the Norway, or brown rat (Rattus *norvegicus*), and the English black rat (*Rattus* rattus *rattus*), with its subspecies or varieties. In different areas different subspecies of Rattus and several species of *Mus* may be responsible reservoirs. The organism is ordinarily discovered through macroscopic and microscopic examination of the organs of the diseased or dead rats routinely collected in plague-infected

communities.

Recurrence of plague in commensal rats in countries where the principal natural reservoirs are squirrels or gerbils without notable repercussions in the nearby human populations cannot be explained. Commensal rats have long been thought the principal reservoir because where bubonic plague has raged or is raging, without exception domestic rats and the classical plague-bearing flea have abounded. Studies in the Kurdistan mountains of Iran, the rift valley of Kenya, and the central states of India, however, suggest that plague, in order to maintain itself in focal areas, requires resistant wild rodents capable of surviving the epizootics. They perpetuate the infection. But it cannot operate without susceptible species capable of rekindling it. The ecological factors in the habitual niches filled with hosts, parasites and vectors are very complex, and the combinations responsible for epidemics in India, Madagascar, Senegal, Peru. Brazil and elsewhere are not fully understood. As M. Baltazard stated, although the rat has made the fortune of plague, it is not the original, probably not even the actual, proprietor of the disease, only the disseminator.

Plague in Wild Rodents (*Campestral* and *Sylvatic* Plague).—Among the wild rodents, squirrels and related species are the chief instruments for exchange of the infective agent; a group of small rodents, such as harvest mice act as complementary and auxiliary hosts. There is ample evidence that plague has spread from wild rodents to domestic rats and mice. About 350 species are subject to natural infection, not infrequently taking the form of a seasonal epizootic among the younger members of the regional wild rodent population.

The Vector.—Members of the family Pulicidae, which includes most of the common fleas. are the third indispensable factor in the propagation of plague. Simond, in his experiments with fleas, in 1898 showed them to be possible disseminators of bubonic plague. either from animal to animal, animal to man, or man to man. The ecology of wild rodent fleas has been well studied to the conclusion that comparatively few (approximately 101) of the estimated 1,500 existing species can transmit plague. The most important vectors are listed in Table I. The classical one is the Indian rat flea, Xenopsylla *cheopis*.

At one feeding on a rat whose blood contains 100,000,000 organisms per millilitre, a flea uill ingest about 5,000 organisms and will ordinarily become infective because the organisms are likely to multiply in its digestive tract. The flea is not a mere passive carrier. A few days, or even longer, after it has fed on infected blood, under the microscope clusters of plague bacilli can be seen in its stomach. Later its proventriculus becomes plugged by gelatinous masses of bacilli, and the valvular action becomes inadequate. Because of this obstruction. the blood being sucked by the flea cannot enter its stomach. The esophagus containing virulent bacilli becomes distended, and the elastic recoil of the walls of both pharynx and gullet when the flea stops sucking may drive back into the bite wound highly infective blood. The infective flea may regurgitate as many as 10,000 to 24,000 organisms at one biting. Some of these usually enter the blood of the new host, and if the new host is susceptible, bubonic or septicemic plague is the result.

TABLE I.—Vectors of Plague

Flea (known to bite man)	Distribution	Reservoir hosts	Transmits primarily to:
Xenopsylla cheopis	Widely disseminated	*Rattus rattus*	Rats and man
Xenopsylla brasilensis	Uganda, Kenya, Sigeria	Rats	Rats and man
Xenopsylla hawaiiensis	Island of Hawaii	Field rats	Field rats
Xenopsylla astia	India, Ceylon, Burma, Mesopotamia, Mombasa	Rats	Rats
Xenopsylla nubicus	Tropical east and west Africa	Rats	Rats
Xenopsylla philoxera	South Africa	Wild rodents	Wild rodents
Pulex irritans	Nearly cosmopolitan	Man, swine, rodents, carnivores	Man, rodents
Nosopsyllus fasciatus	Temperate zone of Euroue and America	*Rattus norvegicus*	Rats
Diamanus montanus	Western United States	Ground squirrels	Ground squirrels
Polygenis platensis cisandinus	South America	Cavies	Cavies, or cuys, and man
Delostichus talis	Southeast U.S.S.R.	*Cricetus*	*Cricetus*
Ceratophyllus tesquorum	Russian steppes	*Citellus pygmaeus*	Ground squirrels
Oropsylla silantiewi	Manchuria	Rodents (tarabagans)	Rodents

Many species of fleas merely become infected without occurrence of blockage; these rarely if ever become pestiferous. Others may carry the bacilli in their intestinal tubes for a long time and become blocked later. This last relationship between the flea and the plague bacillus is important because in it may lie one explanation for the carry-over of the infection from season to season in hibernating rodents.

Fleas that have fed on severely infected rodents may spread the organisms with their mouth parts without being blocked. This mode of transmission is of particular importance during epizootics when plague is rampant. There is experimental evidence that this type of mechanical transmission by a large number of fleas is as efficient in spreading infection as is the bite of a single blocked flea. Of least importance is fecal transmission. The flea pellets are viscous. and unless the skin is broken plague bacilli could not gain entrance into the tissues of the bitten. Furthermore, not all fecal pellets contain enough organisms to overcome the inherent high resistance of many wild rodents.

Killing of vermin (lice or fleas) with the teeth may cause tonsillar infection with the plague bacillus.

The maximum life span of an infective flea with a blocked proventriculus is only 20 to 30 days, but infected unblocked fleas may live much longer. A flea infected in October can retain the infection and transmit it during the following March. Among the preservers of plague from season to season. the flea is probably important. The microclimate of subterranean burrows with a constant moderately high temperature and a constantly low saturation deficiency is particularly favourable to the longevity of the flea. Transportation of infected fleas in all kinds of cargo is frequently assured when the time of transport is not too long and climatic conditions are favourable.

The type of fleas and the extent of flea infestation of rats in an area have been stressed as factors in the severity of an outbreak. The total number of fleas per rat varies with the climate, the season and other factors. But, on the basis of epidemiologic comparisons, these factors are of less importance than the number of infected fleas that become blocked and therefore infective.

Detecting campestral or sylvatic plague among wild rodents in rural areas is greatly facilitated by the examination of their fleas, removed either from fur or burrow openings.

As an epidemic scourge, plague has been conquered, but the source of harm remains. In spite of great progress. there is no satisfactory answer to the old question of why plague assumes a short- or long-term periodicity in its local or global manifestations. Fluctuations in rodent populations may be responsible; immunity acquired by animals that survive epizootics and temporarily transmit it to their offspring enters into the balance. Fabian Hirst devotes a long chapter to this stimulating problem in his book The Conquest *of* Plague and recalls that Louis Pasteur suggested that the causative agent might persist in nature in an attenuated form, with a sudden return of virulence controlled by climate and economic factors.

Clinical Characteristics of the Human Disease.—Plague may take three clinical forms: bubonic, pneumonic or septicemic. Misleading use of the word "bubonic" (which means characterized by buboes, or inflammatory swelling of lymph nodes) has given rise to the erroneous idea that true plague is necessarily bubonic and that nonbubonic types are a different disease altogether.

The illness varies within the widest limits, exhibiting all gradations of severity from mere indisposition, which may pass almost unnoticed, to extreme violence, equaled only by fulminating cholera. The mild infections are always bubonic; the other forms are invariably severe and almost always fatal unless treated. The incubation period is usually three to six days; it may be as short as 36 hours or as long as 10 days. As a rule the onset is sudden and well marked.

Bubonic Plague.—Bubonic plague constitutes about three-

fourths of the total cases. In a typical case there is usually shivering at first, occasionally a rigour, followed by a rise of temperature, with vomiting, headache. giddiness. intolerance to light; pain in the epigastrium, back and limbs: sleeplessness, apathy or delirium. The headache is described by the patient as splitting; delirium is usually of the busy type, like delirium tremens. The temperature varies greatly; it is as a rule not high on the first day — from 101° to 103°F.—and may even be normal, but sometimes it rises rapidly to 104° or 105°, even to 107°; it frequently falls two or three degrees on the second or third day. The eyes are red and inflamed. The tongue, somewhat swollen, is at first covered with a thin, white fur, except at the tip and edges, but later it becomes dry, and the fur, yellow or brownish. Prostration is marked. Constipation is the rule at first; the occurrence of diarrhea is a grave sign. Frequently the severely ill patient appears dazed and stupid. is thick of speech and staggers, giving the impression of drunkenness.

There is nothing, however, in all these symptoms and signs that is positively distinctive of plague. The really distinctive sign is the appearance of buboes. which happens early in the illness. usually on the second day; sometimes they are present from the onset; sometimes they cannot be detected before the third day or even later. The commonest seat is the groin, and next to that the armpit; the cervical, submaxillary and femoral glands are less commonly affected. Sometimes the buboes are numerous and on both sides of the body, but more commonly they occur on only one side. The pain is described as tearing or sharply cutting. If the buboes are not treated. they usually form pus and open outward by sloughing of the skin, but they may subside spontaneously or remain hard. Petechiae (small: round red spots caused by hemorrhage in the skin) appear over the buboes or on the abdomen shortly before death. Boils and carbuncles are rare.

Pneumonic Plague. — Pneumonic plague was described in many of the old epidemics. Its precise significance was first recognized in Bombay by L. F. Childe. who found the bacilli in the sputum and showed that the inflammation in the lungs may be set up by primary plague infection. The pneumonia is usually lobular, the onset marked by shivering. with difficult and hurried breathing. cough and expectoration. The prostration is great. and the course of the illness, rapid. The breathing becomes very hurried — 40 to 60 respirations in a minute — and the face dusky. The expectoration soon shows an admixture of blood, and later in the disease large amounts of blood-containing sputum teeming with plague bacilli may be coughed up. The temperature is high and irregular. The physical signs are those of bronchopneumonia; edema of the lungs soon supervenes; and death occurs in three or four days.

Septicemic Plague.—When the organisms are injected by the flea directly into the capillaries or cannot be localized in the buboes. generalized septicemic plague may develop. Prostration and cerebral symptoms are particularly marked. The temperature rises rapidly to a very high level. The patient may become comatose and die within 24 hours, but more commonly on the second or third day. Recovery is rare.

Recovery from all three forms is slow. Second attacks are rare.

Diagnosis. — In an endemic area. typical severe bubonic or pneumonic plague is relatively easy to identify. However, when the disease breaks out only sporadically, the bubonic form must be distinguished in its early stages from tularemia, lymphogranuloma venereum and pyogenic infections. In the tropics the septic and pneumonic forms may resemble various fevers — relapsing, dengue, typhus or fulminating malaria. Primary pneumonic plague has been confused with influenza, as in the Oakland, Calif., outbreak. or with lobar pneumonia, as in the Los Angeles outbreak. There may be no clinical signs from which diagnosis can be made; bacteriologic examinations are essential. These include microscopic examination of edema fluid from a bubo or of sputum, serum hemagglutination, agglutination and complement fixation tests. Early diagnosis is of greatest necessity, not only to the patient, whose recovery may depend on immediate treatment, but also to his family and physician and to the community because of the infectivity of this disease agent.

Treatment. — A highly potent horse antiserum prepared at the Haffkine institute in India was proving quite effective in the treatment of plague shortly before the remarkable successes with sulfonamide therapy were achieved in 1940. Experimental and field trials assessed and confirmed the value of antibiotic treatment of all forms of plague, provided the drug is given early in the course. Supplementing drug therapy with inoculation of antiserum apparently offers the severely infected patient a better chance for recovery. Some of the antibiotics — streptomycin: chloramphenicol and the tetracycline compounds terramycin and aureomycin — are excellent in the treatment, even of pneumonic plague; the sulfonamide compounds? though less curative, are extremely useful and offer highly relevant advantages.

In countries where the antimicrobial drugs are scarce and expensive and where plague still causes many acute illnesses and deaths every year, the inexpensive sulfa drugs have a sound position in both the cure and the prevention of this infection. In field trials the antibiotics set a new record in lowering the mortality rate in pneumonic plague, in which the prognosis was formerly so poor. In general the consistently satisfactory experimental and field trials with streptomycin, marred only a little by the development of streptomycin-resistant strains of the plague bacillus, make it the first choice among the available antiplague drugs. Chloramphenicol. terramycin and aureomycin are active against the streptomycin-resistant strains.

Prevention. — The suppression of bubonic plague is attempted by (1) appropriate sanitary measures directed simultaneously against the vectors and the rodent reservoir; (2) efforts to enhance the resistance of the individual; and (3) isolation of the sick and the handling of all infectious material with the greatest caution.

Since plague-infective fleas represent the immediate hazard to man. it is imperative that insecticides be used early in the outbreaks. Rat ectoparasite control with the insecticide DDT (dichlorodiphenyl-trichloroethane). introduced and tested during World War II, achieved spectacular and consistent control of Xenopsylla cheopis and other fleas that carry and transmit plague. Dusting rat runs with DDT brings epidemics under control. This is the method of choice to speed up a suppressive program and to increase its effectiveness. Not only does it kill the ectoparasite on the rats, but some of the powder is carried by the rats back to their nests and harbourages, and this is distributed over the breeding places of the fleas. Under certain circumstances the chemical kills even the rats. During an epidemic. houses are effectively disinfected with DDT-aromex soap, which remains effective for weeks, if not longer. Several other chlorinated hydrocarbons, such as aldrin and dieldrin, later proved even more effective than DDT.

Because fleas acquire their infections by feeding on plague-infected rats, it is equally important that these reservoir hosts be effectively controlled in order to eliminate the source of the disease agent. For destroying large numbers of rodents, poisoning and fumigation are more effective than trapping. Red squill, phosphorus, barium carbonate, arsenic trioxide, zinc phosphide and thallium sulfate were some of the poisons commonly used before World War II. Research during the war produced ANTU (alpha-naphthyl thiourea) and 1080. the latter with an unprecedented oral toxicity for rats. The lethal anticoagulant Warfarin. developed in 1948. consistently reduces rat populations of Rattus *norvegicus,* R. *rattus* and *Mus musculus,* but not R. *hawaiiensis.* It has the advantage that it is self-baiting and can be given in cornmeal. Proper use of all rodenticides requires considerable skill and experience. Since some of the preparations (1080, ANTU and others) are highly poisonous for mammals, including man and domestic animals, adequate safety precautions must be employed.

No rat-control program is complete without supportive sanitation and until harbourages are destroyed and buildings are ratproofed. Importation of rats from endemic areas should be guarded against by ratproofing ships and applying measures to prevent the escape of rats from vessels and their boarding of ships from the wharves. This is accomplished by rat guards on the hawsers. Ratproofing and the use of rodenticides have reduced the necessity for fumigation of ships.

Suppressing wild rodent plague in rural districts is almost im-

possible. The area is usually of unmanageable size, and knowledge of the many ecologic factors that influence control operations is so inadequate that, except in a few small areas in California, and, according to the Russians, in the Caucasian steppes, curtailment of the rodent population cannot yet liquidate plague among the species involved. For this reason it is essential that domestic premises be surrounded by rodent-free belts.

In an outbreak persons engaged in rat control should be immunized and should wear fleaproof clothing. While flea repellents do not prevent fleas from alighting, the insects do leave impregnated surfaces without biting.

Vaccination or the injection of antigens made from killed virulent organisms is used to immunize inhabitants of epidemic regions. These do not invariably prevent infection, but they do reduce the morbidity and mortality rate of bubonic plague. The steady decrease of plague in Indonesia mas attributed to the use of vaccines consisting of living avirulent plague organisms. Equally favourable results were reported from Madagascar with this type of preparation. Workers in India, using the so-called Haffkine, heat-killed broth culture of a highly virulent strain, showed repeatedly that the total number of cases and the death rates were lower in the vaccinated than in the unvaccinated groups. Whatever means is used, repetition of vaccination strengthens the immunity produced.

Unless the necessary precautions are taken, pneumonic plague spreads from one person to another, and some additional measures must be taken against the other forms. Strict isolation of the patients in insectproof rooms is essential. The patient's clothing must be disinfected and disinfested of fleas in a steam sterilizer. All those who come in contact with patients must wear gloves and gowns. If the infection is pneumonic or suspected of being pneumonic, physicians, nurses and any others in contact with the patient must be protected by complete overalls, gloves! hoods equipped with goggles, and face masks of eight layers of gauze covered by a deflection mask.

The air of the room in which patients with pneumonic plague are housed! preferably under an oxygen tent, should be kept dry; possibly other auxiliary protective measures against aerogenic infection deserve consideration. The chance of infection through droplets or droplet nuclei is quite high, and infection of medical personnel, not uncommon. Persons other than medical attendants who are exposed to plague pneumonia must be quarantined for seven days, and chemoprophylaxis with sulfadiazine may be instituted. *See* also BACTERIAL AND INFECTIOUS DISEASES; EPIDEMIOLOGY; FLEA; RAT.

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PLAICE (*Pleuronectes platessa*), a flatfish that ranges from Iceland and northern Europe to south of Great Britain and one of the most important commercial fishes of the North sea. Other species of somewhat similar form. with large eyes on the right side and with a small terminal mouth, are the dab and flounder; from these the plaice is easily distinguished by the red spots scattered over the body.

The pharyngeal bones are strong and bear large blunt teeth, used for crushing the shells of the bivalves that are the principal food of this species. A length of more than 30 in. and a weight of 8 lb. may be attained, but nearly all the fish marketed are less than half that length.

PLAIN. The term plain is commonly applied to any part of the earth's surface that is relatively level and at relatively low elevation. The surface of plains is, in general, more level than that of hill regions; and. of course, plains are much flatter than mountains. Plains are usually distinguished from plateaus by their lower elevations. There are, however, numerous exceptions to these generalizations. The roughest parts of the world's plains are considerably more rugged than many areas named hills and even some areas locally named as mountains.

Some plains (for example the western part of the Great Plains of the United States) stand at elevations of more than a mile above sea level and are thus higher than some areas designated as plateaus. But despite numerous exceptions most plains are comparatively low and flat. Various attempts have been made to standardize the definitions of plains and other land forms but none of the proposed schemes of classification has been widely accepted.

Size and Distribution.— Plains vary widely in size. The largest plains cover hundreds of thousands of square miles; at the opposite extreme, in some rougher areas of the world, small flat areas of only a few acres are called plains.

Plains are found on all continents except Antarctica. There are plains north of the Arctic circle, in the tropics and in middle latitudes. Extensive plains are located in the deserts and also in humid areas. Plains are located in the centres of continents and also at the continental margins. Some plains are tree covered, some support scrub brush and bunch grass. others are grassy; some support only the most sparse and scanty vegetation. Some plains are nearly waterless deserts; others exhibit widespread swamps. An unusual distributional characteristic is that most of the world's major plains—those in Africa, Europe. North America and South America—are all drained by rivers that empty into the Atlantic.

Economic Importance.— Plains are the great centres of population. industry. commerce and transportation, for a number of reasons. The flat surfaces of plains are most easily cultivated and generally contain the most productive soil. They became some of the principal areas of population growth relatively early in human history. Their level surfaces offer fewer obstacles to land transportation than do hills. tnountains or plateaus, and the rivers of plains are generally much easier to navigate than those of rougher terrain.

Most of history's great civilizations have developed on plains. Babylonia and Assyria and the other early civilizations of the near east arose and flourished on the great plains adjacent to the Tigris and Euphrates rivers. Egyptian civilization developed on the Nile plain. Most of the Greek cities were on small plains scattered in and adjacent to the hill lands of the Greek peninsula. Most of the civilizations that have endured for such long periods in the far east were based on the extensive plains along the eastern margin of Asia. West European civilization developed on the so-called North European plain. The significance of plains in human history is further demonstrated in the following discussion of major plains of the world.

North America.— Some physical geographers and geolagists regard all of North America east of the Rocky mountains as a plain interrupted only by the Ozarks, the Appalachian mountains and plateaus. and the Laurentide mountains lying north of the St. Lawrence river valley. Under this view more than half of Xorth America consists of plains.

Atlanfic-Gulf Coastal Plain.—One of the simplest types of plains is represented by the Atlantic-Gulf coastal plain, which in the east lies between the Appalachian highlands and the Atlantic, and which stretches from Virginia around through all the southern states to the Rio Grande river, and thence south for nearly 500 mi. along the Gulf coast of Mexico. This plain was uplifted from the sea in recent geological times. The net effect of waves and currents is to level off the undersea surface by filling in the depressions. When such a surface is uplifted from the sea without being seriously bent or broken it forms a low flat plain bordering the ocean,

and is called a coastal plain.

The coastal plain of eastern North America, like most coastal plains, is a low, flat, almost featureless plain. Because it is so flat drainage is poor. Swamps cover broad areas; the Okefenokee snamp of southern Georgia is the best known. Rivers are broad and sluggish. The plain is underlain in many places by unconsolidated sands, gravels and clays that were originally deposited beneath the sea. Although in places the coastal plain extends inland more than 150 mi., it generally lies only 100–200 ft. above sea level.

Great Plains.—The Great Plains stretch more than 2,000 mi. north and south along the eastern base of the Rocky mountains and average approximately 300 mi, in width, sloping gently to the east from the base of the mountains. The surface of the Great Plains varies from extreme flatness (as. for example, in north Texas) to areas so rough that most persons would not regard them as plains. Over vast areas the plains are built of material eroded from the Rocky mountains and spread out in a great alluvial apron at their base. These alluvial materials (some in the form of rocks, others consisting of loose sand and gravel or clay) underlie the plains. The Great Plains are an enormous expanse of grassland (see PRAIRIE).

Laurentian Plateau—The whole northeastern quarter of North America is one of the areas that physiographers and physical geographers have classified in various mays. It has been designated as the Laurentian plateau, as hill country and as a plain. It is a vast area of low relief; a country of rolling hills, swamps and tens of thousands of lakes. The plain has been formed by the erosion of extremely ancient mountains to low relief. In the immediate geologic past the whole area was severely glaciated Glaciation removed the loose surface materials, leaving the present surface largely bare rock. It smoothed and evened the surface, and thereby so disarranged the drainage pattern that it created the myriad lakes and swamps now found there. Nearly all the area is now covered by coniferous forest except on the northern margins where it grades into tundra.

Interior Plains.—Lying west of the Appalachian highlands and between the three plains areas previously described is a plain known by various names such as the Interior plains and Interior lowlands. These plains are less extensive than those mentioned previously but are extremely important agricultural areas. They contain the corn belt, the dairy areas of the lake states, the blue grass region of Kentucky and the Nashville basin of Tennessee. In general these plains are underlain by relatively flat-lying sedimentary rocks such as shales. sandstones and limestones; but in some places the rocks are warped upward into low arches or downward into shallow depressions.

The northern part of the region—north of the Missouri and Ohio rivers—is an area of glacial deposition. where the material eroded from the Laurentian rock plains was deposited. Originally the areas had three major types of vegetation—mixed conifers and hardwoods in the north, magnificent hardwood forests in the Ohio basin and farther south, and long grass prairies in the centre.

Europe and Asia.—The greatest uninterrupted expanse of plain on the globe sweeps from the Pyrenees mountains on the French-Spanish border across northern Europe and Asia nearly halfway around the world almost to the Bering sea. In western Europe the plain is comparatively narrow, rarely exceeding 200 mi, in width; but as it stretches eastward it broadens steadily until it reaches its greatest width in eastern Siberia, where it extends more than 2.000 mi. from the mountains of central Asia north to the Arctic ocean.

A plain of such vast extent exhibits a wide diversity of conditions. It embraces wide differences in human geography, rock structure and composition, climate and vegetation.

North European Plain.—The European section covers all of western and northern France, Belgium. the Netherlands, Denmark, northern Germany, southern Scandinavia, and nearly all of Poland and Finland. From northern France and Belgium eastward it is commonly called the North European plain.

Conditions in the North European plain are complex in detail. The terrain is flat or gently undulating. Most of the area has been glaciated and large sections are underlain by relatively unproductive sands and gravels. Sandy dune lands border the North sea and the Baltic. In the Netherlands an extensive delta plain is formed by the deposits of the Rhine river. Delta plains generally are among the most productive and populous. The soils are usually rich and fertile because the materials have only recently been deposited by the delta-forming stream. The terrain is flat, a favourable condition for agriculture if the land can be properly drained, and the stream that forms the delta is useful for transportation. The section of the North European plain bordering the North sea is one of the most densely populated areas in the world.

Finland and *the U.S.S.R.*—In Finland and adjacent parts of the C.S.S.R. are plains very similar in several characteristics to the Laurentian plains of northeastern North America. Finland is underlain by ancient, resistant, crystalline rocks that have been morn down to a surface of low relief and then severely glaciated in recent geological times. With its extensive areas of lakes and swamps caused by the disarranged drainage pattern, thin soils and coniferous forests. the Finnish plain is very similar to northern and eastern Canada in character and appearance.

The continental glaciers that planed, eroded and polished the rock surfaces in Finland deposited part of the material over the plain to the south. Heaps of glacial material called moraines are strewn in great arcs across northern Germany, Poland and the European sections of the U.S.S.R. Interspersed with the moraines are long parallel spillways where glacial meltwaters flowed to the sea parallel to the ice front. These spillways were covered with sand and gravel by the rushing glacial streams; consequently they are flat, poorly drained and relatively unproductive.

The European section of the U.S.S.R. is deeply underlain by a relatively rigid platform of ancient rocks. However, at various times in its history this area has slipped beneath the sea and been covered with sedimentary rocks. These have been mildly bent and warped but nowhere have they been sharply deformed. Consequently the whole area from the Black sea to the Arctic is one uninterrupted plain, everywhere below 1,500 ft. elevation.

Despite its great uniformity in terrain the Russian plain is not featureless. Climatic differences produce great belts extending approximately east-west across the country. The southern part of the plain is an area of semiarid grasslands which grade toward the north into more humid lands with taller grasses and rich, fertile soils. North of the grasslands lies a belt of hardwood forests; in the severely cold north lies a belt of coniferous forests, and bordering the Arctic ocean a belt of tundra.

West Siberian Plain.—The West Siberian plain of northern Asia is an extension of the Soviet European plain. In the north the sweep of the plains is interrupted by the narrow belt of the Ural mountains but in the southern half there is no break whatever. It is one of the largest and flattest areas in the world. It is underlain by flat-lying sedimentary rocks, which in the northern part are quite recently deposited. The northern part is also covered with glacial deposits. Vast sections of the northern Siberian plain are underlain by permanently frozen ground, although the surface layer thaws in summer. It contains enormous areas of swamp. The same belts of vegetation and soils are encountered in Siberia as were noted in the European section of the plain. In the south almost 1,500 mi. of semiarid steppe grades into desert. The huge steppe and desert plains east of the Caspian sea range from flat to quite rough in some areas. They are very sparsely inhabited except in the irrigated oases.

Other Plains *in* Asia.—Eastern Asia is predominantly a land of hills and mountains. Flat land makes up a relatively restricted part of the whole vast area; but partly because plains are so restricted in area they are of critical importance. The two large plains are the Manchurian plain and the North China plain.

The Manchurian plain is surrounded on three sides by mountains but opens out to the sea to the south. It is underlain by sedimentary rocks that have been only slightly warped. It is an erosional plain and consequently parts of it are quite rough. It is mostly semiarid and so had a grass cover under natural condi-

tions. This grassland produced excellent fertile soils, highly productive under agriculture.

The Manchurian plain connects by a very narrow strip of coastal plain with a great plain to the south — the North China plain or Yellow plain. The Yellow plain since earliest history has been one of the major centres of Chinese culture. It is a great alluvial deltaic plain. built into the sea by deposits of the Yellow river and a few other minor rivers. The North China plain is very flat and one of the most densely populated areas on earth. A population at least half that of the United States occupies a plain covering only about 125,000 sq.mi.

To the south the Yellow plain merges into the Yangtze plain, a somewhat smaller plain built by the Yangtze river in essentially the same manner as the North China plain. It too is densely populated.

Extending from the Yangtze plain south along the eastern coast of Asia is a relatively narrow coastal plain. which widens out in a few places where large rivers debouch into the sea and have built wide delta plains. Examples are the plain on which Canton is located in southern China, and the deltas at the mouths of the principal rivers of southeast Asia — the Irrawaddy, Salween and Mekong.

One of the larger plains of Asia occupies all of the northern part of the Indian peninsula south of the Himalayas — the Indo-Gangetic plain or lowland. Most of it is a great alluvial plain deposited by the Ganges and Brahmaputra rivers in the east and the Indus river in the west. Near its western margin it is an erosional plain. The eastern part of the plain has light rains or drought in the winter but in summer rainfall is so heavy that vast areas become swamps or shallow lakes. The plain becomes progressively dry toward the northwest and in western Pakistan is a true desert.

A narrom coastal plain borders nearly all of the Indian peninsula.

The last major plain of Asia is the great alluvial plain formed by the Tigris and Euphrates rivers in Iraq, mentioned previously as the scene of some of the earliest civilizations.

Africa. — Plains make up a far smaller proportion of Africa than of any other continent, if plains are defined as occurring only at low elevations. A strip extending along the Mediterranean sea in northwest Africa and occupying most of Egypt is a desert plain. Much of west Africa is also a vast desert plain. Elsewhere in Africa flat lands at low elevations occur only as an extremely narrow coastal plain along the west coast south of the equator and as a somewhat wider coastal plain stretching along the entire east coast south of the Red sea. These coastal plains vary from dense, tropical jungle with heavy rain and extensive swamps to some of the hottest and most rigorous deserts in the world, along the east coast north of the equator.

Vast sections of the interior of Africa are very flat and lie at elevations less than those of the western High Plains of the United States They could be described as plains but ordinarily interior Africa is classified as a vast plateau.

South America. — Similar disagreements concerning classification are possible for the plains of South America. The Andes mountains run in an unbroken chain along the western margin of South America from the northern to the southern tip. All along the eastern base of the Andes is a great flat alluvial apron spread out by the streams flowing east from the Andes. These areas are universally regarded as plains. The vast areas of the middle and lower Amazon basin and the eastern Parana basin are rolling, slightly hilly lands. Some authorities regard these as rough plains and others consider them hill lands. Under a broad definition of the term more than half of South America consists of plains.

Australia. — Most of the interior of Australia stretching from the mountains along the eastern margin to the plateaus in the far west is one vast desert plain. Parts of the western part of the plain are moderately rough.

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PLAINFIELD, city in Union county, N.J., U.S., 24 mi. S.W. of New York city. It is served by a \fell-knit transportation system of express highways, major railroads, motor freight carriers, bus lines and a local airport which connect it with the surrounding metropolitan areas. Although the city is primarily residential in character and is culturally active, it possesses a number of major industries that make it the business centre of central New Jersey. Its chief manufactures include automotive equipment, printing equipment, electronic products, machinery, chemicals, garments and appliances.

Plainfield was settled in the 18th century as Milltown because it possessed a large gristmill. During the American Revolution it was part of Washington's system of defense for northern New Jersey. In 1847 it became a township; in 1869, an incorporated city. For comparative population figures see table in NEW JERSEY : Population. (W. **L. CA.**)

PLAINS INDIANS. The tribes of the central portion of the North American continent, on the open plains and parkland prairies extending from Alberta and Saskatchewan to Texas and from the Rocky mountains almost to the Mississippi river, formed a natural unit, both in environment and culture. Essentially, this territory was the habitat of the American bison (buffalo) ; and on that animal the Plains tribes primarily depended for food, shelter, clothing and many utensils, and to its habits many of their customs were adapted. The eastern tribes, in the prairies, seasonally combined bison hunting and maize farming; the western ones, in the plains proper, were wholly nomadic. Originally, they transported their tents and belongings on travois frames dragged by dogs.

After the introduction of the horse by the Spaniards, beginning about 1650. this animal gradually replaced the dog, tribal movements became freer, while their numbers augmented and their culture elaborated. They camped in large circles of tepees, conical tents of bison skins supported by long poles leaning on a primary tripod (or four poles) — a highly specialized, convenient dwelling quickly pitched and struck. Cooking was by roasting, or aith hot stones in bison rawhide containers; meat predominated heavily in the diet. Property and food were stored and transported in rawhide bags and parfleches. Clothing was of deer (antelope, elk) skins, supplemented by bison robes, and was well tailored, ample, comfortable and often highly ornamented with embroidery of porcupine quills, later beads.

Social organization was simple: matrilinear clans, patrilinear clans or nonexogamic bands. according to tribe. Warfare was constant, being carried on partly for profit (horse raiding) but chiefly for honour, a man's career depending directly on the prestige of his war exploits; hence arose the system of counting coups, that is, publicly recounting blows struck on enemies. The best known ritual was the so-called sun dance. Most other rites were conducted by societies, which among some tribes were age-graded. Supernatural power was sought in visions by most men, warriors as well as curers. The Plains tribes are proud, brave, outspoken and direct and possess an unusual sense of individuality and personality. With their long braided hair. fringed costume, eagle feather war bonnets and tepees, the Plains tribes pass popularly as the most representative of Indians.

The most typical Plains tribes are the Dakota, Assiniboine, Blackfeet, Gros Ventre, Arapaho, Cheyenne, Kiowa, Comanche; others are the Sarsi, Plains Cree, Plains Ojibwa, Wind River Shoshone, Mandan, Hidatsa, Arikara, Pawnee, Omaha, Ponca, Iowa, Oto, Missouri. Kansas, Osage, Wichita, Kiowa Apache; and. among the tribes in or across the Rocky mountains, the Kootenay. Flathead. Nez Percé, Bannock, Ute and Jicarilla Apache have been especially influenced by Plains culture. The preponderant stock is the Siouan; next, the Algonkin; Shoshonean, Athabascan. Caddoan are also each represented by two or more tribes. (A. L. K.)

PLAINSONG or **PLAIN CHANT.** A general term for a certain style of unisonal music, comprising chiefly the church music called Gregorian. which belongs to Rome, and that called Ambrosian, which hails from Milan. But the other western collections of church music, much less well known than these, and a good many groups of eastern church music could also quite properly be put under this heading.

Origin. — There are various factors in the genesis of music which determine its essential characteristics. Music intended for a dance is necessarily regular in its rhythm; so also, though less tied, is music which is set to metrical verse. On the other hand music fitted to a prose text is not so regular. Thus there arise different kinds of rhythm in music, ranging from strict time to the freest of movement. Again some music arises from recitation and the need to declaim some words artistically and audibly; while other music aims at melody, that is to say a succession of sounds, which is pleasant for its own sake, and would be so independently of any words.

The ecclesiastical music which is called plainsong is so named because it is unmeasured music, not regular in rhythm, a *cantus planus* as contrasted with *cantus mensurabilis* or measured music. It is this feature that chiefly differentiates it from modern music; and at the same time allies it with such things as sea-chanties, counting-out rhymes, and the like. The Christian church, like other worshipping bodies, requires euphonious sounds for the recitation of its psalms, and for the reading of its scriptures in public. As these passages are not (for the most part) written in any strict metre, the music to be provided is essentially a "plain" chant; there are several classes of such plainsong.

Influence of the Psalter. — The chief influence in this evolution has been that of the Psalter. Hebrew poetry follows a metrical system, but this disappears in translation. There survives however, a more obvious feature of the original, viz., its parallelism. This consequently becomes a prominent characteristic of certain sorts of plainsong, so that the chants directly derived from the psalms take a binary form. The recitation demands a reciting note, on which the text can be freely recited in its own rhythm and shape. If this note alone is used, the effect soon becomes, in the strict sense of the word, monotonous. Therefore the music adopts the natural tendency of the voice to rise up to its reciting note at the beginning and to drop down from it at the end of the phrase. Thus arises the commonest chant-form of plainsong, consisting of (1) an intonation, (2) recitation, and (3) cadence, in each half-verse. The psalm-tones whether Gregorian or Ambrosian take this shape; and the form is capable of more or less elaboration for the psalms. The Gregorian tones are very simple; more elaborate forms of them are used for the Gospel-canticles; and still more developed forms for the Introits. A limit is naturally set to the amount of elaboration either (a) when whole psalms are to be sung at length, or (b) when they are to be sung by the whole congregation. When, however, select verses only are sung, and are sung by trained singers, there is far more scope for elaboration; and the developed responds used both at Mass and at the Choir-office exhibit this chant-form in a highly ornamental shape.

The chief development occurs in the Cadences. In its simplest form the musical cadence affects only the last syllable, *e.g.* there is the drop of a minor third. Next it concerns the last two syllables. These two simple cadences are familiar, even to those who do not know the Gregorian tones, from their being used in the Versicles and Responses of the Prayer Book. The more elaborate cadences naturally followed the "cursus" used by Latin prose-writers of the best, or at any rate, the most formal, style. In the responds a five-syllable cadence is constantly in use, and often in a highly decorated form.

All this music arises out of the recitation of psalms. For the purpose of declaiming the lessons of Scripture only the simpler inflexions were used; and the same is true of the prayers or collects, except a few which are of exceptional solemnity such as the "Preface" or the Lord's Prayer, as used in the consecration prayer at Mass; or the Hallowing of the Font at Baptism.

Antiphons. — Next to be considered is a totally different way of beautifying the recitation of psalms or other prose texts. Instead of elaborating the chant itself there was interpolated between the verses a suitable refrain. These refrains came to be known as "antiphons": and thus side by side with the older method, which came to be called "responsorial" from the responds which represented it at its fullest development, there arose the newer "antiphonal" method. The former music developed from recitation, and even in its most elaborate forms in more or less degree it hung round a reciting note. The antiphons were purely melodic and the method had its quality and meaning determined, not by reference to a "dominant" reciting-note, but to the "final" note on which it ultimately came to rest.

Antiphonal music underwent modification and development just as the responsorial music did. Its relation to the psalm altered; the singing of the refrain after each verse survived mainly in processional use. In choir offices the refrain was dropped so that it was sung only at the beginning and end of the psalm, or else in a curtailed form at the beginning and in full only at the end. In the psalmody of the Mass the opposite form of abbreviation was adopted. For at the Introit and the Communion the psalm became restricted to only one or two verses, and at the Communion it ultimately disappeared altogether, leaving the Antiphon alone.

Some antiphons composed on a large scale arose independently of any connection with a psalm. These were used especially in processions. Others retained the idea of a psalm-verse, hut utilized for such verses not the normal psalm-tones, but independent melodies, perhaps as elaborate as the psalm itself. Such antiphons especially prevailed at the Offertory in the Mass.

The greater part of the classical Gregorian plain-chant falls into one or other of these two classes. The amount of elaboration depended mainly upon two considerations (1) the importance of the occasion; and (2) the capacity of the singers. A great festival or a specially dignified part of the service demanded richer treatment: and the trained singers undertook more difficult music than the congregation, the soloists than the choir generally.

The Gregorian Music. — The *Cantilenu Romana,* Gregorian chant proper, is thus a body of music, purely vocal and ecclesiastical, evolved by the Papal choir in the course of the fifth and sixth centuries. This was codified in the time of St. Gregory *(c.* 540–604) (*q.v.*) and stands as the basis of all the Gregorian Music. The Milanese tradition was similar but less artistic. It is called "Ambrosian" *(see* AMBROSE, SAINT) but the term has no historical significance as the term Gregorian has. A comparison of these two families of plain-chant brings out clearly the comparative crudity of the Ambrosian tradition as distinct from the artistic balance and delicate finish of the classical Gregorian chant. The same is true also of such other specimens of Western ecclesiastical chant as are known. The Gregorian reform marks the close of a golden age of classical monody. The middle-ages subsequent to St. Gregory produced nothing so good; and the later part of them while producing only little and decadent plainsong depraved also the form of the classical tradition.

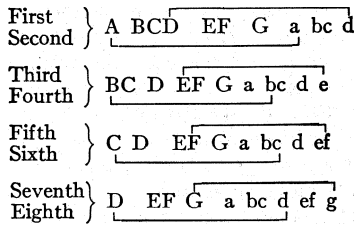
Something more must be said to describe the contents of the Gregorian *corpus* and also to explain the musical theory which lay behind it. The music covers the whole set of services of the Roman rite, but principally the Mass and the series of daily Choir Services. At the Mass some of the things sung are invariable, while others change according to the Sunday, or Festival, or occasion generally. The unchanging elements are chiefly the *Kyrie, Credo, Sanctus, Agnus dei,* and *Gloria* in *excelsis.* For these the old tradition provided little or no change of music; and what there was followed very simple lines suitable for congregational singing. The variable elements were principally the Introit-psalm, the Gradual-respond, the Offertory-antiphon and the Communion-antiphon. The Gradual was at times replaced or supplemented by an Alleluia with a Verse attached to it, or by a Tract. The Alleluia belonged specially to festive seasons and occasions, the Tract to penitential. Neither of these falls exactly into either of the two chief categories responsorial and antiphonal. The Tract is a very ancient but elaborate type of the developed psalmody; the Alleluia was an innovation which came in towards the end of the classical period, and extended beyond it into the "Silver Age" when little else was being composed.

For the choir-offices there was provided a large number of antiphons to go with the psalmody, and a considerable number of responds which mainly served as interludes between the lessons at Mattins. When hymnody began with St. Ambrose it was taken up and incorporated into the services by the monks; but Rome was for a long time too conservative to admit hymns. The plain-

song hymn-tunes are, in the nafure of the case, more definitely metrical than the other music: but they retain a considerable freedom of movement, and are not "measured," like modem hymn-tunes.

Underlying Musical Theory. — The musical theory which lies behind this music is based on a series of eight scales or Modes. It uses the old diatonic scale of the Greek theorists (equivalent to the white notes of the pianoforte with the addition of B), but the modes themselves are different from the old Greek modes, and the use of the old Greek names only leads to confusion. The eight-mode system was probably the same as the ὀκτόηχος which underlies the Eastern church music; but the origins are obscure alike in East and West. The scheme seems to go back at least to St. John of Damascus (c. 750); but it is known in the West only in theoretical treatises derived through the Byzantine teachers at the court of Charlemagne at the end of the eighth century.

The eight modes are really four pairs, each pair being founded on the same note, the one scale. (called Authentic Mode) being an octave ranging above the foundation or final note, the companion (called Plagal) being an octave ranging above and below it.



Each of these pairs has a character or tonality of its own, dependent upon the position which the semitones have in the scale. None is similar to the major or minor key of modern music. It is this tonality which gives the special character to plain-song melody. Some theorists have reckoned twelve or even fourteen Modes; but this is unnecessary. So far as pitch goes, the range of two octaves covered by the eight modes is adequate; and so far as tonality is concerned, the new modes would be only the same as the first four or six over again with the Bb used instead of B. (For further discussion of the Modes see HARMONY.)

This modal theory does not fully account for all the procedure of the classical plain-chant (practice always surpasses theory): but these eight modes are clearly the foundation of this music, whether responsorial or antiphonal.

In the middle ages the *cantilena Romana* was handed on by tradition from St. Gregory's days; in the ninth century it was recorded in the notation reames. The notation on a staff which began a couple of centuries later, while it fixed accurately the pitch of each note, failed to reproduce the rhythmical delicacies which the earlier notation had recorded. Hence the recent renascence of classical plain-song has been based on a return to the reames, as interpreted by the subsequent tradition.

The revived interest in music of the Carolingian era stimulated composition, which had been long in abeyance. Not only new music for new feasts arose, but fresh settings of the "Ordinary" (fixed elements) of the Mass. While the old music was preserved, it was padded out with new and inferior interpolations called by the generic name of "Tropes." These had their day and pervaded all the church music for a century or more; but then they went out of fashion, leaving only two considerable legacies, (a) a further series of settings of the "Ordinary," (b) the new form of rhythmical, or (later) metrical, poem called Sequences or Proses. These survived in considerable numbers down to the sixteenth century, but at the present time only a few are in use.

Modern Revival. — The rise of the art of harmony beginning from the eleventh century, diverted attention from the monody of plain-chant, and part-singing had the effect of "measuring" the music so that it fell into regular time and was no longer free or "plain." Under these influences the old plain-song was progressively debased and as harmonized music went up, plain chant went down. Not until the nineteenth century did this degradation cease. The efforts then made in various quarters to recover alike the true rhythm and tonality of the old music have culminated in the work of the Benedictines of Solesmes and their followers, and in the revival which has produced the new Vatican Gradual and is producing by degrees a restored Antiphonal as well. With the recovery of the music has come a new insistence upon its use and study, as being the official music of the Roman church. (W. H. F.)

PLAINTIFF: see PRACTICE AND PROCEDURE.

PLANCK, MAX KARL ERNST LUDWIG (1858–1947), German physicist, introduced the quantum theory, one of the great achievements of modern science, for which he won the Nobel prize in physics in 1918. Planck was born at Kiel on April 23. 1858. He studied at the universities of Munich and Berlin and received his doctorate at Munich in 1879.

Although he studied under Gustav R. Kirchhoff and H. L. F. von Helmholtz in Berlin, his early work drew its inspiration from Clausius' writings on thermodynamics, and Planck devoted himself for some years to clarifying the concept of entropy and showing its importance in thermodynamics. During these years he was first instructor (Privatdocent) in Munich, from 1880 to 1885, and then associate professor of theoretical physics in Kiel until 1889. In that year he was called to the University of Berlin as Kirchhoff's successor and taught there until his retirement in 1928.

In 1900 Planck introduced the quantum theory in order to solve the problem of black-body radiation: experimental observations on the wave-length distribution of the energy emitted by a black body as a function of temperature were quite incompatible with the predictions of classical physics. Planck first determined the correct mathematical law for this distribution by using empirical arguments guided by his mastery of thermodynamics, and then on December 14, 1900, he announced his derivation of the law. This derivation was based on the revolutionary idea that the energy emitted by an oscillator. continuous according to all previous ideas, could take on only discrete values or quanta. The quantum of energy for an oscillator of frequency ν is hν, where h is a universal constant, now named for Planck, having the units of action and the magnitude $(6.6252 \pm 0.0005) \times 10^{-27}$ erg sec.

Planck himself did not take the lead in the great developments of his idea. These were initiated by Albert Einstein in 1905 with the application of quantum ideas to the explanation of the photoelectric effect. Bohr's theory of atomic structure (1913) was based on the quantum theory, and since the full fruition of Planck's original ideas in the work of Max Born. Werner Heisenberg and others (1926) the concept of quanta has influenced virtually every aspect of modern physical science. Planck's work was widely acclaimed. In 1918 he won the Nobel prize in physics for his quantum theory. In 1926 he was elected a foreign member of the Royal society of London and in 1928 received that society's Copley medal. He became president of the Kaiser Wilhelm Society for Scientific Research (later the Max Planck society) in 1930.

Planck felt it his duty to remain in Germany during the Nazi period, but he openly opposed some of Hitler's policies, especially the persecution of the Jews. His second son was executed by the Gestapo for his part in the unsuccessful attempt to assassinate Hitler in 1944. Planck lost his home near Berlin during the bombings and he suffered many hardships before his rescue by the Americans in 1945. He died in Gottingen on Oct. 3, 1947.

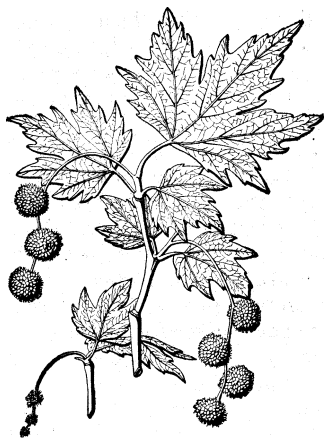
See also QUANTUM MECHANICS; PHYSICS: GENERAL SURVEY.

See Planck's Scientific Autobiography and Other Papers, with a memorial address on Planck by Max von Laue, Eng. trans. by Frank Gaynor (1949). (M. J. K.)

PLANE, in botany the common name of a handsome tree, *Platanus* orientalis (family Platanaceae), a native of Greece and western Asia, a favourite shade tree of the Greeks and Romans, introduced by the latter to southwest Europe. It is a successful tree in industrial cities: the smooth face of the leaf is easily washed by rain; and periodical peeling of the bark also serves to get rid of surface deposits. It is a large tree with widely spreading branches and alternate, palmately five-lobed leaves resembling those of the sycamore maple in shape, but hairless and of a brighter green. The bud in the leaf axil is protected during its development by the hollow base of the leaf-stalk,

nhich lifts off like an extinguisher when the leaf falls in autumn. The minute. unisexual flowers are borne in dense pendulous heads, which contain either male or female flowers; the small one-seeded nutlets, each bearing a tuft of long silky hairs. are densely crowded in a ball, from nhich they gradually separate in drying, and are readily carried by the nind.

A variety of forms are known in cultivation; var. *laciniata* has very deeply much-divided leaves, and var. variegata, variegated foliage. The London plane, P. *acerifolia,* features three-lobed leaves. Several authorities regard this as a natural hybrid (P. occidentalis × orientalis) rather than as a distinct species. *Platanus* occidentalis, an allied species, is a native of the United States, being most abundant and growing to its largest size in the basin of the lower Ohio and the Mississippi rivers. It was introduced into England early in the 17th century, and is occasionally met with in western and central Europe; it is known in America as sycamore (*q.v.*) and buttonwood. It differs from P. orientalis in its less deeply lobed, more leathery pubescent leaves and in the usually solitary balls of fruit. Both the native sycamore and the London plane are extensively planted as ornamental trees in the eastern United States. The California sycamore (P. mcemosa) and the Arizona sycamore (P. *wrightii*), of the extreme southwest, are much smaller than the eastern species.



PLANE (PLATANUS ORIENTALIS), SHOWING BRANCH WITH FRUITS. A. BRANCH WITH DROOPING FEMALE HEADS WHICH ARE WIND POLLINATED

PLANER: see MACHINERY AND MACHINE TOOLS; WOODWORKING MACHINERY.

PLANET. The term "planet" was applied in the ancient Ptolemaic or geocentric astronomy to the seven heavenly bodies which were observed to change their places as projected against the background of the so-called fixed stars. These bodies were the sun, the moon, Mercury, Venus, Mars, Jupiter and Saturn, all of which were supposed to revolve around the earth. In the modern or heliocentric astronomy (taught by Aristarchus of Samos in the 3rd century B.C. but forgotten or neglected till revived by Copernicus in the 16th century A.D.) it is applied to all dark and opaque bodies in revolution round the sun: and the number of such bodies known has been greatly increased by successive discoveries. In 1781 William Herschel discovered Uranus. In 1801 Giuseppe Piazzi discovered Ceres, a small planet revolving between the orbits of Mars and Jupiter and the first of a great host of small bodies known as minor planets or asteroids; while in 1846 Neptune was added to the list of major planets following on the mathematical work on the unexplained irregularities in the motion of Uranus by Urbain Jean Joseph Leverrier and, independently, by John Couch Adams (see NEPTUNE). In 1930 a yet more remote planet was found at the Flagstaff observatory near the position predicted by the late Percival Lowell. It was named Pluto.

Most of the major planets possess moons or satellites. Neptune is known to possess 2, Uranus 5, Saturn g, Jupiter 12, Mars 2 and the earth 1.

Distances **of** the Planets.—An empirical rule expressing the planetary distances from the sun was discovered by Titius of Wittenberg in 1766 and later brought into notice by Johann Bode. If a series of 4's be written down, and 3 be added to the second, 3×2 to the third, 3×2^2 to the fourth, and so on, the sums of the numbers are 4, 7, 10, 16, 28, 52, 100, 196, 388, 772, etc. Division of these numbers by 10 shows fair agreement with the actual mean distances up to Uranus (see Table I), provided that the figure 2.8 is thought to represent the mean position of the asteroid ring. The success of representing approximately the first seven planetary distances by the Titius-Bode rule is not remarkable, since it was accomplished with five parameters (the three constants 4, 3 and 2 and the two rules, of putting the exponent of 2 at $-\infty$ for Mercury and of starting the regular count at Venus with the exponent 0). Furthermore. the rule fails for the major planet Neptune. The modern equivalent is to consider the planetary distances as a rough geometric progression, *i.e.,* the radius of each orbit differs by roughly a constant factor from its neighbour. Actually, the factor varies from 1.4 to 2.0 (not counting Pluto, see below). It appears to have been determined largely by the local density of the solar nebula from which the planets formed.

TABLE I.—Principal Elements of the Orbits of the Major Planets *for the Epoch 1956, Jan. 1. G. M. N.*

Planet	Symbol	Mean distance from sun in: Astronomical units *a*	Mean distance from sun in: Millions of Miles	Eccentricity *e*	Inclination *i*	Period of sidereal revolution*
					° ′ ″	P (Years)
Mercury	☿	0.387099	36.0	0.2056257	7 00 14.1	0.24085
Venus.	♀	0.723332	67.2	0.0067040	3 23 39.1	0.61521
Earth .	⊕	1.000000	92.9	0.0167276	.. ..	1.00004
Mars .	♂	1.523691	141.6	0.0933644	1 50 59.8	1.88089
Jupiter	♃	5.202803	483.4	0.0484288	1 18 20.1	11.86223
Saturn	♄	9.538843	886.3	0.0556056	2 29 24.3	29.45772
Uranus	♅	19.181962	1,782.4	0.0471085	0 46 22.9	84.01320
Neptune	♆	30.057731	2,792.9	0.0085717	1 46 26.8	164.79375
Pluto	♇	39.51774	3,671.9	0.2486438	17 08 38.4	248.4302

*In tropical years.
Source: *American Ephemeris and Nautical Almanac* (1956).

Orbits and Phases **of** the Planets.—From the observations of Tycho Brahe, the great Danish observer, Johann Kepler deduced the following three great laws of planetary motion:

(1) The planets move in ellipses with the sun at one focus. Hitherto it had been believed that the celestial motions took place in circles. the circle being the perfect geometrical figure.

(2) The straight line from the sun to a planet (radius vector) passes over equal areas in equal times. The importance of this law was that it involves a continually varying rate of motion, which was also contrary to accepted beliefs at the time. To maintain the equal description of areas in unit time a planet must travel faster in the neighbourhood of perihelion where the radius vector is at a minimum than near aphelion where it attains its maximum value.

(3) The squares of the periodic times (the times required for the orbital revolutions of the planets) are proportional to the cubes of the mean distances (the semimajor axes of their orbits). This is known as the harmonic law and defines the relationship between a planet's orbital motion and its distance from the sun.

From these laws of planetary motion Isaac Newton deduced his law of universal gravitation which has achieved such remarkable success and prepared the way for Albert Einstein's relativity theory.

The dimensions, form and aspect of a planet's orbit as well as the position of the planet in the orbit at any time are defined by six quantities known as its elements. These are:

(1) Half the major axis, or mean distance (generally denoted by a). This defines the size of the orbit and also the period (P) by means of Kepler's third law, above.

(2) The eccentricity (e) or the ratio of the distance of the sun from the centre of the orbit to the mean distance. This defines the shape of the orbit.

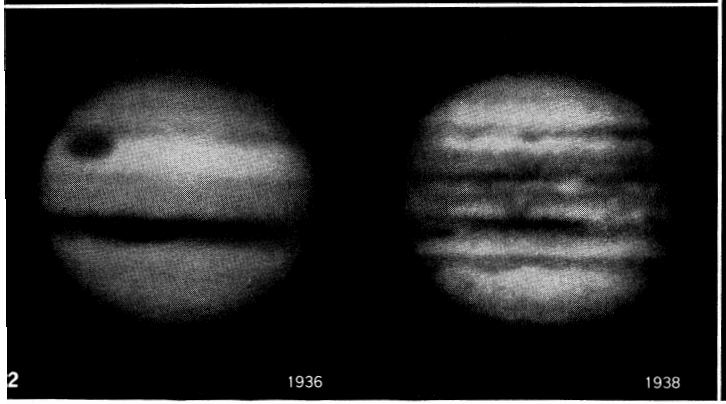
(3) The inclination (i) of the orbit plane to the ecliptic, *i.e.,* to the plane of the earth's orbit.

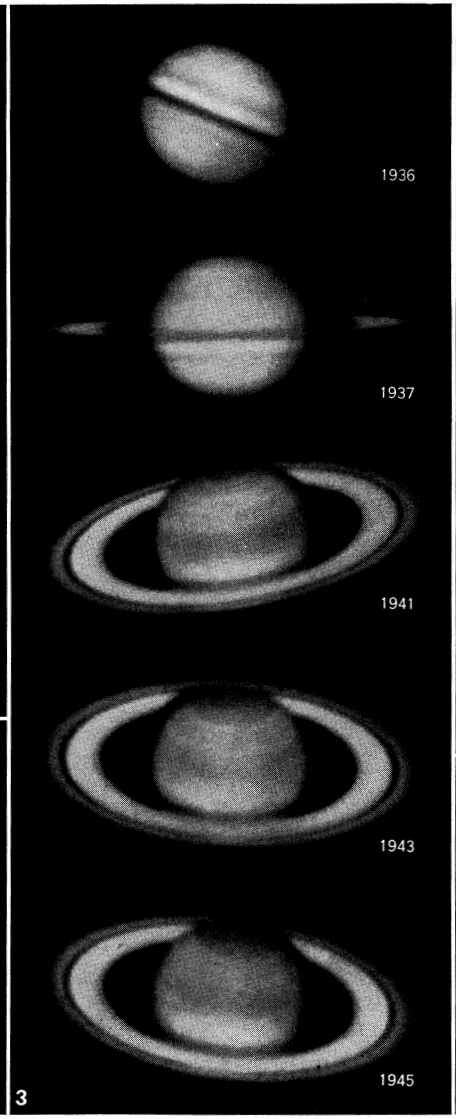
(4) The longitude of the ascending node (Ω), *i.e.,* the direction at the sun of the point on the orbit (measured from the vernal equinox or "first point of Aries") at which the planet crosses the ecliptic from its south to its north side. This defines the aspect of the orbit.

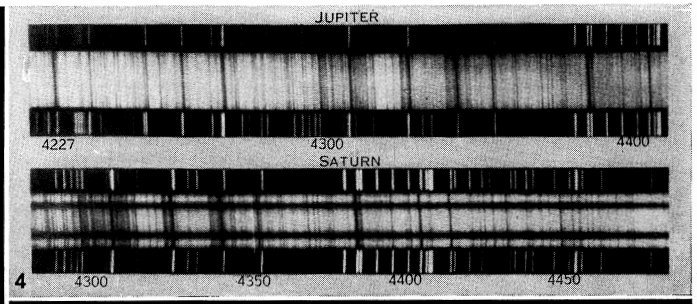
(5) The longitude of the perihelion ($\bar{\omega}$). This defines the direction of the major axis in the plane of the orbit.

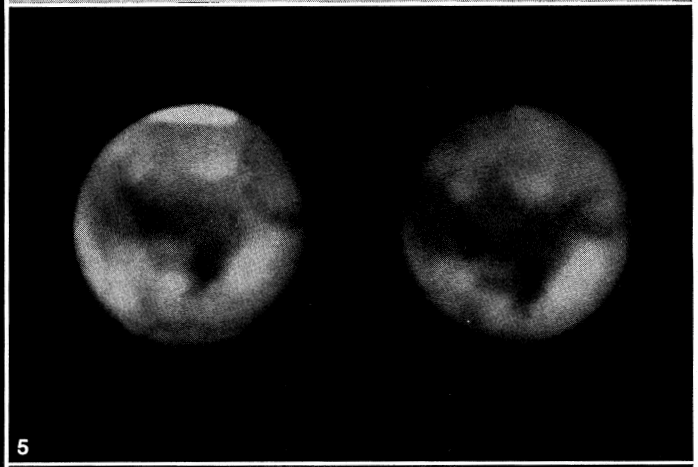
(6) The longitude (L) of the planet at the epoch or time (T) of the planet's perihelion passage. The elements a, P, *e* and *i* are given for the several planets in Table I.

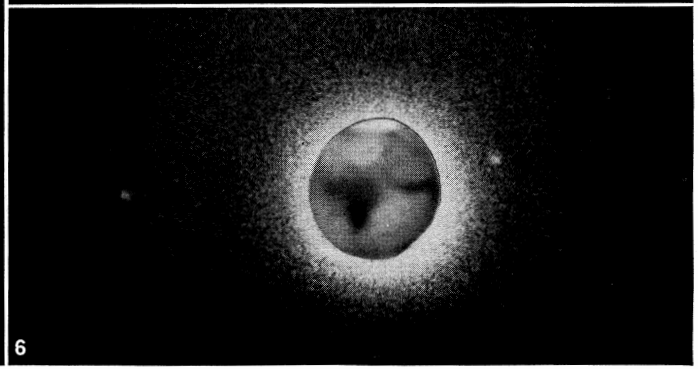
Since the orbits of Mercury and Venus lie within that of the earth these two planets when observed telescopically will show phases similar to those presented by the moon. When on the far side of the sun, *i.e.,* near the time of superior conjunction, each











BY COURTESY OF E. C. SLIPHER, LOWELL OBSERVATORY

PHOTOGRAPHS OF PLANETS

1. Venus, showing the phases and greatest range in diameter resulting from revolution about the sun in an orbit inside that of the earth. When passing between earth and the sun, the night side of Venus is completely encircled by a ring of light (lower right) due to sunlight reflected through the planet's atmosphere
2. Jupiter, 1936 (left) and 1938 (right), showing the great red spot and notable changes in the belts
3. Saturn. Various aspects of the planet and its ring system (1936-45)
4. Spectra of Jupiter and Saturn illustrating the rotation of these planets and the meteoric nature of Saturn's rings. (The white line drawn at λ 4349 shows how the spectral lines of Saturn would appear if the ball and rings rotated as a unit)
5. Mars, showing its southern hemisphere in springtime (left) and in summer (right) with notable changes in the polar snow cap and the dark markings
6. Mars and its satellites, photographed Aug. 17, 1924. Phobos is close to the planet, at the right; Deimos is fainter and farther from the planet, at the left. Composite photograph

of them will appear like a small full moon. As the angle earth-planet-sun increases. a proportionally diminishing fraction of the illuminated surface will be presented to view; and when the angle reaches 90°, the planet will appear half-illuminated like the moon at first quarter. Following this, a crescent form of steadily diminishing breadth will be assumed as the planet moves toward inferior conjunction. at which point it passes between the earth and the sun. Subsequently to this, the phases described will be repeated in the reverse order up to superior conjunction when the planet will again be "full." The phases of a planet revolving outside the earth's orbit differ from those of Mercury and Venus in as much as the angle earth-planet-sun can never increase to 90°. Thus Mars. although at times presenting a gibbous aspect like an eleven or twelve days' old moon, is always more than half illuminated. In the case of Jupiter the defect of illumination is so small as to be almost imperceptible. In the cases of the planets revolving outside Jupiter the phase is quite imperceptible even in powerful telescopes. The variations in apparent diameter and brightness will. of course, also be small in the cases of the remoter planets.

Planetary Atmospheres. — There are striking physical distinctions between the giant planets. Jupiter. Saturn, Granus and Neptune on the one hand and the terrestrial (or earthlike) planets Mercury, Venus, earth, and Mars on the other hand. The planets of the first group, besides being much larger and more massive than the terrestrial planets, show no fixed permanent surface features and are of very low density. The density of Saturn is actually less than that of water. The terrestrial planets range in density from 4.1 that of water for Mars to 6 for Mercury. Both Mars and Mercury show fixed markings on their surfaces. Impermanent clouds. often arranged in roughly parallel belts, can be seen in the atmosphere of Venus. The masses and, consequently, densities of those planets possessing satellites are derived with great precision from the distances and periods of their satellites by an application of Kepler's third law. The masses of Mercury and Venus are deduced from their gravitational disturbances on the motions of other planets. whereas the mass of Pluto has proved too small to be so determined.

The knowledge of the mass and diameter of a planet permits the calculation of the attraction of gravity at its surface. g, and the velocity of escape, v_e. ahich is the limiting velocity which a particle must exceed if it is to escape from the planet. The computed values of g and v_e are found in Table II. Note that for planets of different density, ρ, the values of g and v_e are not proportional; the reason for this is found from the definitions ($g = Gm/r^2$; $v_e = \sqrt{2Gm/r}$; $m \sim r^3\rho$; m and r are the mass and radius of the planet and G is the constant of gravitation).

The rate of escape of molecules from the uppermost layer of a planetary atmosphere (called exosphere) depends not only on v, but also on the temperature and the molecular weight of the gas: both a high temperature and a low molecular weight will increase the molecular velocities and therefore the fraction that exceeds v. The exosphere temperature depends on the strength of the solar radiation received (which may be computed for each planetary distance) as well as on the atmospheric composition. Thus for each planet a prediction may be made as to which gases. if any, will be retained near its surface. It is found that Jupiter and Saturn will retain even the lightest gases, hydrogen and helium, for astronomically long intervals of time (several billion years or more); while the earth and Venus will lose these light gases but will retain all heavier ones. Mars will retain carbon dioxide, argon, and probably nitrogen, but may lose oxygen (which. because of its strong ultraviolet absorption heats up exceptionally).

The observations support these conclusions in a general way. The spectra of the giant planets show strong absorption bands due to methane and ammonia, identified by Rupert Wildt in 1932 and confirmed in detail by T. E. Dunham. Uranus and Neptune show weaker absorptions besides. due to molecular hydrogen and probably HCO. both discorered by Gerard P. Kuiper in 1949 and identified by Gerhard Herzberg in 1952 and 1951, respectively. Helium causes no visible absorptions of its own, but G. Herzberg. from laboratory experiments, found evidence that the planetary spectra of hydrogen show pressure effects attributable to helium. Kuiper discovered methane on Saturn's satellite Titan in 1944, but no ammonia, which would have frozen out; and concluded that Pluto and Neptune's satellite Triton may have tenuous atmospheres, which would account for the rather strong ultraviolet reflectivity of these bodies; so far no specific molecular absorptions have been found.

On the earth hydrogen and helium are constantly being replenished in the atmosphere, by the photodecomposition of water vapour in the upper atmosphere and radioactive decay in the crust, respectively. The other gases in the atmosphere, though of secondary origin (*i.e.*, due to degassing of the crust), are not now being lost. In pregeologic time, however, there must have been very severe losses to the protoatmosphere as is shown by the very low relative abundances of the inert or noble gases, neon, argon, krypton, and xenon. These gases must always have been part of the atmosphere and are therefore of great importance in tracing its early history. On Venus a dense atmosphere of carbon dioxide was discovered by Walter S. Adams and T. E. Dunham in 1932; but water vapour and oxygen could not be detected. Mars has an atmosphere totalling about one fifth in mass of the terrestrial atmosphere, as determined from its light-scattering power; but Adams and Dunham found the oxygen and water-vapour content too small to be detected spectroscopically. With a newly developed infrared detector, Kuiper discovered carbon dioxide in 1947 and also that the Martian polar caps were water snow, not carbon dioxide snow. Traces of water vapour must therefore be present on Mars; the frost point is estimated to be about −73° C. from the extent of the polar caps and the computed ground temperatures. Most of the martian atmosphere may be nitrogen, with some radiogenic argon added. Mercury has no perceptible atmosphere, the upper limit being 0.3% of our atmosphere, according to A. Dollfus. The moon may have a trace, about 10^{-13} terrestrial atmospheres, as appears to follow from certain radio observations. Such an amount is about what would be expected from the rate of argon production in the lunar crust, coupled with the expected rate of escape to space from the lunar exosphere.

Planetary Surface Temperatures. — The heat radiated to space by a planet is nearly in balance with that fraction of the solar radiation which the planet absorbs. For the terrestrial planets the heat flow from the interior is so small that the balance is precise; for Jupiter and Saturn the heat flow from the interior is not negligible, as is shown by the "spontaneous" disturbances in their cloud covers. Nevertheless, even for these planets there will be approximate balance. Now the heat loss by radiation per unit area is proportional to T^4, while the gain by absorption per unit area is proportional to $(1-A)/a^2$, where A is the planetary albedo and therefore $(1-A)$ the absorbed fraction of the received solar radiation; while a is found in Table I. For a surface placed at right angles to the solar rays one finds, from the known "solar constant," the equilibrium radiation temperature to be $394° \times (1-A)^{1/4}/a^{1/2}$, counted from the absolute zero. For a rapidly rotating planet the solar radiation is spread over an area four times that of the cross section of the beam, and therefore the temperature will be $4^{1/4} = \sqrt{2}$ times lower than for a "normal" surface. The computed mean radiation temperatures for rotating planets are found in Table II. They apply to whatever atmospheric or surface layer is most effective in the radiation to space. Note that this layer on Venus is no narmer than that on the earth. owing to the high albedo. For planets with dense atmospheres and condensation products, the surface temperatures must be higher than the radiation temperatures owing to the greenhouse effect. For the earth the difference is about 40° C. and the difference is not constant. as is shown from the occurrence of ice ages.

Planetary temperatures may be measured by placing a thermocouple or a Golay cell at the focus of a large reflector. Such work has been done especially at the Mt. Wilson and Lowell observatories. The measures are hampered by the variable amounts of water vapour in our atmosphere but the region from 8 to 14μ is comparatively free and is used. This means that temperatures much below 300° absolute are not readily accessible. Results on the giant planets are therefore rather in the nature of upper limits; furthermore, they are strongly affected by particular molecular

TABLE 11.—Physical Constants Pertaining to the Major Planets

Planet	Mass ⊕=1	Mean diameter ⊕=1	Mean density (water=1)	Inclination of equator to orbit	Rotation period	Albedo A	Mean Radiation Temp. (° absolute)	Surface gravity	Velocity of escape km./sec.
Mercury	0.0543	0.366	6.1	7°	88 days	0.058	625*	0.40	4.4
Venus	0.8136	0.961	5.06	30°	10–30 days?	0.71	241	0.88	10.4
Earth	1.0000	1.000	5.52	23°27′	$23^h56^m4^s/1$	0.36	250	1.00	11.3
Moon	0.0123	0.273	3.33	1°32′	$27^d\ 7^h43^m$	0.072	274	0.16	2.4
Mars	0.1069	0.523	4.12	25°	$24^h37^m22^s/6$	0.148	217	0.39	5.1
Jupiter	318.35	10.97	1.35	3° 7′	$9^h50^m–56^m$	0.51	102	2.65	61.0
Saturn	95.3	9.03	0.71	26°45′	$10^h–11^h$	0.50	76	1.17	36.7
Uranus	14.54	3.72	1.56	98°.0	$10^h.7$	0.66	49	1.05	22.4
Neptune	17.2	3.38	2.47	29°.0	$15^h.8$	0.62	40	1.23	25.5
Pluto	0.05?	0.45	3?	?	6d/39	0.17	42	0.25?	4?

*For subsolar point, since Mercury does not rotate with respect to the sun.

emissions in the 8–14μ region, such as are due to ammonia. Thus, the measured temperatures of Jupiter and Saturn are essentially the temperature at which ammonia vapour makes its appearance, about 130° absolute (−143° C.). For the terrestrial planets and the moon the results are more significant and good general agreement exists with the computed temperatures. Edison Pettit established the important result that the day and night sides of Venus are virtually at the same temperature, of 241° absolute (−32° C.), indicating rapid atmospheric convection between the two hemispheres. For the moon Pettit measured, among others, the temperature drop during a lunar eclipse, which led to a determination of the coefficient of thermal conductivity; from these data the lunar surface was found to be covered with a fine powder (probably caused by meteoritic impacts). For Mars the noon temperature at the equator was found to be about 0°–10° C., somewhat less, as it should be, than the maximum attainable for a normal surface exposed indefinitely, being 34° C.

Composition of the Planets.— The terrestrial planets are composed of silicates and metals, in varying proportions, as follows from their different densities. Mercury, though of small mass and therefore little compressed, is denser than the earth which, if uncompressed, would have a density of about 4.2. Mercury must contain about $\frac{2}{3}$ iron. and this suggests that the liquid core of the earth is iron also and not a high-pressure phase of silicates. Jupiter and Saturn are composed of about 80% and 60% hydrogen, respectively, according to William H. Ramsey, who suggested that Uranus and Neptune may be partly composed of metallic ammonium. All four giant planets must have earthlike cores at their centers, though more massive and more compressed than the earth, since these planets arose from protoplanets that were more massive than protoearth. Intermediate between the earthlike cores and the mantle of metallic hydrogen, Jupiter and Saturn may possess a shell of compressed ice, as was suggested by R. Wildt.

Origin of the Planets.— It is reasonably certain that the planets condensed from large gaseous clouds, or protoplanets, about 5×10^9 years ago; and that these protoplanets were essentially of solar or cosmic composition. Protoearth was some 500 times more massive than the present earth; proto-Jupiter about 20 times. The protoplanets appear to have segregated from a primeval nebula that surrounded the sun; the mass of the solar nebula was about 6% of the solar mass. The process of planetary formation appears to have been incidental to the formation of the sun itself, with the solar nebula consisting of the material that. because of its large angular momentum, stayed behind in the general contraction process. The protoplanets formed by gravitational instability within the nebula before the sun had completed its contraction and had become luminous. The temperature in the nebula at the time of break-up appears to have been exceedingly low, some 40° absolute, which, because of the abundance of snows, greatly speeded accretion. Later. when the sun got bright, its radiations drove off the gaseous envelopes or protoatmospheres of the terrestrial planets and left them virtually bare. It also greatly reduced the masses of the giant planets. These gigantic mass losses had several indirect effects, such as great increases in the inclinations of the planetary equators (see Table II); the loss of satellites to interplanetary space (probable formation of Pluto from Septune, and Hidalgo and the Trojan asteroids from Jupiter); and the formation of a dozen irregular satellites (being lost satellites that were recaptured).

The minor planets or asteroids appear to have originated as condensations in a tenuous part of the solar nebula between proto-Jupiter and proto-Mars. Gravitational instability could not occur in this tenuous ring so that not one large condensation (or planet) developed but instead innumerable smaller condensations formed by accretion, much like snowflakes in a cloud. A similar tenuous ring must originally have existed outside proto-Neptune, which appears to have given birth to the comets. The dimensions and compositions of the asteroids and of the comets are in general accordance with the predictions based on this theory.

Habitability of the Planets.— The giant planets appear to have solid surfaces only at great depth, as a result of excessive pressures (over 100,000 atmospheres); while the atmospheres are strongly reducing (large excesses of free hydrogen). No life as we know it could exist there. The moon and Mercury are unsuited for life due to lack of atmospheres. Venus must have produced some free oxygen or its atmosphere would be expected to contain carbon monoxide as well as carbon dioxide, since both are produced by terrestrial volcanism. This oxygen originated probably from photolysis of water vapour, not from organisms. The apparent absence of appreciable quantities of water and oxygen, and the high carbon dioxide content, make Venus an unlikely place for life to have developed.

In addition, the greenhouse effect of the Venus atmosphere is probably very large, with the surface temperature exceeding the boiling point of water. The Venus cloud cover is probably composed of a photochemical product of CO_2 and CO, such as C_3O_2, polymerized into particles that may be about one micron in diameter.

The case of Mars is distinctly different. This planet possesses an atmosphere containing carbon dioxide in quantities similar to the earth, as well as traces of water vapour, and probably nitrogen and argon. Photosynthesis is therefore possible. The daily temperature range, while larger than in the terrestrial deserts, is not extreme. The night temperature may reach −80° C. or −100° C., but would not be fatal to some organisms. as lichens, occurring on the earth. In fact, some terrestrial lichens, if transplanted to Mars, might survive.

The dark areas on the planet bear some resemblance to those on the moon and on Mercury, and are therefore likely to be extensive lava fields. The delicate green and brown colours occasionally observed on these dark areas may represent a hardy type of vegetation partially covering these lava fields.

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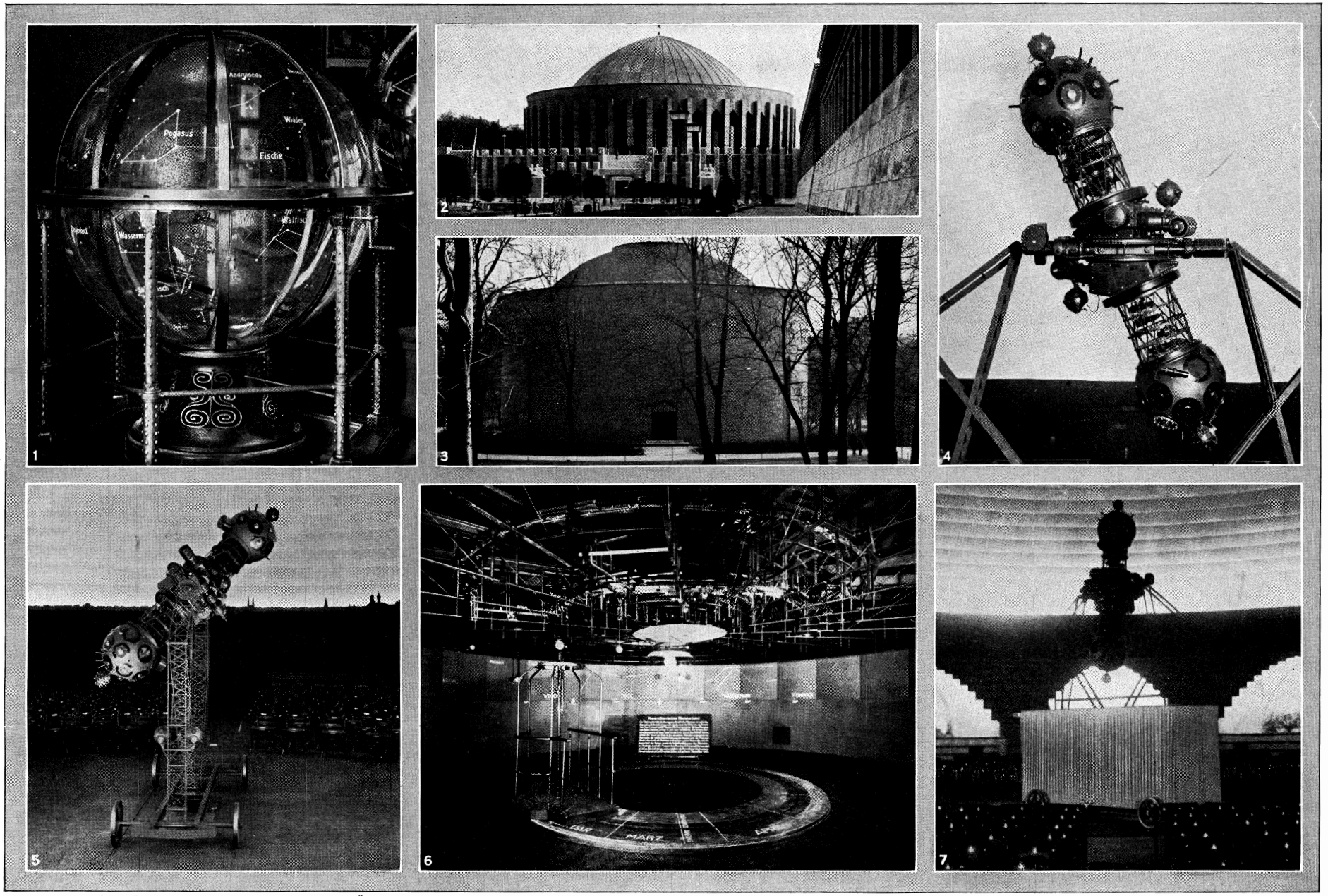
(F. L. WE.; G. P. K.)

PLANETARIUM is the name given to an arrangement, made by Carl Zeiss of Jena, for producing an artificial sky. By optical methods images of the sun, moon, planets and stars are projected on a large hemispherical dome and by mechanical and electrical means the apparatus can be revolved so as to show the principal motions. The name planetarium is apparently given because of the success with which the apparent motions of the planets among the stars can be shown; but the apparatus makes possible the representation of many other astronomical phenomena.

For several centuries orreries have been used to demonstrate the motion of the planets round the sun according to the Copernican system. Perhaps the best arrangement of this kind is in the German museum at Munich where the observer can be carried in a cage which is moved in a path representing the earth's orbit. By means of a periscope he can look out on the motions of the other planets and at the stars of the zodiacal constellations shown

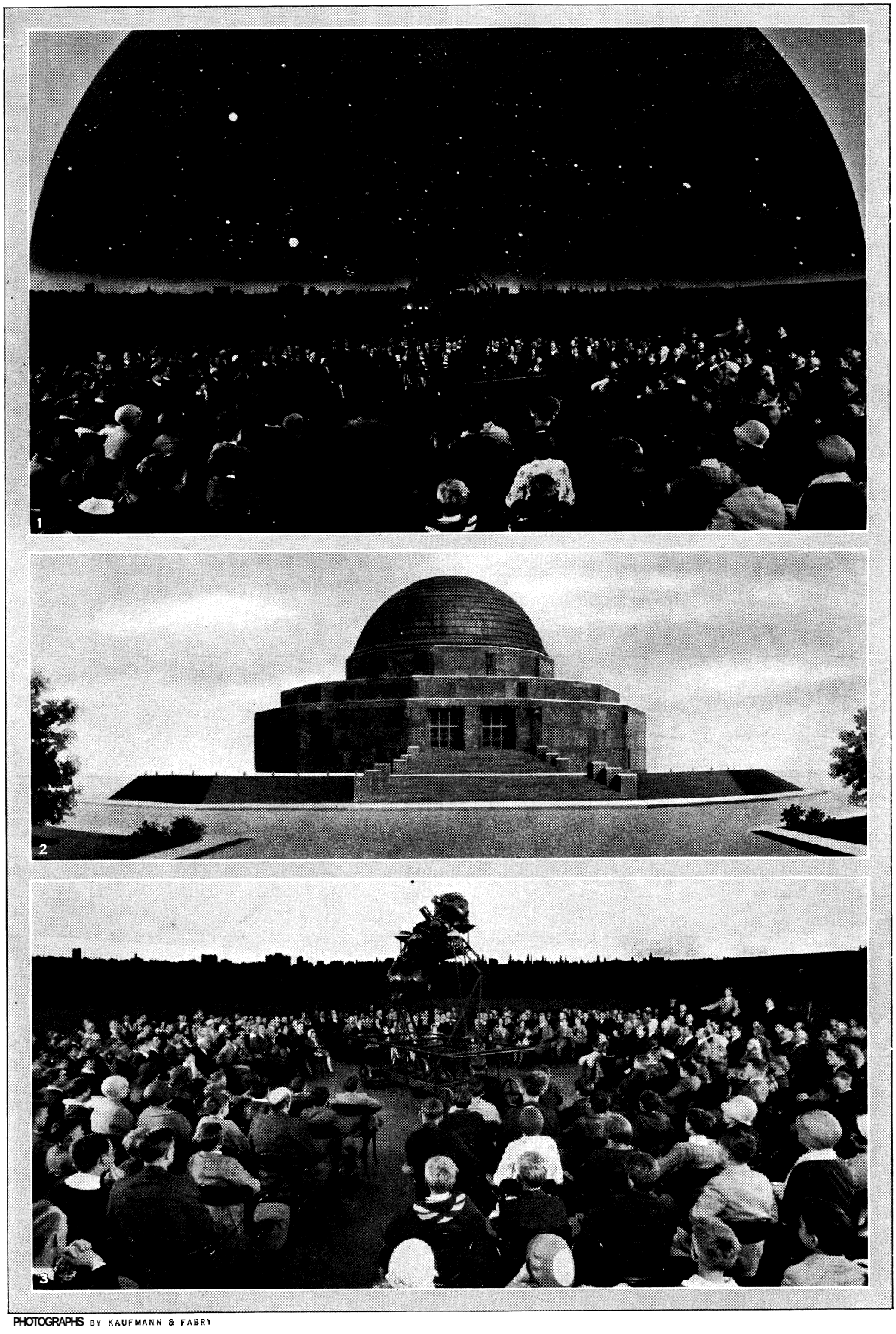


BY COURTESY OF (1, 6) DEUTSCHES MUSEUM, (2, 7) JULIUS SOHN-DÜSSELDORF, (3, 5) O. E. SCHWEIZER, (4) CARL ZEISS

CONSTRUCTION AND HOUSING OF THE PLANETARIUM, AN OPTICAL APPARATUS FOR REPRESENTING ASTRONOMICAL PHENOMENA

1. Ptolemaic Planetarium. **2.** Exterior, Düsseldorf Planetarium. **3.** Nurnberg Planetarium, exterior view. **4.** Projection apparatus, principal axis perpendicular to plane of earth's orbit. **5.** Rotunda, Nurnberg Planetarium. **6.** Copernican Planetarium, Munich. **7.** Interior, Dusseldorf Planetarium

PLANETARIUM



PHOTOGRAPHS BY KAUFMANN & FABRY

ADLER PLANETARIUM AND ASTRONOMICAL MUSEUM AT CHICAGO
THE GIFT OF MAX ADLER

1. Interior showing projector of heavens and silhouette of the skyline of Chicago
2. Exterior entrance
3. Interior showing seating capacity and projection

on the wall by means of small electric bulbs. But it is impossible in a model of this nature to make the relative distances correct and thus to get the proper alignment of the various bodies. When this instrument was ordered from Zeiss in 1913 it was suggested that another astronomical model might be made depicting the heavens as actually seen from the earth and it was suggested that the heavenly bodies might be represented by electric bulbs fixed or moving on a rotating dome. This suggestion, however, was soon discarded in favour of another, by Dr. Bauersfeld, in which the images of the bodies were projected optically on a fixed dome. The resulting apparatus has been a great success. It is found that when a dome 50 ft. or more in diameter is used, the appearance is extremely like that of the actual sky. For the stars it is merely necessary to have the projector mounted so that it can be rotated about an axis parallel to the earth's axis. For the sun, moon and planets small models, true to nature, are constructed. The angles between the orbit planes are allowed for and by the use of eccentric circular motion the elliptic motion is quite closely represented. For showing, say, the planet Venus, the model has pins representing Venus and the earth moving round the sun. A little projector is attached to the pin representing Venus and a linkage between the planets always directs the light away from the earth. Consequently, the image of the planet on the dome is in the correct position among the stars. The gearing is so arranged that the mean motions are accurately represented and only comparatively slight periodic errors affect the positions of the sun, moon and planets. The phases of the moon are shown by an occulting device.

The planetarium can be operated at varying speeds corresponding to the phenomenon to be demonstrated so that even such a slow motion as that of the precession of the equinoxes is within its range. To show the rising and setting of the heavenly bodies a day is compressed into an interval of from 1 to 4 min.; to show that of the planets the diurnal motion can be put out of gear and a year run off in intervals varying from 7 sec. to 4 min. The original model was made for one latitude only, but in later ones, by introducing an additional axis of rotation, the latitude can be altered at will. The stars are shown brighter than they appear in the sky—the eyes of the spectators coming from the daylight would otherwise take too long to be sensitive enough to see them. It is, of course, impossible to make the sun as bright as in nature but this has the advantage of enabling the stars to be seen in the sky along with the sun and thus demonstrate the motion of the sun among the stars.

With the planetarium the spectator can see in an hour or so motions which can be seen in the heavens only by years of watching. When a year is compressed into a minute or two the planets can be seen chasing one another about the sky, describing loops, advancing and retrograding, just as they do so slowly in nature. Great attention has been paid to details so as to make the apparatus as perfect as possible; *e.g.*, the brightness of the objects is dimmed as they approach the horizon and the light is practically cut off as the star actually reaches the horizon. The date corresponding to the configuration can be projected on the dome as well as the names of the constellations, and by means of a luminous pointer a lecturer can point out objects of interest. Planetaria have for some time engaged popular interest in a number of German towns.

In the United States the first to be erected was the Adler planetarium at Chicago, but others are now to be found in Los Angeles, Calif., Philadelphia, Pa., New York, N.Y. and Pittsburgh, Pa. (J. JN.)

PLANING MACHINES rank in importance with the lathes and drilling machines, and cut various kinds of plane surfaces in metal. The principle is that of attaching the metal to a long table which slides truly upon a massive bed, so that by holding a cutting tool in a slide overhead, the material becomes shaved off as the table moves. The width of surface is treated by giving the tool a cross-traverse. The slide moves on a horizontal rail for this purpose, and the rail is adjustable up and down, two uprights flanking the bed. Toolslides are often put on the faces of the uprights as well, so that the sides of the work may be planed. Planing machines are of value both for big and small articles; they may take one of the former and deal with it singly, or a whole string of small objects can be clamped in line on the table and surfaced off. (See also WOOD-WORKING MACHINERY; MACHINERY AND MACHINE TOOLS.)

PLANKTON is the name used for that great section of marine life which drifts under the influence of sea currents, to distinguish it from those organisms (the nekton) which can swim against the currents and those (the benthos) which are found attached to, and crawling on, the sea floor. Planktonic life is important because all animal life in the sea is ultimately dependent on it for existence. The great majority of planktonic organisms are microscopic plants and animals; by definition, the plankton also includes bigger organisms, even the largest jellyfish and the floating Sargassum weed. Little was known of any except the largest of them until, in 1845, Johannes Miiller towed a small conical net of fine-meshed cloth behind a boat and collected a sample of the minute plants and animals. Many forms new to science were soon collected in this way, even in coastal waters, although it was not until 1872–76, when the "Challenger" expedition explored the great oceans of the world, that a real impression was obtained of the almost infinite variety hidden in the sea. In 1889 Victor Hensen (who first used the name plankton) led his special "Plankton expedition" to make a more detailed survey in the Atlantic; many others followed, the most recent being the series of "Discovery" expeditions to study the life of whales in antarctic waters. In 1902–08 the International Council for the Exploration of the Sea set an example of co-operation in research by arranging for its fishery program to include an international survey of plankton distribution in and about the North sea. Equally as important as all this work at sea was that done by the marine shore stations, of which those at Naples, Plymouth, and Woods Hole (Mass.) are among the most famous.

The Cycle of Life in the Sea.—Just as all life on the land is ultimately dependent on the sun for its existence, so it is also in the sea. Simple nutrient salts (phosphates, nitrates, etc.) are everywhere dissolved in minute quantities in the water together with carbon dioxide. With the aid of light energy from the sun's rays, the large seaweeds of the shores build these into the complex materials of their tissues. For this reason the seaweeds live only within reach of the sun's rays and, since they are normally attached, they can form only a fringe of vegetable life around the continents and islands. Again as on land the marine animals need their food in a complex form, ready-made either by plants or by other animals which themselves have fed upon plants. The seaweeds, however, are too few to feed more than a small proportion of marine animals, and most of these depend on the planktonic plants (phytoplankton). These plants float in countless millions in the upper layers of the water, buoyed by a 'variety of devices which lessen their density so that they remain in the sunlit zone. When the supplies of nutrient salts are sufficient, and the light and temperature adequate, they may double their numbers daily until in places the sea becomes coloured with them or even foul. They provide the food of the minute planktonic animals (zooplankton) which in their turn form the chief food supply of young fish; in their youngest stages the fish too may feed on the plants. Some fish, such as herring and mackerel, feed largely on plankton for the whole of their lives, as also do the whalebone whales. Other fish, as they grow, feed more and more on larger animals, either fish or animals which live on the sea floor, such as crabs and whelks. This life of the sea floor, in its turn, is fed by the rain of dead and dying plankton which is continually falling from the upper layers of the water. The whole system forms a network of feeding "chains," which, as the salts and carbon dioxide are returned to the sea by excretion and death, is seen to be part of an elaborate chemical cycle.

As the sunlight strengthens and penetrates deeper during the spring, the few green plant cells which have remained in the upper layers over the winter months begin to divide and spread through the waters, usually first near the coasts and then farther out to sea. The warming of the surface waters in late spring and summer sets up a boundary between the less dense surface water and the deeper layers which are still cool, so that chemical exchange between them becomes difficult. The phytoplankton con-

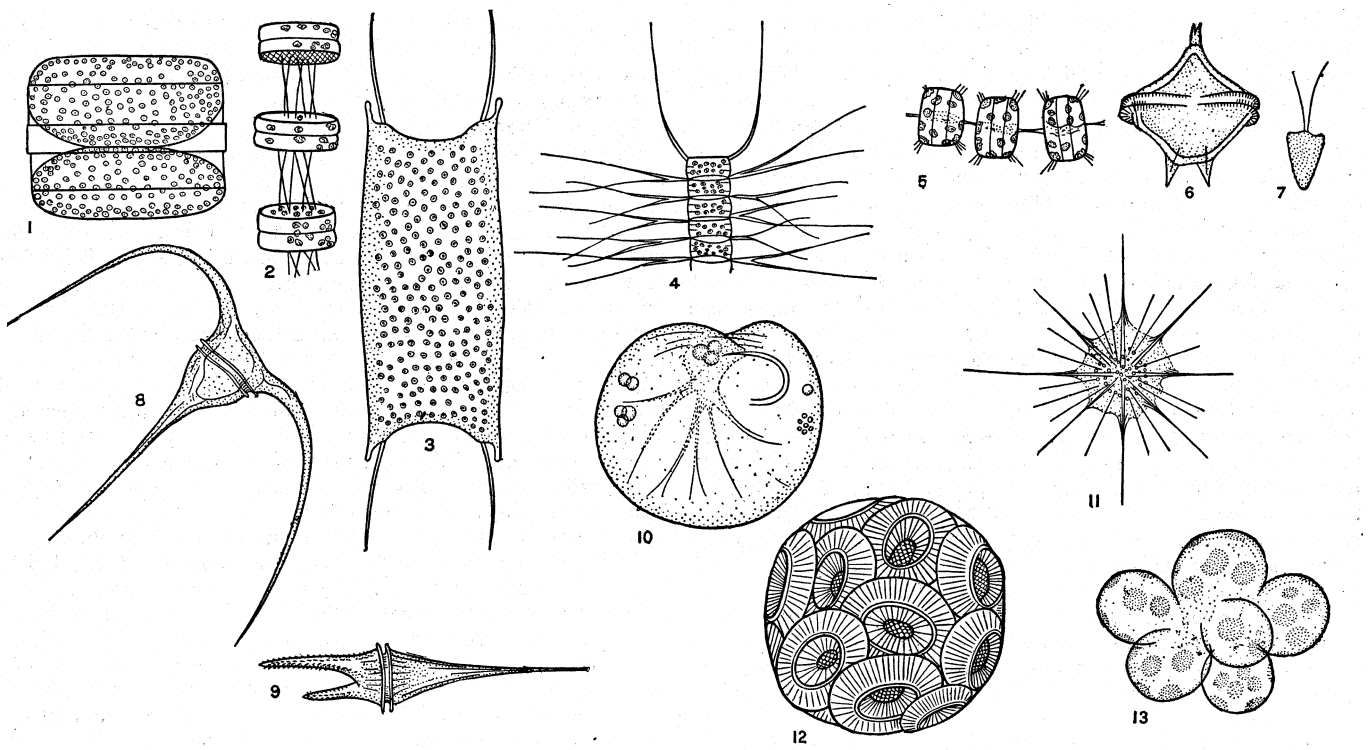


FIG. 1.— UNICELLULAR PLANKTON: MAINLY PLANTS

1-5. *Diatoms* (1. *Coscinodiscus*, 2. *Coscinosira*, 3. *Biddulphia*, 4. *Chaetoceros*, 5. *Thalassiosira*); 6., 8., 9. *and* 10. *Dinoflagellates* (6. *Peridinium*, 8. *and* 9. *Ceratium*, 10. *Noctiluca*); 7. *Algal spore;* 11. *Radiolarian (Acanthometron);* 12. *and* 13. *Other flagellates* (12. *Coccosphaera*, 13. *Phaeocystis*)

sumes most of the surface supplies of nutrient salts during its spring increase so that the phosphorus and nitrogen exist only in the plant tissues and in the animals which have fed upon them. Partly as a result of this consumption, and partly as a result of the "grazing" of the zooplankton, the green plants are normally scarcer in the summer; in their places develop smaller numbers of brownish dells (dinoflagellates) whose requirements of salts are much less. The zooplankton, however, has increased greatly, both by the reproduction of permanently planktonic animals and through the hatching of innumerable planktonic larvae of fish and bottom-living species. A little later these planktonic larvae take up their adult lives as swimmers or bottom-dwellers; their survival up to this stage has depended on the supplies of phytoplankton available to them.

Fish and other animals take their toll of the permanently planktonic animals which, by the autumn, are decreasing. The year is not over, however, for there is a second (autumnal) harvest in the sea. As the autumn storms develop and the sun's rays decline, the boundary between the light surface waters and the denser deep ones breaks down and the two layers can mix again, providing fresh supplies of salts to those waters still lighted by the sun. Another crop of green plants, not always the same kinds as in the spring, has a brief period of abundance before winter sets in. Usually, little plankton is to be found in the winter months, either plant or animal, but during this time the supplies of salts are redistributed and restored (following the continual processes of decay) by strong vertical and horizontal water movements.

The cycle just described is typical of temperate waters in the northern and southern latitudes; the seasons are similar even though the months are reversed. In higher latitudes the spring and autumn plant harvests are respectively later and earlier until in the polar regions they meet as one. In warmer waters neither is so prominent; the plant numbers at any time are far fewer but, with the possibility of reproduction over the whole of the year, the quantities available for animal food may still be appreciable.

Planktonic life is usually found in recognizable communities, taking the form of distinct patches in the sea. They are, however, by no means static; their natures and constitutions are continually changing, not merely because of the rapid rate of increase and decrease common to all small organisms, but also because of changes in their environment and the complex interactions between the organisms themselves. The proportions of prey and predator in the different food chains are never constant, and a change in one is rapidly reflected in others since the chains are parts of a continuous network. Feeding relationships are not the only ones whereby the organisms interact, for there must also be relationships depending on the plants' varying needs of the different nutrient salts. Another type of interaction is based on observations that many plankton animals (and some others) are relatively scarce where the plants are very numerous; the animals appear to avoid regions in which plant activity has been excessive.

The Kinds of Plankton.— There are representatives in the zooplankton of nearly every important group of animals from the fish downward, although only one major plant group, the algae, is found in the phytoplankton. The best-known members of the phytoplankton are the diatoms, unicellular greenish-brown plants enclosed in a transparent shell of silica. They range in size from forms like the long *Rhizosolenia styliformis,* just visible to the naked eye, to the minute species of *Nitzschia.* Many, like these, live as separate individuals, but others (*e.g., Thalassiosira)* are joined in chains; some forms have their shells drawn out into long hairs (*e.g., Chaetoceros).* Together they form the most conspicuous plankton plants and in places their dead have accumulated to give rise to large beds of "diatom ooze" composed mainly of the shells. They were long thought to be the chief food producers in the sea, but it is now known that far greater numbers of smaller algae, mainly green flagellates, may play a more important part. The flagellates are also unicellular and the most familiar are the brown ones (dinoflagellates); they are typical of the summer and produce much of the phosphorescence seen then (*e.g., Ceratium, Peridinium,* etc.). They build living tissue as the diatoms do but, by means of a pair of whiplike flagella, they can move and eat the very smallest particles of food as well. They are adaptive to environmental conditions, apparently changing their shapes gradually in response to changes in temperature, so that their varied forms have been used to dis-

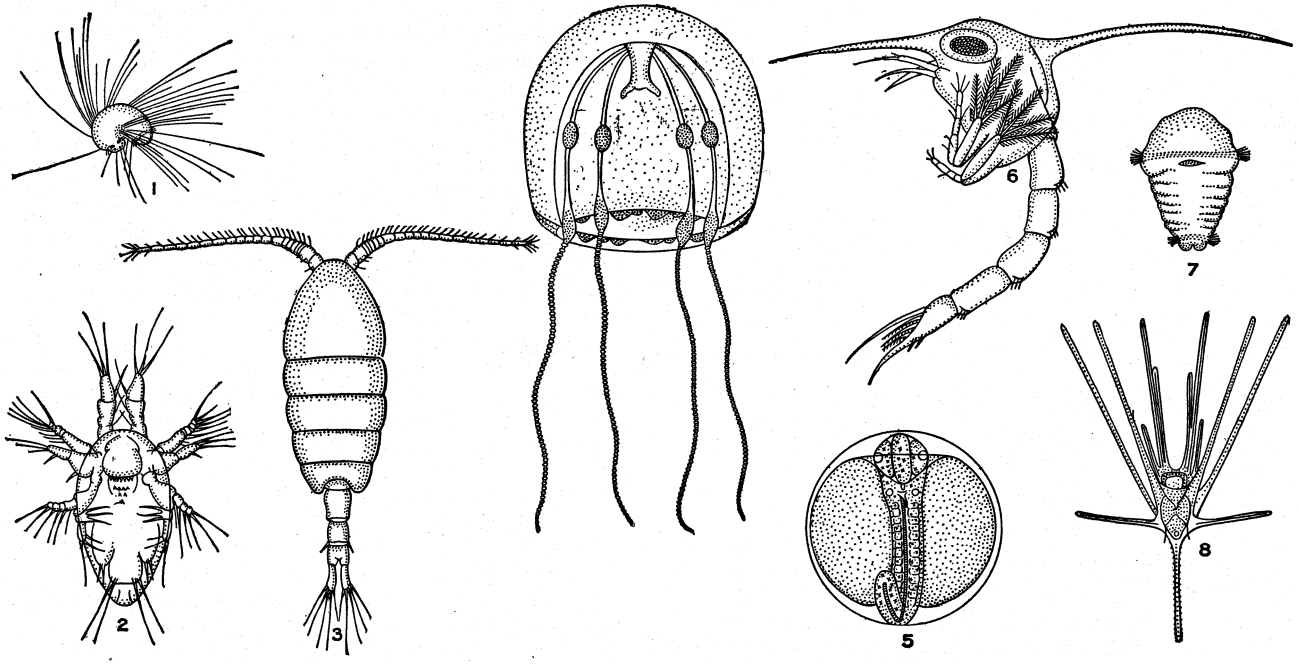


FIG. 2.— ANIMAL PLANKTON: MAINLY LARVAE

1. Splonid larva of marine worm; 2. Nauplius larva of copepod; 3. Adult copepod (*Parapontella*); 4. Medusoid larva of Eucope; 5. Developing fish egg; 6. Zoea larva of crab; 7. Metatroch larva of marine worm; 8. Pluteus larva of brittle starfish

tinguish water masses of different origins. The smaller green flagellates live wholly like plants, except for their locomotion by means of flagella; at certain seasons may be included with them in the phytoplankton the myriads of flagellated spores and germ cells released by larger marine plants. Most of the green flagellates are individual, but one form is familiar for its habit of living colonially in a gelatinous mass and is normally nonmotile. It is called *Phaeocystis,* and may at times be abundant enough to clog herring fishermen's nets, causing much trouble in cleaning.

The coloured flagellates, with their animal movements and plant nutrition, have been studied by both zoologists and botanists, but there are numbers of colourless ones which can be considered only as animals: a large and unusual one, *Noctiluca,* is another cause of luminescence on summer nights. Two more unicellular plankton groups, both related to amoeba but far more striking, are the Radiolaria and the Foraminifera. Both of these have elaborate skeletons and, following the deaths of the adults, these also have accumulated in such numbers over certain parts of the oceans as to give their names to distinctive oozes on the sea bed.

Most marine animal groups are represented in the plankton for a time by large numbers of eggs and larvae, and few of them are without at least one wholly planktonic representative. Among the most beautiful are the Ctenophores, Siphonophores and jellyfish *(see* MARINE BIOLOGY) as well as the medusoid larvae of the bottom-living coelenterates. Among the worms the arrowworm (*Sagitta*) is particularly important in plankton research; other worms provide their trochophore larvae and a number of wholly planktonic adults. The molluscs include whole groups which are planktonic. There are the pteropods (*Limacina,* etc.) which, by their cast shells have given a name to yet another type of ooze, and the heteropods (*Carinaria, Pterotrachea,* etc.); in addition there are the veliger larvae of many bottom-living molluscs. The pluteus larvae of the echinoderms are also prominent members of the plankton, although the pelagothurians are the only wholly planktonic echinoderms. Another group, closely related to the sea squirts, includes the salps and doliolids, with their barrel-shaped gelatinous bodies; they are wholly planktonic and, in coastal waters, may be valuable indicators of oceanic water. A related animal is *Pyrosoma,* which is luminescent, but found only in warm waters.

The Crustacea must be considered the most important members of the zooplankton. They have many kinds of planktonic larvae (*e.g.,* the zoea larvae of crabs); and one particular section, the planktonic copepods, plays in the sea some of the parts played by insects on land. Most of the copepods are less than one-eighth inch in length but they are among the most numerous animals in the sea, grazing down the phytoplankton and providing basic food for fish. There are many species, but the best known of them is *Calanus finmarchicus,* abundant round all the shores of the North Atlantic. The Euphausians, with their serried luminous organs, are another important planktonic section of the Crustacea. These are the chief food (krill) of the largest animals the world has known, the blue and fin whales. So dense are their swarms in antarctic waters that the whales can, by taking gulps of water and straining the plankton through their whalebone, feed fast enough to grow within 2 years to sexual maturity and a weight of about *60* to 70 tons.

An early but most important discovery was made by G. O. Sars when he showed that most fish, including those of economic importance, have planktonic eggs and larvae; herring differ in laying their eggs on the sea bed but, on hatching, their larvae immediately drift into the upper waters. This discovery answered one of the early objections to the use of heavy trawls in fishing, for many fishermen had feared that by trawling they would ruin the spawning grounds of the fish.

Distribution and Movements.—There are few, if any, masses of water without plankton and, although the phytoplankton is necessarily limited to the illuminated layers, zooplankton has continued to be found (in gradually decreasing numbers but often increasing size) as new methods have made deeper sampling possible. Before the cruises of Wyville Thompson in the "Lightning" and "Porcupine" (1868–70) it had been thought that life was impossible in depths greater than *300* fathoms. These and later expeditions suggested that depth determined only the nature of the life and never prevented it. Whether on the bottom or free in the water, life at great depths is necessarily scarce, since it and all the animal life for perhaps five miles above it is indirectly dependent on the activities of the plants within a few metres of the surface. While there are many exceptions, it is general for transparent or pale blue animals to be limited to the surface layers, in contrast to the deeper occurrence of reds and violets; vivid scarlets and blacks are mainly to be found only in the great depths. The full reasons for this are ill understood, but they are likely to be associated with the manner in which light rays penetrate water, the red ones least of all and the blue ones most. More

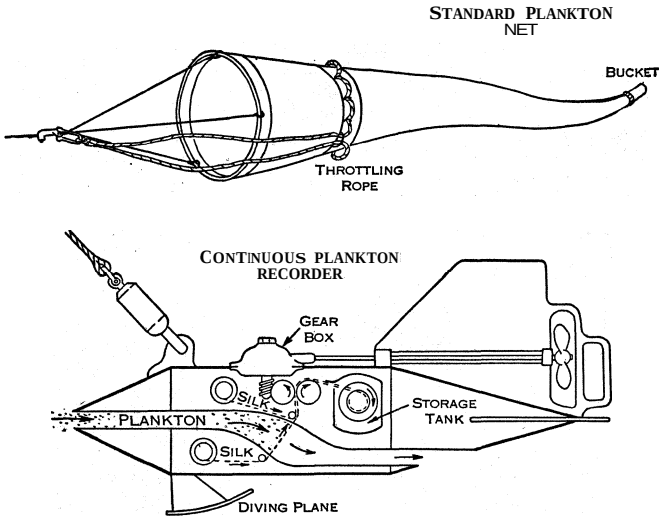


FIG. 3.—COLLECTING APPARATUS

A typical plankton net, with throttling rope, is shown above. In the continuous plankton recorder, shown below, the plankton is collected between two bands of silk mesh driven by the propeller working through a gear box

astonishing is the abnormal development of the eyes in some deep fornis and, often in the same animals, the elaborate structure of their luminous organs.

Light has been thought to play a major part in the regular vertical migrations which most plankton animals make each day. Usually they move upward as the light declines and downward again, sometimes over hundreds of feet, as the light strengthens in the morning. Many observations and detailed experiments have been made to uncover the processes resulting in this vertical migration. While light must almost certainly play a large part, some research has suggested the possibility of its interplay with other factors, such as a changing response to the effects of gravity, a daily rhythm in the need for plant food and reactions to slight changes in the acidity of the environment. Some plankton animals appear to vary in the range of their vertical migrations roughly in accordance with the extent to which they appear to avoid phytoplankton. One theory suggests that it is by descending for the daytime that the animals escape those products of plant activity which they appear, when viewed from above, to be avoiding. At night, when the plants' activities are changed, the animals migrate upward to feed. During vertical migration, the animals alternate between layers of water which often move at different speeds and directions; their horizontal positions are automatically changed, not only in relation to each other, but also in relation to the phytoplankton, from beneath which they tend to be removed.

Apart from the influence of light, it is probable that temperature is the chief governing factor in the distribution of the plankton. Many animal forms are to be found deeper during the summer months than in the winter. Others with a wide distribution may appear at the surface in polar waters, but live only in the depths of tropical waters, where a low constant temperature is maintained. Heat must be the controlling factor there, although light may have a part in the seasonal migration. Within the surface waters there are striking changes as one travels from the north, through the tropics and so to the antarctic. In contrast to the vast quantities of plankton in the higher latitudes the tropical waters are much more thinly populated; this may be a partial explanation of the distribution of the chief commercial fisheries. On the other hand, the tropics provide a wealth of variety which has made the plankton there a permanent source of wonder to marine biologists.

While some of the organisms are almost world-wide in distribution, most are limited by some factor or other so that each of the seas has its own particular combinations of life; and collections from different places, and also from different depths, can easily be recognized. Within them all, however, it is convenient to make another type of distinction, in which the saltiness of the water is important. The proportionate constitution of sea salts scarcely varies over the whole sea, but their total quantity in relation to the water rapidly diminishes near the coasts and the polar ice masses, where the fresh water dilutes the sea. The coastal waters have their distinct types of plants and animals, usually termed neritic in contrast to the more widespread, but less abundant, oceanic plankton. The mixed waters between them in temperate and polar seas are among the richest in the world, for the oceanic waters provide large supplies of nutrient salts and large plant crops develop there each spring. Supplies of salts are also replenished by deep ocean currents upwelling against the coastal banks, so that phytoplankton flourishes there and the bottom life is abundant. It is in just such places that the largest trawl fisheries have been established. The interplay of oceanic and coastal waters is intensively studied for this reason, and an important advance was made when it was found that some of the larger and more typical planktonic forms (such as the species of *Sagitta)* may be used as easily recognizable indicators of the relative strengths and distributions of these waters in different years.

Methods of Collecting **Plankton.**—The commonest means of collecting plankton have changed little since J. Müller first towed his conical net at the sea surface. At the tail of his net he had a small glass tube into which the filtered organisms were washed and so preserved from damage. A net such as this may be used by any naturalist in local waters to add greatly to his enjoyment of the varied forms of life. The plankton nets used on the "Discovery" expeditions of 1924–39 were essentially the same, though developed and specialized for various purposes. The finest and smallest are of silk (up to 200 meshes to the inch) and long in proportion to the net opening so that the meshes provide as great a filtering area as possible; in place of glass tubes, they have small detachable metal "buckets" to collect the samples. Larger and coarser nets are made of stronger material and are used for the larger animals. Since the nature of the plankton varies greatly with the depth of water it has become essential, whether the net is used vertically or not, to know at what depth it has been fishing, and it is common for nets to be fitted with throttling ropes so that they may be opened and closed when desired. Series of such nets may be used together at various depths on one towing wire, being opened and closed by weighted "messengers" running down from net to net and operating trip mechanisms through which the throttles are worked. Such methods can be used only from specially equipped research ships working slowly from station to station, but they have provided the bulk of our knowledge of plankton distribution. They can be supplemented by pumping water through a flexible pipe and filtering the plankton on deck; this has the advantage of more complete control than nhen using nets, although delicate planktonic forms may be destroyed by the water pressure For some purposes samples are best taken in a "nater bottle" (see MARINE BIOLOGY) which can be closed or opened at will to collect a known quantity of water, perhaps with a temperature record, for chemical and biological analysis. This is suitable for small forms which easily pass the meshes of the finest silk; they may be collected into a small volume of water by centrifuging and then examined.

Tno other instruments have been used in later years. One, the plankton indicator (mentioned below), collects samples on a disc of silk mesh placed at the end of a small tube; it is convenient for certain types of research and for commercial purposes The other, the continuous plankton recorder, is a development of this for collecting continuous samples of plankton on a moving band of silk. It is so arranged that it may be loaded in a laboratory and handed to the officers of commercial ships for automatic collection and preservation of plankton while being towed between selected points on their routes; the machine nith its record is then returned to the laboratory for analysis. With this apparatus continuous records of plankton can be obtained regularly over wide areas at a small cost; they provide standardized data for comparison nith hydrological observations and the landings of fish

Plankton and the Fish Supply.—Though the place of plankton in marine economy had been realized for some years, its practical applications were still only beginning to be developed in

the 1930s. Not until a wide knowledge of the types of plankton and their variations in abundance had been obtained could scientists begin to ask those questions which might give answers of commercial value.

A casual association of the herring with plankton had long been realized before detailed analysis of thousands of stomach contents showed it to be dependent on plankton throughout its life. Its fate immediately after hatching hangs on a supply of plant plankton; then, as it grows, it feeds on the smallest animals, and later on larger ones. Even when adult, the herring can get from the plankton alone those supplies of oil which seem to be necessary for its own reproduction. and make its flesh so valuable as human food. From late spring to summer, varying a little with the years, herring feed intensively on the copepods (especially the large one called *Calanus*) and their growth rate depends on this supply of food. It is known that the success or failure of a fishery may be influenced not only by the abundance and distribution of the copepods, but also directly by the plants. Small samples of plankton were taken regularly over four years with the plankton indicator in waters fished by herring drift nets; each was analyzed and correlated with the numbers of herring caught in association with it. One of the resulting correlations showed the regular scarcity of adult herring in waters where the plants were very abundant; since this applied when the herring were scarcely feeding. there appeared to be a definite avoidance of such waters by them. In confirmation it was shown that dense patches of diatoms or the colonial flagellate, Phaeocystis, may deflect the spawning shoals of herring from their usual grounds. The other correlation showed that more herring were caught when the copepod, Calanus, was abundant than when it was scarce.

In addition to studying the structure of the different types of plankton. most valuable work has been done in marine stations on the conditions which are necessary for their life. There the nature of the annual cycle in the sea was worked out and the first attempts were made by J. E Allen to provide a suitable mixture of nutrient salts which would allow full and free growth of the plants in the laboratory. While all require the phosphates and nitrates which are familiar in plant growth on land (artificial manures), the specific additional needs for full growth are difficult to'discover. So far, only a small proportion of even the best knonn have been cultured in this way, but success with them has laid the basis for an attempt at larger scale work. From the small flasks of the laboratory, one step was to "manure" large tanks of natural sea water in which oysters could be placed to lay their eggs, so that their planktonic larvae should have an abundance of plant food as they hatched; after this nursery period they were transferred to commercial oyster beds for later growth. Another experimental step was to construct a plankton well which could be filled with sea water, manured and inoculated with plankton; it was then used for observing aspects of planktonic life which can not be studied in the sea and may never proceed satisfactorily on a small scale. A development of this was to isolate a small area of the sea (a small sea loch), to manure it and compare processes in this part with those nearby where only natural nutrients were found. The benefits of artificial manuring were seen in the increased quantities of planktonic plants and animals. More important was the large-scale proof of the effect this had upon the bottom animals in the experimental stretch of water; they also increased and, in turn, supplied enough food to young fish to enable them to grow at twice their normal rate.

In his early attempts to introduce rigorous methods into plankton research, the pioneer Victor Hensen hoped to be able to estimate, from actual counts of plants and animals, the productivity of different parts of the sea. If he was not successful it was mainly because much more knowledge was needed before even approximately useful estimates could be made. The plants must be the basis of any estimates of production, but their total numbers at any moment bear little relation to what has been, or what will be, produced during the year; many have yet to appear and others have already sunk to the bottom or been converted into animal tissue. Better estimates are made from knowledge of the decreases of nutrient salts in a body of water and the amount of phytoplankton they may produce. In the English channel, for example, something like five tons of wet plant material is produced each year, on the average, for each acre of surface; this may be compared with the similar average yield of potatoes on land and the higher weights of some other crops. Only a fraction of this weight is now available to man in the form of edible fish, etc. (although some forms of plankton, particularly *Calanus*, are quite eatable); but future methods may greatly increase this fraction.

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PLANTAGENET, a surname conveniently, but unhistorically, applied to the royal line descended from the union of Geoffrey, count of Anjou, with the empress Matilda, who are now styled by historians the Angevin house. It was, historically, only a personal nickname of Geoffrey. as was "Curtmantel" of his son (Henry 11), and was derived from his wearing in his cap a sprig of the broom (genet) plant.

When the fashion of personal nicknames passed away, the members of the royal house were usually named from their birthplace, as Thomas "of Brotherton," Thomas "of Woodstock," and so forth. But Edward I and his younger brother, the founder of the house of Lancaster, had nicknames, respectively, as "Longshanks" and "Crouchback." In the later days of the dynasty the surname of Beaufort was adopted by the legitimated issue of John of Gaunt by Katherine Swynford, but that of Plantagenet was bestowed on Arthur, natural son of Edward IV. who was created Viscount L'Isle. It appears, however, to have been adopted as a surname by Richard, duke of York (father of Edward IV), about 12 years before his death.

At the death of Geoffrey's grandson, Richard I, his younger brother John succeeded. John's younger son, Richard, king of the Romans, left a son Edmund. earl of Cornwall, with whom his line ended; his elder son, Henry III. left two sons, of whom the younger was created earl of Lancaster and was grandfather of Henry, earl of Lancaster. whose heiress married John of Gaunt (*i.e.*, Ghent). (See LANCASTER, HOUSE OF.) John of Gaunt's next brother, Edmund of Langley, founded the Yorkist line. (See YORK [HOUSE OF].)

Although no other dynasty has reigned so long over England since the Norman conquest, the whole legitimate male issue of Count Geoffrey Plantagenet became extinct in 1499. See EDWARD VI (genealogical table).

PLANTAGINACEAE, a family of dicotyledonous herbs, the best-known members of which are the plantains (Plantago), cosmopolitan weeds, of which upward of 30 species occur in the United States, and 5 in Great Britain. (See PLANTAIN.) The family contains 3 genera and about 260 species. The seeds of *Plantago* psyllium (Mediterranean) are used in silk and cotton manufacture. The flowers, usually hermaphrodite and inconspicuous, are wind pollinated.

PLANTAIN, a name given to certain plants with broad leaves. This is the case with certain species of Plantago, Alisma and *Musa*, to all of which the term is popularly applied. The species of *Plantago* (family Plantaginaceae) are mostly weeds with a dense tuft of radical leaves and scapes bearing terminal spikes of small flowers; the long spikes of *P.* major, when in seed, are used for feeding cage birds; P. lanceolata, so-called from its narrow lanceolate three- to six-ribbed leaves, is popularly known as ribwort. *P.* psyllium and P. indica produce leaves in whorls on branched stems; their mucilaginous seeds are used as demulcents under the name of Psyllium; Alisma *plantago-aquatica* (family Alismataceae) is the water plantain. The tropical fruit known as plantain belongs to the genus Musa. See BANANA.

PLANTAIN EATER: see TOURACO.

PLANTAIN LILY: see HOSTA.

PLANT BREEDING. Not until the middle of the 18th century was the sexual nature of plants incontrovertibly demonstrated, and the term "plant breeding" did not become widely used until after 1900. Thereafter the intentional breeding of superior

plants quickly became a world-wide activity; by the middle of the 20th century the breeding of field and horticultural crops was so standardized that it was largely in the hands of experts, much of it centred in a few large agronomic and horticultural institutions operated mostly at government expense.

For a variety of reasons the breeding of new and superior ornamental plants, though carried on in part by scientists and by tradesmen, was largely in the hands of gifted amateurs. As the result of their efforts. thousands of new varieties of dahlia, gladiolus, African violet, peony, narcissus, iris and rose came into being.

The breeding and purveying of these new varieties to the public spawned hundreds of small business enterprises. In the U.S. alone the business of producing and marketing new varieties of African violets was, by the mid-1950s, grossing more money per year than all the marketing of fruit trees, vines and bushes (both temperate and subtropical) in the same area.

Mode of Reproduction. — Any successful plant breeding program must be based upon a sound understanding of the exact mode of reproduction of that plant. Plants may reproduce in two ways: (1) vegetatively (that is. asexually) through the increase of a small portion (bulbs, tubers, etc.) of the original plant; and (2) sexually through the flower and seed. Even for those plants in which vegetative reproduction is not highly developed under natural conditions, the artificial rooting of cuttings and the grafting of roots and of stems, make it possible to disseminate pieces of a superior individual by vegetative means. Asexual propagation through seeds is of fairly frequent occurrence in the higher plants, and careful research work is required to establish the exact degree to which it may be a factor in any breeding problem. Either an unfertilized egg cell may develop into a mature but very weak plant (and yet of potential economic importance to the hybrid maize industry, for example, since such a plant offers a rapid means of isolating useful, true-breeding strains), or in any one of several different ways the embryo in the seed may be formed directly from the tissues of the mother plant.

Frequently the two processes go forward side by side so that some seeds are true sexual offspring and others from the same seed head are vegetatively derived from the mother plant. The more thoroughly these matters have been investigated for any particular crop, the more completely is it possible to set up a successful breeding program. Vegetative reproduction is of great practical importance in permitting the rapid increase of a single desirable individual.

Different kinds of plants not only vary in the extent to which they may be propagated sexually, but also in the degree to which they are naturally inbred or outbred. Among the higher plants both extremes are found. There are crops such as wheat which are naturally very inbred, being almost completely self-pollinated. Others such as maize are mostly cross-pollinated under field conditions, though self-pollination is possible by artificial means. Still others (many plums for instance) are naturally self-sterile and cannot be self-pollinated though any particular flower may function effectively as either a male or a female in crosses with other plants.

Self-Fertilizing Species. — Naturally self-fertilized species have largely been improved by pedigree or pure-line selection. Most of the older varieties of wheat, oats, barley, cotton, beans and tomatoes have so arisen. However, as the ceiling of remaining variation is reached by selection, hybridization of pure lines is resorted to for further improvement. The pure-line method of breeding is based on the principle that the progeny of any individual plant selection in naturally self-pollinated species breeds true. The problem is then one of isolating the superior pure lines and increasing stocks of these.

Proper statistical treatment is often essential in detecting the most efficient strains. The second quarter of the 20th century showed a remarkable increase (virtually world-wide) in the expert use of field plot techniques for estimating the extent to which yield differences are due to inherent superiority rather than favourable soil or climate.

Cross-Fertilizing Species. — Naturally cross-fertilized species are more difficult to handle, because any inbreeding necessary to fix desirable characters often leads to a decline in vigour. One may accordingly use continuous mass selection broadly, avoiding inbreeding. One may, on the other hand, use a combination of inbreeding and controlled hybridization to utilize the phenomenon of hybrid vigour as was done so spectacularly in hybrid maize improvement.

Hybrid Maize. — The hybrid corn industry in the U.S. traces back to the scientific research of G. H. Shull and E. M. East who reported their results of inbreeding followed by hybridization in 1907–10. Not until the 1920s were these theoretical results incorporated into practical breeding programs. Phenomenal increases in uniformity, in yield, and in resistance to lodging (dropping of ears) and disease then became possible. As late as 1933 only a fraction of 1% of the Iowa corn acreage was devoted to hybrid corn, but in less than 10 years the percentage was 99.

The bases for hybrid corn are self-pollinated or highly inbred lines. These inbreds are crossed, usually detasseling the mother rows to make either single crosses (line A × line B), or by utilizing these single crosses to produce double crosses (the cross of line A × line B crossed with the hybrid of line C × line D). Most commercial field corn is produced from double crosses. Seed from the commercial crop is not saved by the grower for seed stock the next year but new seed is purchased each year from expert corn breeders. This has led to the development of a multimillion dollar hybrid seed corn industry which produces seed for most of the commercially important maize-growing areas in the U.S. and exports a fair amount to other countries.

Use of Male Steriles. — This inbred-crossbred breeding method is technically facile in maize because the male (tassel) and female (ear) inflorescences are in different parts of the plant, making artificial self-pollination or controlled cross-pollination economically feasible even on a field scale. Few other crop plants are so readily manipulated, but by the use of male-sterile strains the mass production of cross-bred seed is made possible. It requires such a precise understanding of the genetics of the crop in question that male-sterile plants can be created at will. They are then grown in isolated plots adjacent to male-fertile lines of the variety which is to serve as the male parent and the desired matings are produced naturally by insect or wind pollination.

Hybrid tomato seeds quickly became a commercial success by this method and the use of male steriles for the more economical production of hybrid seed was soon extended to other crop plants, including even maize (where it helped reduce the expense of artificial detasseling).

Breeding Bacteria and Fungi. — Breeding of bacteria and fungi for increased efficiency in fermentation processes quickly passed from the experimental into the industrial field. Beginning in 1935 with work in Denmark, better strains of yeast were produced by hybridizing different species and varieties. The rapid development of antibiotics led to large-scale selection and breeding programs with many strains of microorganisms.

Polyploidy. — It mas a full quarter century after the improvement of small grains had been reduced almost to a rule of thumb before the significance of chromosome numbers in plant breeding was well understood. Gradually it was realized that a considerable proportion of the higher plants have their germ plasms arranged in several sets of chromosomes. The simplest condition is similar to that which prevails among the higher animals. There are two sets of chromosomes and the species (or variety) is said to be diploid. However, there are in the higher plants many species and varieties with four (tetraploid) or six (hexaploid) or even more sets. Any organisms with more than two sets is said to be polyploid. Generally speaking, polyploids with even numbers of sets of chromosomes are more or less fertile, those with odd numbers being generally sterile, sometimes completely so. For instance, if a cross is made between a fertile tetraploid and a fertile diploid, the hybrid normally inherits two full sets from its tetraploid parent and one set from its diploid parent and is in consequence a triploid, which may be quite sterile for this reason alone. Breeding programs with such organisms must, to be successful, take polyploidy into account. They may work with diploids and tetraploids to produce further triploids. They may, by expert manipulation

with such external agents as colchicine, at length succeed in doubling the chromosome numbers of the sterile triploids, producing fertile hexaploids from them.

As an understanding of the main facts of polyploidy gradually spread to more and more amateurs and tradesmen, the improvements of such partially polyploid ornamental crops as irises, orchids. and narcissuses lost much of their mystery. In all of these crops polyploids are often intrinsically more valuable than diploids since an increase in flower size and keeping quality frequently goes along with polyploidy. All of these crops had tended to have the smaller diploid varieties of a century ago, replaced by the larger flouering tetraploids and triploids when they accidentally arose.

Until the significance of chromosome numbers to breeding problems was generally realized. plant breeders did not know how to interpret the differences in breeding behaviour between closely related triploids and tetraploids. The development of rapid methods for determining chromosome numbers and the consequent clarification of various breeding problems related to polyploidy has catalyzed both amateur and professional plant breeding with such crops.

Plant Breeding Institutes. — Some well-known centres for plant breeding in the second half of the 20th century were: *Australia*—department of agriculture, Sydney; Brazil — Instituto Agronômico do Estado de São Paulo, Campinas; *Canada*—Dominion Experimental farm, Ottawa; England — University of Cambridge, school of agriculture, Cambridge, and Welsh Plant Breeding station, Aberystwyth; Germany — Kaiser Wilhelm Institut für Ziichtungsforschung, Miincheberg ; India — Indian Agricultural Research institute, Pusa, New Delhi; Sweden--Sveriges Utsädesforening, Svalof ; *United* States — U.S. department of agriculture, Washington, D.C.; regional laboratories at State College, Pa.. and Charleston, S.C., and state experimental stations with well-equipped laboratories and experimental plots (California, Connecticut, Illinois, Indiana, Iowa, Minnesota, Missouri, New York, Ohio, Wisconsin).

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PLANT CELL (TISSUE) CULTURE. The cultivation of specific tissues or of specific organs apart from the complete organism on artificial media inside sterilized glass containers is commonly spoken of as tissue culture. The cultivation of plant cells by this means is treated in this article. (See also ANIMAL CELL [TISSUE] CULTURE.) Isolated small groups of cells, such as root tips, cambium and growing points, are separated from the rest of the plant and grown on suitable culture media. The procedure is comparable to that employed with bacteria and fungi. It makes available for physiological study of specific parts of higher plants the techniques used so successfully with microorganisms. Without interference from influences of other parts of the plant, for example, it is possible to determine what metabolic substances and what amounts of each one may encourage growth, what ones may inhibit growth, and what materials are produced by the attendant physiological processes.

History. — The need for growing isolated portions of higher plants in vitro (*i.e.,* in glass) was long recognized. A critical step forward was made in 1922 simultaneously by workers in Germany and in the U.S. with the cultivation for some weeks of root tips from peas, cotton and corn in artificial media. These media contained yeast extract or meat extract, sugar and mineral salts. The cultivation of tomato root tips for as long a time as desired in a comparable medium was achieved in 1934. The callus or "tumour" type of culture was achieved in 1939 by several different investigators working simultaneously and independently in France and in the U.S. Among the early successful cultures were those secured from carrot root sections, from natural galls occurring on tobacco hybrids, and from tissue resulting from inoculations with the crown gall bacterium *Agrobacterium tumefaciens*. Furthermore, excellent media were perfected which contained only nutrients with known chemical formulae. This positive information about every nutrient present was a great advantage for physiological studies. For example, with blood serum or coconut milk in the medium, it was difficult to tell which portions of these complex materials encouraged growth. Furthermore, if analyses of the medium were made after growth, it was difficult to differentiate between the compounds in the original medium and those produced during the growth process.

Many kinds of tissue have been cultivated from a number of different plants. Over 200 kinds of cultures have been made mostly from diseased or normal growth of the dicotyledons. However, some cultures also have been made from monocotyledons, ferns and other plants. Thus the way was opened for applying to portions of higher plants the standard bacteriological, physiological and biochemical techniques so long and fruitfully employed with bacteria and fungi.

Nutritive Media. — The nutritive media most commonly employed contained nitrate as a source of nitrogen, some ordinary sugar as a source of carbon, and well-balanced common mineral salts. The tissue from diseased growth commonly manufactured enough hormones and vitamins so that none were added. However, some cultures from normal tissue needed supplements such as coconut milk, yeast extract. or traces of indole-3-acetic acid or naphthalene acetic acid. For root tips, liquid media were commonly used. For other cultures, 0.6% agar was ordinarily added to support the tissue on the surface. The basic media were modified so as to secure much fundamental information about the nutritional requirements of the various tissues and also about the critical balance of concentrations that favoured or inhibited growth and that influenced differentiation.

Tissues Cultivated. — A series of different kinds of tissue were grown in culture by the following aseptic techniques: To secure root tips, a surface sterilized seed was germinated and about 1 cm. of a root was removed aseptically and placed in a shallow sterile liquid medium in a flask or bottle. To secure growth from plant embryos, a fairly mature and actively growing embryo was removed aseptically from the ovary. Ordinarily they required a well-enriched medium. Such technique permitted the growth of plants from certain cross pollinations which otherwise never would have developed. "Nurse" technique, discussed below. has offered possibilities with much younger embryos. For callus or "tumour" cultures, galls with as little contamination as possible were cut into a large number of pieces about 2 mm. across. Many of them were contaminated with bacteria or fungi, but perhaps one-fifth were aseptic. Among these, several grew satisfactorily in tissue culture. For callus from normal tissue, similar isolations were made aseptically of sizable pieces from actively growing parts such as the growing tip or the cambium. Usually normal tissues required some such supplement as a trace of auxin. In certain cases. such normal tissue became "habituated" during culture so that it grew without added auxin.

The tissues in culture varied enormously in their rate of growth — from extremely slow to rapid, some doubling their weight in five days. Those which grew rapidly were transferred after four to eight weeks. The amount of growth was measured either by visual estimate or by removing the tissue from the culture medium and by weighing it.

Contaminations have been a continual problem with tissue cultures, as with any other pure culture procedures. Certain fungi or bacteria sometimes grew inside the tissue mass without being apparent from the surface. Consequently routine maceration and incubation of a tissue sample in a rich medium was a necessary routine to reveal any contamination if it were present.

Application. — The applications of this relatively new but extremely useful technique have covered much of biology. This subject has been discussed in the article ANIMAL CELL (TISSUE) CULTURE and is not repeated here because of the fundamental similarity in growth and metabolism shown by cells in plants and in animals. The work with plant tissues has three important experimental advantages over that with animal tissues: (1) Culture media for animal tissues commonly contain complex substances like serum and embryo extract. By contrast. most plant tissues grow on simple synthetic media, with the experimental advantages

explained earlier. (2) Animal tissues commonly require a change of nutrient every few days, a time-consuming process associated with elaborate precautions against contaminations. Most plant tissues grow satisfactorily for a month or more on the original medium. (3) Many animal cells send pseudopods or dendrites into the substratum so that cells and media are inseparable. The kind and amount of growth are relatively difficult to measure. The plant cells have no such processes. After incubation, the cultures are removed from the medium and the amount of growth is measured precisely by weighing the tissue and by subtracting the weight of the original tissue piece. Thanks to such techniques, a number of important basic studies have been completed.

The nutrients necessary for stimulating growth have been studied intensely with various tissues, and the common sources of carbon, nitrogen, mineral salts, vitamins and hormones have been established. Rather strikingly the amount of the nutrient often has appeared to be as important as its chemical formula.

The inhibition of growth correspondingly has been demonstrated for certain common metabolic substances. Among these were some of the simplest of the organic acids. their homologous alcohols and a number of amino acids. The size of the tissue mass apparently was critical in determining whether or not the tissue could grow in the presence of certain mildly inhibiting metabolites. An inhibition by certain antibiotics, such as terramycin and aureomycin, was demonstrated.

Some factors influencing the differentiation of tissues have been clarified in a striking manner. Tobacco pith tissue formed roots or shoots in culture depending upon the presence of a suitable balance in the amounts of auxin, adenine (an amine purine), kinetin (6-furfurylaminopurine) or related substances. Numerous chemicals similar to kinetin were active in stimulating cell division and growth. Various growth stimulating factors were found in coconut milk, in horse chestnut milk and in actively growing tissues.

Large mass cultures of plant tissue are theoretically possible. A medium was developed which was so effective that a liquid culture became solid in several weeks from the extensive cellular growth. Tissues from various alkaloid and food-producing plants were cultured. The possibilities of plant tissue cultures for food or special chemicals remain to be explored.

The use of tissue cultures for studying various plant diseases opened several important fields. For example, certain rust and mildew fungi, which do not grow on ordinary media, were grown on tissues in culture. Likewise, nematodes (roundworms) pathogenic on plants were thus cultivated. Certain viruses have been carried for years on tissues in culture and have been used for fundamental studies on virus multiplication and inhibition. Tissues from plant galls incited by insects have also been successfully established. The complete physical and chemical control of such tissues in vitro provides many experimental advantages for basic research; *e.g.*, on pathogenicity, susceptibility and resistance.

An important potato variety, in which all plants were infected with virus, was freed from the virus by tissue culture. The cells at the growing tip of a rapidly growing shoot were found to grow away from the virus. These cells were cut out aseptically and grown in tissue culture, and from these cells potato plants without the virus were again developed.

Cultures grown from individual cells of higher plants isolated from the established cultures were made possible by the development of a "nurse" technique. In. numerous trials, an individual cell was placed aseptically on filter paper and that on living plant tissue in culture, which nourished the single cell through the paper. These plant cells have no dendrites or pseudopods that might grow through the paper. The clones of tissue thus derived showed that the original tissue mass was not homogeneous, but contained cells with various different characteristics. With this "nurse" technique or a suitable modification, cultures are possible of numerous tissues both from plants and animals which otherwise would not grow.

These and other phases of the tissue culture technique made practical numerous investigations of a fundamental nature, including those dealing with diseased growth, many of which appeared to be near the heart of the cancer problem.

See R. J. Gautheret (ed.), "La Physiologie des cultures de tissus vegetaux," *Int. Union of Biol. Sci.*, series *B* (colloques), no. 20, Secrétariat General de l'U.I.S.B. (1955); P. R. White, *Cultivation of Animal and Plant Cells* (1954). (A. J. R.; A. C. HT.)

PLANT COLORATION. The colours of the plant world are predominantly the green of leaves and stems, attributed to chlorophyll; the yellow and orange of many flowers. fruits and leaves, attributed to carotenoid pigments; and the scarlet, red, blue and purple of flowers and fruits, attributed to anthocyanin pigments. These three classes of pigments account for most of the colours found in plants. and only a very small fraction of plant pigments belong to other chemical classes. The anthoxanthin pigments. while universally distributed in plants. are pale yellow to yellow-orange in the pure state; consequently, they contribute little to the visible colours of petals and leaves in which they occur White flowers — which are often actually pale ivory or cream-coloured — usually contain anthoxanthin pigments, the presence of which can be recognized by the yelloning that occurs upon exposure of the petals to the vapours of ammonia.

Most flower petals. nhite or coloured, contain mixtures of two or more kinds of pigments. Brownish and red-orange flower petals owe their colour to the presence of mixtures of anthocyanins and carotenoids. Yellow flowers usually contain carotenoids and flavones, but certain yellow flowers, such as the garden coreopsis or tickseed are pigmented by mixtures of carotenoids and the deep yellow-orange benzalcoumaranone (aurone) pigments. It is to a member of the latter class of substances that the yellow colour in the lips of the ivory-coloured garden snapdragon is due.

The autumnal reddening of leaves is due to the disappearance of chlorophyll and the formation of anthocyanins (in many cases especially the cyanidin-3-glucoside. chrysanthemin). Anthocyanin formation is promoted by high light intensity and low temperatures. Thus, autumnal colouring is often most striking when a succession of clear, sunny days precedes the advent of frost.

Certain mineral deficiencies in plants often contribute to and can be recognized by the formation of red anthocyanin coloration. Phosphorus deficiency in tomatoes, calcium deficiency in corn (maize) and boron. zinc or molybdenum deficiencies in other plants often manifest themselves by the appearance of reddening of the leaves and stems. However, such reddening can occur only in those plants that possess the genetic factors necessary for the synthesis of anthocyanins.

Disease and injury often cause reddening of the affected plant as a result of derangement of normal metabolic processes and consequent diversion of synthetic pathways toaard anthocyanin formation. On the other hand. virus infection is also known to cause the disappearance of normal anthocyanin pigmentation. The "breaking" of red flowers to nhite in virus-infected stock (Matthiola incana) and sweet pea (Lathryrus *odoratus*) is a well-known example. See also CHLOROPHYLL. CHEMISTRY OF; ANTHOCYANINS AND ANTHOXANTHINS; PLANTS AND PLANT SCIENCE: Plant Physiology.

See T. A Geissman, in K. Paech and M. V. Tracey (eds.), *Modern Methods of Plant Analysis*, vol iii (1955); F Blank, in W Ruhland (ed), *Encyclopedia of Plant Physiology*, vol. x (1958). (T. A G.)

PLANT DISEASES. Plants as well as animals are susceptible to injurious and often fatal diseases. Some of these disorders can be attributed to inanimate and nonparasitic factors such as adverse environmental conditions: unfavourable temperature or humidity; unsuitable soil and light conditions; excess or deficiency of minerals needed for proper plant growth; and presence of poisonous substances in the air or in the soil. Furthermore. physical and mechanical damage brought about by violent storms. improper cultivation practices. etc, besides being disastrous in themselves. may prepare the way for nidespread infection by other disease agents.

Among living agents such animals as insects, besides often interfering directly aith plant metabolism, frequently serve as carriers in transmitting other disease agents from plant to plant. Since the development of plant pathology (or phytopathology, the study of plant disease) and entomology into separate disciplines,

the study of insect and mite pests has usually been considered the province of economic entomology (*see* ENTOMOLOGY: *Applied Entomology*). The damage done to plants by larger animals (slugs, birds, rabbits, rodents, etc.), though not strictly speaking disease, may be of local importance; the depredations of these pests are studied in economic zoology (*see* ZOOLOGY: *Economic Zoology*). These plant eaters and plant dwellers also may serve as carriers of disease agents, though they are of far less importance in this regard than are insects.

The greatest number of economically important disease-causing plants are found among bacteria and fungi; a few algae are responsible for some relatively unimportant tropical plant diseases (*see* BACTERIOLOGY; FUNGI; ALGAE). Among flowering plants only a few forms are of occasional importance (*see* PARASITISM AND PARASITOLOGY: *Parasitic Plants*). Several slime molds (organisms bordering the animal and plant kingdoms) and numerous viruses (*q.v.;* organized particles bridging life and nonlife) also are important agents of plant disease.

This article is divided into the following sections:

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  1. Definition
  2. Classification
  3. Symptoms
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I. HISTORICAL BACKGROUND

Plant diseases are referred to in some of man's earliest writings. Among the abominable curses reported in the Bible (Deut. xxviii) for disobedience to the commandments were doubtless both rust and bunt or stinking smut of wheat. These diseases probably did not often wipe out an entire crop but, like poverty, they were ever present, sometimes mild, sometimes severe. Frequent biblical references to blasts, mildews and plagues of locusts are suggestive of the fear in which these pestilences were held.

The early Greeks—Aristotle, and particularly his pupil Theophrastus, the father of botany—described diseases of a number of cultivated crops. The Romans were so concerned about rust on their grain that each spring they tried to appease Robigus, the god of rust, with the feast of Robigalia, in which they supplicated him to stay his hand so that rust would do less damage to their crops.

In Shakespeare's time, discussion of the damage caused by rusts and smuts reached parliament. In 1660 a law was passed in Rouen, Fr., to the effect that barberry bushes, which had recently been shown to be associated with cereal rusts, were to be eradicated. Similar laws were passed in the New England states during the American colonial period.

The Irish famine began in 1845–46 following an epidemic of late blight on potatoes. The epidemic continued for several years, and starvation occurred in many places in western Europe after failures of the potato crop. Other famines have occurred from time to time because of failures of wheat, rice and other food crops brought about by plant diseases. The extensive plantations of larch trees in western Europe were destroyed after about 1860 by larch canker. Powdery mildew in 1851 and downy mildew in 1878 began devastating epidemics in European vineyards. The epidemic of coffee rust in Ceylon, beginning in the 1870s, is sometimes credited with helping to keep the English confirmed tea drinkers; after the rust destroyed the thriving Ceylonese coffee industry, new plantations were grown to tea, and South America became the coffee-growing centre. In the United States the American chestnut was practically wiped out following the introduction of the chestnut blight fungus in 1904. Peach yellows, curly top of sugar beets and flax wilt have been disastrous from time to time in the United States before being brought under control.

Plant diseases have always caused substantial reductions in yield of many economic crops. For example, in 1958, 70% of the production costs of a large fruit company in Central America were expended in controlling banana diseases. In addition to the actual losses in production caused by plant diseases, there also have been violent fluctuations in crop yields: when the crop was in short supply, prices went up; when large plantings were made to allow for losses that never occurred, there was a superabundance of crop with a corresponding fall in prices and disturbance in economic balance. One or another plant disease is a continuing threat against each of the economic crops.

Fortunately, the microorganisms causing diseases of plants are not agents of disease in animals and man. Some of the fungus structures are poisonous, however, if eaten. Ergot (*Claviceps purpurea*) of rye appears as elongated, hard, purple, beanlike masses (sclerotia) which replace certain grains on the rye head. Ergot-infected rye was often used in cheap bread until the poisonous nature of the infected grain was understood; ergot poisoning, which often induced gangrene, swept over France nine times in the 17th century and seven times in the 18th century (*see* ERGOT). Grain infected with the scab fungus (*Gibberella zeae*) also is toxic.

Although the history of plant pathology is too extensive to be treated here, two occurrences are especially noteworthy. First, Bénédict Prévost, in his classic work on wheat bunt (1807), demonstrated that microorganisms cause disease; his findings went unheeded till Anton de Bary confirmed them in 1853. Second, following the epidemic of downy mildew on grape in 1878, Bordeaux mixture, discovered by P. M. A. Millardet, established the use of sprays against plant diseases. Bordeaux mixture, because of its robin's-egg blue precipitate, was originally applied along the roadside edges of the vineyards to discourage thievery of the grapes. Happily, it proved to be also a control against downy mildew.

II. DEFINITION, CLASSIFICATION AND SYMPTOMS

1. Definition.—The early plant-disease terminology was frequently borrowed from medicine. The term plant disease was used although men knew that plants had no feeling of ease or discomfort. Likewise, plant populations were mentioned although plants were not people, and when disease affected large numbers of individual plants it was called an epidemic (meaning "on people"), although some plant pathologists have preferred the term epiphytotic ("on plants").

It is difficult to arrive at a definition of plant disease that covers all cases. One definition regards a diseased plant as an abnormal plant. Normality, then, may be defined in terms of rough averages of important plant characteristics, and disease as a serious departure from the norm. Among the various definitions the following has proved useful as a working statement: A diseased plant is one which is so impaired as a whole or in any of its important parts that its usefulness to itself or to mankind is seriously reduced.

2. Classification.—Classification of plant diseases commonly is based on causal agent: nonparasitic, virus, bacterial, fungus, etc. Classification also may be made according to plants affected. Host indexes (lists of diseases known to occur on certain hosts) are valuable; *e.g.,* when a new disease is found on a known host, a check into the index for the specific host may often lead to identification of the causal agent. Classifications according to symptoms have been tried, but they fail in many detailed approaches because one causal agent may induce several different symptoms which often intergrade.

3. Symptoms. — The symptoms of plant diseases, though they may be quite variable, are frequently helpful in diagnosis. Among the more important symptoms are the following:

1. Change in colour. Instead of the normal green, leaves frequently are pale green or yellow (chlorotic) or spotted. Coloured spots vary between red, green, yellow, brown and black. In some cases a separation of the epidermis of a leaf from the tissue below may cause "silvering."
2. Shot hole in leaves. Certain fungi and certain toxic agents induce in leaves many small holes, as though the leaf had been hit by shotgun pellets.
3. Wilt. Plants often droop and lean or fall over, usually from lack of water but sometimes from injury to the supporting stems or roots.
4. Death of the entire plant or of a part is called necrosis, a common symptom.
5. Stunting or failure to develop. This may involve the whole plant or only leaves and flowers.
6. Galls. An increase of size of cells is called hypertrophy. An increase in the number of cells is called hyperplasia. Often they occur together in galls.
7. Transformations occur when parts are replaced, as in ergot of grain, in corn smut or when flower petals develop as abortive green leaves.
8. Mummification involves the shriveling and drying of fruits.
9. Alterations in growth habit and in normal symmetry involve many changes in the stems, leaves and flowers.
10. Destruction of organs through changes in flowers and seeds, as in loose smuts of cereals.
11. Dropping of leaves, blossoms and fruits.
12. Production of malformations. These are of many kinds, including abnormal hairs, blisters, warts, galls, cankers, witches' brooms, hairy root, curling, fusion of plant parts (fasciation) and deformation of fruits.
13. Extrusion of liquid or oozes. Examples are the sticky exudate in fire blight, slime flux of trees, formations of masses of gum, production of resin and exudation of milky sap.
14. Rots. The soft rots usually are watery and have a bad odour. They commonly are associated with soft tissue, dry rots with woody structures. Often the rots are characterized as root rots, stem rots, bud rots, fruit rots, wood rots and so on, depending upon the part affected.

III. CAUSES

Factors inducing plant disease may be classified as physiological or nonparasitic, virus and living organisms. (The viruses, as mentioned above, hold an intermediate position while their status as nonliving or living is debated.)

A. Nonparasitic Agents

Injuries which occur because of "accidents," poisons or defects in the environment often result in diseased tissues. In addition, these injuries may enable microorganisms to enter secondarily and cause still further damage. The cause of such disease is sometimes obvious (*e.g.*, lightning or drought), but often it is obscure to untrained eyes. Only when the cause is known can an intelligent search for a remedy or a means of prevention be conducted.

1. Physical and Chemical Injury. — Fire, water, frost, higher animals, insects and machinery as well as poor agricultural techniques may cause serious damage to crops and permit invasion by disease agents. Graft knots often follow badly fitted grafts on apple trees grown from piece-root grafts. Waste products such as noxious gas, smog, dust and smoke may provoke injuries.

Many chemicals are profitably used alone or in combinations to prevent damage by insects and microorganisms or to kill weeds. However, when these materials are applied improperly, serious physiological diseases may result. Such injuries are fairly common from improperly used sprays, seed treatments, fumigation, soil treatment, fertilizers, herbicides and hormones.

2. Unsuitable Environment. — Plants in unfavourable environments may vary so far from their normal growth habits that they are considered diseased. In addition, such plants often are unusually subject to attack by microorganisms.

Too high a temperature may cause sun scald and death in the tips and margins of leaves. In some small plants, cankers develop at the soil surface where the temperature in direct sunlight may greatly exceed the air temperature. Frost injury is relatively common, but even low temperatures above freezing may cause damage, such as net necrosis in potatoes. On many exposed northern trees frequent alternations of thawing by day and freezing by night kill the bark and cause southwest canker.

Drought often accompanies high temperatures and causes stunting, wilting and burning. On the other hand, if water covers the roots too long they may be damaged because of insufficient oxygen. An excess of water, if it falls on a warm day followed by a cool night, may induce flooding of the tissue with liquid. Such diseases result as water core of apples, celery heart rot and tomato blossom end rot. The last two often lead to invasion by secondary microorganisms. Abundant moisture usually favours infection by bacteria and fungi.

Both the intensity of light and the hours of daylight may have strong influences on the development of plants. With insufficient light, sun-loving plants may become chlorotic. In certain greenhouses a short day may combine with a high temperature. These conditions promote rapid but relatively succulent growth. Spindly growth thus formed may be more susceptible to attack by pathogens than is normal growth.

Poor aeration may cause black heart in stored potatoes. An accumulation of certain gases from the respiration of apples in storage may cause apple scald.

Plants require various essential elements for their normal growth. The classic ones include carbon, hydrogen, oxygen, nitrogen, sulfur, magnesium, iron, calcium, potassium and phosphorus; chlorine also has been listed as essential. In addition, many other trace elements are necessary, among them boron, zinc, copper and manganese. Characteristic symptoms occur with an excess or deficiency of mineral salts.

Thus a considerable group of nonparasitic or physiological diseases occur when, for one reason or another, the plant's physiology departs critically from the normal. In addition to their influences on the host plants, these environmental factors often affect the activities of pathogens, as well as the interactions that result between hosts and pathogens.

B. Viruses

A number of infectious diseases result from viruses (*q.v.*), particles visible only in the electron microscope and small enough to pass through a filter that excludes ordinary bacteria. Plant viruses thus have great economic importance. To mention tobacco, potato, sugar beet, peach, orange and elm is only to begin the list of economic plants which are affected by viruses.

The plant disease symptoms caused by viruses include: (1) change in colour such as yellowing, mottling and vein clearing (becoming translucent); (2) malformations such as distortion, rosetting (close, tight whorls of leaves), proliferation and little or no leaf development between the veins; (3) necrosis such as leaf spots, rings, streak, wilt, droop and internal death, especially of phloem tissue; and (4) stunting. In some cases infected plants may carry the virus and show no disease; thus they are symptomless carriers which provide a source of inoculum for other host plants.

Transmission of viruses from one plant to another in some cases involves only touching a diseased plant and then touching a healthy one, but in others it occurs less easily. Many viruses are carried by insects, especially aphids and leafhoppers. Transmission of a virus disease is practically assured by budding or grafting. Certain viruses have been able to persist in the soil. Seed transmission has not been common, but it has occurred, for example, with certain large-seeded legumes, melons and squash, stone fruits (*Prunus* species), lettuce, barley and elm.

In many cases a single virus may infect a number of different kinds of plants, and a single kind of plant may be infected by a number of different viruses.

Control of viruses has been accomplished by using resistant plants, by destroying infected plants, by inspection and certification of disease-free stock, by quarantine and by other special means. Infected peach twigs and sugar cane shoots have been heat-treated for a short time so that the new plants developed from them were free from viruses. Certain rapidly growing sprouts from diseased dahlias and chrysanthemums have outgrown the slower traveling virus, so that the stem tips could be used vegetatively to propagate healthy plants. With certain potatoes, a few cells from the growing tips have been grown

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PLANT DISEASES

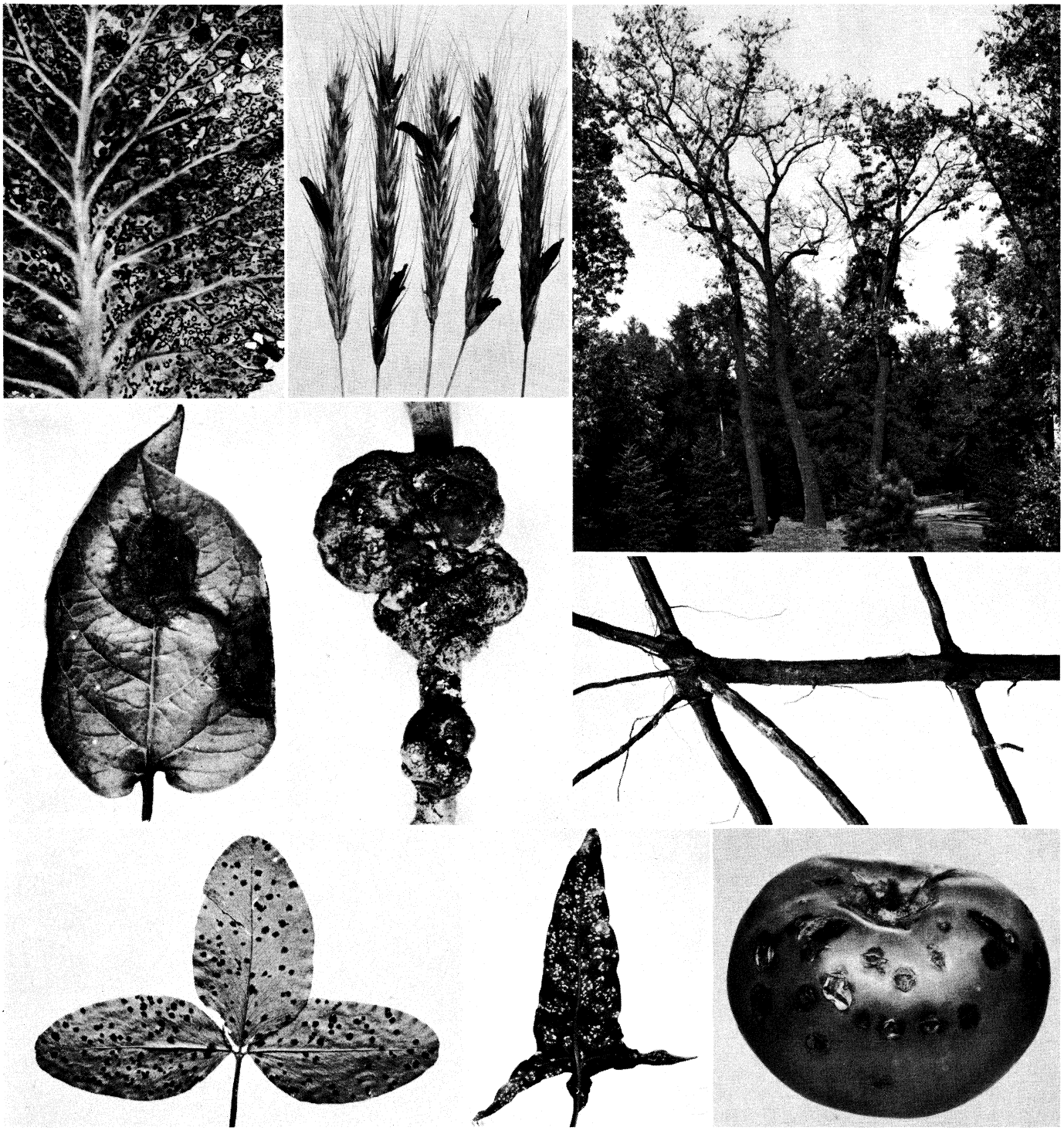
Top row, left to right: Cedar-apple rust on crab apple leaves. Apple fire blight. White pine blister rust

Second row, left to right: Normal China aster (left) and an aster attacked by the "yellows" virus (right). Tobacco mosaic, a virus disease. Two healthy red onions (above) and two susceptible white onions showing smudge spots (below). The resistance in the healthy onions comes from protocatechuic acid inherited in association with the red colour

Third row, left to right: Apple scab. Cabbage attacked by black rot followed by soft rot. Smut on ear and leaves of corn

Bottom row, left to right: Healthy onion (left) and three onions attacked by smut (right). Potato bacterial ring rot. Two stems of oats (left) showing the red stage of black stem rust; two stems at right are afflicted with crown rust

PLANT DISEASES



BY COURTESY OF (ALL EXCEPT TOP RIGHT) WISCONSIN AGRICULTURAL EXPERIMENT STATION, (TOP RIGHT) FOREST PRODUCTS LABORATORY, UNITED STATES DEPARTMENT OF AGRICULTURE

PLANT DISEASES

Top left: Ring spot (virus) on a cabbage leaf
Top centre: Ergot on rye
Top right: Three red oaks attacked by oak wilt
Centre left: Late blight on potato leaf
Centre: Crown gall on branch of apple tree
Centre right: Grafted oak roots which transmit oak wilt fungus from one tree to another
Bottom left: *Pseudopeziza* leaf spot on red clover leaf
Bottom centre: White rust on spinach leaf
Bottom right: Bacterial spots on a tomato

aseptically in tissue culture (see PLANT CELL [TISSUE] CULTURE), and from them the whole plant has been developed free from virus. A delay in the spread of virus infection has been accomplished by control of insect vectors and by sanitation in agricultural operations.

Among the numerous virus diseases of plants. that caused by the tobacco mosaic virus (TMV) is well known and has great economic importance. Besides affecting many members of the nightshade family (Solanaceae), which includes tobacco, tomato and potato, TMV occurs on some 30 species of plants in 14 other families. The symptoms characteristically appear as dark green spots irregularly elevated and scattered on the tobacco leaf. The remainder of the leaf becomes more and more pale green and sometimes yellow in colour. The name "mosaic" derives from these variable small blotches of different colours. The effects from TMV often are similar to those caused by the cucumber mosaic virus.

TMV, like some other viruses, is resistant to many uniavourable conditions. It has been the subject of many important fundamental researches on viruses that have led to a better understanding not only of plant viruses but also of animal and human viruses. TMV was the first virus to be crystallized: this was accomplished in 1935 by W. M. Stanley. Twenty years later its rodlike structure was shown to consist of a central core of ribonucleic acid (RNA) surrounded by a spiral of amino acids forming proteinaceous material.

C. LIVING ORGANISMS

Relationships between microorganisms and higher plants are not always disadvantageous. The root nodules of leguminous plants (such as alfalfa, clover, soybean and pea) are produced by bacteria with resultant fixation of atmospheric nitrogen and benefit to the plant (see SYMBIOSIS). Various fungi assist in the germination of seed and the growth of plants, such as orchids, heaths and forest trees (see MYCHORHIZA).

1. Parasitism and Pathogenicity.— Most microorganisms are beneficial in clearing away the debris of dead plants and animals and in building up the soil for more plants to grow. Those growing only on dead tissue are called saprophytes. However, some microorganisms secure their food from plants which are still living. They are called parasites, and if they cause significant injury or disease they are termed pathogens. An obligate parasite requires living tissue; a facultative parasite can grow on either living or nonliving material.

Proof of *Pathogenicity*.—The evidence necessary to prove that a certain pathogen is the cause of a particular disease is frequently arranged in a series of experimental steps called Koch's postulates, after the German bacteriologist Robert Koch. Only when these four steps are successfully carried out is the pathogen definitely identified as the cause of the disease:

1. The pathogen must be found in the diseased tissue of the infected plant (or animal), and must always be associated with the disease in question; conversely, the disease must never be found without the pathogen's being present or having been present.
2. The pathogen must be isolated from the diseased host and must be grown in pure culture (*i.e.*, without other pathogens present as contaminants) and characterized in the laboratory.
3. Some of the laboratory-grown pure culture is then inoculated into a healthy host, under favourable conditions, and symptoms of the disease as it appeared in the original host must appear in this experimental host.
4. From the experimental host the pathogen must again be isolated and definitely proved to be identical to the first isolated pathogen.

Many different culture media are used for the isolation and laboratory cultivation of pathogenic microorganisms; one favourable for the culture of certain bacteria and fungi pathogenic on plants is a mixture of potato extract, distilled water, agar and dextrose (PDA medium). After the medium has been properly processed (potatoes cooked, extract decanted and mixed with other ingredients, acidity checked, filtered and placed in culture tubes or flasks plugged with cotton), it is sterilized about 20 min. at 15-lb. pressure in a steam sterilizer (autoclave). When melted the agar medium may be poured into sterilized covered dishes (Petri dishes) and allowed to solidify.

Isolation of pathogenic bacteria usually follows the common dilution poured-plate technique. In this method the bacterial culture is diluted in media. and after suitable incubation characteristic colonies are transferred to culture tubes for further study.

In isolating fungi, many small pieces of diseased tissue, each weighing usually 4 to 12 mg., are taken from the most advanced margin of the infected area. Three to ten of these pieces are placed aseptically on sterile medium in each of several Petri dishes and incubated several days at a suitable temperature (usually 20° to 28° C.). In many cases the pathogen, free from other microbes, grows from some of the pieces. The pathogens are transferred to fresh sterile medium in culture tubes. The small size of the diseased tissues. their points of origin and their considerable number improve the chances of pure cultures of fungi free from the secondary invaders that usually follow rapidly behind the pathogens. Development of many specialized techniques has been necessary to facilitate the recovery of the pathogens and their identification (see BACTERIOLOGY; FUNGI).

Inoculations of susceptible plants are made with temperature, moisture and other factors favourable for the pathogen. The details of the technique depend on the life history of the causal agent. Pathogens occurring commonly in the roots frequently are introduced into the soil where the plants are growing. Seed inoculations often are used by applying spores to the seed. Growing plants are commonly sprayed with a liquid containing the pathogen. A favourite method is the introduction of bacteria or spores through artificially made wounds—cuts, stabs, etc.

In identifying virus and obligate pathogens Koch's postulates must be modified by other rules of proof since these forms can reproduce only in living tissue. Man may experimentally inoculate susceptible hosts with viruses by mechanical abrasion or grafting, or by the use of insect vectors, especially aphids and leafhoppers, or virus-bearing dodder (see below).

Life History in Relation to Pathogenesis.— Large populations are the primary interest of the plant pathologist because individual plants are seldom of great value. He is, therefore, especially concerned with epidemics. Epidemics develop as an endless chain of events, chief among which are transmission of the pathogen to the host plant, its entrance, its establishment and development inside, and its exit and once again its transmission to new hosts. Depending on favourable or unfavourable weather and on the intervention of harvest or of winter, the number of times this cycle is repeated influences the severity of the epidemic.

The chief events in this life history may be clarified further. Entrance of the pathogen may be by direct penetration through the outer covering or cuticle of a leaf, through wounds made by insects or other agencies or through natural openings in the plant. Such natural openings include growing tips of roots or stems, lateral root exits, lenticles on stems, stomata, open ends of leaf veins (hydathodes) and flower parts. Once insihe, the pathogen may become established either between or inside the cells, sometimes both. As a pathogen develops and produces the characteristic symptoms, portions of it may grow to the surface or reach the outside after decomposition of the tissue. The pathogen then may be carried to a new host by wind, water, animals, insects or agricultural operations. While many of these agencies operate in relatively localized areas. pathogens can be distributed widely over the world in shipments containing plants or plant materials; for example, straw used to pack around dishes has been found to carry important small grain pathogens.

Life Cycle.—In fungi, in addition to this life history. the life cycle, particularly when the fungus has an alternate host, may be important. The life cycle of black stem rust of wheat (discussed below) shows as many as five different kinds of spore-bearing structures, with as many different kinds of spores and two kinds of mycelium. It is essential to know these different stages and their bearing on the life history in relation to pathogenesis for both the primary and the alternate hosts. Such information may show the weak links in the endless chain of events in an epidemic, may indicate how such links may be broken and thus how control may be achieved. Critical points in the development of an epi-

demic may appear if the temperature and moisture should become unfavourable. Thus the weather often provides control, but it is notoriously unreliable.

Environmental Influence on Host and Parasite.—The important environmental factors listed under Nonparasitic Agents, above, also affect host plants and their pathogens. Among these factors temperature, moisture and soil reaction may be particularly important. What is good for one pathogen may be bad for another. For example, red pine seedlings growing in Plainfield sand at a forest nursery in Wisconsin have been attacked by one damping-off fungus (Pythium) uhen the soil was cool, moist and neutral to slightly acid; this fungus was almost completely replaced by another damping-off fungus (Rhizoctonia) when the soil was relatively warm, dry and acid. Special studies with pathogens and hosts under closely controlled conditions both in the laboratory and greenhouse are useful to describe environmental conditions. Records of what happens in nature as the season progresses also are essential.

Seasonal Development of Disease.—To understand how a disease develops in the field is critical for the successful application of control measures. Records of important factors should be taken from the beginning to the end of the growing season. Some of these factors are: (1) weather (maximum and minimum daily temperature and humidity, amount and times of rain, dew and sunshine); (2) growth of the host (increase in vegetative growth, time of flowering and development of fruit); (3) presence of the pathogen (availability of inoculum and of insect or other vectors for spreading it); (4) development of lesions from primary and secondary natural inoculations (parts infected, spread of the lesions, formation of secondary inoculum for further spread of disease); (5) incubation periods following artificial inoculations made at frequent intervals throughout the season; and (6) times of sprays or applications of other control measures. With such information the investigator may, for example, take the date when natural infection appears, subtract the days necessary for an incubation period and determine the date when natural inoculation took place. By checking the records he may determine the natural conditions that were favourable for infection. Thus when sufficient evidence is available, the critical times and conditions for control efforts are clarified.

Disease Forecasting.—Valuable forecasts are being made in certain cases from a background of long experience with seasonal development studies and from long-range weather predictions. Time and expense have been saved by avoiding unnecessary spray application; *e.g.*, against potato late blight and apple scab.

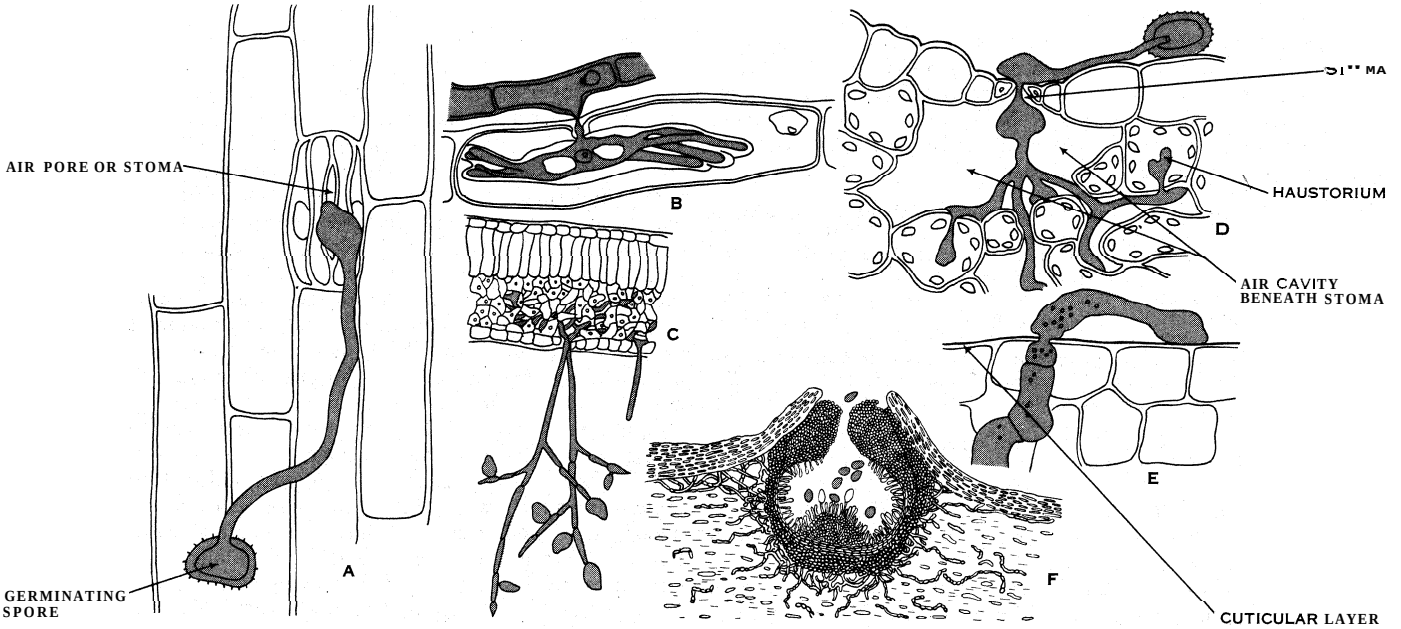
2. Bacteria.—Over 150 different bacterial species incite diseases in plants. In general these diseases fall into the following categories. galls, wilts, local spots or lesions, extensive lesions and soft rots. All these symptoms may grade into one another. Sometimes two or more bacteria, bacteria and insects or bacteria and fungi combine to produce a much more damaging disease than may be produced by one agent alone. After bacterial and fungus pathogens have entered a plant, saprophytic organisms usually follow closely and assist in the disintegration of the injured or killed tissue.

Plant bacteriologists have learned a great deal from medical bacteriologists and in return have made many contributions to the advancement of the general field (see BACTERIOLOGY). Two representative bacterial plant diseases are mentioned briefly.

Fire Blight.—The first plant disease proved to be of bacterial origin was fire blight on apple, pear and related plants. The bacteria (*Erwinia* amylovora) invade blossoms and rapidly growing shoots, killing the tissue. With suitable warm, moist weather a bacterial exudate appears on the surface. In susceptible species the bacteria may move down the stem, producing an extensive canker; the bacteria may even go down into the root system. This disease has driven certain high-quality pears and apples out of intensive cultivation in the eastern United States.

The life history is simple. The bacteria may enter the tree through wounds, stomata and particularly through flower parts to uhich they are carried by bees. The bacteria invade the tissues between the cells, but soon kill and enter the cells. The bacteria overninter in stem cankers (slowly decaying bark and wood). They come to the surface as a bacterial exudate, and new plant parts and other trees are infected when spring rains splash the bacteria-laden exudate and bees carry contaminated nectar from blossom to blossom.

Control in warm, rainy weather is difficult to accomplish. It consists of the removal of diseased parts and the application of antibiotic sprays during the blossom period. In Oregon much success has been achieved by growing a low framework from a blight-resistant pear tree. In the branches of this stock, twigs from high-quality but susceptible trees are grafted. Then if the blight starts in one branch it kills only down to the point of grafting



FROM (A) "PHILOSOPHICAL TRANSACTIONS," BY COURTESY OF THE ROYAL SOCIETY; (D, E) "ANNALS OF BOTANY"; (B) "BOTANICAL GAZETTE" (UNIVERSITY OF CHICAGO PRESS); (C, F) DUGGAR, "FUNGOUS DISEASES OF PLANTS" (GINN & CO.)

FIG. 1.— FINER STRUCTURE OF SOME PARASITIC FUNGI (MAGNIFIED)

(A) Surface view of plant leaf showing rust spore germinating. (B) Haustorium or absorptive process of mildew within plant cell. (C) Fructification of potato blight fungus with egg-shaped spores. (D) Section of leaf showing entrance of rust fungus through a stoma. (E) Penetration of cuticular layer of plant by fungus. (F) Fructification of black rot fungus embedded in the tissue of an apple, rupturing outer skin of the fruit

and a new graft may be substituted for it.

Crown *Gall.*—Perhaps the best known of the bacterial plant diseases is crown gall, which derives its name from the knobby growth which appears near the top of the ground or at the crown of the plant. The disease occurs widely over the world, apparently distributed with nursery stock. Its host range is wide, including among many dicotyledonous plants, such economically important ones as peach, apple, pear, rose, raspberry and sugar beet.

The bacteria (Agrobacterium *tumefaciens*) enter only through wounds. They apparently live between cells, which they stimulate to grow both in size and in number. When the galls develop, bacteria appear on the surface, from which they may be washed into the soil or picked up and carried by chewing insects. The disease has been held in control by nursery inspection, disinfection of parts used for vegetative propagation and by planting in well-drained soil that is free from root chewing insects.

Crown gall often has been called a plant tumour. Many detailed studies have been made of the bacteria, the host plants and the galls. This has been excellent material for fundamental work on diseased growth, and an extensive literature has developed. Crown gall tissue, free from the causal bacteria, provided the material for early work on plant tissue cultures (see PLANT CELL [TISSUE] CULTURE).

3. Fungi.—Fungi are responsible for by far the greatest number and diversity of plant diseases. Descriptions appear elsewhere of the various fungus groups and of their activity (see FUNGI). Although many members of the numerous genera among the fungi are purely saprophytes, interest here is with the many disease inciters. All the economic plants apparently are attacked by one or another of the fungi; often a dozen or more different fungi induce disease on a single species. A few diseases are mentioned briefly as examples.

Late Blight.—The late blight fungus (Phytophthora *infestans*) commonly occurs in the cool, moist regions wherever potatoes are cultivated. A devastating epidemic of this disease on potatoes beginning in Europe in 1845 brought about the famine, particularly in Ireland, that caused starvation, death and mass migration; it influenced the economic, political and cultural development of many people. The damage late blight caused to the potato crop in Germany during World War I is credited with helping to terminate the war.

Symptoms of late blight may appear on any part of the potato; above ground, small black or purplish lesions having pale green margins often increase in size rather rapidly. A whitish mildew is usually present near the margin of the lesions. The progress of the disease over a potato field may be rapid in moist, cool weather; commonly it is checked by dry weather. Tubers may be infected in the field. A brown or rusty, sometimes purplish skin discoloration appears first and usually extends into the tuber five to ten millimetres. A damaging rot, in association with secondary organisms, may develop. Tuber rot, a slimy, evil-smelling soft rot that may completely destroy the tuber, may continue in storage.

The infection cycle begins with the planting of infected tubers in which the fungus overwinters. The infection may come also from infected cull piles or plants in a field. Spores developing from these sources may infect nearby plants and may spread rapidly in an almost endless cycle so long as cool, moist weather prevails.

Control has been achieved by various means, including suitable sanitary measures, the use of resistant varieties, forecasting of weather favourable for a blight epidemic and applications of protectant sprays.

Chestnut Blight.—The American chestnuts have been practically eliminated from their commercial range by a fungus imported from the orient. The blight occurs in Japan and China as a minor disease on the native chestnuts there. When it appeared in New York in 1904 it was a curiosity: its seriousness was not realized until several years had passed. By 1908 it had produced extensive damage in areas around New York and had appeared as far away as Delaware and Virginia. Numerous efforts failed to bring the epidemic under control, and it continued with alarming and deadly rapidity. By conservative estimate made in 1911 the financial loss had exceeded $25,000,000, but this was insignificant compared with the subsequent destruction of the extremely valuable species.

Young infections on two- to six-year-old chestnut shoots appear as yellowish or brown patches contrasting with the olive green of healthy bark. The lesions spread until the shoot is encircled, at which time the shoot dies. Fruiting pustules of the fungus appear. During moist weather, spores embedded in a mucilaginous matrix are extruded from the pustules, forming long, irregularly twisted threads or spore horns, buff to yellow in colour. After one to several years, large trees assume a staghead appearance; later, the entire top of the tree dies. The roots have a surprising capacity for sending up sprouts, which often escape the disease for a number of years.

The causal fungus is Endothia *parasitica*. The spores extruded from the pustules are carried short distances by splashing rain and wind. The rapidity and pattern of spread over long distances have been correlated with the flight of migratory birds. Presumably the birds carry spores upon their feet from a diseased branch to a healthy branch, sometimes some distance away. The number of spores produced, as with many fungi, is enormous; a single, average spore horn contains over 100,000,000 spores.

Although no control measure was found to save the American chestnut, other species have shown more or less resistance. Long-range breeding experiments have been undertaken to develop blight resistant trees of good timber quality. Crosses between American and Asiatic chestnuts have produced trees with excellent nuts, but timber quality has been closely linked with susceptibility to blight.

Dutch Elm Disease.—A serious new disease on elms was described in 1921 in the Netherlands, thus acquiring the name "Dutch elm disease," though it doubtless originated much farther east. Following the description of the disease, reports of its occurrence soon came from many regions in both Europe and Asia.

On an infected twig the leaves progressively wilt, curl or turn yellow and drop off. The progress of the disease is rapid on succulent, young, rapidly growing trees and relatively slow on older or more slowly growing trees. As large trees die slowly during several years, the dead upper branches appear stagheaded. A cut across an infected branch shows a brown arc or ring where brownish gum has accumulated in the water-conducting vessels. These symptoms are easily confused with those caused by *Verticillium* or Dothiorella wilts. Laboratory culture of the causal fungus, *Ceratostomella ulmi* (or *Graphium ulmi*), has been necessary for accurate diagnosis.

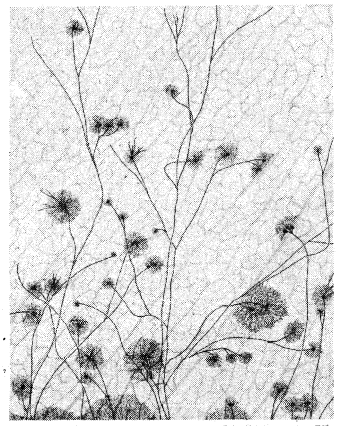
The fungus spreads rapidly through vascular tissue of the trees. European and American elm bark beetles bore into and colonize the larger killed branches. Subsequently, spores of the fungus develop in great abundance in the insects' tunnels or galleries. The insects then inoculate the spores into other trees.

Selected smoothleaf elm (*Ulmus* carpinifolia) seedlings have shown promising resistance in the Netherlands. Likewise, a few American elm (U. americana) saplings have withstood severe, successive inoculations. Some species such as Chinese elm (*U. parvifolia*) and Siberian elm (U. *pumila*) have appeared somewhat resistant. Tree breeders may hope that suitable disease-resistant trees can be developed.

Meantime, the best control measures consist of removal and destruction of beetle breeding sites, which consist of all dead and weakened elm wood. In addition to this, a dormant spray with a suitable insecticide has proved useful to prevent feeding by the beetles on the small elm twigs. Control measures, to be effective, must be carried out with great care. A few undestroyed breeding sites or poor spray coverage may vitiate the entire effort. Such control measures are expensive, but in urban areas the removal and replacement of dead elm trees as well as the resultant loss in real-estate values are also expensive. Research seems promising both on resistant trees and on chemicals that are active against either the causal fungus or the insect vector. (See ELM.)

Black Stem Rust of Wheat.—One of the oldest known and still one of the most important diseases of food crops is the black

stem rust caused by the fungus Puccinia graminis. Its destructive ability on wheat crops in the U.S. may be judged by a few examples. In 1935 almost 60% of the hard red spring wheat crop was lost in Minnesota and the Dakotas. In some areas the loss was practically complete. The grain harvested was lightweight and inferior in quality. In 1953 and 1954 about 65% to 80% loss occurred over the same area in durum wheat and 10% to 35% loss in the spring wheat. The short supply caused sharp changes in prices and large economic disturbances.



BY COURTESY WISCONSIN AGRICULTURAL EXPERIMENT STATION

FIG. 2.—DRAWING OF STERILE MYCELIUM OF THE BLACK PATCH FUNGUS (RHIZOCTONIA LEGUMINICOLA) GROWING ON SURFACE OF RED CLOVER LEAF (TRIFOLIUM PRATENSE)

This rust has a wide host range, but the discussion here is limited to wheat. It occurs practically everywhere that wheat is grown. In its complex life cycle there are several different kinds of spores, some on wheat and some on the barberry.

The uredial or red rust stage occurs on wheat leaves and stems as elongate pustules containing enormous numbers of reddish spores called uredospores. The epidermis is broken, giving a rough appearance. The spores are blown to other wheat plants where they germinate and again give infection. The cycle repeats so long as susceptible living wheat and suitable weather occur. The symptoms vary from tiny scattered yellow flecks to numerous pustules close together. Sometimes chlorosis develops. Different kinds of resistance or susceptibility have been classified by the characteristics of these pustules.

The red colour turns to black as the uredospores blow away and the blackish teliospores develop (hence the name black stem rust). These thick-walled two-celled spores are hardy; they live over winter and germinate in the spring to form special spores called sporidia or basidiospores. Sporidia cannot infect wheat. They blow onto the leaves of common barberry bush, and there the fungus develops to form spermogonia on the upper surface. These orange-yellow spots exude a sticky liquid containing spermatia. Following a suitable cross-fertilization between spermogonial spots, the fungus develops a cluster of tubular cups called aecia on the lower surface. These cups contain still another type of spore, aeciospores, which infect wheat but cannot infect barberry. When aeciospores blow onto wheat or grasses the red rust stage again develops. The wind may carry red spores hundreds of miles.

The susceptible common barberry (Berberis *vulgaris*) has been successfully eradicated in most areas of North America. The Japanese barberry (B. thunbergi), a common ornamental shrub, is immune to wheat rust.

Both the rust fungus and the wheat plant are highly variable. By means of distinctive rust symptoms on a dozen differential wheat varieties, over 250 physiological races of black stem rust have been described. As researches on physiological races have shown, certain varieties of wheat may be resistant to some races and susceptible to others. Practical breeding programs for wheat have centred on the important regional races of black stem rust, on resistance to other rusts, smuts, root rots and on the various characters which add to the quality of the grain. To keep ahead of the variability of the fungi, breeding must be a continuing process. One curious evidence of resistance has been described as the necrotic fleck reaction. After the rust fungus has entered a leaf and has made contact with the wheat cells below, both wheat cells and fungus have died, thus cutting off the progress of the pathogen and leaving only a fleck spot. (See also SMUT AND BUNT.)

The blister rust (caused by Cronartiunt ribicola) on white pine trees has a comparable cycle with gooseberry and currant bushes as the alternate hosts (see BLISTER RUST).

Wood Rots.—Certain higher fungi actively decompose forest timber. The losses from dead trees and from the effect of decay on growth may approach 45% of the losses of timber from all causes combined. Furthermore, such fungi may decay lumber and wood products in use so that expensive replacements become necessary (see DRY ROT).

4. Other Pathogens.—Although viruses, bacteria and fungi comprise the greater number of pathogens, flowering plants and microscopic roundworms or eelworms (nematodes) are sometimes important.

Flowering Plants.—Among the numerous parasitic seed plants, mistletoe, dodder and witchmeed serve as examples.

Mistletoe, really a semiparasite, is well known, especially for its ornamental and sentimental uses at Christmas time. But various species are dangerous parasites of certain deciduous and coniferous trees. The bushy green growth appears on the tree branches, becoming especially conspicuous after the deciduous leaves have fallen; the dwarf mistletoe that is common on conifers is not so obvious. After the parasite has grown for a year or more the branch may die or break off. Infection may also induce delayed growth in the spring and stunting. The sticky seeds sometimes are ejected and carried a few yards by the wind; they may also be carried longer distances by birds. Once the seeds adhere to a branch, they germinate and penetrate the water-conducting tissue where they obtain primarily water and mineral salts. (See MISTLETOE.)

Dodder has various uncomplimentary names such as strangleweed, devil's hair and hellbind. The numerous species are widely distributed (see DODDER), and it has appeared seriously in southern Europe and the U.S.S.R., being of less importance in North America. Its chief damage is to clover, alfalfa and flax. The yellow-orange threadlike stems wind around the host plants. By extending to other plants it may draw them together and toward the ground. The area invaded seldom exceeds three metres the first year, but the spread may be much more rapid in later years. Dodder may be widely distributed as a contaminant in seed. For control in the field dodder may be cut, dried, sprinkled with fuel oil and burned.

Witchweed (*Striga asiatica*) is widely distributed in Asia and South Africa. It appeared in South Carolina in 1951 and caused increasing concern in that region. Witchweed parasitizes the roots of a wide host range, including corn (maize), sorghum, sugar cane, rice, rye and oats. Serious infestations can destroy the yield from a cornfield. The parasite grows eight to ten inches high and has red or orange flowers It produces enormous numbers of tiny seeds that live in the soil for years until stimulated to grow, apparently by an excretion from the root of a host plant. Witchweed robs the host of water and food. Infected plants fall far behind normal plants in growth and often die. Control has been difficult. Some methods have proved helpful, such as rotation with a resistant crop and prevention of seed set by growing trap crops and then destroying them, and by covering a small area with dry refuse and burning it. Active research is seeking better control measures.

Nematodes.—Plant parasitic nematodes are slender microscopic eelworms of great economic importance. One or more species attack practically all crop plants. Usually they live in the soil and attack underground parts, but occasionally certain eelworms inhabit the buds, stems, leaves or inflorescence. More than 100 species cause decline, stunting or death (see NEMATODA).

Nematodes usually attack only small roots. Root injury develops partly from the nematodes' feeding on cells penetrated and partly from the toxic salivary excretions of the parasites. The tissues often respond by producing either an enlargement (hypertrophy) or degeneration of cells, and sometimes both. In the field nematodes may associate with fungi and bacteria to induce disease complexes such as root rots that are more conspicuous than the injury caused by nematodes alone.

Many nematodes are native and transfer to cultivated plants when their natural hosts are removed. Others have been introduced with seedling plants, bulbs, tubers, seeds and particularly in soil balled around the roots of nursery stock.

Root knot nematodes (Meloidogyne species) are well known

because of the conspicuous tiny gall-like swellings they induce on roots. Many kinds of higher plants are subject to their attack. Losses are often heavy, especially in warm regions with long growing seasons; certain species, however, such as the northern root knot nematode (*M. hapla*), are found where the soil may freeze to a depth of two or three feet. Truck crops, potatoes, tomatoes, melons, cotton, strawberries and orchard trees are commonly attacked. Garden plants and ornamentals frequently become infested through planting stock.

Root lesion nematodes (Pratylenchus species) are migratory internal parasites (endoparasites) which cause severe losses in many crops by penetrating roots and making their way through the tissues, breaking down the cells as they feed. They deposit eggs from which new colonies develop. After the root begins to decline they move out into the soil in search of healthy roots. Lesions form as fungi and bacteria enter the damaged tissues, and root rot often sets in. Annual crops may succumb early in the season, but perennials and orchard trees may not show decline for several years.

The golden nematode of potatoes (Heterodera rostochiensis) is a leading menace of the potato industry of Europe. Great effort is being made to control it. A related species, the sugar beet nematode (H. *schachtii*), is a critical pest that has restricted the acreage of sugar beets in Europe, Asia and America.

The citrus nematode (*Tylenchulus semipenetrans*) occurs throughout the citrus-producing regions and exacts a heavy toll. Typical symptoms are the common slow decline and dieback visible in many groves over 15 years old. Infested nursery stock has given the parasite wide distribution.

The burrowing nematode (Radopholus *similis*) is a serious parasite in the tropics, where it attacks citrus, banana, pepper, abacá and other important crops, causing severe losses.

Many important surface parasites (ectoparasites) feed on the roots of plants somewhat as aphids feed on the stems. Among the most important are the American dagger nematode (*Xiphinema americanum*), stubby root nematodes (*Trichodorus* species) and spiral nematodes (Rotylenchzts species).

Leaf (foliar) nematodes include the bulb and stem nematode (Ditylenchus *dipsaci*), which has caused severe losses in the bulb industry and in clover, alfalfa and other crops.

The wheat nematode (Anguina tritici) is a dangerous pest that transforms the seed into a blackened cockle. Other species of Anguina destroy the seeds of many grasses.

Nematode control is approached in several ways. Many nematodes have certain host preferences so that crop rotations give satisfactory control. Resistant varieties of plants have been selected against certain species of nematodes and have been grown successfully over large areas. Such work is promising for the future. Direct control by means of soil fumigants, known as nematicides, has become an established procedure for certain high-value crops such as nursery stock and seedling plants.

IV. CONTROL

Control of plant diseases covers a broad, highly technical and rapidly developing field of study. A technique effective with one disease may be ineffective for another. Also, the effective method for a disease in one situation may be ineffective for the same disease in other circumstances. Furthermore, with continuing research, improved procedures keep developing. Discussion of control in this article is limited to general considerations and to a few representative examples. Locally useful information may be obtained from governmental agricultural research centres.

A. Vulnerability of Pathogens

Various preventive measures are possible at each of the stages in the life history of plant pathogens.

The entrance of a microorganism into the host may be opposed, for example: (1) by employing chemical preventives such as sprays, dusts, disinfectants (applied to seed, propagating stock or wounds) and wound dressings; (2) by using disease-escaping or resistant varieties; (3) by removing the host from the contaminating organism, as through the selection of disease-free seed and through rotation with other nonhost crops; and (4) by reducing the inoculum with available sanitary measures or with environmental conditions such as soil character, soil reaction, moisture and temperature that are unfavourable to the microorganism.

Establishment and multiplication of a pathogen in the host may be lessened, for example, by employing sprays which burn out initial mild infections, by pruning or excising diseased parts, by using resistant varieties and by providing environmental conditions unfavourable for the microorganism.

Exit of the pathogen from the host may be prevented by various sanitary measures, including excision of diseased plant parts or destruction of diseased plants, removal of agents of distribution, such as insect vectors, and disinfection of contaminated tools.

Transfer or distribution of the causal agent may be reduced by various means, such as prevention of exit or entrance, removal of alternate and weed hosts, control of insect vectors, disinfection of tools, shipping containers and other contaminated materials, use of disease-free or disinfected seed, use of chemical or other sanitation procedures and enforcement of inspection and quarantine measures.

Control measures have been classified in various ways; they include the use of inhibiting agents, proper cultural practices, repulsion of disseminating insects and development of disease-resistant varieties.

B. Inhibiting Agents

Applications of inhibiting or eradicant agents are effective preventive measures for certain diseases. Diseased seed may be treated in some cases by hot water and in others by various disinfecting solutions, slurries or dusts. Hot water has been effective for loose smut of barley, and various chemicals have controlled smut of oats and bunt or stinking smut of wheat. Seed treatments may be considered wherever the pathogen is carried by seed; suitable machines have been developed for treating seed. Sprays on growing plants are important in the control of such diseases as apple scab, cherry leaf spot, cucumber downy mildew and potato late blight. Direct attack on pathogens by eradicant fungicides has shown promise against apple scab. Many of the sprays are combined so that one application acts against both insects and plant pathogens. Large industries have developed to supply both the chemicals and the machinery for applying them.

Much research has been aimed at finding a chemical that will move from place to place in a plant and confer systemic resistance against infection. Some experiments have given encouraging results.

C. Cultural Practices

Control may be achieved through cultural practices including sanitation. These may involve the selection and treatment of the soil in which the crop is grown. Crop rotation has been effective against pathogens which may disappear from the soil within one to three years. Many pathogens, however, are little affected by rotation, either because they readily establish themselves as saprophytes in many soils (*e.g., Rhizoctonia* and Fusarium species. and the potato scab actinomycete, *Streptomyces* scabies), or because the spores apparently, in some percentage at least, remain dormant but viable for many years (*e.g.*, the fungi causing club root of cabbage and onion smut). In selecting a suitable location for a crop, certain diseases (*e.g.*, crown gall of raspberry) that develop in connection with injuries by root-chewing insects have been partially overcome by avoiding ground heavily infested with such. insects (old pastures, newly cleared land and weed patches). Soil treatments. often are effective where the value of the crop justifies the expense. In some cases suitable fertilizers may stimulate the host to outgrow the injury from the pathogen.

Destruction of sources of inoculum, an important measure of control involving various cultural and sanitary measures, may take many forms. (1) Burning, fall spraying or plowing under debris containing the overwintering fungi have been used against, for example, apple scab, brown rot of plum and *Septoria* blight of tomato. (2) Removing weed hosts was effective against cucumber

mosaic. (3) Similarly, the eradication of alternate hosts has been employed, for example. with white pine blister rust and wheat rust. (4) Destruction of diseased plants has proved effective in many cases. Removal of diseased plants (roguing) and testing of crops before general release to growers (indexing) are practised, for example, on potatoes as a control against potato viruses. The destruction of citrus canker in southeastern United States provided a dramatic story of eradication. Infected trees were sprayed with oil and burned During the campaign (1914–31) more than $2,500 000, not counting the value of 260,000 trees, was spent on eradication in Florida alone. (5) Pruning and excision of the diseased portion of the plant, followed by a wound treatment. have served to destroy the sources of inoculum for fire blight of apple and pear trees.

Other cultural practices important for prevention of plant diseases are connected with methods of propagation, as mentioned above with graft knots and fire blight. High-yielding rubber trees have been developed by two grafts. Seedling rootstock received a scion from a selected high-quality but susceptible tree. This in turn, after spray protection until it was tall enough, received a top graft from a disease-resistant tree.

A sanitary measure of value in controlling certain diseases has been the disinfection of contaminated articles. Tools require disinfection when used for excision of fire blight. Likewise, contaminated packing and shipping containers must be disinfected to prevent the development of various transit and storage diseases.

Limitations on shipments of diseased plants are common. At important ports of entry most countries have agricultural inspections and quarantines against injurious insect pests and plant diseases (see PLANT QUARANTINE).

D. Repulsion of Insect Vectors

Control of insect vectors has been effective in reducing various diseases such as apple fruit rot, cucumber wilt and aster yellows. In the first two instances, attacks by the apple maggot and cucumber beetle, respectively, have been opposed by sprays or dusts. In the last case the virus-bearing leafhoppers have been excluded from plants by cloth enclosures.

E. Use of Disease-Resistant Plants

When other control measures are impractical, the main hope is control by the use of disease-resistant varieties. Extensive efforts to develop disease-resistant varieties have been made, and conspicuous success often has been attained. Some investigators have claimed that this is the ultimate solution of a disease problem. Although great flexibility and potential to change exists in most agricultural plants. flexibility also exists in the pathogens. New strains may appear among pathogens through importation. through development from already existing strains or through new associations with insect vectors. Also, a plant breeder may develop a new variety that may be susceptible to a previously unimportant pathogen.

1. Types of Resistance. — Disease resistance may be mechanical or physiological. Mechanical resistance has been attributed to certain external characters, such as hairiness, a thick waxy layer, small or sunken stomata and thick cuticle or bark layers; and to internal characters, such as thick cell walls, composition of the middle lamella, production of gum and formation of layers of suberized cells or wound cork.

Physiological resistance has been associated with factors such as osmotic pressure, cell-sap acidity, tannin, nutrition. substances toxic to the parasite and substances which neutralize parasitic action. Various combinations of factors may enter into a given case; the concepts of resistance and of parasitism complement each other; there are overlapping grades of parasitism as well as overlapping grades of resistance.

A good example of physiological resistance is the resistance of coloured onions to fungus smudge. When an extract of coloured onions was chemically purified and tested for resistance to the fungus. it was shonn that two substances, protocatechnic acid and catechol, were the source of resistance. However, in many cases resistance is more complex than this.

2. Variable Resistance. — The characters which may be associated with resistance or susceptibility are subject to several kinds of variations. Among the nongenetic variations are fluctuating variations exhibited as a result of the unequal influence of different environmental conditions; and possibly a relatively temporary change (*Dauermodifikationen*), exhibited as a result of development under particular abnormal conditions, which perhaps may persist under normal conditions for one or more generations through the female line.

Among the genetic variations (see GENETICS) are combinations owing to the normal operation of the Mendelian mechanism, including segregation, recombination, linkage and crossing over; and mutations. There are different kinds of mutations, including gene mutation, polyploidy and sectional chromosome mutations such as deletion, duplication, inversion and reciprocal translocation. Changes in the characters of a plant by these or other means may have a bearing on disease resistance.

3. Securing Disease-Resistant Plants. — Several means of securing disease-resistant plants commonly are employed either alone or in combination. These include introduction from an outside source, selection and induced variation. All three may form different stages in a continuous process. For example (1) a large number of varieties which are free from injurious insects or plant diseases are introduced for comparison with local varieties; (2) the more promising strains are selected for further propagation; and (3) these are further improved, first by promoting as much variation as possible through hybridization or special treatment. and then by selecting the plants having greatest promise. This commonly is a continuing process.

Among the special treatments for inducing useful gene changes is the application of mutation-inducing chemicals such as colchicine and mustard oils. Irradiation with ultra-violet light and X-rays commonly induces deleterious genetic changes, but occasionally produces a beneficial alteration

A prime requisite in experimental studies of disease resistance is the presence of the pathogen under conditions that allow no susceptible host plant to escape infection. Natural infection or artificial inoculation may be used in different cases. For instance, in the development of wilt-resistant asters and peas. natural infection has been adequate. The causal organism lived abundantly and persistently in the soil so that the chances for infection of susceptible plants were practically 100%. Those plants that showed no infection under these conditions were judged to be resistant.

In general, plant breeders wish to supplement natural infection with artificial inoculation under controlled favourable conditions. This is particularly valuable to remove plants that have appeared resistant because they escaped natural infection and to ensure uniform trials for progenies of succeeding generations.

A knowledge of genetic behaviour of a character or characters for resistance has been valuable in developing disease-resistant varieties. Artificial crossing and the selection of desirable characters in the progeny of later generations have given promising results.

From the foregoing account it appears that the complete investigation of a plant disease clearly ramifies into various branches of biological science. The research may call for work in many disciplines: mycology, bacteriology, virology, entomology, nematology, soils. physiology, taxonomy. morphology. genetics, cytology, chemistry, physics, engineering and mathematics. Important advances have been emerging from a co-ordinated group attack on plant diseases by investigators having diverse backgrounds and abilities. For more information on particular plant diseases see the article dealing with the host plant; *e.g.,* APPLE; BANANA; COFFEE; HOP; LEMON; PEACH; POTATO; ROSE; WHEAT: etc.; and articles on pests; *e.g.,* LEAF MINER; CORN BWRER; etc.

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PLANT ECOLOGY: *see* PLANTS AND PLANT SCIENCE.

PLANTIN, CHRISTOPHE (1514–1589), French printer, was born in a village near Tours (probably Saint Avertin). He learned bookbinding and bookselling at Caen and, having married in that town, settled in 1549 as bookbinder in Antwerp, where he was soon known as the first in his profession. A bad wound in the arm seems to have 'been the cause that first led him (about 1555) to apply himself to typography.

The first known book printed in his office was *La Institutione* di *una fanciulla nata nobilmente,* by J. *M.* Bruto, with a French translation, and this was soon followed by many other works in French and Latin, which in point of execution rivaled the best printing of his time, while the masters in the art of engraving then flourishing in the Netherlands illustrated many of his editions. In 1562, Plantin himself being absent in Paris, his workmen printed an heretical pamphlet, which caused his movables to be seized and sold. It seems, however, that he recovered a great deal of the money, and in 1563 he associated himself with some friends to carry on his business. Among them were two grandnephews of Daniel Bomberg, who furnished him with the latter's fine Hebrew types. Christophe produced editions of the Bible in Hebrew, Latin and Dutch, a *Corpus juris* and Latin and Greek classics.

A much greater enterprise was planned by him in those years—the publication of a *Biblia polyglotta,* which should fix the original text of Old and New Testaments on a scientific basis. In spite of clerical opposition he was supported by Philip II, king of Spain, who sent him the learned Benedictus Arias Montanus to superintend the work. It was finished in five years (1569–73, 8 vol. folio).

Plantin earned little profit, but received the privilege of printing all liturgical books for the states of King Philip, and the office of "prototypographus regius." Though outwardly a faithful son of the church, he was till his death the partisan of a mystical sect of heretics.

Besides the polyglot Bible, Plantin published in those years editions of St. Augustine and St. Jerome, the botanical works of Dodonaeus. Clusius and Lobelius, the description of the Netherlands by Guicciardini, etc. In 1575 his printing office reckoned more than 20 presses and 73 workmen, besides a similar number that worked for the office at home. But in Nov. 1576 the town was plundered and in part burned by the Spaniards. and Plantin had to pay an exorbitant ransom. He established a branch of his office in Paris; and when in 1583 the states of Holland sought a typographer for the newly erected university at Leyden, he left his much reduced business in Antwerp to his sons-in-law John Moerentorf (Moretus) and Francis van Ravelinghen (Raphelengius), and settled there.

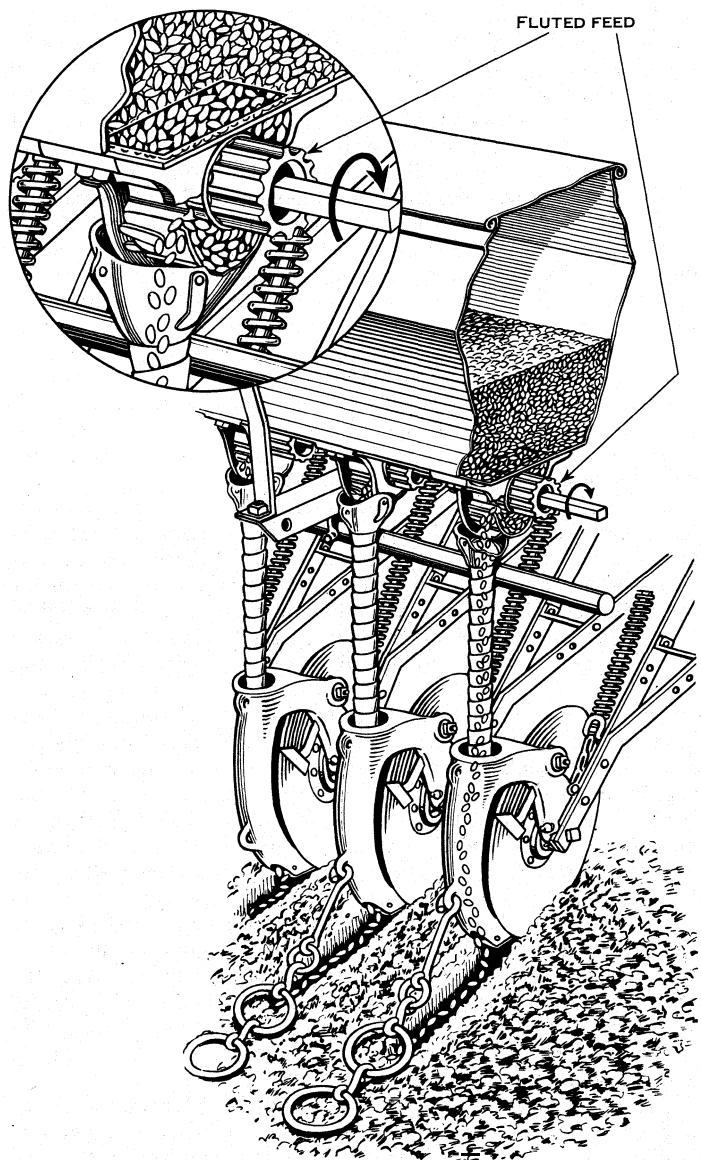
When in 1585 Antwerp was taken by the prince of Parma and affairs there became more settled, he left the office in Leyden to Raphelengius and returned to Antwerp, where he worked until his death on July 1, 1589. His son-in-law, John Moretus, and his descendants continued to print many works of note "in officina Plantiniana," but from the second half of the 17th century the house began to decline. It continued, however, in the possession of the Moretus family, which religiously left everything in the office untouched, and when in 1876 the town of Antwerp acquired the old buildings with all their contents, for 1,200,000 fr., the authorities created one of the most remarkable museums of its kind in existence, the Musée Plantin, opened **Aug.** 19, 1877.

(P. **A.** T.)

PLANTING MACHINERY. Putting seed in or on the ground is the means of starting most food and fibre crops the world over. Hand seeding by scattering the seed on the ground was the earliest planting method and is still practised where conditions are not suitable for machines. Very small fields, extremely rocky, stumpy and steep lands must be seeded by hand. Dibbling sticks used to make a hole in which to place the seed were an early, primitive improvement to secure better germination *(see* AGRICULTURE, PRIMITIVE).

This article describes broadcast seeders, grain drills, corn (maize) planters. potato planters, transplanters and airplane seeders. For preparation of the ground before planting *see* TILLAGE MACHINERY. *See* also FARM MACHINERY and separate articles on individual crops. as CORN; TOBACCO; etc.

Broadcast Seeders.—Hand seeding was followed by the development of mechanical means of scattering or broadcasting the seed. Knapsack seeders with a fanlike wheel to scatter the seed developed later into endgate seeders which are mounted on the



COURTESY OF JOHN DEERE

FIG. 1.— EXTERNALFLUTED FEED TYPE DRILL

The picture shows what happens from the time the seed leaves the seed box until deposited in the seed furrows and covered by the covering phains. Part of the seed cup and spout has been cut away to show how the seed fails into the big-capacity seed cup, is picked up by the flutes of the feed roil, carried over the adjustable gate, and released into the grain spout. Closed rear-delivery disk boots deposit the seed on the bottom of the trench before any soil can drop back

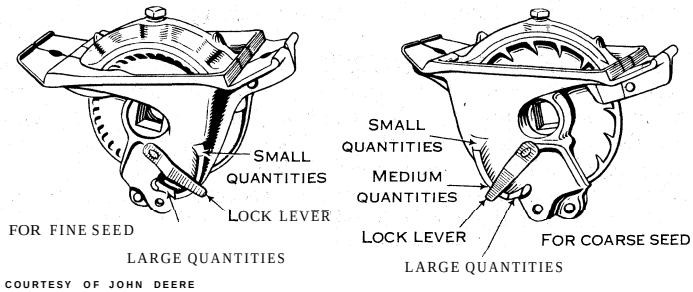


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FIG. 2.—DOUBLE-RUN FEED WHEEL

Left, small side of feed wheel, showing positions at which the lock lever may be set for regulating quantities to be seeded. Right, large side of feed wheel. Lock lever is set at position for sowing medium quantities

back of a wagon. A chain drive from a sprocket on one of the rear wheels provides the motion for the distributing wheel. Wheelbarrow seeders have a long hopper with an oscillating rope or chain in the perforated bottom to regulate the seeding rate.

Grain Drills.—The forerunner of grain drills. which place the seed at a controlled depth and in accurate amounts, made its appearance as early as 2000 B.C. in China and Mesopotamia. This machine consisted of a plow of that era equipped with a seed hopper and a tube to convey the seed to the groove made by the plow point. The method of metering is not known. In the 16th and 17th centuries, metering systems to ensure accuracy of rate were invented. Almost all of these used wheels equipped with small spoons. These dipped into the seed carried in a hopper and transferred a measured amount to seed tubes which guided it to the furrows made by plow points or special openers. This metering and feeding method was still used in many European drills in the second half of the 20th century. In the 19th century there were numerous developments particularly in the United States where there was a trend to force-feed systems which provide a more positive metering of the seed.

Types of Grain Drills.— In general, drills are classified by the type of metering system (spoon or cup feed, external fluted roll and internal double run) and by the type of furrow opener used (hoe, shoe, single disk and double disk).

Metering Systems.— The seed is carried in a hopper with the metering devices (one for each row to be seeded) located in the bottom and actuated by the wheels which carry the machine. The seed is carried by a tube from each metering unit to a furrow opener which is forced into the soil by means of springs or weights. Usually a short length of chain is dragged behind to cover the seed. Some drills have additional hoppers to carry fertilizer and grass seed.

The cup feed drill is used in the flat land of southeast England and on the European continent. It has a seed box divided into compartments and must be kept level to ensure a uniform supply of seed to each distributing unit. In a separate chamber behind the seed box there is a horizontal geared shaft carrying a number of flat disks with cups mounted on each side at the periphery for lifting the seed from small hoppers or feed runs into funnels connecting with the furrow openers. The seed passes from the seed box to the feed runs through apertures which may be fitted with slides for regulating the supply of grain at this point. Cups may be made with two seed faces so that by reversing the shaft different kinds of seed can be sown. The shaft is driven by a pinion from one of the drive wheels, and the rate of sowing can be altered by using pinions of different sizes. This was the earliest type of metered drill.

In the external fluted feed type a fluted roll revolves in the bottom of each small hopper. The quantity of seed sown per acre is controlled by exposing more or less of the feed roll to the seed inside the feed cup, although in some machines the feed may be further controlled by adjusting the size of the opening through which the seed flows. (See fig. 1.)

In the internal double-run type of drill the rate of sowing is regulated by altering the speed of the shaft by gearing devised for the purpose and by a small gate inside the feed cup. The double-run feed wheel or disk (fig. 2) is flanged on both sides with corrugations around the inside of the rim—coarse on one side for large seed and fine on the other for small seed.

Furrow Openers.—The hoe furrow opener (fig, 3) consists of a single- or double-pointed shovel fastened to the lower part of the boot which is usually fitted with a replaceable break pin or compression spring for its protection when encountering an obstruction such as a heavy stone or large root.

The shoe opener (fig. 4) is made from two flat pieces of steel on edge welded together in a wedge and curved upward at the front. The boot is attached on the upper side at the rear and open end of the wedge.

The single-disk furrow opener (fig, 5) is saucer-shaped. similar to a harrow disk. It is for cutting through trash and is of two types, the open boot nhere the disk serves as one side of the seed tube and the closed boot nhere a separate tube extends to the bottom of the furrow.

The double-disk opener (fig 6) consists of tno disks, usually flat. facing each other at a slight angle to form a wedge where they penetrate the soil By this arrangement a small ridge is left in the furrow, causing the seeds as they are deposited. to make two distinct rows approximately one inch apart.

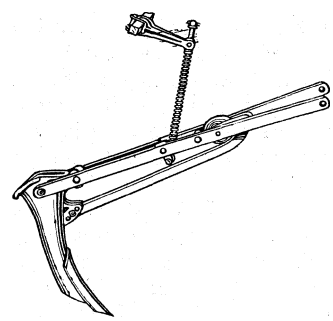

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FIG. 3.— HOE-TYPE FURROW OPENER

Features and *Attachments*.—In the second half of the 20th century it became recognized that under many conditions a more satisfactory stand of grass could be secured if planted just above a band of fertilizer. Hence hand seeding features for combined grain. fertilizer and grass seeding drills were developed.

Seeding attachments resembling a grain drill are sometimes mounted on a one-way disk plow (disk tiller) or on a corrugated roller soil pulverizer; they are mounted on the latter mainly for sowing grass seed.

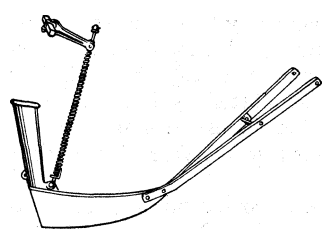

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FIG. 4.—SHOE-TYPE OPENER

For planting beets or beans. drills fitted with the same type of internal double-run feed as is used in wheat drills are available to plant in 18-. 20-. 24-. 26- or 28-in. rows. For planting sheared or ',segmented" sugar beet seeds. drills with special fluted feeds or with holed plates similar to corn-planter plates are used. Segmented seed is made by grinding down seed balls to one germ as an aid to thinning the beet plants. which, because of the nature of the seed, normally come up in clumps.

Corn (Maize) Planters.— In the "corn belt" of the U.S. almost all corn is planted four rows at a time. but six-row machines

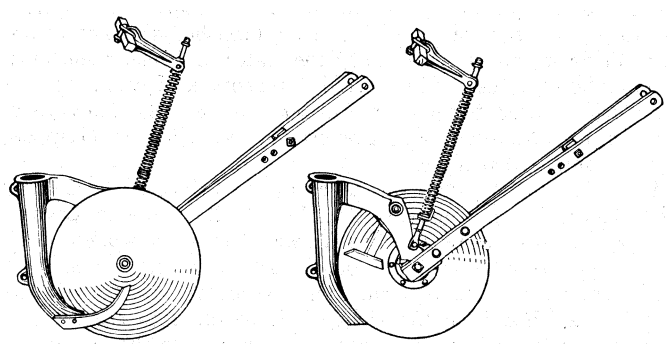

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FIG. 5.— SINGLE-DISKFURROW OPENER WITH CLOSED REAR-DELIVERY

This type is made in the 13-in. size for 6-. 7- and 8-in. spacing. Left, convex side of single disk, showing rear closed-delivery disk boot. Right, concave side of single disk showing adjustable T-shaped scraper, bearing and Alemite-zerk fitting

are also used. In areas of smaller farms, many two-row planters are used. Most are pulled behind a tractor but mounted machines and unit-planters, which feature a self-contained unit for each row planted, are available for mounting on tractor tool-bars. Pull-type machines have two or more wheels to carry the planter and to drive the planting mechanism. Press wheels are mounted behind each planter unit to firm the soil over the seed. The trend has been to the use of pneumatic carrying wheels and zero-pressure rubber tires for press wheels.

A vertical cylindrical seed box is provided for each row. In the bottom of this box is a revolving seed plate with seed cells. Plates with holes to suit the various sizes and shapes of seed are used. If the corn is to be drilled the seeds fall at regular intervals directly into the boot of each furrow opener and thence into the ground as the plate revolves and the cells register with the opening underneath. The seeding rate or the spacing in the row depends upon the rotation rate of the seed plate and the number of cells in the plate. Corn planters are available for drilling only, but checkrow planters can be used as drills by locking open the valves in the boots.

Checkrow Planters.—If the corn is to be checkrowed (planted in checkerboard fashion), a planter with a check head is used, and this requires a check or trip wire with uniformly-spaced buttons. With the trip wire laid across the field in the direction of planting, the planter in position and the wire placed in the check head, the operation is as follows: as the machine proceeds the drive wheels actuate a feed shaft, which by means of the seed plates causes the seed (2, 3 or 4 per hill, according to the nature of the soil) to be deposited in the upper valve in the boot. As the button trips this valve, the lower valve already charged with seeds discharges into the furrow opener and into the furrow. and the seeds from the upper valve drop into the lower one, ready for the next hill. The main wheels positioned directly behind the furrow openers then cover the seed and compact the soil around it. The common types of furrow openers are the stub runner, the curved runner and the single and the double disk. Row markers are provided to keep the rous equidistant.

Fertilizer Attachments.—Corn planters may be fitted with equipment to apply dry or liquid fertilizer. It was formerly customary to use a split-boot which, under ideal conditions, placed the fertilizer in bands on both sides of the row of seeds. However, the fertilizer was sometimes placed too close to the seed, impairing germination, and consequently separate furrow openers uere developed to place the fertilizer well to one side and below the seed.

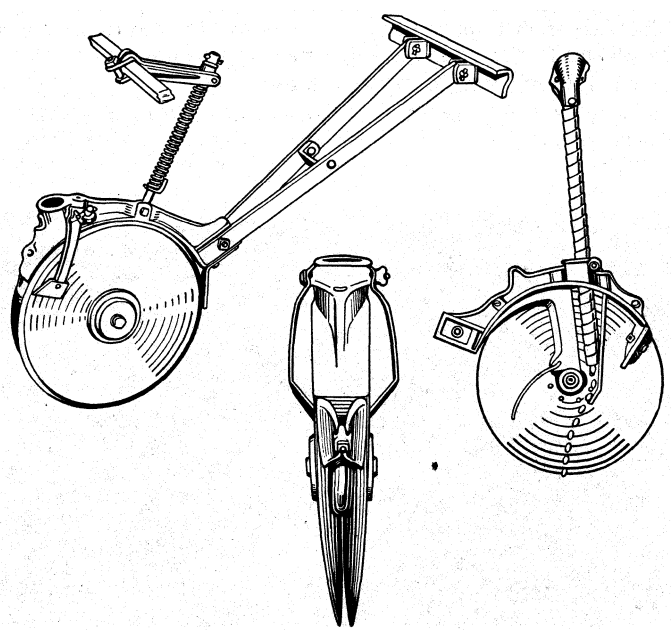

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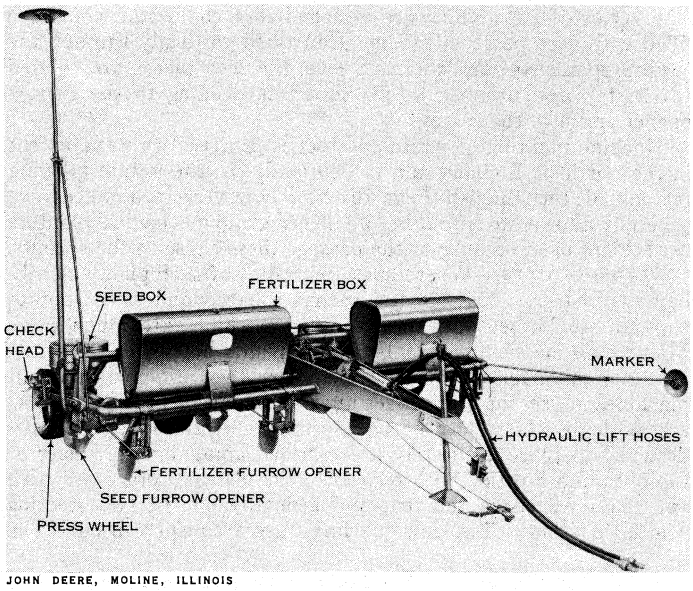
FIG. 6.— DOUBLE-DISK FURROW OPENER
Left, complete double-disk opener. Centre, rear view. Right, inside with one disk removed, grain reaches bottom of furrow before turn of disk starts upward



JOHN DEERE, MOLINE, ILLINOIS

FIG. 7.— CORN PLANTER WHICH CAN SEED AND FERTILIZE AT THE SAME TIME
It also can be used to plant cotton and other crops

Liquid fertilizers are metered by pump or by orifices selected to give the desired rate. (See figs. 7 and 8.)

Listers.—In dry regions. corn is sown or listed with an attachment to a middlebuster (similar to a right- and left-hand plow bottom mounted back to back) designed to open a narrow furrow, in a previously prepared seedbed, into which the seeds are dropped. They are then covered by cover disks and compacted by press wheels. By altering the plates in the corn planters and listers cotton seed can be planted and also many other coarse seeds such as peanuts, beans and kafir corn. Cotton, however, is seldom checkrow planted.

Potato Planters.—In the United States machine planting of potatoes is common practice, and two types of machines are used—the automatic and the semiautomatic, or assisted-feed. With the automatic type, one man only is needed to plant. As the machine is pulled forward on its two wheels, two disk openers produce a ridge, on both sides of which fertilizer may be deposited if the machine is provided with an appropriate attachment. Following this is a V-shaped opener shoe which splits the ridge, opening a furrow for the seed pieces and covering the bands of a fertilizer simultaneously. The seed pieces are deposited at uniform distances in the furrow by the dropping mechanism. This consists of a spider or disk to which are attached picker arms revolving through the seed potato hopper. Each arm, fitted with a picking hand or sharp staplelike points, picks a seed piece as it rises in the trough in the hopper bottom. As the arm descends on the other side the seed is automatically dropped into the furrow and is covered with soil by a pair of saucer-shaped disks. Frequently a press-wheel attachment is used in place of the covering disks.

The semiautomatic, or assisted-feed, planter differs from the automatic mainly in the dropping mechanism. This consists of a device to elevate the seed pieces from the hopper into the pockets of a horizontal revolving feed ring. One seed piece should be in each of the pockets—if there are two, one must be removed, and if none, one must be supplied. The feed ring carries each piece to the planting tube through which it drops into the furrow already prepared. This is a two-man outfit since it requires an extra man to attend the feed ring.

The above two types of planters are available in one-, two-, three- and four-row sizes, with row spacings varying by 2 in. increments from 32 in. to 42. Spacing in the row may be varied from about 6 in. to 24 in. by varying the dropping mechanism.

Another type of potato planter is the cup type. This consists

of a series of cups which are attached to a chain and which are filled uith seed potatoes as they are passed vertically through the seed hopper. As the chain proceeds, the seed pieces are carried to the top and dropped into a seed tube leading to the furrow opener and into the furrow.

Machine planting of white potatoes is practised to some extent in the north of England and in Scotland. In the potato-growing regions of the English Fens district, however, seed pieces are generally allowed to sprout before planting and mechanical planters are seldom used because of the damage these cause to the sprouts.

Transplanters. — Where large quantities of such plants as cabbages, tomatoes, strawberries, celery, tobacco and sweet potato slips are to be set out, transplanting machines are much used. Many such machines not only set the plants but water them and firm the soil over the roots. There are two principal types of machines in use, the manual-setting and the mechanical transplanters, both of which may be equipped with fertilizer attachments designed to place accurately a prescribed amount of fertilizer at the optimum position with respect to the plant. Both types have two main wheels in the rear and generally one or two steering wheels in front. Two-row machines are frequently used. The

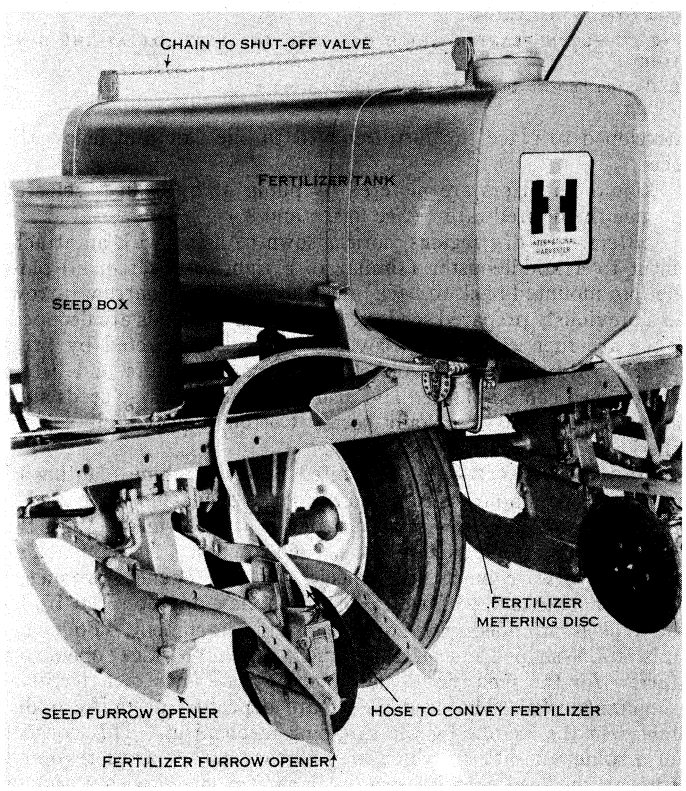


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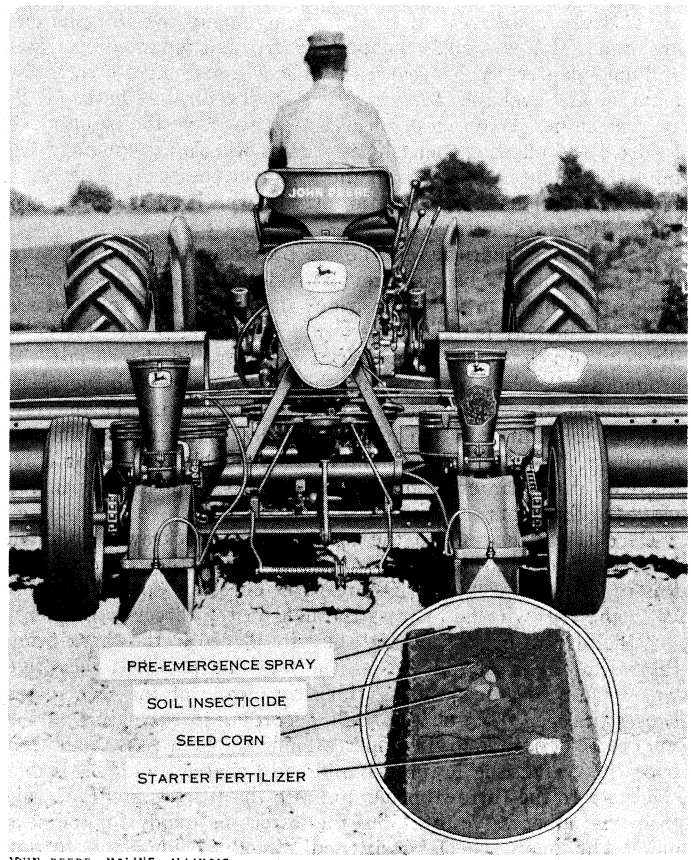
FIG. 8.— MACHINEFOR APPLYING LIQUID FERTILIZER WHEN PLANTING

machine must be strong, for it must support the weight of the drive, two plant setters for each row, a 40-gal. to 55-gal. steel tank containing water, and possibly 150 lb. of fertilizer and plants.

The manual-setting type of transplanter usually has a subframe carrying the planting mechanism, which consists of a furrow opener or shoe, a water valve in the heel of the furrow opener, and press wheels or plates. As the machine proceeds down the field and the water valve opens automatically for each plant, the operators, or setters riding on the machine, alternate in manually setting the plants in the furrow, which is immediately closed and compacted by the press mechanism.

The distance between plants in the row may be varied from about 8 in. to 60 in.

In the mechanical transplanter the plant setters place the plants in transplanting pockets or grippers which firmly hold them and revolve on a chain until they are automatically released in the furrow already opened, As the plant is released the water valve



JOHN DEERE, MOLINE, ILLINOIS

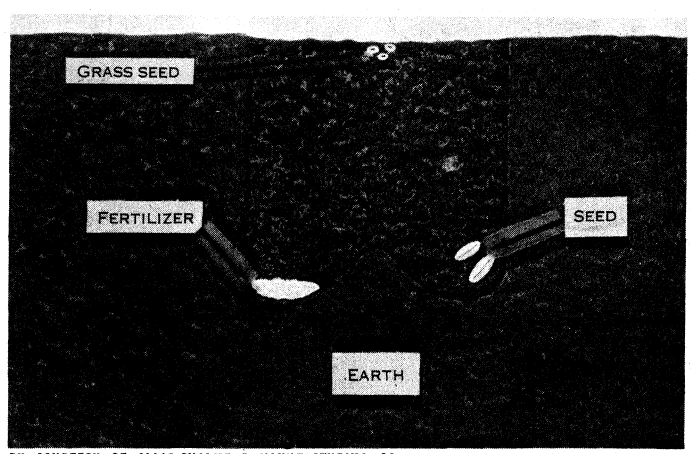
FIG. 9.— PLANTER WITH WHICH WEED-CONTROL CHEMICALS, SOIL INSECTICIDES AND FERTILIZER CAN BE APPLIED

supplies water and the packing device closes the furrow and compacts it.

Airplane Seeders. — Airplanes were first used for seeding rice in 1929. This method permits seeding in flooded fields. Airplanes are also used for seeding rough range land. The seed is metered from a hopper in the plane to a venturi tube (that is, a tube with flaring ends and a constricted connecting throat which reduces the pressure of the air and increases its velocity) below the fuselage. The blast of air through the venturi spreads the seed to provide a swath about 25 ft. wide when flying at a height of 20 to 30 ft.

See also AGRICULTURE (ARTICLES ON).

See Roy B. Gainer and others, *Principles of Farm Machinery (1955)*; Archie A. Stone and Harold E. Gulvin, *Machines for Power Farming (1957)*. (R. B. G.; G. E. PD.)



BY COURTESY OF ALLIS-CHALMERS MANUFACTURING CO.

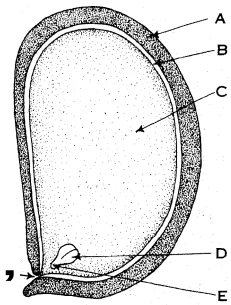
FIG. 10.— BAND SEEDING

Grass seed is placed above a band of fertilizer, giving the young grass a good start. Seed of the nurse crop can be kept away from the fertilizer band to avoid germination damage

PLANTING OF TREES: *see* TREE: *Tree Planting.*

PLANT PROPAGATION is the perpetuation of plants as independent units by means of seeds, bulbs, layers, cuttings or grafts. Theophrastus (370–285 B.C.) in his *Inquiry Into* Plants wrote that "the mays in which trees and plants, in general, originate are these: spontaneous growth. growth from seed, from a root, from a piece torn off, from a branch or twig, from the trunk itself; or again from small pieces into which the wood is cut up." This list of techniques has been slightly modified and refined, but only a relatively few new methods have been added. Since in most species of plants seeds result from fusion of the male and female gametes or sex cells, raising plants from seed is termed sexual propagation. Asexual or vegetative propagation encompasses all other methods for raising plants that do not depend on seeds or sexual combination.

Sexual Propagation.— The typical seed when mature consists of the young embryo, or miniature plant; variable amounts of elaborated food, or endosperm; and the seed coat or coats, the testa *(see* fig. 1). The endosperm may be lacking in seeds of a few plant species; the embryo and seed coats are found in all seed types.



BY COURTESY OF U.S. DEPARTMENT OF AGRICULTURE

FIG. 1.—LONGITUDINAL VIEW OF SEED OF WILD SARSAPARILLA SHOWING: (A) OUTER SEED COAT OR TESTA; (B) INNER SEED COAT: (C) ENDOSPERM; (D) COTYLEDON; (E) RADICLE; (F) MICROPYLE

Since the plant kingdom covers a wide range of climatic conditions, the methods utilized by the various species to maintain themselves have resulted in a wide variation in the nature and behaviour of seed. There are seeds that because of climate germinate almost immediately when placed in a favourable environment. Other types of seeds cannot germinate even under favourable growing conditions.

Many trees and shrubs of the temperate zone produce seeds that require a conditioning period before development occurs. If such were not the case, many young seedlings developing from fruits that mature during late summer and autumn would be killed by cold during the winter months; in these species a full growing season for the seedlings is ensured by the inability of the seed to germinate until it has been subjected to temperatures around 40° F., combined with moisture for varying periods of time, depending upon the species.

Supplying the required low temperature and moisture is a process known as cold stratification, and the term afterripening describes the complex biochemical or physical changes through which the seed must pass before it can develop normally. Depending upon the seed type, changes in the permeability of the seed coat and adjoining layers, development of immature embryos, dispersal of natural inhibitors, changes in chemical and hormonal balance systems, or combinations of these with other biochemical or physical changes may constitute afterripening. For small lots of seed that require relatively short afterripening or conditioning periods, moist, shredded sphagnum moss is mixed with one-third the volume of seed, placed in a polyethylene bag and stored in a refrigerator at 40° F. Example of seed types requiring a simple type of stratification are afforded by honeysuckle *(30–60* days), apple *(30–90* days), pear *(60–90* days), hemlock *(60–120* days) and magnolia *(120–180* days).

In contrast to this simple type of stratification are more complicated types requiring an alternation of warm and cold periods coupled with moisture. In these types the afterripening changes take the form of a series of steps. each dependent upon the other, that must take place in sequence before the seed is able to germinate. Dogwood, hawthorn, snowberry and viburnum seed have this peculiarity and for this reason are often referred to as two-year seed. In many leguminous plants, *e.g.,* black locust and clover, the seed is singularly impervious to water, and stratification has little short-term effect; in these cases the seed coat may be made permeable by treatment for a few minutes with concentrated sulfuric acid. followed by thorough washing, or wetting with scalding water. Large seed types having impermeable seed coats may be mechanically scarified, using sandpaper or by filing.

Many plants of the temperate zone have no seed stratification requirement, and it is rare in tropical plants.

Duration of germinative ability in seed varies greatly with the species; elm, magnolia and soft maple seed among the temperate-zone plants, and seed of many tropical plants, are short-lived, in some cases lasting only a few days. Some weed seed, in contrast, have germinated after being stored *25* years. Lettuce seed is usually short-lived, but melon seed frequently germinates well after four years. Retention of viability in seed usually is affected greatly by conditions of storage. In the tropics, for example, without special care, cinchona seed often deteriorates greatly in three or four months; storage in dry atmosphere has prolonged its life, with very little deterioration, for as long as *30* months.

Many seeds are sown in the open ground and, barring extreme wetness or extreme aridity, germinate well enough for practical purposes. Other kinds, however, are so exacting in their requirements that these are best met in a propagating house where humidity and temperature conditions can be more rigidly controlled. Because of their high oxygen requirement, the medium in which they are sown generally should contain more sand than ordinary garden soil does. Greater porosity makes these media more subject to rapid drying. however, and moisture must be carefully watched. Since many soils harbour fungi destructive to sprouting seed and young seedlings. soil that is to be used for germinating seed commonly is sterilized by heat or chemicals. Many diseases of plants are caused by fungi and bacteria carried in or on the seed itself, and treatment of the seed with disinfectants, such as bichloride of mercury, organic mercury compounds, formaldehyde and hot water, is beneficial when it is to be planted in cold soil or soil at normal growing temperatures. So-called clean seed may be treated with protectants, such as zinc oxide, organic mercury compounds and many of the copper compounds, in order to minimize losses from soil-borne pathogens.

For general seeding practices. trays or flats are filled two-thirds full of soil. This is then sterilized and puddled, and a quarter inch of sterilized sand, peat or vermiculite is added. The seed is then sown in shallow rows *1* to $1\frac{1}{2}$ in. apart in depth usually twice the diameter of the seed being planted. The seed is then covered lightly with a medium such as shredded sphagnum moss, and the entire tray or flat covered with glass or polyethylene sheeting. At the time the seedlings emerge the glass or polyethylene cover is removed, and the seedlings are watered at regular intervals thereafter.

With more and more cultivated crops, practical advantage has been taken of heterosis, or hybrid vigour; *i.e.,* enhanced vigour and productivity of the first-generation descendants from crosses between two strains previously kept pure by selfing (inbreeding) for several generations. By *1945* hybrid corn constituted a major portion of the U.S. maize crop, and the same procedure has been introduced with the onion, tomato and petunia crops, as well as many others.

Asexual Propagation.— With crops that produce seed freely and come true closely enough for the purposes in view, growing from seed usually is the cheapest and most satisfactory method of propagation Some species of plants are grown, however, that in the cultivated forms do not produce seed; *e.g.,* banana. pineapple and sugar cane. In a great number of cultivated species, seedlings vary so much that the desired traits are found in only a small proportion. Among dioecious plants the natural distribution of sex, approximately *50–50,* does not suit the purpose for which they are grown. Female trees of ginkgo and poplar are undesirable for street planting because of the unpleasant smell of the fruits, particularly when trodden underfoot; in date or pistachio orchards or muscadine grape vineyards, one male plant will effectively pollinate several pistillate plants, and since the males produce no fruit, a surplus would be a needless expense. To meet these various requirements asexual propagation. *i.e.,* division or separation and indefinite subdivision of the original plant having the desired traits, is utilized.

Many people have held—and voiced—the opinion that asexual propagation is unnatural and that plants thus derived lack the hardiness or the sturdiness of plants grown from seed. Asexual

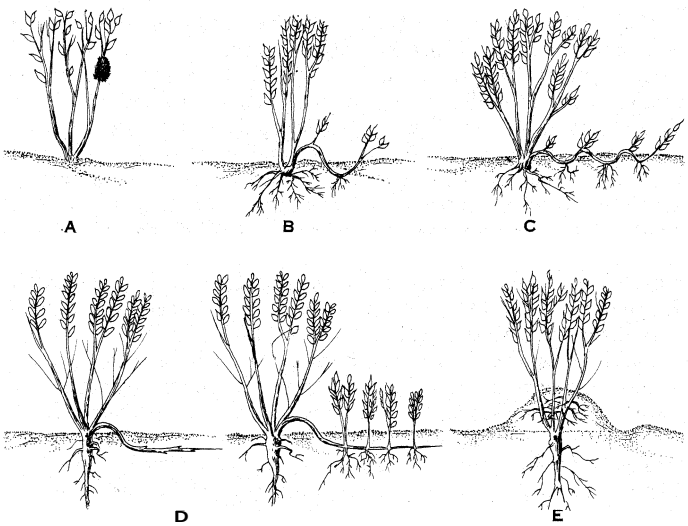


FIG. 2.— PROPAGATION BY LAYERING: (A) AIR LAYER: (B) SIMPLE LAYER: (C) SERPENTINE OR COMPOUND LAYER: (D) TRENCH OR CONTINUOUS LAYER BEFORE AND AFTER SPROUTING AND ROOTING: (E) MOUND OR STOOL LAYER

propagation, however, is not unnatural; some of its forms. *e.g.,* layering and grafting, are rather common in nature. The only justification for the generalization that asexually propagated plants lack hardiness or sturdiness is the fact that virus diseases can be transmitted by asexual propagation and that most such diseases are not transmitted through seed. In severe cases the build-up of a particular virus complex may result in a decline of the productivity of an asexually propagated horticultural crop or in the extinction of the infected clone or variety.

Division.—In some respects, the simplest method of asexual propagation is the form known as division, in which the aggregate of roots is cut roughly through the crown, and the fractional parts are planted out as separate units. In dividing the dahlia, care must be observed to include a bud with each root, but in some plants, *e.g.,* rhubarb, buds are so numerous that any random division is adequate. In bulbous plants new buds form at the base of the old structure; these may be separated and replanted. This process is hastened in the hyacinth by scooping or slitting the base of the bulb and replanting it. Lily bulbs may be divided concentrically into scales, which form new bulbs. In the potato the modified stem or tuber may be divided into as many segments as there are buds or eyes, each of which, when planted, will produce a new plant. In practice larger segments of the potato tuber are used, since a greater food reserve gives the new stem a better start.

Layering.—The great majority of plants can be induced to emit roots on their stems. Many do this naturally, particularly in a moist environment. Black raspberries, dewberries and one form of forsythia, for example, regularly develop roots at the tips of the stems, where these touch the ground. This process, tip layering, may be accelerated by pegging the tips so they will not sway in the wind, or by placing a small amount of soil over the stem, leaving the tip bud protruding (fig. 2B). At the end of the growing season the rooted tips are cut loose from the parent plant and set in plantations or in nursery rows. Some plants may be layered by bending whole shoots so that they can be pegged down or held in place by stones in narrow trenches, which are filled with earth a little at a time as the new lateral shoots grow (fig. 2D). This method is particularly adapted to multiplication of the more vigourous varieties.

A method used frequently with gooseberries and with the less vigourous clonal apple rootstocks is known as mound layering (fig. 2E); this involves cutting back an established plant close to the ground and progressively erecting a mound around the bases of the new shoots as they develop. Basic principles in handling layering by these methods are: (1) to cover with soil or suitable medium the bases of the new shoots before they have hardened but after they have lost their original softness; (2) to keep the soil around the plants moist but not wet. Production of roots is increased, if necessary, by wire constriction, by ringing, *i.e.,* removing a ring of bark, or by notching the stem just below the point where the roots are desired. With some plants the same effect can be obtained with less labour by twisting the stem.

Aerial or Chinese layering (fig. 2A) brings the rooting medium around the stem at a point above the soil, sometimes high in the air. The procedure is to place a pot of soil or a ball of sphagnum moss or similar rooting material around the stem, which has been wounded or girdled at the desired rooting point. To further facilitate rooting, a proprietary root-promoting growth substance may be dusted on the wounded area The entire area together with the moist rooting medium, is then wrapped in polyethylene plastic film and bound firmly at either end with a waterproof tape. After rooting, the plastic is removed and the rooted layer severed from the parent and potted or placed directly in a nursery row. Layering, in general, is rather expensive in space and time and is not particularly successful in many soils and climates.

Cuttings.—Plants whose stems emit roots readily are generally propagated by cuttings as the preferred vegetative method. Hardwood cuttings of the previous season's growth, taken in the dormant season and comprising 6–12 in., according to the species and amount of wood available for propagation, and planted in the open, are preferred, as they are most easily handled. Most American and some European grapes, currants and most poplars and willows are grown by this method. Greenwood or semihardwood cuttings using shoots, ordinarily two to six inches in length, which are still somewhat succulent, are more suitable with many plants that do not root freely from mature stems. Softwood or herbaceous cuttings (fig. 3, left), as well as the more mature greenwood cuttings, must retain some foliage if they are to root and, therefore, must be protected against loss of excessive moisture; hence they are usually placed in a cold frame, hotbed, greenhouse or out-of-doors in full sunlight under a fine, controlled mist spray. The medium in which they are set should be porous and free of rot-producing organisms; these requirements are generally met by using washed river sand, vermiculite or processed volcanic rock as the rooting medium. In cases where the water is not applied automatically, frequent moistening of the rooting medium and maintenance of high atmospheric humidity are necessary.

Cuttings set for rooting in cold frames generally require covering with sash and shade for maintenance of humidity. Temperature requirements of evergreen and greenwood cuttings vary widely according to species; conifers in general root better, though slowly, at lower temperatures (60°–65° F.), while roses root better at higher temperatures (65°–70° F.). Important factors in success with cuttings, regardless of type, are selection of time for taking cuttings, degree of maturity of the cutting at the point where it is severed and, in some measure, general condition and physiological age of the mother plant.

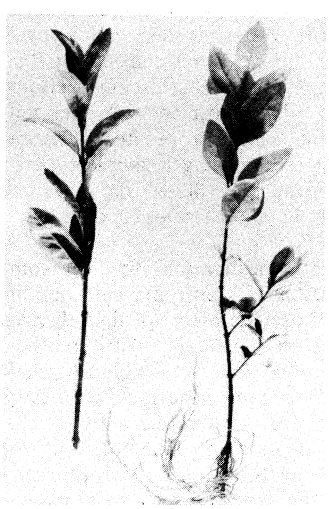


FIG. 3.— SOFTWOODCUTTING:(LEFT) UNROOTED PRIVET CUTTING; (RIGHT) ROOTED CUTTING READY FOR TRANSPLANTING

With such plants as carnations, usually propagated from softwood cuttings, the guide to proper condition is the type of fracture made when the cutting is broken from the parent plant: if the stem crushes, it is too young; if the fracture is stringy, it is too mature; when it makes a clean fracture without crushing, the chances for successful propagation are highest.

Use of root-promoting growth substances applied to the basal end of cuttings has greatly facilitated propagation of many species, increasing the amount of rooting and, through speeding the process, in some cases reducing loss from fungus diseases. The principle materials used have been indolebutyric acid, indoleacetic acid, naphthaleneacetic

acid and several of the phenoxyacetic acid compounds.

In order to prevent the increase and distribution of systemic diseased cuttings and plants. a technique knonn as culturing is used to maintain clean propagating stock plants of chrysanthemum and carnation. The general procedure is to place on agar plates surface-sterilized stem sections removed from the basal end of cuttings The cutting. which is numbered to correspond to the plate number and parent plant, is placed in a sterile test tube for holding. The agar plate and stem sections are then incubated, and if no organisms grow from the sections. the cutting is removed from the test tube and rooted in the usual manner. If any organisms grow from the stem sections, the cutting, together with the stock plant from which it was taken, is discarded.

When cuttings have rooted adequately (fig. 3, right), they are generally potted or planted out in transplant beds or nursery rows. This stage may require some care in protection against sudden exposure to strong sun and drying air currents for a few days until the plants are established in their new environment.

Root cuttings, *i.e.*, pieces of the roots. ordinarily about four inches long. are used in the propagation of a few plants, among them blackberries. clonal strains of black locust and some of the herbaceous perennials. These cuttings should be taken in the dormant season. either autumn, winter or early spring. Root cuttings of blackberry grow well if laid horizontally in rather shallow trenches. but root cuttings of clonal apple rootstocks seem to grow better if placed vertically, nith the distal end down and the proximal. or portion closest to the crown, just below the surface of the ground. Obtaining root cuttings of most plants in quantity is expensive, and use of the method is limited.

Leaf cuttings. utilizing leaves only, or portions of them. are used for the propagation of a few plants. Leaves of many plants can be induced to form roots. but only a few will develop shoots in the absence of a pre-existing axillary bud from the stem. Many begonias and sansevieria are frequently propagated by this method.

Grafting.—When vegetative propagation is necessary and layers and cuttings are not easily made, or increased growth rates over own-root material is desired recourse to grafting is common (see GRAFTING [IN PLANTS]). By this process a bud or a twig of the plant whose propagation is desired is transferred to another plant already supplied with a root system or capable of forming one readily.

Budding. as separate from grafting, generally is understood to be a form of lateral grafting that makes use of a scion having only a single bud. Grafting is used. in one form or another, on plants either in the groning or in the dormant stage.

(JN. P. M.)

PLANT QUARANTINE. Plant quarantine is that branch of law enforcement established by a country to prevent the introduction and distribution of foreign plant pests, principally insects and plant diseases. within its boundaries. The objective is to protect a nation's agriculture and horticulture from injury by any type of foreign plant pest that may be introduced. Similar regulatory procedures may also be adopted by a civil division within a country to prevent the internal spread of plant pests that have gained a limited foothold within its borders, or to facilitate eradication of such pests. Governmental agencies enforcing plant quarantine laws are variously designated in different countries as plant quarantine, plant protection. phytopathological and phytosanitary services. Most of these plant regulatory services are under the supervision of the national department or ministry of agriculture. The services usually operate in close co-operation with the customs service.

Plant Quarantine Service Operation. — Plant quarantine prohibitions and restrictions, applying to both the individual and the commercial shipper of such material, affect the importation of plants and plant products into most countries of the world. Plant quarantine regulations usually provide that before restricted plant material may be brought into the country the importer must apply in writing to the department of agriculture or equivalent agency for an import permit authorizing the entry of the desired items. Such a permit is also known as a certificate of introduction or import licence. This application allows the plant quarantine service to determine whether the consignment is prohibited entry, may enter under certain safeguards or is entitled to unrestricted entry. An import permit also informs the importer of any requirements for a phytosanitary or health certificate from the department of agriculture or some authorized official of the country of origin, certifying that the material has been officially inspected. Certification may also be required from the country of origin that the area where the material was grown is free of a particular pest, that the material was inspected in the field during the growing season or was grown beyond a certain distance from an area known to be infested by a specified pest, or that the material has been fumigated, disinfected or otherwise treated. The permit may also specify the port through which the material must be entered and the mode of transportation.

Upon arrival under the terms of the import permit, imported material, in general. is still subject to inspection by the plant quarantine service of the country of destination. If found infested or infected by injurious insects or plant diseases the material may require fumigation or other treatment. If such treatment is ineffective, the material may be destroyed or returned to the country of origin. Plant material for scientific purposes may enter under special provisions.

Examples of internal plant quarantine measures designed to control the spread of plant pests or to eradicate such pests are found in the rigid measures adopted by Great Britain to eradicate all infestations of the Colorado potato beetle (*q.v.*) and the interstate quarantines imposed by the U.S. to retard the spread of such pests as the Japanese beetle (*q.v.*), pink bollworm, white-fringed beetle and black stem rust of grains.

Insect Migration Between Countries. — The cosmopolitan nature of a country's insect population is illustrated by a statement of the U.S. department of agriculture in 1917 that "The majority of the insect pests of the United States which now occasion the greatest damage to orchard, field, and garden crops and to stored products and in homes: etc., are of foreign origin, and were introduced with the host plants or accidentally in the course of commerce." The statement was supported by a list of 110 of the most important insect pest introductions of previous years. Furthermore. the department listed about 1.800 insects which occurred in different parts of the world and were liable to be introduced at any time with nursery stock, in merchandise or as accidental stowaways on ships or in baggage.

The rapid migration of a dangerous insect when allowed to spread freely through articles of commerce is well illustrated by the instance of the pink bollworm of cotton. (See COTTON AND THE COTTON INDUSTRY: Pests and Diseases of the Cotton Plant.) This insect, a native of India, is the most destructive known pest of cotton. The worm exacts a double toll from the crop: it damages both the lint and the seed, resulting in loss of cotton and reduction in oil content of the seeds. About 1908 this pest was introduced into Egypt in bales of cotton from India. Destined for an Egyptian spinning mill. the ginned cotton contained a very high proportion of infested cottonseed. When the Egyptian infestation was discovered in 1910, the worm was already well established in widely separated localities.

In an attempt to get improved cotton varieties for planting in the Laguna district of Coahuila, Mex., a cotton grower planted imported Egyptian cottonseed in a field near Monterrey, thereby introducing the pink bollworm to a new country. When this infestation mas first reported in Nov. 1916, the worm was found to have spread throughout the entire Laguna district. Surveys were begun in the vicinity of 11 cottonseed-crushing mills in Texas that had received seed from the Laguna area. By the end of 1917, infestations had been found in cotton fields adjacent to two of the mills. Further, an extensive infestation was found late in 1917 at Anahuac, Tex., on Trinity bay. The latter spread was attributed to Mexican cottonseed that was washed far inland when the great storm of 1915 wrecked a Mexican steamship en route to Galveston, Tex. Thus in less than a decade a major cotton pest, through a series of intercontinental distributional leaps, was spread through commercial channels from Asia to Africa, and to the North American continent.

Horticultural items of exotic beauty may nevertheless serve as avenues for introducing noxious pests, as illustrated by the Japanese cherry trees around the Tidal basin in Washington, D.C. The first shipment of 2,000 trees received from Japan in 1910 was so heavily infested with insects that it was burned. While much freer of insect pests than the first gift shipment, a second lot of these trees imported from Japan and planted in 1912 was responsible for the introduction of the oriental fruit moth. Now spread throughout the U.S., this moth is one of the most destructive pests of peaches in that country.

Among the hundreds of noxious insects and plant diseases that countries seek to keep out are: the golden nematode of potatoes and tomatoes; pink bollworm of cotton and cotton boll weevil; harmful species of fruit flies, such as the Mediterranean, oriental and Mexican fruit flies and the melon fly; Colorado potato beetle; citrus canker; and various virus diseases.

Functions of a Plant Quarantine Service.—A comprehensive national plant quarantine service provides for the following:

1. Inspection stations at all important maritime. border and air ports of arrival to enforce all plant quarantine prohibitions and restrictions prescribed by the national government.

2. Inspection of surface ships and aircraft and their cargoes, stores and baggage, as well as arriving mail, express shipments and freight, at all ports of entry. In addition, at land ports of arrival, inspections are made of pedestrian, passenger-car and truck traffic, freight cars, passenger trains and dining cars. This inspection is for the purpose of determining whether arriving plant products meet the requirements for entry, or whether they must be treated, destroyed or re-exported.

3. Fumigation or other treatment of any type of carrier, cargo or products, or destruction of infested products or packing materials, when necessary to ensure freedom from injurious pests. The principal fumigants used by plant quarantine services are hydrocyanic acid gas, methyl bromide and ethylene dibromide. Release of an agricultural insecticidal aerosol in foreign aircraft may be required immediately upon landing.

4. Inspection of domestic plants and plant products intended for export and certification of the products to meet the phytosanitary requirements of the country of destination.

Air travel introduced an important additional hazard of pest spread. Insects particularly now have a much better chance of reaching another country alive, since the short elapsed time of air travel permits them to survive without food or water. For example, the oriental fruit fly was discovered in Hawaii in May 1946, presumably having travelled by military air transport from Saipan. In another instance, an overseas flight that originated in Cairo, Egypt, stopping en route at Paris, was found upon arrival in the U.S. on June 26, 1956, to contain 51 live adults of the European chafer (*q.v.*). The plant quarantine inspectors who searched the plane were informed by crew members that during their stopover in Paris the chafers were swarming "like bees" around the lights at the airport. The chafers were found in the passengers' compartment as well as in baggage and cargo compartments. This destructive insect already had been unwittingly introduced and established in several scattered areas of northwestern New York.

The benefits of a plant quarantine can be illustrated by California's experience in introducing the eucalyptus tree from Australia in the seed stage. This is the safest stage in which to make introductions, since clean seeds that have been surface treated and fumigated carry few insects or bacteria, fungus or virus organisms. In its native home the eucalyptus has a large number of insect enemies. Not a single Australian insect species was brought to California with the seeds. In contrast, eucalyptus importations, probably in the form of Auslralian-grown nursery stock, resulted in the introduction into South Africa and New Zealand of several destructive eucalyptus pests. By utilizing a perfectly natural plant quarantine barrier, California protected itself from pests that it might otherwise have received.

History of Plant Quarantine Development.—Prior to 1870 there was little realization by national governments of the dangers inherent in a free exchange of the plants and plant products that are hosts to injurious plant pests. As a result of this indifference, many harmful insects and destructive plant diseases travelled with their hosts to distant lands. In their new environments these pests frequently found hosts more susceptible to their attack. Natural enemies and other controls which often held them in check in their native home were absent. Characteristically, most introduced foreign pests become well established in a new country before their unwelcome presence is discovered.

Also, comparatively pest-free plants introduced into a new environment may be attacked by a previously unimportant pest. The pest may then spread throughout the range of the newly found host. Such was the case with the Colorado potato beetle, a relatively unimportant insect first described in 1824 and thriving on native weeds in the Rocky mountain area of the U.S. When cultivated Irish potatoes were planted nearby it fiercely attacked the new food crop and in the short span of 16 years, from 1859 to 1874, spread from Nebraska to the Atlantic coast of the U.S., an average annual migration of 85 mi.

Two North American insects that became established in European countries and in Australia were responsible for the inception of national plant quarantine legislation in the decade following 1870. During this decade, many national governments realized that destructive insects and disease-producing organisms are abundant in many parts of the world, ready to be taken to other countries and there attack the native agricultural and horticultural crops.

The Colorado potato beetle incidentally was responsible for the first legislation affecting the international movement of a plant product. This prolific pest was transported in potato exportations to Germany, where a localized infestation was found in 1874. Following eradication of the small infestation, a decree was issued by the German government on Feb. 26, 1875, forbidding the further importation of potatoes and potato sacks. This decree appears to be the pioneer in plant quarantine legislation affecting the international movement of a plant product. France also imposed exclusion measures against this new U.S. pest in 1875. These two exclusion orders antedated by only two years the Destructive Insect act adopted by the United Kingdom in 1877.

About 1859 the grape Phylloxera (see PHYLLOXERA), a native of eastern U.S., was introduced into France through the medium of imported grapevine cuttings. During the following zo years the Phylloxera spread until it was established in the entire grape-growing area from Spain through central Europe to the Black sea district of Russia. Within 25 years after it was discovered in France it had destroyed nearly one-third of the French vineyards. Whereas the grape in Phylloxera's native habitat had acquired practical immunity to its attack, European grape varieties proved easy prey. The sight of the small galls on the leaf and the gall-like swellings on the roots formed by this minute, aphidlike insect caused near panic among the growers when outbreaks grew to serious proportions. Similar shipments of vine cuttings from France to Australia about 1872 spread the Phylloxera to the latter country. Plant quarantine legislation to suppress this infestation was passed by the Australian legislature in 1877. This act gave power to quarantine and even to eradicate vines and destroy vineyards. In France regulation relating to Phylloxera was proclaimed in Oct. 1878.

The first widespread concerted action in Europe in the field of plant quarantine was taken in Nov. 1881, when an international conference held in Berne, Switz., drafted an international agreement known as the Phylloxera convention. The conference also considered means of preventing the introduction of the Phylloxera from the U.S. and restrictions and regulations on the movement of grapevines and grape products to prevent its further spread between European countries.

Adoption of the Phylloxera convention of 1881 emphasized to European nations the need for restrictions on the movement of plants and plant products to prevent the accidental introduction of alien insects and plant diseases. Within a few years plant quarantine restrictions affecting a number of U.S. plants and plant products in addition to the grape had been adopted by several European countries.

Most important of the emergent European plant quarantine orders was an embargo placed in 1898 on plant material that might be infested with the San Jose scale. This scale had been introduced into the United States from China with importations of such ornamentals as the flowering peaches that were planted on a large estate at San Jose, Calif., in 1870. The pest was named after the town where it was first observed. In 1880 the scale was recognized as the most pernicious pest of deciduous trees then known. Shipments of nursery stock from the San Jose area spread the scale to an orchard in Virginia and to several nurseries in Missouri, New Jersey and New York, where the infestations came to public notice in 1893. One state after another promulgated quarantines to keep out this pest. These quarantines were followed in a few years by practically world-wide quarantines banning the importation of C.S. plants and placing restrictions on the importation of U.S. apples and other fruits.

Legislation intended to control local infestations of the migratory grasshopper was enacted by the midwestern states of Kansas, Minnesota, Missouri and Nebraska in 1877. These laws made no attempt to control initial invasions by these pests, since this was considered impossible. The laws did provide for the compulsory destruction of migratory grasshoppers in localized areas already invaded. The object was prevention of further spread the following year through migratory flights from invaded areas.

In addition to its instigation of plant quarantine legislation among European nations, the grape *Phylloxera* was also the incentive for the first interstate plant quarantine in its country of origin. This pest was found in a vineyard near the town of Sonoma, Calif., in Aug. 1873. It had been accidentally transported from its native habitat in the eastern U.S. to California vineyards having European-type plantings. Sentiment for control legislation grew so strong among viticultural (vine-growing) and other horticultural interests that on March 4, 1881, the California legislature passed an act "to protect the interests of horticulture and viticulture," the first legislation adopted in the C.S. to prevent the spread of injurious insects. This act, as subsequently modified and strengthened, authorized state officials to require inspection and other measures to prevent the entry of pests from other states or from foreign countries. In 1890 California became, so far as is known, the first area in the world to inaugurate a system of maritime port inspection against insects and plant diseases. For 31 years following the act of 1881, California's was the only existing legislation in the U.S. to protect the country from the entry of injurious foreign plant pests. The U.S. was the last of the major nations of the world to protect itself by law against the importation of plant pests. Its Plant Quarantine act was not passed until Aug. 20, 1912.

Professionally, plant quarantine is recognized by the Entomological Society of America through its section on control, extension and regulatory entomology and by the American Phytopathological society through its committee on regulatory work and foreign plant diseases. Courses in plant quarantine are offered in several colleges and universities in the U.S., including the universities of Florida (Gainesville) and Minnesota (Minneapolis) and Colorado Agricultural and Mechanical college (Fort Collins).

International Plant Quarantine Agreements. — Closer liaison between plant quarantine services of different countries was established as a result of the drafting of an International Plant Protection convention by the Food and Agriculture organization of the United Nations in 1951. This international agreement dealing specifically with plant quarantine matters became effective April 3, 1952. Its purpose is to strengthen co-operation among governments for the protection of plant resources. By May 1957, 38 governments, including signatories which had ratified it and subsequently adhering governments. had become parties to this convention which replaced the Phylloxera convention of 1881 and the International Convention for the Protection of Plants of 1929.

The 1951 convention provided, in part, for uniform phytosanitary certificates, the establishment of plant protection agencies by each contracting government, the promulgation of national quarantines only as biologically warranted. the creation of regional plant protection organizations, a world reporting agency and a procedure for settling international disputes.

By June 1957 regional plant protection organizations had been created in Europe, southeast Asia and the Pacific, and in Central America and Mexico. Similar regional organizations had been developed independently in that part of Africa south of the Sahara and in the southern half of South America.

A world-wide reporting service on plant diseases and pests was established by the Food and Agriculture organization in 1952 under the provisions of the International Plant Protection convention. The service issues a monthly publication, the *FAO Plant Protection Bulletin*, the first number of which appeared in Oct. 1952. Published in English, French and Spanish, the bulletin disseminates information on plant quarantine of world-wide interest, especially current reports on the occurrence, outbreak and control of insects and plant diseases of economic significance. The service also assembles information on all plant quarantine legislation and regulations in effect throughout the world. A Digest *of Plant Quaruntine Regulations* was first published by FAO in 1949, prior to adoption of the convention. A more complete edition was issued in 1952, covering the regulations of 40 countries, and a supplement in 1954 covered 38 additional countries and territories.

BIBLIOGRAPHY.—Publications on the subject are somewhat fragmentary, being mostly scattered, brief references in textbooks, scientific papers and government bulletins The background and plant disease phases of the subject are well covered in W A McCubbin, "The Plant Quarantine Problem." *Ann. Cryptog. Phytop.* (1954). *See* also H. S. Smith *et al.*, "The Efficacy and Economic Effects of Plant Quarantines in California," University of California College of Agriculture Bulletin 553 (Berkeley, Calif., 1933). (R. W. SH.)

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